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Drivers of Product Innovation: An Investigation of German Manufacturing Companies

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ABSTRACT

Drivers of Product Innovation: An Investigation of German Manufacturing Companies

Product innovation is an important driver for manufacturing companies to remain competitive. Although new products are essential to high-technology companies, other sectors are also focusing on product innovation. As the importance of product innovation becomes widely recognised, there is a need to analyse the relationship between product innovation rates and the percentage of revenues generated from new products (defined as product innovation position). Therefore, the purpose of this study is to determine why companies (business units) within the same industry sector (i.e., in the engineering and electrical & electronics engineering sector) operate with different product innovation positions.

Much of the management literature is based on the assumption that product innovation leads to improved company performance in terms of competitive advantage, higher revenues with new products, higher market share and cost or quality advantages. Taking this argument into account, it might be expected that firms with high performance are innovating at a faster rate than less successful companies. But this relationship is not as clear as it appears. Overall, the reasons why companies innovate at different rates require investigation. In other words: the factors which influence product innovation positions need deeper examination.

In order to identify the reasons for varying product innovation positions, the research was divided into three phases: The first phase was a survey of 81 business units, which collected data on the number of new products developed by companies. This phase identified errors in measuring the percentage of new products introduced in the last three years (product innovation rate). Therefore, in the second phase, the errors in measuring product innovation rate were corrected through a survey and telephone interviews. In this phase, data from 78 business units were analysed. In the third phase, further investigations focusing on the question why business units have different product innovation positions were conducted through case studies. The investigation used a model of Cooper and Kleinschmidt (1993) as a basis for the case study research of 11 business units in the industry sectors engineering and electrical & electronics engineering.

The results identified three key drivers for product innovation positions: market, competition and product innovation strategy. Further, the two areas NPD management and corporate culture were found as key drivers for the management of product innovation processes. One further important finding is, that product innovation position do not show how innovative a business unit is. With regard to profits, the cross-case analysis found that independent from product innovation position only two of 11 business units earn more from new products than from the whole product portfolio (i.e., from both existing and new products). This implies that the product innovation rate and the percentage of revenues are related to the context. It has to be noted that an investigation of product innovation position was only possible by using a combination of both survey and case study approach.

ACKNOWLEDGEMENTS

Completing a Ph.D. parallel to full-time employment is a challenge, especially the circumstances that in the long time of this research project I was under my own management. The work began with the launch of the German International Best Factory Awards (IBFA) in 1997. The research was based around an analysis of survey and case data on companies from the IBFA database of the Export-Academy Baden-Württemberg in Reutlingen, Germany. Collecting comparative data on companies' performance is difficult, and would not have been possible without the help of the sponsors of the German IBFA programme.

One important factor for finishing my Ph.D. were the people around me.

I would like to thank Professor Keith Goffin who took the risk of admitting a middle–aged man's way through the Cranfield School of Management doctoral program. He gave me support with any questions around my research and helped me to stay on the track writing my thesis. Throughout my doctoral research he was a very good supervisor keeping my thinking sharp and my standards for evidence high.

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I owe the most to my family – my wife Petra and our sons Patrick and Clemens. With unhesitating faith and support they encouraged me to pursue my aim to get a Ph.D., amidst all of the demands of family life. Doing this research on product innovation has indeed been disruptive to them in terms of time and absence from home. I dedicate this thesis to my wife and our sons.

Thanks to my family.

Tübingen (Germany), August 2003

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CHAPTER ONE

INTRODUCTION

1.0 INTRODUCTION

This management research project focuses on product innovation in Germany – an issue that is widely accepted as critical for both German companies and the economy as a whole. With high labour and social costs, German companies are looking for ways to become more competitive, and product innovation is widely recognised as an important priority for companies (e.g., Rommel, 1991; Brinker et al, 1997; Janz et al, 2001; European Commission 2001b). Potentially new products bring many advantages for businesses. They can help increase market share in existing markets, enable entry into new markets and increase market profitability (Nevens et al, 1990; Cimento et al 1993; Wieandt, 1995; Blachandra and Friar, 1997). Companies may focus on new customer groups or differentiate themselves from their competitors with new products (Cimento and Knister, 1994; Dürand, 1998). New products can also complement existing company offerings, promote increased customer loyalty, and stimulate demand for other products (Porter, 1985).

Without frequent new products, companies can quickly lose competitiveness and market share – "if you do not innovate, old products will be overtaken by new technology" (Gourlay, 1996). For example, Kaplan and Norton (2001) stated that "product innovators must accelerate the time to develop and commercialise new products". The ability to introduce new products is one of the key challenges facing European companies, as identified by a survey of manufacturing managers (De Meyer and Pycke, 1996) and from the European Commission (2000). Companies that have recognised this are responding and several have launched major innovation initiatives (Buckler and Zien, 1996; Coyne, 1996; Rueter, 1999). However, many studies which focus on product innovation are anecdotal (e.g., Nevens et al, 1990; Mass and Berkson, 1995; Leonard and Rayport, 1997; Nicholson, 1998) or focus solely on well known companies and therefore the generalisation of the results is questionable (e.g., Jelinek and Schoonhoven, 1990; Griffin and Page, 1996; Swink et al, 1996).

There are various forms of innovation – product innovation and innovation in manufacturing processes, services and business processes. Companies need to be innovative in all these areas (e.g., Schumpeter, 1934; Wind and Mahajan, 1988; Kay, 1993; Goffin and Pfeiffer, 1999). However, for manufacturing companies, product innovation is particularly important to market success (e.g., Warner and Blackmaon, 1993; Pleschak et al, 1994). Therefore, this study concentrates on product innovation and focuses on German manufacturing industry, which is attempting to improve its performance in this area (e.g., Lay, 1997; Janz et al, 2001).

The research investigates product innovation by focusing on the product innovation rate, defined as the percentage of new products in the product portfolio which are less than three years old. Further, the relationship between product innovation rates and the percentage of revenues gained from new products is examined. These two variables are investigated at the business unit level which is characterised by having its own production facilities and a strong involvement into all research and development (R&D)

processes and marketing activities. The reasons for varying levels of product innovation rates and percentages of revenues from new products are investigated through surveys and case studies.

As stated earlier, much of the management literature is based on the assumption that product innovation leads to improved company performance in terms of competitive advantage, higher revenues with new products, higher market share and cost or quality advantages (e.g., Groski and Machin, 1992; Cooper and Kleinschmidt, 1993; Zarah, 1993a; Acs, 1994; Berth, 1997; Ittner and Larcker, 1997). Particularly the popular press suggests that companies which are more innovative achieve higher profits than their competitors (Anonymous, 1995a; De Meyer and Pycke, 1996; Sõren et al, 1999). Taking this argument into account, it might be expected that firms with high performance are innovating at a faster rate than less successful companies.

But this relationship is not as clear as it appears. Previous research shows that even direct competitors have very different innovation rates (Goffin and Pfeiffer, 1999; Goffin et al, 2001). Further, it is questionable why companies within the same industry sector develop very different numbers of new products (e.g., Kluge et al, 1996; Gassmann, 1997; Kulicke et al, 1997; Janz et al, 2001). Overall, the reasons why companies innovate at different rates are open and require investigation.

In other words: the factors which influence product innovation rates need deeper examination. For example, Audretsch and Vivarelli (1996) showed that relatively new companies introduce more new products than established ones. Another factor was identified by Zirger and Hartely (1996) who found that companies with a first to market strategy also introduce higher numbers of new products into the market. However, in contrast to these findings many other studies had not identified any individual factors which influence product innovation activities (e.g., Benkenstein and Hübner, 1995; Ellis and Curtis, 1995; Balachandra and Friar, 1997; Clement et al, 1998).

Although there is a wealth of literature on the factors influencing product innovation activities, it is difficult to find a suitable framework showing the relationship between all factors. However, to reflect this complexity Cooper and Kleinschmidt (1993) developed a model. Their model offers six different areas which influence product innovation (market, competition, corporate environment, nature of project, new product process, strategy). This model was used as a basis to explore the reasons why different companies (business units) have different product innovation rates and why they achieve a different percentage of revenues from new products.

1.1 OVERVIEW OF PROJECT AIMS

From a detailed review of the literature it became clear that the reasons for varying product innovation rates and the relationship between product innovation rate and the percentage of revenues from new products warrants further investigation. It was also shown that the many and complex factors with influence on the product innovation rate make it difficult to investigate this topic.

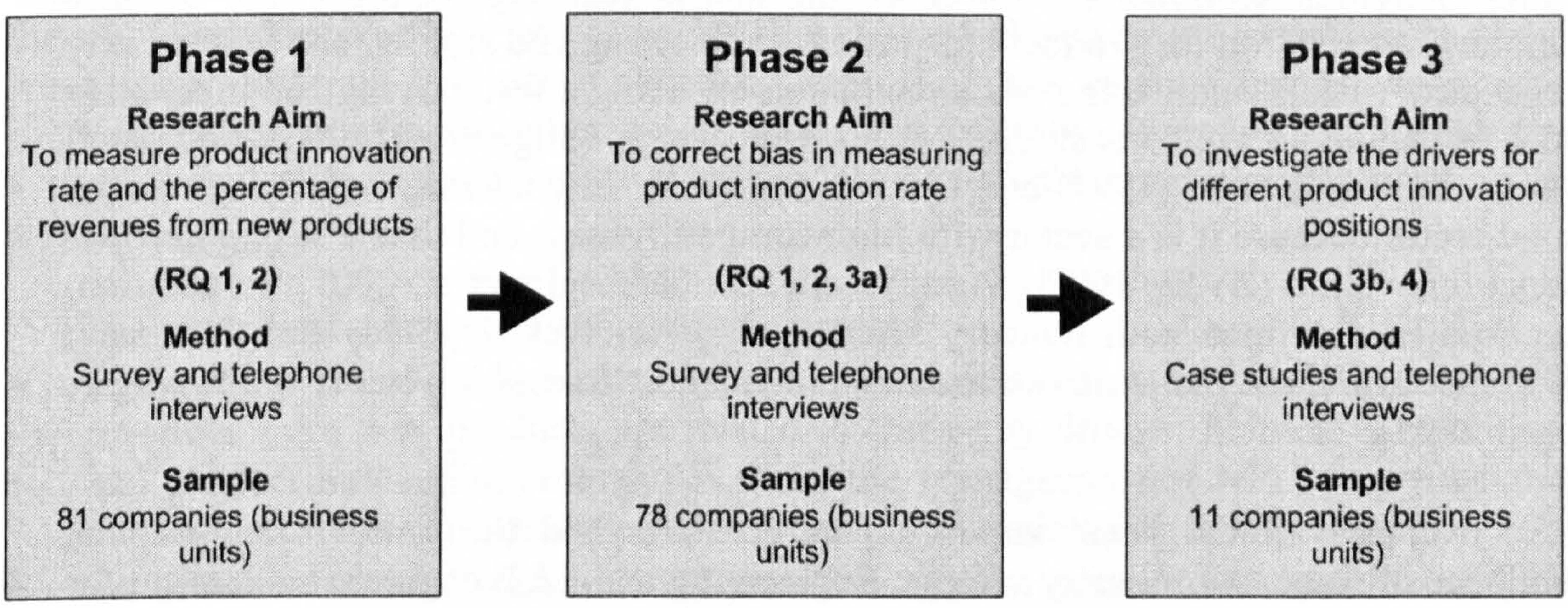
Taking these findings into account, the aim of the research was to reveal whether significant differences exist between the product innovation rates and the percentage of revenues from new products in different German manufacturing companies. In addition, a key aim was to identify the drivers of different product innovation positions, i.e., to find out the reasons why companies (business units) operate with different product innovation rates and why business units achieve different percentages of revenues with new products that have similar product innovation rates.

To achieve these aims, it was necessary to use multiple methods and a three phase design.

1.2 OVERVIEW OF METHODOLOGY

In order to identify and investigate the reasons why business units have different product innovation rates a methodology running over three different phases was chosen. The research aims of each phase, the research method used and the dataset analysed is given as an overview in Figure 1.1.

Figure 1.1: Overview of the Three Phases of the Research



The research over the three phases had following characteristics:

- The study investigated product innovation in Germany and two industrial sectors were chosen – engineering and electrical & electronic engineering (E&E engineering).
- The study combined two approaches – survey and case study research. Using these two research techniques it was possible to cross check data during the case studies (for example, in interviews with managers). With the information from these cases deeper insights into the reasons for product innovation can be gained.
- The research was divided into three phases: The first phase was a survey of 81 business units, which collected data on the number of new products developed by companies. In this phase, the first insights into the complex field of product innovation processes in companies were also gained. However, this phase identified errors in measuring the percentage of new products introduced in the last three years (product innovation rate). Therefore, in the second phase, the errors in measuring product innovation rate were corrected through a survey and telephone interviews. In this phase, data from 78 business units were analysed. In the third phase, further investigations focusing on the question why business units have different product innovation positions were conducted through case studies at 11 business units.

As discussed earlier, the industry sectors engineering and E&E engineering were investigated. The reasons for the choice of the two industry sectors are given in the next section.

1.3 CHOICE OF INDUSTRY SECTORS

In order to get meaningful results and to be able to generalise the findings, the research focused on two different industry sectors – the engineering sector and electrical & electronics engineering sector. In the two chosen sectors new products play a crucial role in Germany (Anonymous, 2002a) and therefore they are an interesting field for research activities. Rommel (1991) chose the mechanical engineering sector because "Germany's reputation for product innovation, engineering and styling, and high quality is legendary". E&E engineering has a reputation for being a fast moving and innovative field – as shown by previous studies of this sector, e.g., Kluge et al (1996), Loch et al (1996), Iansiti and West (1997) and Datar et al (1997). Engineering was chosen as the second sector because it is a sector with high competitiveness and thus a strong need for product innovation (ZVEI, 1999b; Anonymous, 2000a; Legler et al, 2001). In addition, other studies examined both industry sectors, e.g., Adler et al (1996) and Gassmann (1997), because these industries seemed to be the "most interesting ones" to investigate (Reger, 1997).

An overview of the latest import/export activities and the turnover support the importance of these two industry sectors. Engineering and E&E engineering account for 51% of the whole national exports volume (Federal Statistic Office, 1999). With goods from these industries an export surplus of 63.75% was achieved in 1998 (average over all industries 16.7%). In summary, 56% of the whole turnover in the German manufacturing industry was created by these two industry sectors.

By first sight, the approach to concentrate the product innovation research on two industry sectors seems to be questionable, because previous studies have found that one of the main reasons for different numbers of new products are different markets and competitors (e.g., Porter, 1980; Ali, 1994; Terwiesch et al, 1998; Janz et al, 2001). This was supported by Acs (1994) who stated that "there are considerable differences in innovation across industries". Taking these findings into account it could be concluded that a more suitable way is the concentration of the research on direct competitors within one branch. However, most of these studies looked at the number of new products introduced into the market which is quite different from the product innovation rate – product innovation rate shows the relationship between the numbers of old and new products. In consequence, it is not clear if the product innovation rate is dependent on industry sectors, too – with an investigation of two industry sectors it is possible to investigate this relationship. A further reason why two industry sectors were chosen is the possibility for generalising the results. As the balance of new and existing products within the product portfolio is crucial for staying competitive (e.g., Brockhoff, 1993; Cramp, 1994; Johnson and Scholes, 1999), an investigation of two industry sectors will help to generalise the reasons for different levels of product innovation rates and percentages of revenues from new products.

Based on the investigation of the two industry sectors, the contribution to knowledge and the key results are summarised in the next section.

1.4 EXPECTED CONTRIBUTION AND KEY RESULTS

The investigation used a model of Cooper and Kleinschmidt (1993) as a basis for the research. The relationship between product innovation rates and the percentage of revenues from new products (defined as product innovation position) in combination with the Cooper and Kleinschmidt model was used for analysing the reasons for product innovation activities. The literature review showed that previous researchers mainly focused their research activities on the number of product innovations without taking the whole product portfolio into account. This gap was closed by the examination of the reasons for different product innovation rates (i.e., the relationship between new products and existing products) on a deep level. The following overview summarises the expected contribution to theory and methodology and the expected contribution to practice.

The contribution to theory and methodology are:

- The current research showed that product innovation rate and the percentage of revenues from new products are related to three key drivers: market, competition and product innovation strategy. Further, the management of NPD processes and corporate culture were identified as key drivers for developing new products.
- As previous research in product innovation was often made on macro level or project level, this research investigated product innovation on company (business unit) level which is not common in product innovation research.
- Product innovation rate is difficult to measure. To get valid data, the whole product portfolio (i.e., the number of existing and new products) and the degree of product innovations have to investigated through interviews with managers.

- Product innovation position can not be used as a performance measure. The current research showed that that low product innovation rates and low percentages of revenues from new products do not automatically imply that a business unit is not innovative. (i.e., is developing no new products).
- The research used a combination of survey and case studies. This combination is not usual, and therefore a potential contribution to the innovation research methodology is given.

The contribution to knowledge for practising managers are:

- The model of Cooper and Kleinschmidt (1993) is modified and can be used by managers to identify their drivers on product innovation rate and the percentage of revenues from new products systematically
- It was found that the whole product portfolio (including both existing and new products) is key for making profits. Therefore managers need a detailed understanding of their product portfolio.
- Product innovation rate and the percentage of new products is not related to NPD project management. The advice for managers is to move away from optimising only NPD processes. The innovativeness of business units needs a complex view on market, competition, product innovation strategy, NPD project management and corporate culture.
- Product life cycles are related to the number of existing products within the product portfolio. However, it is not related to the number of new products developed.

The research is based on a survey of a large number of business units and made 11 in-depth studies to give detailed insights into the reasons for high and low product innovation positions. Although the reliability of the dataset is high, the current results should be interpreted with caution because the investigated companies (business units) may not be representative of German industry as a whole. Further, it should be taken into account that the investigation of product innovation rates and the percentage of revenues from new products on a business unit level through interviewing the management team is limited. Therefore, the reasons for varying product innovation positions should be studied in longitudinal research. Nevertheless, the chosen methodology in the current study contributed significantly to the reliability and validity of the results.

1.5 THESIS STRUCTURE

The thesis is structured into 10 chapters:

Chapter 1: An introduction and overview of the whole thesis is given.

Chapter 2: A detailed explanation of the term innovation in regard to different types of innovation and the nature of product innovations is presented in this chapter. Further, a summary of key findings from the product innovation literature and a detailed discussion of key papers is given. The lack of product innovation research and appropriate approaches to decide on product innovation research on business unit level has been noted. Next, a model for the further research is presented and methodological implications are discussed. Finally, a presentation of the research questions derived from the literature is presented.

Chapter 3: This chapter gives an overview of product innovation activities in Germany. Further, a summary of product innovation activities in the German Engineering and E&E engineering sectors is included.

Chapter 4: An explanation of the research design including comments to the philosophical perspective are described. The business unit of analysis is explained in detail and the benchmarking programme International Best Factory Awards is presented. In a summary, the product innovation measurement variables used in the research are listed. Finally, the research methods for the three research phases are explained in detail.

Chapter 5: Results of Phase 1. The aim of this chapter is to give answers on what the typical product innovation rates of business units in the German engineering and E&E engineering sectors are. To find this, survey data were analysed. However, an examination of the dataset via telephone interviews identified an error in calculating product innovation rate.

Chapter 6: Results of Phase 2. Phase 1 showed errors in measuring product innovation rates. In this chapter it is shown, how product innovation rates and the percentage of revenues from new products are related. The errors identified in Phase 1 were corrected to have a valid database for further research. Further, a diagram is presented, which makes it easier to differentiate between business units with different product innovation positions. With the corrected product innovation rates it was also possible to show the relationship between individual product innovation positions and profits with the whole product portfolio.

Chapter 7: Results of Phase 3. This phase concentrated on the cross-case analysis of 11 case business units. Variables with an expected influence on product innovation rate and the percentage of revenues from new products are analysed systematically.

Chapter 8: In this chapter the results of Phase 2 and Phase 3 are analysed and compared to findings from previous research studies.

Chapter 9: The conclusions and recommendations of the whole research are given in this chapter.

Chapter 10: This chapter summarises the results of the research. Further, suggestions for future research projects into product innovation on business unit level are presented.

Finally, the literature used in the current research project is listed. The following appendix includes further background information, e.g., the case study questionnaires, a summary of papers which investigated product innovation in Germany, a summary of innovation measures, background data of the case studies and other important information of the research activities.

1.6 SUMMARY

The main focus of the research is the investigation of the reasons for different product innovation rates within two different industrial sectors. Especially the relationship between product innovation rates and the percentage of revenues from new products was analysed. The research exhibits the following main characteristics:

- It investigated product innovation rate and the percentage of revenues from new products in German manufacturing companies.
- Focus was on the engineering and E&E engineering sectors.
- The unit of analysis was the business unit.
- The project was run in three phases, which used a combination of survey and case methodology.

Product innovation is one of the most important challenges forced upon the German manufacturing industry and so the results are extremely relevant to both researchers and practising managers. The research offers information about the reasons for different product innovation rates, i.e., the relationship between existing and new products within their product portfolio which was not investigated on a deeper level by previous researchers. Managing directors, R&D managers and marketing managers from varying companies gave insights into their strategy, their NPD processes and their competitive position. Further, they explained why they see their product innovation rate and percentage of revenues from new products as the best way to stay competitive.

In the next chapter a detailed account of the product innovation literature is given. This includes discussions of the studies which have focused on the areas which influence product innovation activities.

CHAPTER TWO

THE PRODUCT INNOVATION LITERATURE

2.0 INTRODUCTION

Innovation is a complex phenomenon involving the generation of ideas and the conversion of technology and knowledge into new products, new services or new production methods. In this chapter, the key literature on product innovation is presented in order to show how the research questions were derived. There is a vast anmount of literature on product innovation, resulting from studies by economists, technologists and management researchers. Therefore, this chapter has the challenging role of bringing together many strands of research. One of the reasons that so many articles have been published is the fact that product innovation is influenced by many factors and many of them have been investigated separately (Kline and Rosenberg, 1986; Edquist 1997, 1999). However, the review of the literature shows that:

- There are three main levels of analysis for product innovation studies: the macro level (studies at the macro level investigate product innovation within nations with the aim of showing the competitiveness internationally); the company level (studies at this level investigate the relationship between how product innovation is managed in a company and its influence on financial performance) and the project level (studies at this level concentrate on how specific research projects are managed).
- In the literature many product innovation studies focus on the macro level (e.g., on the influence of government policy on product innovation activities of countries) and project level (e.g., on the management techniques used for research and development projects). Most studies do not investigate product innovation at the company level.
- In practice, product innovation management involves many decisions in areas such as setting product innovation strategy, ideas on generating and developing new products (NPD). However, most research has only focused on one area. Only a few studies have investigated the complex relationship between all areas of product innovation management and product innovation performance at a company level.
- Due to the complexity, many product innovation studies have used small samples or concentrated on a few well-known and highly innovative companies.
- Many studies have used survey or case study research in isolation to investigate product innovation. However, a combination of both research methods could be useful to address the complex field of product innovation. With the two methods information gained by surveys can be checked at a deeper level in case study visits or the results of the case study research can be generalised through the use of surveys.

The five points above are discussed in detail in this chapter (Sections 2.1 – 2.8). Because of the complexity of this chapter, the detailed structure is given in Table 2.1. In the first section, the term product innovation is defined. Therefore, the literature dealing with the definition of product innovation and with innovation in a broader context is discussed. Then, an overview of the investigations of innovation on a macro level is given Section 2.2. In Section 2.3, the literature focusing on investigations at company level is presented. Within this section, research papers dealing with product innovation in the business fields environment, organisation, human resource management and culture, and strategy are discussed in detail. In the following section (Section 2.4) investigations on a project level are given. Studies focusing on the source of ideas, the new product development process and time-to-market are discussed in this section. Then, methodological considerations from the literature are discussed (Section 2.5). Afterwards, the model chosen for further investigation is presented (Section 2.6). In Section 2.7, the research questions identified from the whole literature review are presented. Finally, all aspects identified in the literature are summarised (Section 2.8).

Table 2.1: Structure of Chapter 2

Section	Heading	Contents	Page
2.1	**The Meaning of Innovation**	• Types of innovation • The degree of product innovation	**11**
2.2	**Investigations at the Macro Level**	• Education and national cultural effects on product innovation • Government policy • Diffusion of product innovations • Employment and product innovation • Size of companies and product innovation • Measurement of product innovation on a macro level	**16**
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2.4	**Investigations at the Project Level**	• Source of ideas • The new product development (NPD) process • Time-to-market • Comprehensive studies of product innovation at the project level	**60**
2.5	**Research Methodology in Innovation Research**	• Comments about research methods used in product innovation research	**75**
2.6	**Choosing a Model for Further Investigation**	• Summaey of the key models in the product innovation literature • Presentation of the Cooper and Kleinschmidt model (1993) which was used as a framework for the current research project	**76**
2.7	**Research Questions**	• Presentation of 5 research questions which were identified on basis of the literature review	**82**
2.8	**Summary**	• Short summary of the whole chapter	**84**

2.1 THE MEANING OF INNOVATION

As a starting point for the research on product innovation, the term *product innovation* should be defined. This is important because Balachandra and Friar (1997) found that in a number of studies there is no exact explanation of the term innovation – "it is usually anything that is introduced into the market by the firm, regardless of the extent and type of newness". In this context, the question about the degree of product innovations arises. Producing a bicycle in a different colour does not imply the same degree of innovation as producing one with new gears which allow it to be ridden faster. As managers have different views of what product innovation is and how a new product is defined, it is necessary to give a clear definition of what product innovation is (in order to be able to develop a suitable research design).

Although this study only focuses on product innovation, other fields of innovation are also presented because in today's markets, a combination of several types of innovation are often necessary to be successful (Fisk, 2002). Therefore, "innovation can encompass any change in technology, production processes or organisational and managerial structure and techniques" (Wallace, 1995). A clear differentiation between different types of innovation is necessary, because services are often defined as products, too (i.e., often the term product innovation is used by managers for both physical products and for services such as a new insurance policy). Without any clear differentiation, managers match product innovations with innovations in services. Consequently, their number of new products is a mixture of different types of products which are difficult to compare with new product portfolios from other companies.

In order to give a detailed definition of product innovation in the context of this study, this section discusses two aspects of innovation in detail.

- Types of innovation
- Degrees of product innovation

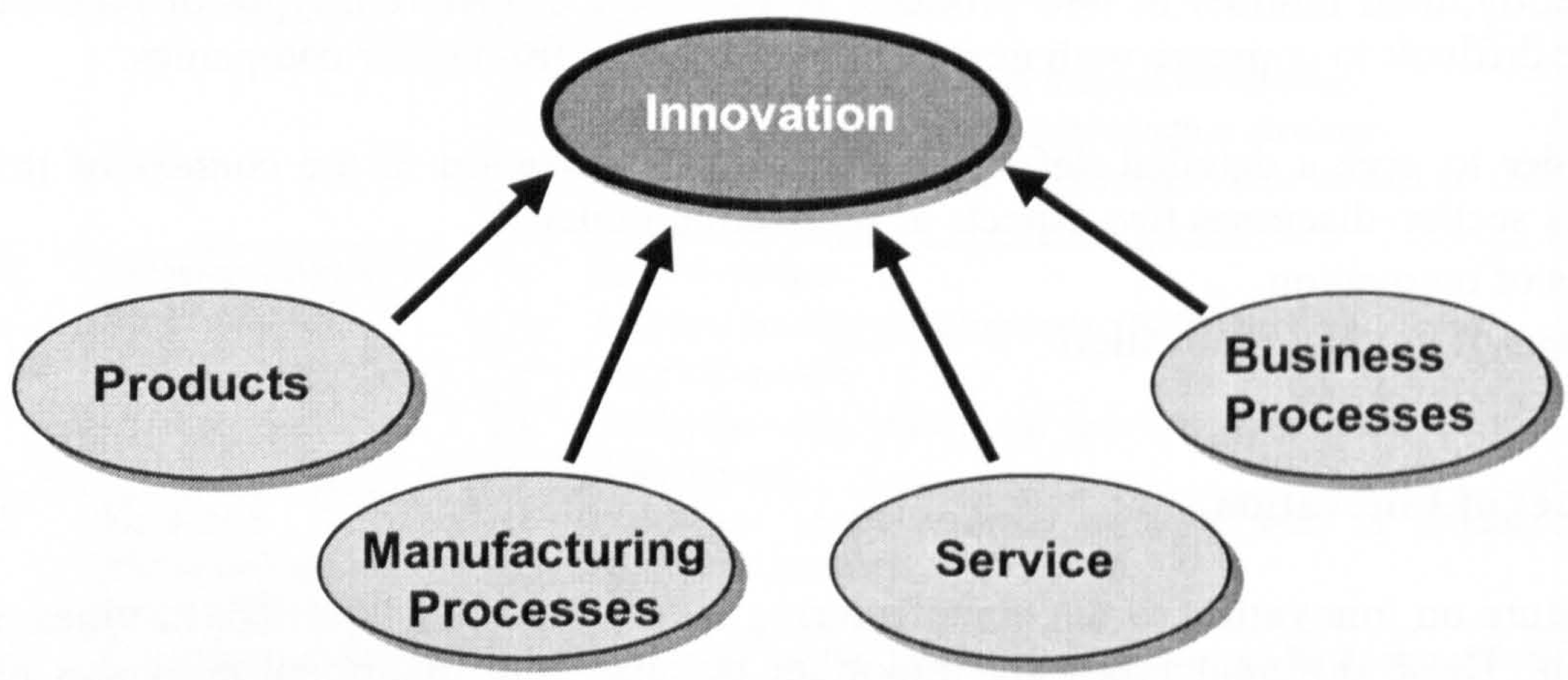
2.1.1 Types of Innovation

The literature on innovation in the manufacturing industry deals with different types of innovation. These different types are important because "the traditional emphasis on product innovation is no longer enough to succeed in an environment of increasingly intense competition" (Cimento and Knister, 1994). For example, new services are also essential (Wind and Mahajan, 1988, Fähnrich, 2002) and process innovation is often a key source of competitive advantage because it is difficult to copy (Pisano and Wheelwright, 1995; Lay, 1997; Heygate, 1996). This is also stated by Kay (1993) who pointed out whilst "competitive advantage can come from size or possession of assets, etc., the pattern is increasingly coming to favour those organisations which can mobilise knowledge and technological skills and experience to create new products, processes and services". Looking at previous research activities, Wind and Mahajan (1988) state that "too much of the focus of new product development is on product features. Successful new product development should focus not only on product features but on the entire product/service/financial offering...". However, new technologies and new products are a key part of new services too. Such a view is taken by Fisk (2002) who points out that the combination of both services and new technologies can lead to a competitive advantage.

A broad view of innovation is also taken by Schumpeter (1934), one of the first researchers who described and investigated innovation. In his view, companies and entrepreneurs have to generate five different types of innovation. The first type of innovation is the introduction of new goods which consumers are not yet familiar with. The introduction of a new method of production is the second type of innovation he identifies. The third type of innovation he attributes to companies and entrepreneurs is the opening up of new markets. The identification of a new source of supply of raw materials or part-manufactured goods is the fourth type of innovation. For the fifth type of innovation he points out that entrepreneurs have to set up new companies or organisations.

Taking all different views into account, the main types of innovation as they are described in the literature comprise (Figure 2.1):
- Product innovation
- Innovation in manufacturing processes
- Service innovation
- Innovation in business processes (e.g., organisational innovation)

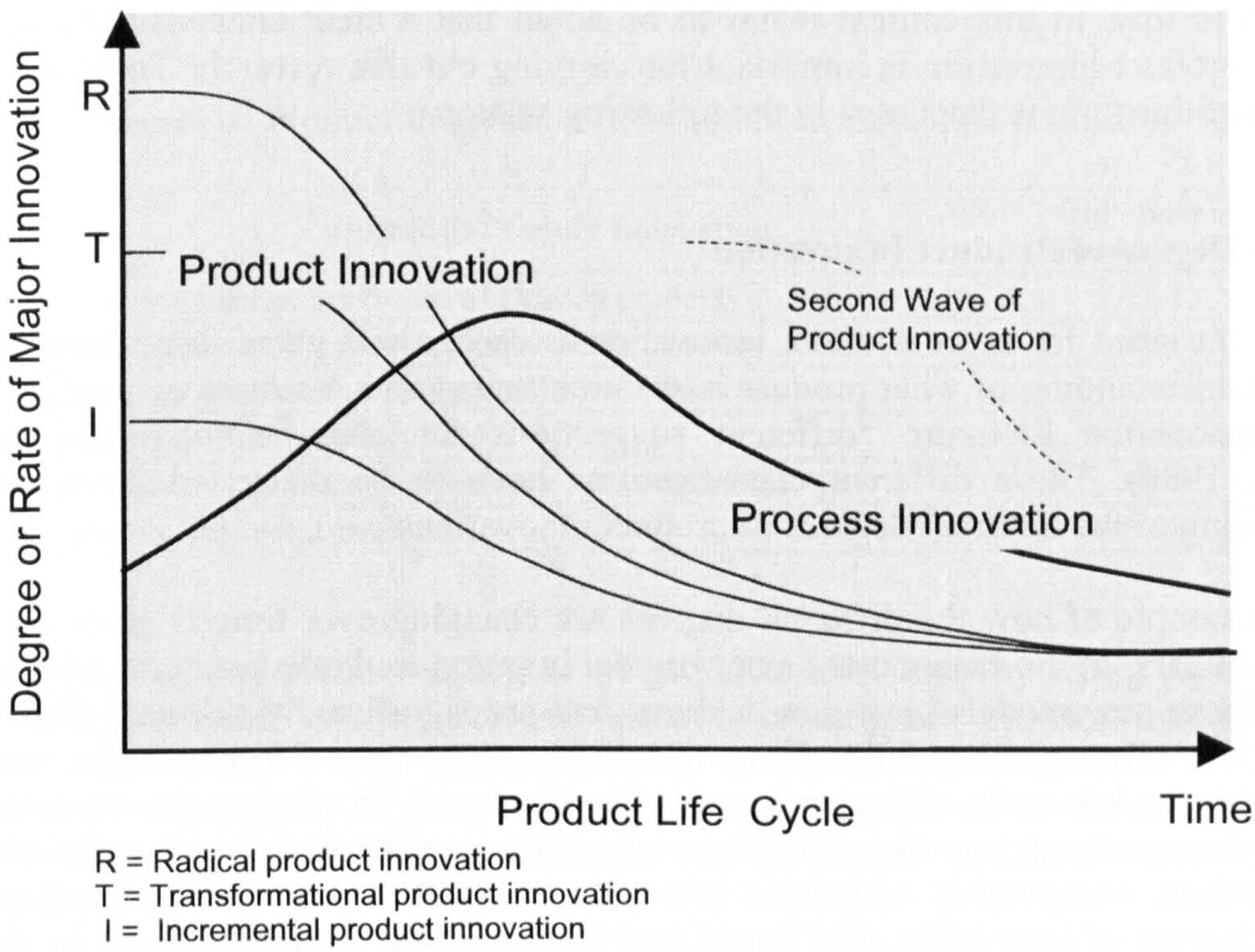
Figure 2.1: Types of Innovation in Manufacturing Industry (Goffin and Pfeiffer, 1999).



Although all types of innovation are important for companies, the research described in this thesis is focused on product innovation. This type of innovation was chosen, because many researchers have identified it as the most important one (e.g., Rommel, 1991; Brinker et al, 1997; Janz et al 2001). Sandberg (1992) states, that Schumpeter's "view of innovation is consistent with the current focus on product innovation". Similarly Pleschak et al (1994) say "product innovation is the most important element [of product policy]" and Pleschak and Sabisch (1996) point out that product innovation is one of the most important sources of profit. One further reason for selecting this type of innovation was the identification of product innovation as the most important area for German industry to concentrate on in order to be competitive (Warner and Blackmon, 1993)

For most customers, product innovation is the most important type of innovation, too (Brockhoff, 1993). Customers often do not ask how new products are manufactured – they are interested in the functions and benefits of a new product. In most cases they do not take into account that many product innovations are combined with other types of innovation to enable the manufacturing of products at a lower cost, a higher quality and shorter manufacturing lead times.

Figure 2.2: The Dynamics of Innovation (adopted from Utterback, 1994)



The importance of product innovation is also identified by Utterback (1994). He investigated the relationship between product innovation and innovation in manufacturing processes over time and develops a model which shows how the scope of both types of innovation changes over time (Figure 2.2). This model is presented in detail, because in his view, the linkages between product innovations and innovations in manufacturing processes are "extremely close". The x-axis of his model is time. The y-axis shows the rate or degree of innovation, which can be low (incremental or small changes in products or processes) or high (radical or major product or process changes). With the implementation of a new product the rate of product innovation is high, while the rate of innovation in manufacturing processes is low. For product innovation three different rates are given in the figure – the rates are incremental, transformational and radical new products[1]. However, the rate of innovation for both types of innovation changes over time, as explained by Utterback. During the introduction phase, a great deal of experimentation with product design and operational characteristics takes place among competitors. Over time, the rate of product innovation slows down and the rate of manufacturing process innovation speeds up. The focus of firms begins to shift from

[1] The rate or degree of new products is discussed in Section 2.1.2 'The Degree of Product Innovation'.

the inventor's workbench to the factory floor. In the specific phase, products become highly defined, and there are often fewer differences between products of competitors than there are similarities. As Figure 2.2 shows, the rate of innovation for both types of innovation decreases over time. However, he points out that it is necessary to have a high rate of innovation to stay competitive. Therefore, Utterback recommends to have a continuous stream of new products for creating a "second wave of product innovation" which in turn generates a further wave of innovation in manufacturing processes.

Utterback's model shows the importance of high rates or degrees of product innovation. Over the life time of a product the degree of product innovation decreases from high to low. In this context it has to be noted that a clear understanding of the degree of product innovation is important for carrying out this research. Therefore, the definition of this term is discussed in the following section.

2.1.2 The Degree of Product Innovation

Although the need for more product innovation is recognised, there is no commonly accepted understanding of what product innovation means in a business context. In the product innovation literature "different suggestions for classifications" are given (Barreyre, 1980). These different classifications have to be discussed for a better understanding of the different degrees of product innovations.

One example of how the different degrees are changing over time is given by the life-cycle of cars. In the car industry a new model is introduced into the market every 3-4 years. These new models have new features and are significantly different from the model before (Gottschalk, 1999). However, in the time period between the model replacements the life-cycle of the car has steadily shortened. Small changes are made to optimise the car from year to year. Especially in competitive, technology-intensive global markets, competitive advantage can only be built through a combination of different degrees of innovation. For Iansiti and Clark (1994), companies need to make both architectural innovations (major changes in product designs), as well as continuous, incremental innovation (small changes in the product design).

As explained with the car example, the degree of product innovation is often affected by different life cycles of products. Tidd et al (1998) show that the degree of innovations ranges from minor to radical changes. "For example, early phases may be characterised by rapid and frequent product innovation, with a proliferation of variety. Later stages might be characterised by a relatively stable product concept with only incremental change..." (Sahal, 1981). Although at first glance a categorisation of new products into different degrees seems to be easy, the literature offers a set of different definitions.

Booz and Hamilton (1982) suggest that there are six main degrees of product innovation (Table 2.2). The first degree they define is the improvement and revision of existing products to provide improved performance or greater perceived value to customers. New products that provide similar performance at lower cost are the second degree of product innovation followed by existing products that are targeted to new markets or market segments. Another degree they find is the creation of new product lines with new products that allow a company to enter an established market for the first time. The addition to existing product lines, like new products that supplement a company's established product lines is the fifth degree. The last degree they suggest is new-to-the-world products, defined as new products that create an entirely new market. Their definitions show a wide range of degrees and it is obvious, that their definitions of the degree of product innovations are related to the markets. To make a separation into different degrees easier, they offer a further categorisation into two degrees of product innovations. In their opinion the six degrees can be divided into "old product development" representing product improvements, and "new product development" representing products which pose greater development challenges. This categorisation is given in Table 2.2.

Table 2.2: Degrees of Product Innovation (adopted from Booz and Hamilton, 1982)

#	Degree of Product Innovation	Old / New Product
1	Improvement and revisions of existing products	Old
2	New products that provide similar performance at lower cost	Old
3	Existing products that are targeted to new markets	Old
4	Creation of new product lines	New
5	Addition of products to an existing product line	New
6	New-to-the-world products	New

Booz and Hamilton mix the degree of product innovation by using product and market characteristics. As the current research investigates product innovation, a definition was chosen which focuses directly on product characteristics. From the definitions of the degrees of product innovation the definition of Iansiti and Clark (1994) was chosen. They offer three different degrees for new products which are used in the further research[2]:

- *Incremental:* Small changes or improvements on an existing product.
- *Transformational:* Is the creation of new products on the basis of a well known technology.
- *Radical:* Something totally new, based on fundamental discoveries.

In this section, it was shown that product innovation is one type of innovation, which is related to others such as process and service innovations. Further, it was shown that product innovation is quite a difficult concept to define – this obviously has implications for the research project described in this thesis. However, now that the definitions of product innovation have been presented, the next sections cover previous research of product innovation, starting at the macro level.

[2] Based on this definition, the degree of product innovation was discussed with the interviewed managers within the case studies (Refer to Chapter 7 'Results of Phase 3').

2.2 INVESTIGATIONS AT THE MACRO LEVEL

Due to its links to economic growth, economists have researched product innovation for a long time, starting with the work of Schumpeter. He concentrated his research activities on macro economics – studying industries and national economics. In the 1934 book, *The Theory of Economic Development,* he looks at the way innovations emerge and threaten established industries. He perceives innovation as being directly linked with entrepreneurial activities and having a direct influence on the economical performance of countries. In his view, entrepreneurialship and innovation are the most important factors for the prosperity of nations.

The fast economic growth after the Second World War, when many product innovations emerged (e.g., consumer goods, television, different types of cars) led him to the conclusion that it is much easier to be innovative than in the past. Therefore, he concluded in 1950 that entrepreneurialship "is already losing importance". He points out that "it is much easier now than it has been in the past to do things that lie outside the familiar routine" – innovation itself is being reduced to routine (Schumpeter, 1950). However, although nowadays most new products are developed in teams, product innovation certainly can not be seen as "routine work" as will be seen from the results of the research. This is shown in section 2.4 where product innovation on project level is discussed. NPD teams have to co-ordinate different areas which makes it difficult to develop new products without any complications (e.g., technology, costs, time, conflicts within the NPD team).

The fact that product innovation is no routine is also proved by the large number of research papers focussing on product innovation at the macro level. The articles discuss product innovation from different viewpoints. This indicates that it is not easy "to do things that lie outside the familiar routine" as Schumpeter argued. Researchers who investigated product innovation in the last 10 years found that it is a complex phenomenon and it is influenced by many different factors. For example, the national and international economic situation together with the local demand and price conditions have an important influence on patterns of innovation (e.g., Porter, 1990; Brockhoff and Boehmer, 1993; Venables, 1996; Beise and Belitz, 1998; European Commission, 2001c).

The review of the literature on product innovation research at the macro level identified six main areas:

- Education and national cultural effects on product innovation
- Government policy
- Diffusion of product innovations
- Employment and product innovation
- Size of companies and product innovation
- Measurement of product innovation on macro level

2.2.1 Education and National Cultural Effects on Product Innovation

The educational systems of countries and their culture can have an influence on the innovativeness of countries, e.g., on the number of new products developed and on the number of high tech companies and start ups within countries (e.g., European Commission, 2001b; OECD, 2000). The first area discussed in this section is the influence of education on product innovation. This area was investigated by several researchers who found that the interface between education and industry is critically important (Koschatzky, 2001; Anonymous, 2000b; Seltmann 2000; Duggan, 1996). Interface in this context is the leverage of knowledge generated by universities and research institutes on product innovation. Know-how transfer into industry is important because most products are produced and distributed by companies. Therefore, the ability to transfer the ideas and knowledge of scientists into companies is an important task to generate new products within industries. One further factor with influence on innovativeness of countries is the qualification level, e.g., percentage of graduates or the percentage of skilled workers. Wagner et al (1997) find a significant statistical impact of qualification levels on productivity growth and export performance which in turn is based on the innovativeness of countries. As education is recognised as an important factor for increasing the innovativeness of countries, investment into human capital is essential. Several studies found that high investments into education make it possible for countries to create more innovative products than other ones (e.g., Branscomb and Keller, 1998; European Commission, 2001b; OECD, 2000).

As education in universities and schools is strongly related to national cultural effects, it is interesting to show how these effects influence national product innovation activities. Several studies found that entrepreneurial thinking, lifelong learning and personal autonomy are strongly related to the culture the people live in (OECD, 2000; European Commission, 2000; European Commission, 2001c). These skills are related to the ability of countries to be more successful (i.e., develop more new products) than other countries. To show how these factors influence national competitiveness two examples are given. Bygrave (1998) argues that the secret of US economic success has been and continues to be its innovative and entrepreneurial culture. With a case history of Massachusetts he concludes that the cradle of the US economy was in the industrial revolution more than a hundred years ago. Another example is given by Pfeiffer (1997) who compares East and West German manufacturing firms. He finds that motivation of personnel is directly dependent on the environment and the culture the people live in. These skills in turn influence the innovative behaviour of employees with effect on NPD success (Mishra et al, 1996). Consequently, Balachandra and Friar (1997) state that innovation needs a supportive social and political environment.

The relationship between the culture of employees and NPD management techniques are investigated by Sounder and Jenssen (1999), who performed a cross-cultural study of US and Scandinavian telecommunication NPD projects. They find that some NPD management approaches may be common to all cultures. These are for example, proficiencies in conducting development, marketing and customer service activities. Differences were found with regard to NPD management systems. In the US, they are more product-market oriented, task focused and project management driven, consistent with the culture of entrepreneurial thinking. By comparison, the Scandinavian NPD management systems are characterised as product-service oriented, driven by self-directed group processes and socially oriented. This can be seen as consistent with Scandinavia's cultural devotion toward helping others. A further study investigates the information transfer in NPD projects in British and Japanese electronic firms (Lam, 1996). Lam finds that British firms are characterised by strict separation between functional departments (design, development, production, marketing). Between these departments information transfer is poor. In contrast Japanese firms have much looser boundaries between departments. Information flow is better and therefore product innovation output (i.e., number of new products, quality of new products, degree of product innovations) is higher than in Britain.

Although the influence of education systems and national cultures on product innovation activities is clear it is difficult to make recommendations. Seltmann (2000) argues that, dependent on their (macro) environment, companies have to identify their optimal way to develop new products. In other words, they have to find the best way of taking advantage of national cultures and different laws that apply in various countries. Because of these different national conditions he points out that "a one-size-fits all approach will not work".

The importance of education and national culture have also been recognised by many governments who have started several support programmes to generate an innovation supportive environment. How government policy influences product innovation activities of countries is shown in the next section.

2.2.2 Government Policy

Within the last 10 years technology and innovation policy have become an integral part of public activity and a considerable amount of public budgets are directed to the support of research and technology in science and industry (e.g., OECD, 1998; Archibugi and Michi, 1999; Howells, 1999; Airaghi et al, 1999; OECD, 2000). These budgets are provided by governments in the form of support programmes with the aim to strengthen the competitive position internationally.

A common focus of support programmes is on technological innovations as Mitchell (1999) finds. He reports that technological advancements have been the most important factors that have created growth in many economies. This in turn has led to government policies (programmes) that place a premium on technological innovations. Key technologies supported by governments (i.e., in Europe, North America, Japan) are for example, the build up of a powerful infrastructure for information transfer, the support of key technologies such as biotechnology, aerospace and military technologies (Brown et al, 1996; Kantzenbach and Pfister, 1996; Watanabe, 1996, BMBF, 2000). The main aim of these governmental programmes is to generate new products in these industry sectors and to place national companies at number one in the world market. The fact that these activities have positive influence on product innovation is also shown by Kuntze (1998). He investigates the research and technology policies (i.e., national investments into R&D) in the US, Japan, Sweden and the Netherlands and concludes that, all in all, R&D policy plays a supporting role in generating new products. However, support programmes are only effective if the knowledge generated in such programmes can be transferred successfully into and through industries. Therefore, know-how transfer within a country is an important issue.

As product innovation is based on know-how, governments are looking for ways on how knowledge transfer can be supported within a country. Youn and Kwon (2000) find that governments can play an important role in launching new networks by providing a platform for knowledge exchange between industry and science in specific areas (e.g., biotech, pharmaceuticals). Although such networks are helpful for knowledge exchange they recommend that "the government [sic] role is always a temporary one". Governmental initiatives are only seen as a first initiative which has to be taken up and carried on by companies, universities and research centres. However, policies can use a wide range of instruments for supporting knowledge transfer as in promoting public-private partnership, changing laws governing universities, and fostering regional concentration of research institutes and specific industries (OECD, 2000; Schmoch et al, 2000; Staudt et al, 1994). For Kantzenbach and Pfister (1996) the financial promotion of research establishments outside universities with the ability to transfer knowledge into companies is seen as important. They point out that for Germany such an establishment is the Fraunhofer Gesellschaft which helps to close Germany's technological gap with other centres of the world economy, i.e., North America and East Asia.

One way in which governments indirectly generate streams of product innovations is by passing laws which force companies to develop new products. Such laws are common for environmental protection. During the last few years the role of regulation has become a key issue of innovation policy, i.e., CO_2 reduction, regulations for exhaust systems and reduction of water pollution (OECD, 1996b). The OECD study concludes that "50% of the environmental goods which will be used in 15 years time do not currently exist". However, laws for regulation have to be adapted to the economic framework of countries to be successful. The adaptation of innovation policies to business environment is essential as Dosi (1981) finds. He suggests that "it is very difficult for public institutions to set and implement objectives that do not correspond to tendencies already existing in the private sector". Therefore, competences of companies within a country and financial resources of both customers and companies have to be taken into account by launching such laws.

Overall, governments may be required to provide innovators with a business environment, which both stimulates their entrepreneurial activity, and minimises the time span between the formulation of a supporting scheme and its realisation (Schonfield, 1981). However, for generating sustainable growth product innovations have to be spread through the market. Therefore, suitable industrial innovation requires a close interaction between all relevant actors such as producers, users, intermediaries and public authorities (Mayer-Krahmer, 1998). The following section describes how this process works.

2.2.3 Diffusion of Product Innovations

Government policy can give impetus for generating product innovations. This impetus has to be picked up by researchers and industry. For governments it is important that such impetus generates a nation-wide movement (i.e., the concentration of many companies on selected key technologies). Therefore, one stream of government measures are directed at encouraging the flow of product innovations into the enterprise sector as a whole (European Commission, 2001a; European Commission, 2000; Walter, 1996). The aim of such measures is the strengthening of the competitiveness of selected industry sectors (e.g., biotechnology, automotive, photonic). However, these specialised industries are only able to grow when their new products can be sold successfully, i.e., when their products are demanded by customers (e.g., other companies or end users). Therefore, diffusion of innovations is an important factor.

Diffusion in this context is defined as "the way, in which innovations spread, through market or non-market channels" (OECD, 1992). When innovations are diffused, they contribute to higher productivity and higher standards of living for an economy as a whole (OECD, 1996a). However, the diffusion process is dependent upon many different factors. It depends on the innovation itself, the population of potential adopters, their decision making process and the flow of information concerning the innovation between the manufacturers and the adopters (e.g., Archibugi and Iammarino, 1999; Isoard and Soria, 1999; Sharp, 1999).

A more specific definition of diffusion is given by Rogers (1995) in *Diffusion of Innovation*. For him diffusion is "the process by which an innovation is communicated through certain channels over time among the members of a social system". This can include both the planned and the spontaneous spread of new ideas through a convergence process involving interpersonal networks. He points out that dependent on the diffusion process an innovation can be adopted quickly or slowly by the users. In his research Rogers identifies five attributes determining the rate of adoption of innovations (i.e., the relative speed with which an innovation is adopted by members of a social system). He points out that 49% to 87% of the variance in rate of adoption is explained by attributes as relative advantage, compatibility, complexity, trialability and observability. In addition, to these five perceived attributes of (product) innovation other factors affect an innovation's rate of adoption, too. These are: the type of innovation-decision, the nature of communication channels diffusing the innovation at various stages in the innovation-decision process, the nature of the social system in which the innovation is diffusing, and the extent of a change agent's promotion efforts in diffusing the innovation.

Although the rate of adoption of innovations is influenced by many different factors (as shown by Rogers), governments are looking for ways to speed up the spread of innovations. One possibility to accelerate the diffusion process within nations is the build up of industry clusters within regions. Such regions are characterised by a close relationship between companies and research centres within one technology, e.g., Silicon Valley for the computer industry, Detroit and Stuttgart for the automotive industry (Nicoletti et al, 2001; Kuntze, 1998). The advantage of such clusters is a good information transfer between research institutes, universities and industry (BMBF, 2000; European Commission, 2001b). Although research centres are important institutions to generate new products the diffusion process often lacks. Therefore, Lewis (1995) demands a new role for high-tech research centres. In his view, the training of the sales force have to be improved in order to bring new products into market more successfully. The fact that in some cases research institutes cannot fulfill this role adequately, is also shown by Staudt et al (1994). They identify difficulties in the work of small and medium enterprises (SMEs) together with research institutes and universities. Reasons for these difficulties are resistances of companies against scientists and too much theoretical knowledge within research institutes and universities.

The literature shows that different factors on a macro level influence product innovation on a national level. It was also shown that governments have several possibilities to support innovation activities, e.g., build up of industry clusters, support programmes for R&D activities. These measures are carried out to generate a sustainable development of countries, e.g., higher gross national product, higher export rate and higher revenue from taxation. The positive effect of governmental support programmes on product innovation is also seen as an instrument for generating new jobs. The influence of product innovation on employment is presented in the following section.

2.2.4 Employment and Product Innovation

One aspect of the research on product innovation on a macro level looks at the effects of product innovation on employment. Most of these studies find that the development of new products could have a positive effect on employment (OECD, 1996a; European Commission, 2001b; Grossmann and Helpmann, 1991; Koenig et al, 1995). For example, Brinker et al (1997) compare productivity, employment and output in France and in Germany. They conclude that new products and services generate new jobs for people who will have lost their jobs because of more efficient processes. However, there are some studies which do not find a positive effect on employment.

As product innovation is closely related to process innovation two studies find that the positive effects on employment are questionable (Rottmann and Ruschinski, 1997; Grossmann and Helpmann, 1991). The studies find that because of automation and better production processes fewer employees are necessary for production. Further more, one study estimates that product innovations can lead to higher unemployment (Cuhls et al, 1998). They carried out a delphi study and found that 74% of the respondents were of the opinion that "technical progress can cause increasing unemployment in the industrial countries". However, as the findings in the delphi study are only hypotheses, this phenomenon has to be investigated further.

One further stream of the literature focuses on SMEs and examines their contribution to employment. The studies in this area show that innovative SMEs are an important basis for generating new jobs (European Commission, 2001b; Legler et al, 2001; BMBF, 2000; OECD, 1996a). For example, Tether and Massini (1998) find a high contribution for jobs by small technological and design innovators. In this context a further finding is interesting. Engel (2002) finds that venture capitalists (who support young companies with new products) are able to push firms to a faster and higher employment growth than other investors.

When discussing the influence of product innovation on employment it is interesting to look at the influence of governmental labour policies on product innovation. This relationship is investigated by Nicoletti et al (2001) in an OECD study. The study shows that employment protection policies have a negative effect on R&D intensity. Taking this finding into account, governmental measures have to be carried out carefully to avoid that R&D support programmes and labour programmes compensate each other.

This section has shown the relationship between product innovation and employment. It was shown especially that innovative SME's are generating new jobs. As SMEs also play an important role in generating new products it could be concluded that the size of companies has an influence on product innovation activities. The relationship between product innovation and size of companies is discussed in the following section.

2.2.5 Size of Companies and Product Innovation

The hypothesis that modern industrial R&D is best carried out by large firms with market power (i.e., Schumpeter, 1942) has been questioned increasingly. A detailed discussion of the Schumpetrian hypothesis is made by Frisch (1993) who shows that the influence of company size and company age on product innovation is not clear. Consequently, different researchers have found contradictory results regarding this relationship.

Bound et al (1984) and Klette and Griliches (1999) find that R&D expenditures increase almost in proportion to firm size. This is also confirmed by Hansen (1992) who investigated 598 companies in the US. He identifies that both firm size and firm age are significant determinants of the number of new products produced per dollars of sales. Further, he finds that the higher the R&D proportion of R&D resources devoted to product rather than process R&D, the more new products were in fact produced. Another study found that in big companies the R&D expenditures and the number of patents is higher than in small ones (Wakasugi and Koyata, 1997). From these findings it can be concluded that the problem small companies have developing many new products is based on the limited financial background for R&D activities. This is stated by Kulicke et al (1997) and Kulicke (1998) who find that small companies often have difficulties in obtaining financial backing for product innovations. Therefore, they suggest that many small companies have more difficulties in developing new products than larger companies. The findings that big companies are more innovative than smaller ones are qualified by Bertscheck and Entorf (1996). They find that initially the scale of research activities increases with the growth of a company, but decreases when the companies reach mid size.

In contrast to the findings above several researchers have found that small companies are more innovative than big companies. For example, Cohen and Klepper (1996a, 1996b) find that the number of new products tends to be higher in smaller companies than in larger companies. They conclude that larger companies are concentrating their research activities more on process innovation. The reason they identify is the possibility for big companies to achieve high cost reductions with process innovations in a very short time. The fact that small firms are important innovators is also found in an investigation of UK companies (Geroski, 1994). A further study investigates the relationship between company size and the percentage of product innovations per employee (Acs, 1994). The study finds that in 1982 the mean small-company innovation rate was 332 per million employees, compared with 225 per million employees in large corporations.

No differences between small and big companies are identified by Audretsch and Vivarelli (1996). They find that higher R&D expenditures of big companies can be balanced with highly innovative employees in small companies. Often, small companies employ more young graduate scientists than larger companies who bring the latest scientific knowledge into the small companies. Therefore, their ability to develop new products is as high as in big companies.

Taking the findings from the different researchers into account it can be concluded that the relationship between the number of product innovations and company size is not clear. The literature on a macro level is complex and the relationship between product innovation and size of companies should not be discussed in isolation from factors such as: firm behaviour, external conditions such as market structure, technological opportunities and economic growth. To capture this complexity, researchers need to measure product innovation. An overview of measures on a macro level is given in the following section.

2.2.6 Measurement of Product Innovation on a Macro Level

Measures of product innovation on a macro level focus on several areas. The European Commission (2001c) developed an *innovation scoreboard* including statistical data of 17 indicators in four areas. Human resources as the first area includes measures such as the supply of new scientists and engineers, share of workforce in medium-high and high technology manufacturing. The second area is knowledge creation with measures such as public R&D expenditures and patents. The third area in the innovation scoreboard is the transmission and application of new knowledge. Variables in this area are for example, in-house innovations in SMEs and innovation expenditures. The fourth area includes the measurement of innovation finance output and markets (e.g., high-tech venture capital, sales from innovations). Similar measures to those used in the innovation scoreboard are used in rankings of nations which were carried out by several research institutes (e.g., Jantz et al, 2001; BMBF, 2000; OECD, 1998; Licht and Stahl, 1998).

From all the measures used, Geroski (1994) identifies three important ones. He states that "the three measures that have been used most often are: R&D expenditures (or the number of scientists and engineers employed in R&D labs), patent counts, and counts of major or minor innovations". However, all three have a number of virtues and shortcomings. For example, R&D expenditures are a poor measure of innovation because "after all, what a company gets for the money it spends on R&D is what ultimately matters" (Iansiti and West, 1997). This is also acknowledged by Rosegger (1996) who states: "when we look at technological change in the aggregate... we are obviously forced to simplify an enormously complicated set of activities". These shortcomings show the necessity to select and analyse product innovation measures carefully.

The problem of measuring product innovation on macro level adequately is shown by the difficulty governments have measuring the efficiency of their support programmes. Nauwelaers et al (1995) point out that although evaluation systems for measuring the innovativeness of regions exist (e.g., rankings of regions) the output of support programmes are difficult to measure. This is also identified by Meyer-Krahmer (1995) who states that "evaluations on the strategic efficiency of programmes, however, are largely lacking". These findings again show that measurement of product innovation on a macro level is not as easy as it fist appears.

The literature on the macro level has shown, that macro level effects can influence product innovation activities within a country. Tidd et al (1998) state that "differences in national endowments of research and production competencies influence managers to search in and around the technological fields and related product markets where the national system of innovation is likely to be most supportive in incorporating innovative activities". Although the relationship between industry structure, R&D investments and product innovation on a macro level has received considerable attention, the actions of individual companies have seldom been investigated by economists (Ali, 1994). However, management researchers from a number of disciplines have been active on this level.

2.3 INVESTIGATIONS AT THE COMPANY LEVEL

As recognised by Rosegger (1996), "innovation research at the macro level is complex" and one could assume that investigations at the company level would be easier. However, on closer inspection, it is clear that investigations at this level also have to account for many different factors. The organisation of R&D labs and the corporate culture for example, have an influence on product innovation activities. As product innovation is influenced by so many different factors, researchers investigating innovation at the company level have difficulties in showing how the different factors interrelate and influence product innovation. In consequence, Nonaka and Kenney (1995) argue that innovation is not necessarily a logical process. Their view is supported by another researcher who states that "the successful management of technological innovation involves a complex set of variables. There is, of course, no single set of broad guidelines that guarantees instant success" (Thamhain, 1990). However, there are several studies focusing on product innovation at the company level.

The literature review identified six different main areas of product innovation that have been investigated at the company level. For each of these an overview is given and the key papers are discussed:

- Business environment
- Product innovation and organisation
- Human resource management, culture and product innovation
- General aspects of product innovation strategy
- Research studies of product innovation strategy
- Comprehensive studies of product innovation at the company level

2.3.1 Business Environment

Every company is influenced by its environment including social and economic forces, other organisations such as suppliers and competitors, technological and economic conditions, customers and employees. Tidd et al (1998) explains the relationship of these effects on product innovation as follows: "The first phase in innovation involves detecting signals in the environment about potential for change. These could take the form of new technological opportunities, or changing requirements on the part of markets".

In order to show the issues and to illustrate how business environmental effects can change the competitive situation of companies within a country, an example from real life is given. Over the course of the last 20 years the Swiss watch industry has lost both volume market leadership and technological supremacy (Glasmeier, 1997). The decrease of the industry started in the late 1960s with the use of quartz crystals to regulate increments of time electrically. This technology was adopted by Japanese companies who developed and produced cheaper and more comfortable watches. The Swiss watch industry underestimated this new technology and still promoted watches based on their mechanical precision. When they realised that the new technology would reach global standards, they had difficulty in changing their marketing and production methods from mechanics to one based on electronics. The example shows that the underestimation of new competitors and changing customer demands (for cheap and more comfortable watches) can lead to decreasing market shares.

Starting from this anecdotal study a discussion of scientific studies is presented. Research papers identified in the product innovation literature dealing with business environmental effects comprise:

- Industry sectors
- Customers
- Competitive market environment

Industry sectors

As business units act in specific markets, signals from the business environment could be dependent upon the industry sector. The ability to commercialise technology, to move a product from concept to market quickly and efficiently, is crucial in light of changes in the business environment (Nevens et al, 1990). Therefore, firms should carefully consider the group structure in the industry when they make decisions on entry, expansion, and other strategic moves (Pegels et al, 2000). For example, Gupta and Wilemon (1990) find that high industry growth may encourage the clear introduction of new products. The fact hat industry sectors have an influence on product innovation is also found by Acs (1994) who states that "there are considerable differences in innovation across industries". Cycle time goals are one indicator for the innovativeness of industry sectors. "Though cycle time reduction goals vary from sector to sector, shorter cycle-times have become more crucial throughout the high-tech industry" (Anonymous, 1996b). For example, the car industry has less aggressive cycle time goals (14.3% of companies in this branch aimed to reduce their cycle times), electronic systems companies aiming for 23% and semiconductor aiming for 27%. Further, industry sectors could have an influence on product development process performance (e.g., NPD management techniques used in industry sectors) as Loch et al (1996) find. These findings show that industry sectors could be a drive or a hindrance for product innovation.

Porter (1980) focuses one part of his research on industries and developes a framework for analysing the structure of a market segment from the viewpoint of its attractiveness to an organisation already in the industry. He argues that there are five competitive forces which operate in a market and each of them will be considered in turn. The forces are: rivalry among existing firms, the barriers to new entrants, the bargaining power of buyers, the bargaining power of suppliers and the threat from substitute products and services. In further research Porter (1990) identifies the association between vigorous domestic rivalry and the creation of persistence of competitive advantage in an industry as an important force for innovation. His findings show that industry sectors could be a reason for different levels of product innovation activities. In other words, the competition of rivals within an industry sector could be a drive to develop more and/or better new products than in other industries.

A further study about the influence of industry characteristics on product innovation is made by Zarah (1993b). As his study investigates the influence of industry sectors on the number of new products, it is discussed in detail. He examines 134 established US manufacturing companies (at least eight years old), to show the effect of industry characteristics and competitive strategy variables on the number and timing of new product introductions. His research investigates factors (variables) on the product decision level and the strategy level. Factors relevant to a firm's new product decision are industry growth rate over the last three years, rivalry which refers to the intensity of price competition in an industry, and concentration (defined as the market share of the four leading companies)[3]. Factors relevant to the competitive strategy level[4] are market scope referred to customer groups, vertical integration of the product transformation process and internal growth. He finds that companies that compete in industries characterised by high growth and non-price competition are likely to introduce more products, and introduce them faster than firms in other industry settings. Further, the study suggests that a broad market scope, vertical integration and a competitive strategy of internal growth are positively associated with a high number of new product introductions. One limitation of his study is, that it does not show, if the products introduced into the market are profitable and if other factors also play an important role. Furthermore he looks on the number of new product introductions without taking the whole product portfolio into account. As companies have to act with the whole product portfolio within a market it would be interesting to investigate the relationship between existing and new products on a deeper level. Although his research gives insight into the reasons for different innovation activities a more comprehensive approach for future research is demanded. He suggests the development of "integrative models that examine the effect of organisational industry [sic], and strategic factors on product introduction decisions as well as other components of corporate entrepreneurialship".

Customers

Looking on business environmental effects the role of customers within different industries has to be discussed, too. The important role of customers is identified by Spreng and Olshavsky (1996). They point out that "innovations can be rejected because they fail to meet or exceed a consumer's evaluative criteria or because consumers may find it difficult to form their expectations concerning an innovation". Therefore, information from customers is important for generating new products. Johne (1994) identifies a "rich body of literature" indicating the potential advantages of using information from customers for product development purposes. Johne's research based on examples from industry defines two different types of customers. The first type of customers are innovators and market leaders in their own marketplace (this kind of customers is investigated intensively by Hippel (1993, 1994) who shows that lead users can be an important idea source for new products[5]. The second type of customer is not so innovative. This group he argues, suggests only incremental and low-risk product changes. Independent from the two groups he points out that emerging trends in the marketplace as a whole need to be weighed against individual customer suggestions. Dependent on the degree of product innovation, the new products may be aimed

[3] Industry growth rate and market share of the strongest competitors was chosen as variables for the case studies (Refer to Chapter 4 'Research Design')

[4] The influence of competitive strategy is discussed in detail in Section 2.3.4 'Strategy and Product Innovation'.

[5] The involvement of customers (i.e., lead users) into the NPD process is presented in Section 2.4.1 'Source of Ideas'.

predominantly at the existing customer base or at new customer groups. For Johne this is particularly important during and after the product launch, "to ensure that canibalisation problems of existing and new products are resolved constructively". From his findings it can be concluded that the product portfolio has to be planned systematically – however this aspect is not investigated in his study[6].

Two examples are given which show how customers influence the development of new products. Based on findings from 50 companies in a wide variety of industries throughout the world, Womack and Jones (1996) identify the need of new products to have a clear customer focus. From their viewpoint the value of a new product has to be defined "precisely from the perspective of the end customer in terms of a specific product with specific capabilities offered at a specific price and time". Further, they demand to let the end user pull the product from the value stream. They explain this with a general concept saying "design and provide what the customer wants only when the customer wants it". A further study showing the importance of customer demands was carried out by Clark and Fujimoto (1990). They performed a case study at Ford and showed that the reason why they started to develop new cars in the early 1990s was the fact that their "cars were widely criticised, quality was far below competitive standards and market share was falling". The two examples show that changing customer demands could be a challenge for companies to develop new products.

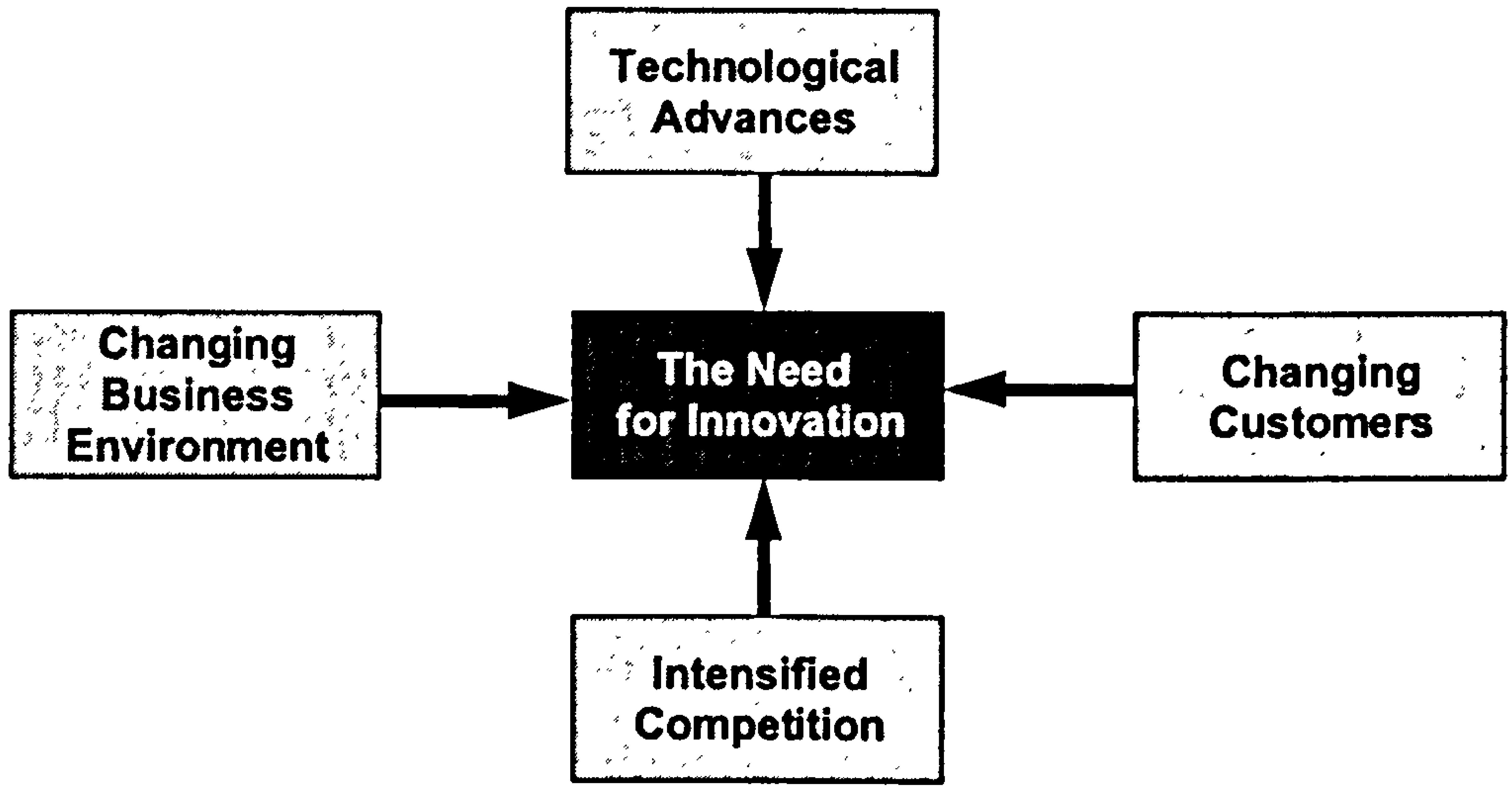
Although customer demands have been identified as an important source for new products, companies have difficulties in picking up such demands systematically. In a study which investigates customer satisfaction Griffin et al (1995) identify no firm with formal processes for feeding customer satisfaction results to product developers. However, customers are only one part in the business environment. A more comprehensive view is taken by Shethh and Ram (1987) who offer a model with business environmental factors influencing product innovation activities in companies.

Competitive market environment

Shethh and Ram's model (Figure 2.3) offers four different drivers in the need for innovation. There are new technological advances, changing customers, intensified competition and changing business environment. To show how the drivers can influence the need for innovation, examples for each factor are presented. Fast changes in information technology are an example for technological advances. The internet for example, makes it easy to transfer information all over the world. The population is an example for changing customers. As the population gets older in the western part of the world, customer demands are different from other parts of the world i.e., specific cars for elderly people. Thirdly, the attributes and sources of competition are changing. Companies are now facing competition from sources normally outside their industries. This is closely related to the last driver, the changing business environment. World-markets are increasingly open and market regulations are being relaxed in many Western countries (e.g., deregulation of telecommunication and parcel service). This in turn is a driver for intensified product innovation activities and competition within open markets.

[6] Strategic aspects dealing with product launch and canibalisation problems are discussed in Section 2.3.5 'Research Studies of Product Innovation Strategies'.

Figure 2.3: Drivers of the Need for Innovation (adopted from Shethh and Ram, 1987).



A comprehnsive view is also taken by Terwiesch et al (1998) who investigate the influence of business environmental factors on company profitability. Terwiesch et al suggest that the overall relevance of NPD performance to profitability depends on the firm's competitive market environment. For measuring NPD performance they use five variables. These variables are: technical performance, proportion of sales from new products, development intensity, market leadership and innovation rate[7]. Industry profitability, life cycle, market growth and market share are used as variables for measuring market environment. Based on a framework of Brown and Eisenhardt (1995) they develop a model (Figure 2.4) where market environment is shown as an area with direct and indirect effects on business unit profitability. Their research design is based on two surveys (1992-1995) made by McKinsey&Company, Stanford University and University of Augsburg. Data from 86 electronics business units[8] operating in 12 different electronics industries (branches) world-wide are analysed. They find that industry membership (i.e., membership to specific product group within the electronics industry, e.g., computer, automotive) accounts for 23% of the variance of profits, with 18% of the variance determined by industry profitability (i.e., average return on sales over the respondents in industry in the last year reported) and 5% by the three dimensions of market context. Market share and product life cycle have a direct effect on profitability, but market growth is not significant.

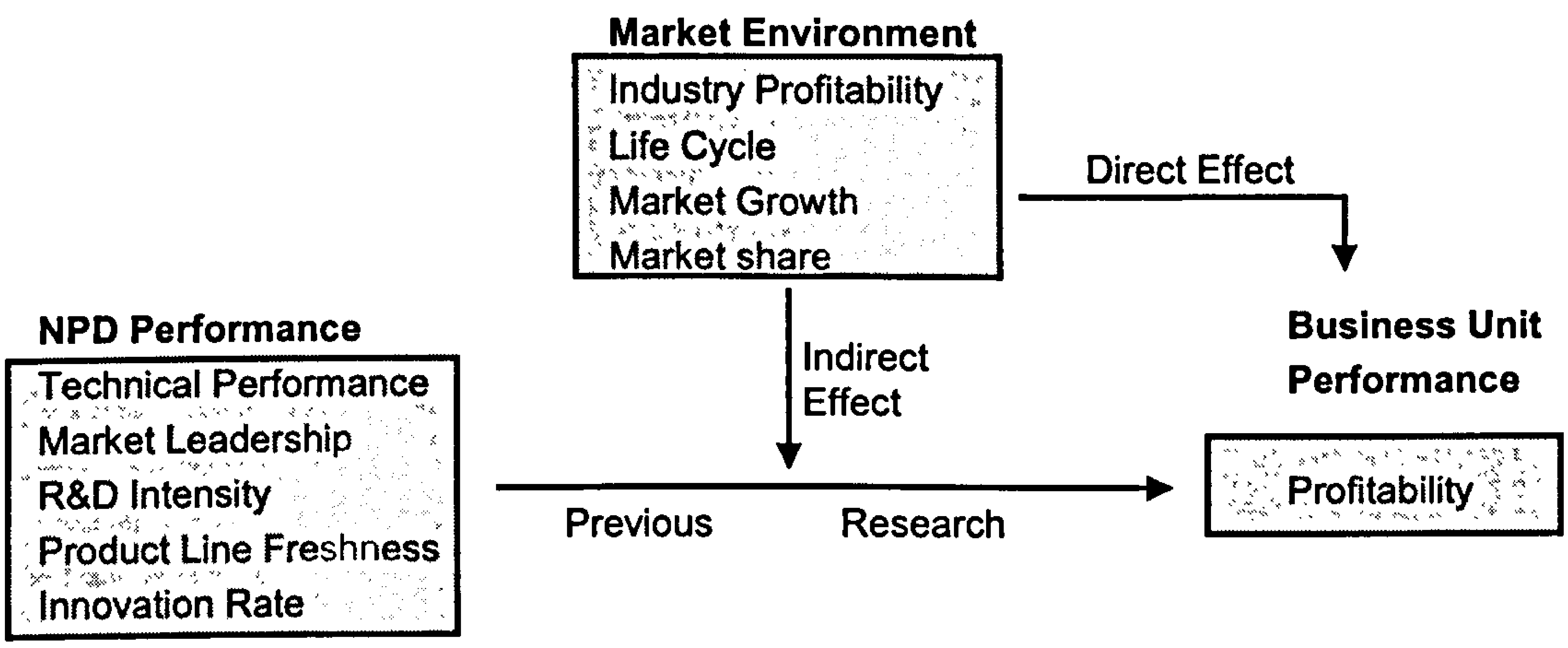
The findings of Terwiesch et al could lead to the conclusion, that a comparison of different industry sectors is not useful because a sector is the main driver for profits. However, their results also show that NPD performance explains 30% of the profitability variance among the high-market-share business units, but none of the variance of low-market-share business units. This indicates other variables could have as high an influence on profitability as industry membership and NPD performance

[7] The definition of innovation rate used by Terwiesch et al (1998) is the same as used in this PhD research.

[8] It has to be noted that the term 'business unit' is not defined precisely in the study of Terwiesch et al (1998).

(e.g., profitability, revenues from new products). As their main aim is to explain market environmental effects on profitability they do not investigate the influence of the five NPD performance variables reciprocally. For example, product innovation rate could be dependent on market leadership, technical product performance and development intensity. Further, product innovation rates could be dependent on environmental market effects, too. Taking these arguments into account, their model could be changed by sorting product innovation rate within the field business unit performance (together with profitability). Further, it has to be noted that their database from two different surveys does not focus on the aims of their papers. However the approach to investigate profitability by investigating a set of different variables at a business unit level is particularly interesting. As this type of research is not common, they demand an interdisciplinary view for further research activities: "In summary, future theoretical or statistical work striving to explain the connection between product development and business unit profitability must combine the effects of the industry and market environment with internal variables on the firm."

Figure 2.4: Framework for the Contingency Model (Terwiesch et al, 1998)



The presented studies give an overview of business environmental effects on product innovation. It was shown that companies have to handle the different factors from outside the company to stay competitive. How these factors are taken up by companies and are transformed into new products is dependent on a company's organisation. The different organisation forms capturing product innovation are discussed in the next section.

2.3.2 Product Innovation and Organisation

Only organisations that can best pull together the experience of the firm and move their ideas and products quickly through the organisation will succeed (Caldwell, 1997). The organisational structure of a company plays a key role in achieving this. According to Tushman et al (1997) the "management of innovation is an *organisational* problem". Companies need to co-ordinate the work of different departments and manage the linkages to other organisations. Tidd et al (1998) point out that "successful innovation correlates strongly with how a firm selects and manages projects, how it co-ordinates the input of different functions, and how it links up with its customers". A framework on how an organisation can be described is given by Nadler and Tushman (1997). They characterise an organisation by four key components: the work, the people who perform the work, the formal arrangements that provide structure and direction to their work, and the informal arrangements – sometimes referred to as culture – that reflect their values, beliefs and patterns of behaviour.

One example of how organisational aspects are seen within a company is an interview with the president and CEO of ABB Asea Brown Boveri who was interviewed by Taylor (1991). To the question about the structure of ABB's global business the president replies: "ABB is an organisation with three internal contradictions. We want to be global and local, big and small, radically decentralised with centralised reporting and control". The CEO of Boveri saw the advantages of a global business in drawing on research from labs across Europe and the world and to structure their operations to push the scale of cross-border economies. However, these general statements stand in contrast to the findings of Reger (1997), Gassmann (1997) and Bund (1997) who identify a trend towards closer (geographical) lab locations. Although the interview gives a detailed understanding of the global organisation of ABB in the opinion of the CEO, it does not investigate organisational aspects on a deeper level.

In the literature three key areas are identified which discuss organisational aspects in-depth. The first area discussed is the organisational structure of departments within a company. The organisational structure gives the framework on how a company is working to generate new products. The second area discusses the involvement of external partners (in the form of co-operations) into product development. The third area presented, discusses the information transfer between different departments and partners in co-operations. In summary, the three areas discussed comprise:

- Organisational structures (internal)
- Co-operations (external)
- Information transfer (internal and external)

Organisational structures (internal)

Literature dealing with organisational structures for product innovation is the first area discussed in this section. Looking at organisational aspects several researchers have found that product innovation within a company is not only the ability to develop new products it also means being innovative in creating new organisation forms. For Acs (1994) "new technologies, new products, and new forms of organisation lead to decisive cost or quality advantages". As all three areas are related to each other, companies who are developing new products have to tune their organisation on their new products (e.g., R&D, marketing, service). Therefore, companies need the ability to change their organisation structures which makes them "more flexible and therefore better able to cope with further change" (Jelinek and Schoonhoven, 1990). The relationship between the new product development and organisational structures of the whole company is also investigated by Hughes and Chafin (1996). They find that product innovation depends on the ability of an organisation (i.e., the interaction of R&D, marketing, sales, service) to convert an idea, or an opportunity into a proposition that adds value to the end users, the company, and the value chain. In their view an new idea has to be converted not only on NPD level, it has to be converted on the organisation level, too.

That product innovations themselves could be the driver for organisational change is stated by Dougherty and Hardy (1996). They investigate 96 firms (US, Canada, UK) that average 96 years of age and identify significant problems related to the innovation and the existing organisational practices, i.e., information transfer, resources, organisation structure of the whole company to solve the problems creatively. However, for the most successful companies they find, that product innovations are the driver to reinforce existing practices and structures of the whole organisation. This view is also taken by Liversay et al (1996). They state that "even in firms focused on innovation, the launching of a new product development project introduces a fresh element of uncertainty to the organisation". The studies presented show that product innovation is related to the whole organisation structure.

As the development of new products is complex, the close relationship of NPD and organisation is essential (Brown, 1991). To develop new products NPD has to be integrated into the workflow of departments to achieve a continuous innovation stream within a company. Schoonhoven and Jelinek (1997) examine how companies organise for innovation, drawing from a longitudinal study of five highly innovative electronic firms in the US. They find that highly innovative companies changed their structures when the problems for which the current structure was designed have changed. Further, they state that "clear organisational structures, frequent reorganisations, and an extensive use of quasi-formal structure contributes significantly to the long-term innovative abilities". Organisational structures are described as clear hierarchies in which executives, managers, and engineers know who their bosses are, who their reporting subordinates are and who their organisational peers are at equivalent hierarchical levels in their organisation. As they only investigate highly innovative firms, it would be interesting if the identified organisation forms function in established companies with a more moderate technology, too.

Such a study with companies from different industries and moderate technologies (i.e., incremental new products) was carried out by Larson and Gobeli (1988). Although the aim of their research was to show how the type of organisation affects the perceived success of a NPD project, it is presented to show how product innovation and organisation structure of a whole company are related. They examine the responses from 500 managers who are members of the Project Management Institute (PMI). From the analysis they conclude that team and matrix organisations are perceived as more desirable than functional ones and project teams are better for complex projects[9]. In complex projects it is becoming a wide corporate task, involving production, marketing, administration, purchasing and many other functions (Tidd et al, 1998). This in turn provides strong pressure for widespread organisational change towards more organic models, i.e., concentration on business processes in new organisational units, delegation of decision competences to lower levels, introducing new leading concepts (Pleschak and Sabisch, 1996). However, Tidd et al conclude that for managing product innovation the most appropriate structural form is dependent upon the particular circumstances. Because of the complexity they state that it is difficult to develop a standardised model.

[9] Other studies found that most successful projects used a functional organisation form, e.g., Brennecke et al (2001). Their findings are presented in Section 2.4.4 'Comprehensive Studies of Product Innovation at Project Level'.

The fact that there is no universal organisational model is also shown in an action research of Koenig et al (1997) which tries to identify the best structure for developing product innovations. They consulted a medium-sized company of the electrical engineering sector. In this company they optimised the organisational conditions for the systematic development of new products as well as for the efficient execution of day-to-day operations in the R&D department. They implemented three teams: a simultaneous engineering team, a market team and a product support team. They found that with this new structure the R&D department has more time for "important"[10] work. The comparison of their specific project (with an individual organisation structure) with previous ones, leads them to the conclusion that there is "no right organisation structure for NPD". They conclude that each company has to look for an individual framework in its organisation.

Co-operations (external)

The second area discussed in this section is the work of companies with external partners. As many companies are looking for ways to involve external specialists into R&D projects co-operation becomes more important. These specialists are often suppliers because they have become increasingly more important in today's competitive environment (Henke et al, 1993; Ragatz et al, 1997). This is also found by Millson et al (1992) who state that "companies can also benefit from supplier-initiated innovations". The fact that co-operation will become an important factor in today's product development is also shown in a Delphi study carried out by the *Fraunhofer Institute, Karlsruhe.* The study suggests that co-operation is becoming more important because of the increasing time and money intensity of NPD projects (Cuhls et al, 1998). Based on these statements it could be concluded that the integration of specialists (i.e., suppliers) into product innovation activities can reduce development time and costs because the selected partners are working more effectively in their competence fields. However, Kirchmann, (1996) finds that in most cases development time reduction cannot be achieved by the closeness of co-operation.

The findings of Kirchmann indicate that partners for co-operations have to be selected carefully and their role within an organisation has to be clearly defined. The fact that outsourcing of R&D activities could be critical is stated by Harris et al (1996). They discuss the outsourcing of R&D and conclude that "the more important the technology is to a firm, the more important it is that the firm controls it". This indicates that NPD projects and the suppliers involved have to be selected carefully. Consequently, only certain suppliers can help manufacturers in the development of new products and processes as Goffin et al (1997a) and White (1998) find. Only selected suppliers (which are willing to work in a close relationship) can help to achieve long-term quality improvements and cost reductions and can provide enhanced delivery performance. Although the advantages of the involvement of suppliers into NPD could have advantages, many companies are not looking for such strategic partners. For example, for German companies, price, quality and delivery time are still the most popular criteria for selecting suppliers rather than their expertise in NPD (Lemke et al, 2000). One challenge within co-operations is the trouble-free information flow between all partners.

[10] Important work is not defined precisely in the study.

Information transfer (internal and external)

Information transfer between co-operation partners and information flow within an organisation is the next area discussed in this section. Effective organisations need information from a complex web of sources, including customers, suppliers, sales and marketing, and company management. For example, Read (1996) states that it is important to rebuild the organisation around the flow of information to create "high value know-how". On the one hand, information has to flow from market environment into the company (e.g., latest customer demands) and between people and departments within an organisation (e.g., between partners within an NPD project). On the other, customers have to be informed about the new products of a company and therefore information has to be transferred from the company into the market, too. Wieandt (1995) concludes that companies first have to invest in information about customer requirements and the know-how in solving their requirements. The second step is to invest in customer relationship (what he calls continuity). In his view, possible management techniques into customer relationship are key account management, technology management or category management. Due to this complexity it is difficult to find the optimal way on how information transfer can be organised (Moenaert and Caeldries, 1996).

The role of communication between individuals within an organisation is investigated by Meyer (1997). He concludes that communication is an important key for new product development success. To solve a problem, required information and problem-solving capabilities must be brought together. However, this is not easy to do and often the transfer of information does not work. Based on empirical studies, Hippel (1994) observes patterns in the distribution of innovation-related problem solving. He investigates information transference with regard to the efforts made by technical problem solvers to reduce information transference costs. He finds that problem-solving activities will tend to move to that locus, where the most cost-intensive technical information is located (i.e., when it is costly to acquire the information and transfer costs are high). The trend to concentrate NPD projects on locations where the key knowledge is located is also confirmed by Reger (1997).

Further research investigates how information transference works in organisations – internally and externally. Wildemann (1993) states that flexible organisations and communication between development and production departments are important prerequisites for achieving time reduction in NPD. However, Reger (1997) finds that hierarchical and structural instruments are not enough to improve information transference. In his view, communication and information have to "run crossways through the vertical ranks". With regard to effective transfer of information efficiency he identifies the trend towards more integration of de-central R&D and the trend towards strengthening and re-centralisation of R&D activities within a few knowledge centres. These findings are surprising because new information and communication technologies (e.g., video conferencing, internet and e-mail) make it possible to communicate without any spatial barriers. This view is taken by several researchers who saw these new technologies offering various possibilities of organisational virtualisation in R&D (Bund, 1997; Chesbrough and Teece, 1996). The findings show that information transference is identified as an important organisational element to create new products. However, as companies have different organisational structures, each of them have to identify their optimal way for information transference.

The literature shows that companies must have the ability to find their own (optimal) organisation form – they have to develop their own specific competences (organisational and informational) which are hard for competitors to imitate. Because of the complexity it is an "ongoing process, rather than a quick fix [or permanent] solution" as Moenaert and Caelderies (1996) state. This ongoing process is strongly related to the culture within a company. Although the impact of corporate structure on a firm's innovative capability has become a central issue in research, it is difficult for analysts to grapple with issues that deal with the more intangible aspects of an organisation such as culture and atmosphere (Johne and Snelson, 1988). How organisation, culture, the people working within an organisation and product innovation activities are linked, is discussed in the next section.

2.3.3 Human Resource Management, Culture and Product Innovation

According to Day et al (2001) an innovative organisation "calls for the full range of organisational and leadership interventions: structure as well as management processes, human resource policies, and corporate culture". Especially human resource policies, and corporate culture have an influence on how individuals work together within a company. The co-operation of individuals plays an important role in generating product innovations because only in this way can technical and organisational knowledge be accumulated through experience of central importance (Tidd et al, 1998). Individuals and their work within a team is crucial for product innovations as Meyers and Wilemon, (1989) find. Dependent on team composition, the quality of the outcome (e.g., NPD time, functionality and costs) can vary greatly. To support an environment which supports the quality of NPD, companies display certain key cultural attributes. These include the propensity to experiment with ideas and to motivate individual employees to develop radical ideas (Buckler and Zien, 1996). However, even product innovation is greatly influenced by culture, "innovation can be managed through culture; but culture alone won't do it" as Jelinek and Schoonhoven (1990) state. Nevertheless, culture is the basis on how organisations are learning and how employees are motivated. This in turn has an influence on entrepreneurial thinking of employees (called as intrapreneurship).

In summary, the following areas dealing with human resource management and culture are identified in the literature:

- Corporate Culture
- Learning organisation
- Intrapreneurship and empowerment

Corporate Culture

"The general message of the corporate cultural literature was that the culture of an organisation – its values, beliefs, ethos, way of doing things – influences its performance and that these elements could be actively manipulated by management" Hailey (1999). Based on this statement she investigated two pharmaceutical companies in the mid 1990s (Glaxo Pharmaceuticals and Hewlett Packard) with two different approaches of managing cultures. Although the two cases do not directly focus on product innovation, they give interesting insights into the management of cultures. At Glaxo no common culture was communicated and therefore each group was working with its own rules. In consequence, she met with some resistance in setting up a new common culture on how the sales force has to behave to fulfil their sales targets.

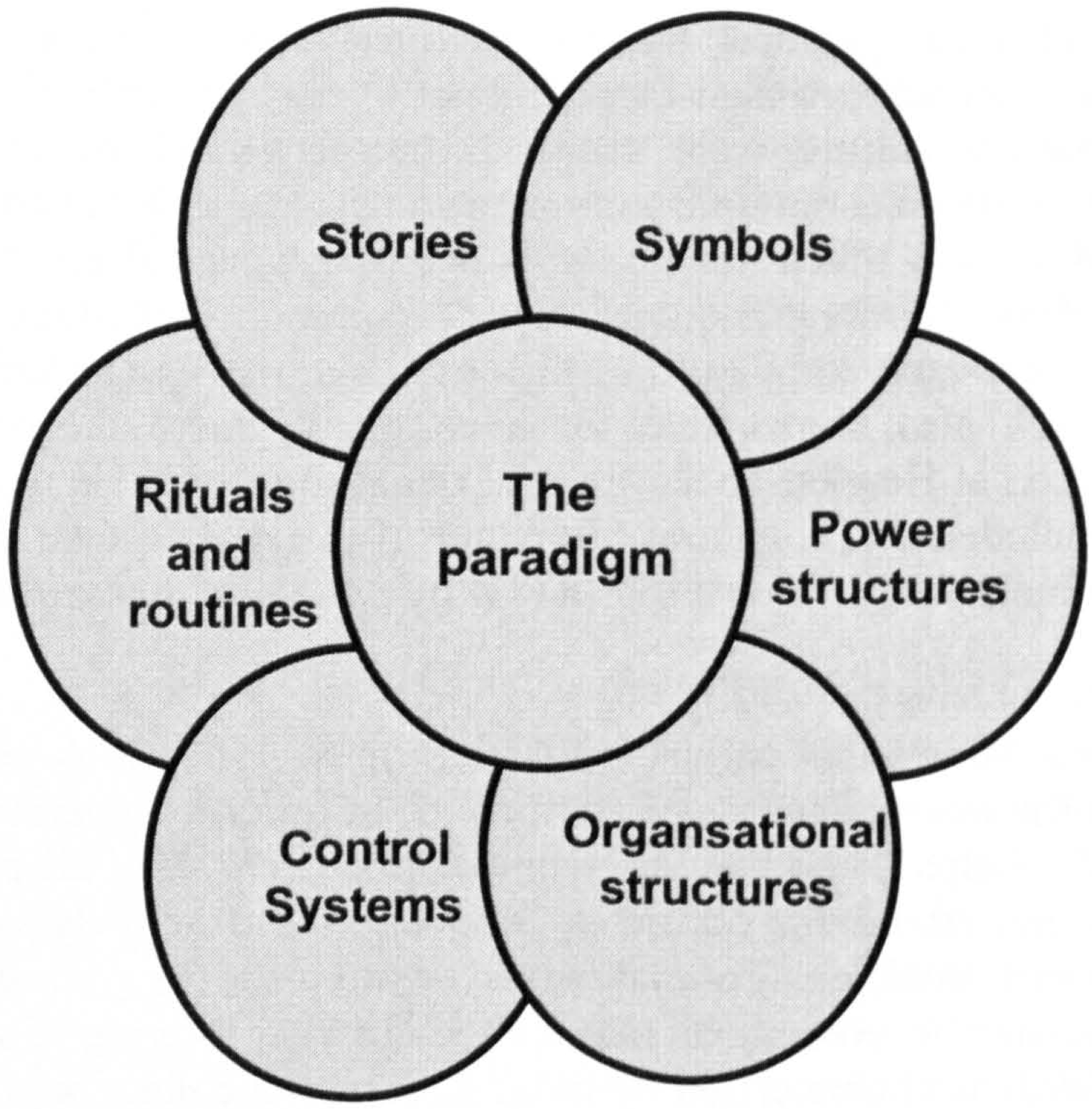
Hewlett Packard, in contrast, has a company-wide culture where individual employees have an openness for their own interpretation of the statement of values. At Hewlett Packard the rigorous application of business planning and performance measurement systems ensure employees' personal targets are tightly prescribed and controlled – however, how employees achieve their targets is not overtly prescribed. She found that both ways of managing culture were successful in terms of the context of each company. Therefore, she points out that "companies can make a choice about how much flexibility is desired, or how much imposition is necessary, depending on what they are trying to achieve". Haley's research shows that no common guidelines for creating a culture exist. Therefore, each company has to look for an individual cultural concept. However, the research also shows that for a company where the commitment of employees is high (i.e., at Hewlett-Packard), it is easier to implement new organisation forms. It can be concluded that for these companies it is easier to take the path of fast changing market demands and to develop new products more successfully than other companies.

Hailey's research shows that culture influences the way in which people think. In turn this influences the innovativeness of companies. In order to generate a wide range of innovative ideas, it helps if the whole organisation is involved. Full potential means that all employees understand the nature of innovation and actively contribute to it through entrepreneurial thinking. To make this creativity work, companies need to establish, and stimulate the process of idea collection and filtering. For Goffin et al (1999) the flow of ideas is characterised by three stages: idea collection, initial filtering, a review of ideas, and investigation and generation of product concepts. However, to get as many ideas as possible, all employees within a company have to be involved into this process. This was found by Bessant and Buckingham (1996) who state: "whereas innovation is often seen as the province of technical specialists in R&D, engineering or design, the underlying creative skills and problem-solving abilities are possessed by everyone". A case study by Zien and Buckler (1997) identifies further cultural factors for promoting product innovation. These are experimentation in all functions, generation of close links to customer, focusing on individuals, and the embodiment of an innovative culture in powerful and purposeful stories.[11]

As culture is influenced by many different factors within a company it is very difficult to measure. A model as to how cultural factors can be analysed is given by Johnson and Scholes (1999). Their cultural web (Figure 2.5) is a representation of the taken-for-granted assumptions, or paradigms, of an organisation and the physical manifestations of organisational culture. They point out that the way employees behave towards each other and towards those outside the organisation influences the ability to be innovative. They offer this framework as an instrument for planning cultural changes (for each factor the actual situation can be compared to an expected situation in the future). In their view the culture within companies can be characterised by stories, symbols, rituals and routines, power structures, control systems and organisational structures.

[11] The idea generation process is discussed in Section 2.4.1 'Source of Ideas'.

Figure 2.5: The Cultural Web (Johnson and Scholes, 1999).



The culture within a company also provides a framework for conflict management. Within a culture where conflicts are constructively used to solve problems, this can help achieve good results. In the view of Eisenhardt et al (1997) good results can be achieved in companies whose members challenge one another's thinking to develop a more complete understanding of the alternatives. They state that this kind of effective decision making is "necessary in today's competitive environments". Such a culture is characterised by honesty and respect of each other.[12]

Learning organisation

A culture of entrepreneurship and openness for new ideas is strongly related to the ability to learn new things. Only the willingness of employees to learn new things makes it possible for organisations to generate new products. To enable employees to learn, organisations have to implement a culture of knowledge transference (Arthur, 1996; Leonard and Strauss, 1997; Gilbert and Cordey-Hayes, 1996)[13]. In consequence, "longer-term competitive advantage is more likely to be secured by organisations who are most competent at managing knowledge creation" (Johnson and Scholes, 1999). Therefore, a link between the innovation strategy and organisational learning is required (McKee, 1992). In order to be able to create new ways of problem solving, today's flexible organisations have to learn also from mistakes (Gomes et al, 1998). A learning

[12]The corporate culture has an influence on NPD management. The way as to how conflicts can be minimised in NPD projects is dependent on how teams are managed and how NPD projects are promoted. This is discussed in Section 2.4.2 'The New Product Development Process'.
[13] How the philosophy of a learning company can be transferred into a small and medium company is described in Rösler (2003).

company has the ability to collect, to gain and to transfer knowledge. On the basis of their new knowledge they dynamically change processes and organisational forms (Garvin, 1993; Porter, 1985; Teece and Pisano, 1994). A detailed description of how a learning organisation can be achieved is given in *The Fifth Discipline* (Senge, 1990). Personnel learning, learning in teams and learning from colleagues or customers are key points for a learning organisation. Senge's philosophy of the learning company is closely related to a culture of tolerance and personal responsibility within a company. Similar attributes are also identified by Burgheim (1996). As a learning organisation is strongly related to the company culture, he points out that the understanding of a company's culture and history is an important element on the way to a learning organisation. However, an improvement of existing knowledge is closely related to the concentration on in-house strengths, skills and resources, too. According to the authors of *In Search of Excellence* (Peters and Waterman, 1982) this combination is one key to success. Although many companies aim to implement a learning organisation, only a few have achieved it. The difficulty in creating a learning organisation is the fact that the implementation of such a culture needs time.

Intrapreneurship and empowerment

A company's culture sets the framework for intrapreneurship (employees who act as entrapreneurs) and motivation. To achieve an innovative culture, the skills and the motivation of people working on product innovation is crucial (Donovan, 1994; Henke et al, 1993; Rosenau, 1989). However, the implementation of such a culture requires a lot of time. O'Reilly and Tushman (1997) point out that the development of shared expectations, risk taking, tolerance of mistakes and teamwork takes time. Similarly Clark and Wheelwright (1992) find that establishing such a working culture is not easy. For example, taking the responsibility for their own work is not easy for employees who are used to working in functional organisation structures within a specialised working field.

McGourty et al (1996) investigated organisational change and its relationship to the employees in thirteen leading companies. They found that personal skills such as openness for new ideas, inquisitiveness, collaborativeness and goal-orientation all impact innovation performance. These findings show that the ability of an organisation for product innovation lies in the creativity and abilities of its people, which is directly related to the living culture within a company. The way in which creativity, intrapreneurship and empowerment is released, is reflected in the way in which employees work together (i.e., in teams). The highest degree of intrapreneurship and empowerment can be observed in groups working on important types of problems with far-reaching consequences for a company (Leavitt and Lipman-Blumen, 1995). Employees in such (hot-)groups are characterised as highly motivated and flexible.

The culture and the way in which human resource management is done, are formulated in a company's strategy which is the framework for all activities. This includes for example, the strategic planning of NPD projects and shows the path from ideas to new products and services (Jelinek and Schoonhoven, 1990). This in turn, suggests different human resource management policies to job design, employee appraisal, development, reward, and participation (Schuler and Jackson, 1987). A detailed literature review of strategy papers dealing with product innovation is given in the following sections. However, because of the complexity of the strategy field, first general aspects are discussed.

2.3.4 General Aspects of Product Innovation Strategy

In the literature the influence of competitive strategy on product innovation has been discussed by several authors. For example, Nadler and Tushman (1997) point out that product innovations need to be selected carefully – "organisations that make the wrong strategic decisions will underperform or fail". This is the case when a company decides to develop a new product line which is not demanded by customers. Therefore, managers can lead organisations to success by consciously identifying opportunities of customers and devising strategies to realise these opportunities (Low and MacMillan, 1988). Although many companies face the same opportunities and challenges they often respond to them in different ways. Covin and Covin (1990) point out that this is dependent on their competitive strategic posture. It could be that even competitors in the same markets act with different product innovation strategies, i.e., develop more new products or less new products as found by Goffin and Pfeiffer (1999).

For Johnson and Scholes (1999) strategy is "the direction and scope of an organisation over the long term". A strategy gives the framework for the organisation for its configuration of resources within a changing environment. Within the chosen strategy, companies aim to meet the needs of markets and to fulfill stakeholder expectations. Porter (1996) summarises the competitive strategy as "being different". For him strategy is defined as choosing from a different set of activities to deliver a unique mix of values. He points out the "essence of strategy is choosing to perform activities differently than rivals do". These individual activities have to be developed in a strategy making process characterised by experimentation, innovativeness, risk taking, and proactive assertiveness as Dess et al (1997) find. Taking the different definitions into account, strategy can be seen as a framework in which the daily work is embedded over the longer-term.

Table 2.3 shows some of the main terms which are used in the strategy literature. In the first two columns the term is given and described. In the last column the term is explained in relation to a personal strategy for becoming fit.

Table 2.3: The Vocabulary of Strategy (Johnson and Scholes, 1999)

#	Term	Definition	A Personal Example
1	**Mission**	Overriding purpose in line with the values or expectations of stakeholders	Be healthy and fit
2	**Vision or strategic intent**	Desired future state: The aspiration of the organisation	To run the London marathon
3	**Goal**	General statement of aim or purpose	Lose weight and strengthen muscles
4	**Objective**	Quantification (if possible) or more precise statement of the goal	Lose 10 pounds by 1 September and run the Marathon next year
5	**Core competences**	Resources, processes or skills which provide 'competitive advantage'	Proximity to a fitness centre, supportive family and friends and past experience of successful diet
6	**Strategies**	Long-term direction	Associate with a collaborative network (e.g., join running club), exercise regularly, compete in marathons locally, stick to appropriate diet
7	**Strategic architecture**	Combination of resources, processes and competences to put strategy into effect	Specific exercise and diet regime, appropriate training facilities, etc.
8	**Control**	The monitoring of action steps to: • Assess effectiveness of strategies and actions • Modify strategies and/or actions as necessary	Monitor weight, miles run and measure times: if progress satisfactory, do nothing; if not, consider other strategies and actions

Researchers on strategy formulation have taken two different views. The first view is that strategy formulation is the realm of top management (e.g., Pettigrew, 1987; Low and McMillan, 1988; Pegels et al, 2000). Other researchers view strategy development as conducted by the whole organisation which is driven by the business environment (e.g., Mintzberg, 1987; Lieberson and O'Connor, 1972). The first view is taken by Porter (1996) who points out that the challenge of developing a clear strategy is often primarily an organisational one and depends on leadership. In his opinion "managers at lower levels lack the perspective and the confidence to maintain strategy". This insight is also taken by Mass and Berkson (1995) who state that "senior managers need to be involved in designing the total strategy package, not piecemeal approaches". Another study investigates the relationship between a firm's NPD performance and the importance assigned to that activity by the firm's chief executive officer CEO (Calatone et al, 1995). They point out that vision and focus on product development is essential and CEOs have to recognise their strategic value. In detail, they find that factors such as new product introduction, design innovation and product technological innovation have a strong positive influence on return on investment (ROI). Similar findings are made by Papadakis (1998) who investigates 97 manufacturing companies and find that CEOs have more influence on the introduction of new products than business environment and internal organisation. However, the view that only the top management sets the goals and strategic guidelines is not shared by other researchers.

For Mintzberg (1987) "new strategies often emerge from local initiatives and experimentation within the organisation". Lieberson and O'Connor (1972) claim that the environment and other factors have the greatest influence on strategy. The fact that top-management can have only a small influence on strategy is shown by Schreyögg (1998) who states that the "conventional picture that a strategy is developed by the head of management through structured and synchronised steps is questionable". He concludes that the middle management and heads of departments are key in the strategy development process. As an example he explains the strategic decision of Intel to concentrate their core business on computer processors. This decision was based on activities of the middle management. In the founding years processors were only seen as an instrument to sell computer chips. Therefore, the official strategy was to concentrate the business activities on both chips and micro-processors. However, this official strategy stood in strong contrast to the daily work. Dependent on the increasing demand the plant-managers increased the production capacity for micro-processors and reduced the production of chips. Based on these facts, the Intel top-management decided (years after the plant managers had decided to produce micro-processors) to leave the chip market and to concentrate their core business in micro-processors.

Table 2.4 gives different explanations for how strategies emerge. Although it is not suggested that all of the presented configurations define exactly how strategy develops over all companies, typical general tendencies of strategy development are summarised. Exhibit 1 and 2 represent views of strategy development which are in essence proactive, planning and rational views of the process. Exhibit 3 and 4 emphasise more cultural and political processes in organisations. From these configurations the more rational, planning view of strategies tends to be seen most by CEOs. The cultural and political processes tend to be seen most by managers below the level of the board. Further, Johnson and Scholes argue that strategies can change incrementally in two different ways. The first way is a logical incremental process (a) which is influenced by the board of management. The second way is the change of strategies incrementally (c) as the outcome of cultural and political processes.

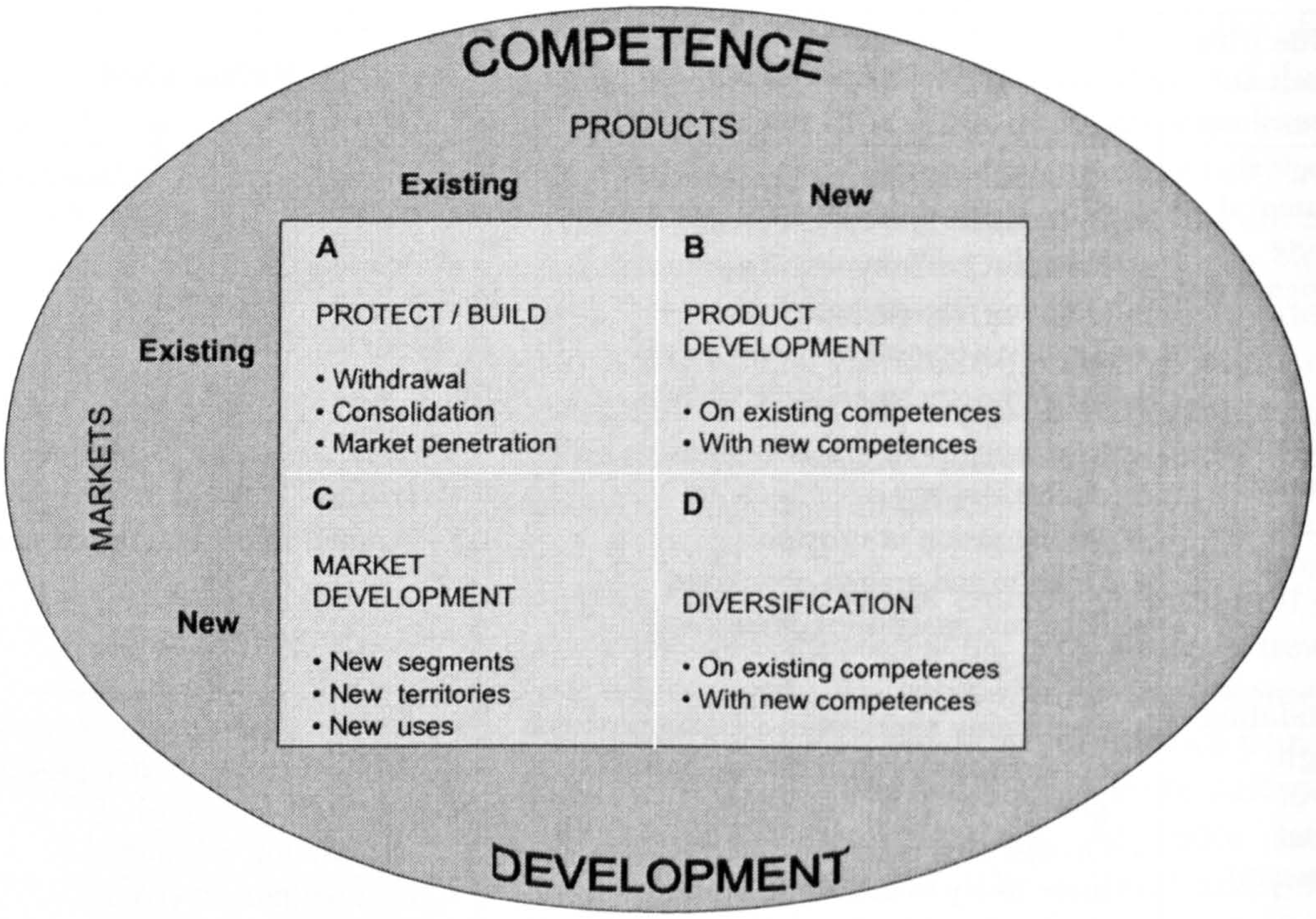
Taking the two views of strategy formulation into account (as given above), the configurations (a) and (b) are based on the strategy formulation of top management (e.g., the view taken of Pettigrew, 1987). In comparison the strategy formulation in configuration (c) is conducted by the whole organisation (e.g., the view taken of Mintzberg, 1987). Overall, it is shown that there is no one way in which strategies develop. Therefore, the managers who are seeking to influence strategy development in companies (i.e., CEOs) have to be aware of the different ways of strategy development processes in their organisation.

Table 2.4: Configurations of Strategy Development Processes (after Johnson and Scholes, 1999)

#	Profile with Dominant Dimensions	Charateristics	Rather Than
1	**(a) Logical incremental** *Planning Incrementalism*	• Standardised planning procedures • Systematic data collection and analyses • Constant environmental scanning • Ongoing adjustment of strategy • Tentative commitment to strategy • Step-by-step, small-scale change	• Intrusive external environment • Dominant individuals • Political processes • Power groups
2	**(b) Rational command** *Planning Command*	• Senior figure or group determines and directs strategy • Strong vision or mission • Definite and precise objectives • Rigorous analysis of environment • Clear plans	• Pronounced political influences • Traditional 'ways of doing things' • External forces determine strategy
3	**(c) Muddling through** *Cultural Political Incremental*	• Bargaining negotiation and compromise accommodate conflicting interests of groups • Groups with control over critical resources more likely to influence strategy • Standardised 'ways of doing things' • Routines and procedures embedded in organisational history • Gradual adjustments to strategy	• Analytical, evaluative rationality • Deliberate, intentional, process • Managers in control of organisation's destiny • Well defined procedures • Analytical evaluation and planning • Externally driven strategy • Deliberate managerial intent
4	**(d) Externally dependent** *Enforced Choice Political*	• Strategy is imposed by external forces (e.g., legislation, parent organisation) • Freedom of choice severely restricted • Groups dealing with the environment have greater influence over strategy • Political activity likely within organisation and between external agencies	• Strategy determined within the organisation • Planning systems impact on strategy development • Managers influence strategic direction

Independent from the source of the strategy the chosen strategy has to be implemented by the organisation. Kaplan and Norton (2001) describe a strategy-focused organisation as one which clearly defines the strategy, communicating it consistently, and linking it to the drivers of change. They also point out that a strategy is based on a *communication system* and therefore executives have to create a climate in which problems are open for discussion. In the first part of this section an overview about strategic possibilities is given. It is shown that strategy can be based on different sources. This complexity makes it difficult to investigate strategy as a whole and therefore most of the studies in this field focus on specific aspects. However, in the literature different models are offered which assist in choosing from a set of different product innovation strategies.

Figure 2.6: Directions for Strategy Development (Johnson and Scholes, 1999)



The first model presented was developed by Johnson and Scholes (1999) who give four strategic directions with regard to products and market. Figure 2.6 outlines the four types of development directions in terms of the two dimensions, markets and products. The four different directions of strategies in their model are marked with A, B, C and D. Strategies for protecting and building on the current position are marked with an A. Possible actions with A are withdrawal, consolidation and market penetration[14]. Strategies dealing with product development are marked with a B. This strategy can be based on existing or new competences[15]. However, in both cases organisations must have the ability to analyse and understand the changing needs of a particular group of customers or clients. The next strategy they offer is market development (marked with a C). This strategy can be used to extend into market segments, new territories or new uses. This is for example, the development of new uses for existing products and geographical spread, either nationally or internationally, into new markets. The last strategy in their model is diversification (marked with a D). This strategy involves directions of development which takes the organisation away from its present markets and its present products. This in turn can be based on both, existing or new competences[16].

[14] No business unit analysed in the case studies used this strategy as the only one for the whole product portfolio (Refer to Chapter 7).

[15] Most business units analysed in the case studies concentrated their R&D activities on existing competences (Refer to Chapter 7).

[16] In the latest history no business unit changed the markets and products. However, looking into the history three business units used this strategy to enter new markets which were seen to be more attractive (BU 7, BU 9 and BU 10). The case studies are given in Appendix B.

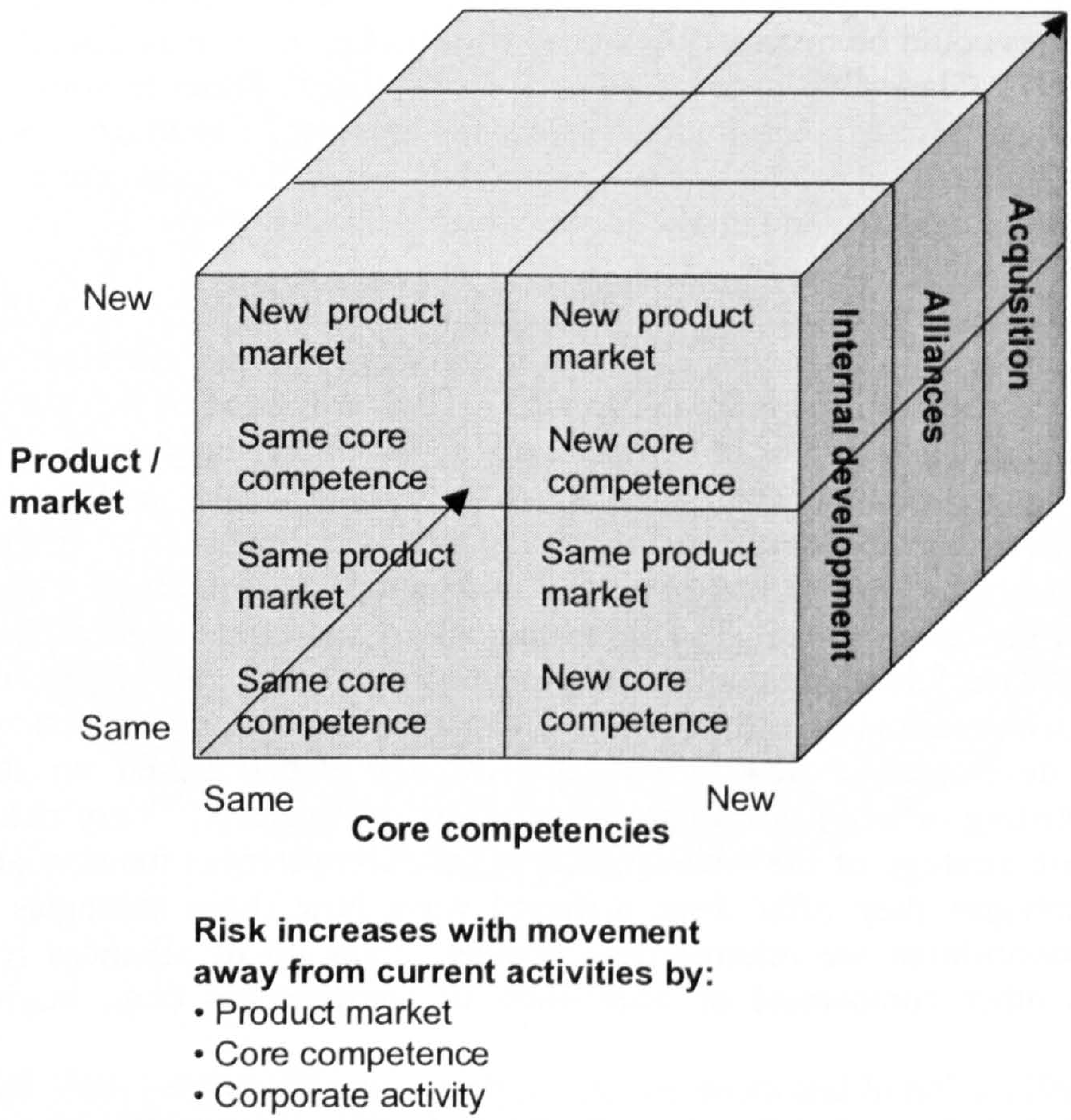
The strategies identified by Johnson and Scholes have a different influence on product innovation rate. The need for new products (i.e., high product innovation rate) is given with the development of new products (strategy B) and diversification (strategy D). These strategies could be necessary when new technologies arise as Burgelman and Rosenbloom (1997), Clark (1989) and Tidd et al (1998) find[17]. Other reasons could be an internal growth strategy or market demands for new products. Strategies concentrating on the existing products (i.e., low product innovation rates) are given with built in protection (strategy A) and market development (strategy C).

Another model was created by Bowman and Faulkner (1997). Although they identify similar innovation strategies as Johnson and Scholes, they differentiate these strategies into different degrees of risk (Figure 2.7). Their definition of risk is related to the core markets and competences of companies (i.e., the higher the degree of product innovation the higher the risk). The first strategy they describe is a careful one and is based on the assumption to operate with existing products in the same market. The second strategy with the "lowest risk option" is the new product development strategy using existing core competences. The development of new competences based on existing products is a further product development strategy, but at a higher risk. The third strategy can be realised by competence extension as licensing or franchising a new technology, or developing a new competence through R&D. Based on the used competences (existing or new) this strategy has a low or high risk. "Very risky" they state, is the fourth strategy of the development of new competences for new products. For all four strategies they offer three different ways how these strategies can be realised. The possibilities are internal development, build up of alliances (e.g., co-operations with other companies) or acquisition of competences (e.g., buying new technologies)

Other researchers have developed similar models. Treacy and Wiersema (1995) define three different strategies that an organisation uses to differentiate itself in the marketplace. A product leadership company pushes its products into the realm of the unknown, the untried, or the highly desirable. Whereas a customer-intimate company builds bonds with its customers – it knows the people it sells to and the products and services it needs. Further, companies with excellence expectations deliver a combination of quality, price and ease of purchase that no one else can match. For Porter (1996) strategy can be based on customers' needs, customers' accessibility, or the variety of a company's products or services.

[17] The need for new products because of technological changes in the market was observed in several business units in the E&E engineering sector (e.g., BU 3 and BU 7). The case study of the business units is given in the Appendix B.

Figure 2.7: The Risk Cube (Bowman and Faulkner, 1997)



All the models presented show that the business environmental (e.g., market and customers) effects and internal company competences and processes (e.g., resources, know-how) are the basis for identifying a suitable strategy. Although the models offer a different set of strategies, it can be concluded that it is not easy for managers to choose the "right" one. The complexity a company's internal of external environment makes it difficult to identify an effective strategy. How product innovation strategies work in practice is discussed in the next section.

2.3.5 Research Studies of Product Innovation Strategy

As the aim of the current research is to explain the reasons for varying product innovation rate and varying percentages of revenues from new products, studies dealing with product innovation strategy are presented in detail. Papers dealing with product innovation strategy cover the following areas:

- Strategic thinking
- Launch strategies
- Investments into R&D
- Product innovation outcome (i.e., profitability, company growth)

Strategic thinking

Product innovation strategies can be based on the capability of managers to combine their varied skills and functional backgrounds to think up revenue-producing products and services (Eisenhardt and Martin, 2000). Based on this capability managers (companies) are able to create products and services which differ from those of their competitors. This in turn influences the "long term competitive advantage" they state. A study of Cimento and Knister (1994) in the electronics industry finds that managers in successful companies have a greater commitment to innovation than other companies. This is also shown by Kim and Mauborgne (1997) who find, that managers of less successful companies all think along conventional strategic lines (i.e., focus on existing products and existing markets) while managers of high-growth companies apply their strategic thinking to business initiatives in the marketplace (i.e., looking for new products and new markets). They find that the most successful companies are creating innovations in three fields: product innovation, innovation in service and innovation in delivery. They investigated companies with high growth in both revenues and profits and companies with less successful performance records. In their study they interviewed hundreds of managers, analysts, and researchers (30 companies around the world in approximately 30 industries). Two limitations in their work are that it does not take into account the influence of cultural factors, nor does it distinguish between different industrial sectors and their specific situations. In the literature review on macro level, both areas are identified as having influence on product innovation[18].

A study of how strategy is influenced by the thinking of managers was performed by Hultink and Robben (1995). They examine how product innovation outcome measures are used over the life cycle of products. To do so, they differentiate the life time of products into the two categories short- and long-term perspective. Short-term is defined as representing 25% of the product life cycle (long-term 75%). They found out that performance measures have a long-term perspective (i.e., are used as a control measures over the whole product life cycle). These comprise e.g., revenue goals, unit sales goals, market share goals, attained profitability goals (e.g., break even), and attained margin goals. The only short-term measure mentioned is the on-time launching of new products. However, measures such as quality, customer acceptance, customer satisfaction and product performance level are considered as important regardless of any time perspective. As the study focuses on different levels of management, they find that managing directors often have a long-term perspective whereas R&D managers appear to have a short-term perspective. Although they only investigated big Dutch companies from different industrial sectors and use a five-point scale (while managers estimate the importance for success measures), the findings are interesting for further research activities in this area. Especially the time perspective of managers and the influence on other measures than product innovation rate should be investigated. Overall, the findings show the necessity to interview different managers to get a comprehensive view of how product innovation strategy is seen within a company.

Further, studies have shown that product innovation strategies are dependent upon the thinking and personnel skills of managers. For example, Reiple and Vyakarnam (1996) find that managers who build a strategic posture (e.g., an outstanding and

[18] The influence of national cultures on product innovation activities is discussed in Section 2.3.1 'Education and National Cultural Effects on Product Innovation'. The influence of industry sectors on product innovation activities is presented in Section on 2.3.1 'Business Environment'.

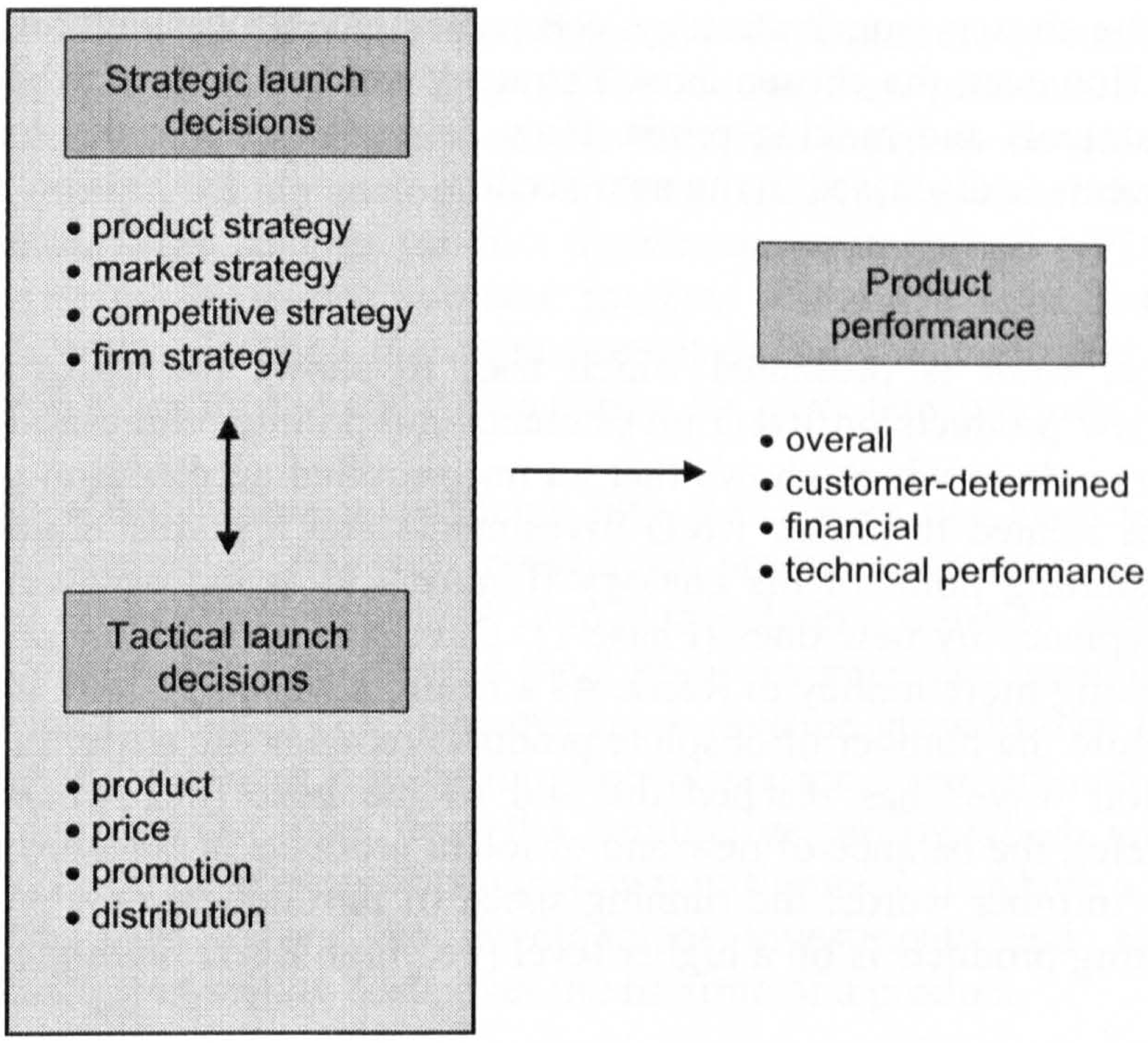
unconventional strategy based on a new product design) may be prepared to take risks and have a high tolerance for ambiguity. Most of these managers have a marketing or R&D background and greater familiarity with their specific industry. Collective strategies (e.g., a conventional strategy based on an existing product portfolio) in contrast are said to require conservative, risk-averse managers, with backgrounds in production or accounting (Gupta, 1988). Dependent on their different views, managers see different possibilities in bringing their new products into the market, i.e., on the chosen launch strategy.

Launch strategies

Hultink et al (1997) investigated the relationships between various sets of strategic and tactical decisions and looked at 221 new industrial products launched by UK firms. They identified that niche innovators have new products with the highest performance and launch innovative products into markets with few competitors. Tactical decisions made by this group include exclusive distribution, a skimming pricing strategy, and a broad product range. From these findings Hultink et al developed a model of the relationship between strategic and tactical launch decisions (Figure 2.8). Strategic launch decisions are defined as product strategy, market strategy competitive strategy and firm strategy. Tactical launch decisions include decisions about the type of product, price, promotion and distribution. Both strategic and tactical launch decisions influence product performance which is defined as overall performance, customer-determined performance, financial performance and technical performance.

In further research Hultink and Robben (1999) investigated the impact of launch strategy and market characteristics on new product performance (i.e., market position, sales levels, quality and technical performance level of the new product). They investigated 272 consumer and industrial new products in The Netherlands through a mail questionnaire. In line with results from other studies, they find that higher product innovativeness (e.g., findings from Kleinschmidt and Cooper, 1991), earlier timing of market entry (e.g., findings from Lambkin, 1992), broader product range (e.g., findings from Robinson and Fornell, 1985), and less intensive competitor reactions (e.g., findings from Heil and Walters, 1993) all have a positive influence on product performance.

Figure 2.8: Impact of Launch Decisions on New Product Performance (Hultink et al, 1997)



Another launch strategy is to introduce new products as quickly as possible. Companies aiming to be first-to-market are named pioneers. Berger (1995) and Stalk (1988) point out that with a first-to-market strategy price differentiation is possible and therefore high profits can be achieved. The reasons why companies act as pioneers is investigated by Ali (1994) who reviewes the economics and management literature on pioneering and innovation. He identifies different factors as to why companies have more or less products. For example, he finds that the rate at which products are introduced is likely to increase with firm size. Further, he finds that companies in industries with moderate entry barriers develop more pioneering products. Another interesting point he found in the literature is the relationship of pioneering activities with organisational structures. He points out that success with pioneering products will increase with R&D flexibility, manufacturing and marketing skills. These examples show that pioneering is influenced by many factors internal and external. However, as Ali's research is based only on a literature analysis he recommends empirical work in addition.

The fact that pioneering is not always the best way to operate in a market is summarised by Lambkin (1998). He finds that "it is widely believed, both by academics and management practitioners, that early entrants into newly developing markets enjoy an enduring competitive advantage over later entrants". However, Lambkin concludes that this is not always the case. Pioneering products can fail and therefore have difficulties in being accepted by customers. Although his finding is not really new, his study shows that pioneering requires a detailed market analysis of the chances and risks.

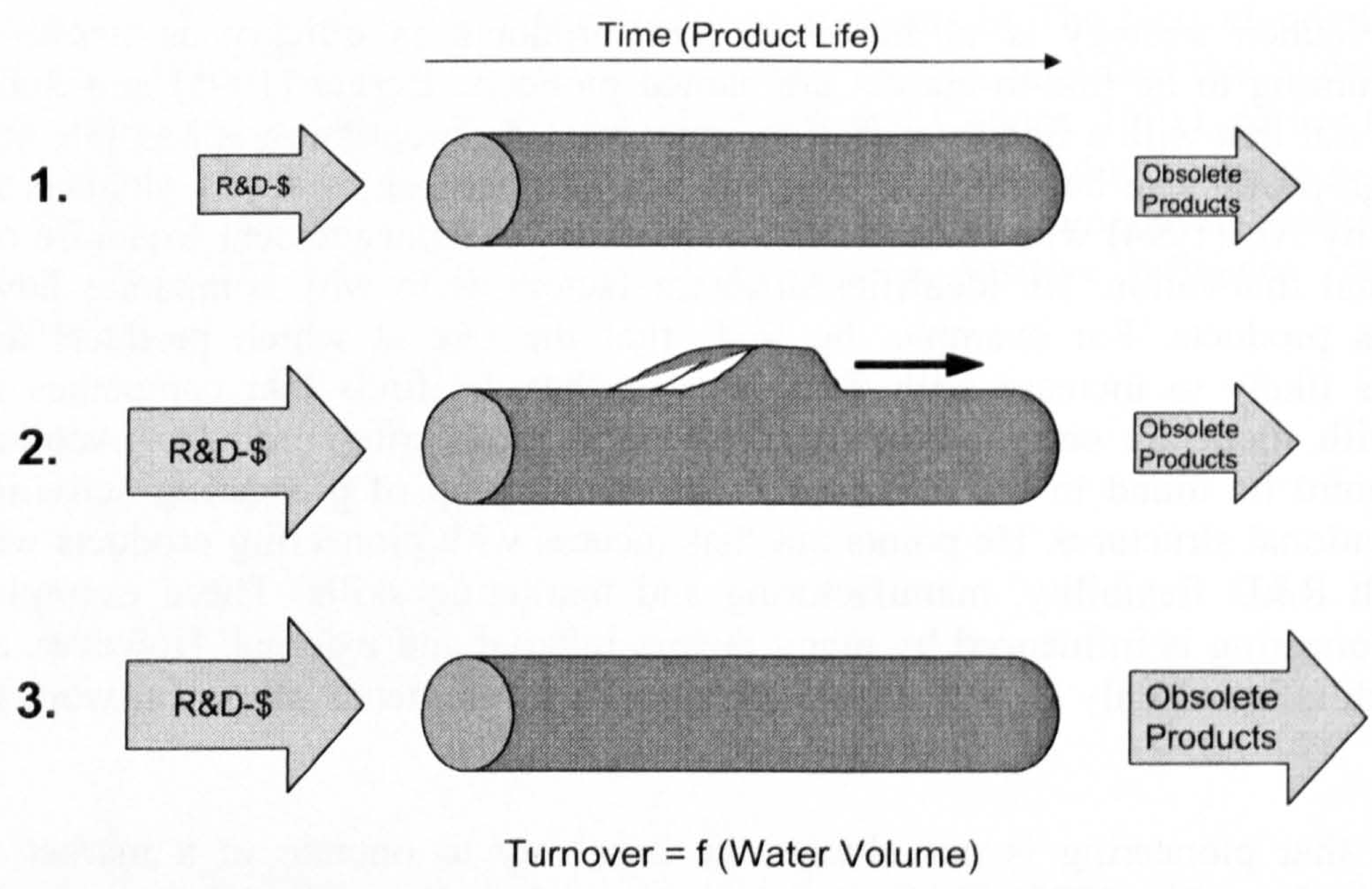
Overall, the most appropriate combination of launch strategies and tactical decisions needs to be chosen (as shown by Hulktink et al, 1997).

Independent from the chosen launch strategy, companies have to decide how much they invest into R&D. However, the chosen launch strategy can be seen as the basis for gaining back the investments and making profit. How new product introductions are related to R&D investments is discussed in the next section.

Investments into R&D

First a more theoretical work is presented which tries to shows the effect of the development of more new products on R&D investments and product elimination rate. Braun (1995) offers an analogy which shows that an uncontrolled acceleration of new product introductions is related to higher R&D investments and a higher elimination rate of products. The starting point of his analogy (Figure 2.9) is the balance where obsolete products are replaced by new ones (Phase 1). Developing more new products (Phase 2) requires investing more money in R&D. As a result, a wave of additional new products is launched while the number of obsolete products remains the same. In Phase 3, when the "innovation wave" has reached the end of the hose (i.e., when more products become obsolete), the balance of new and obsolete products is achieved again, but on a higher level – in other words: the running speed of introducing new products and elimination of existing products is on a higher level (i.e., high R&D investments are necessary).

Figure 2.9: Effect of the Acceleration Trap (Braun, 1995)



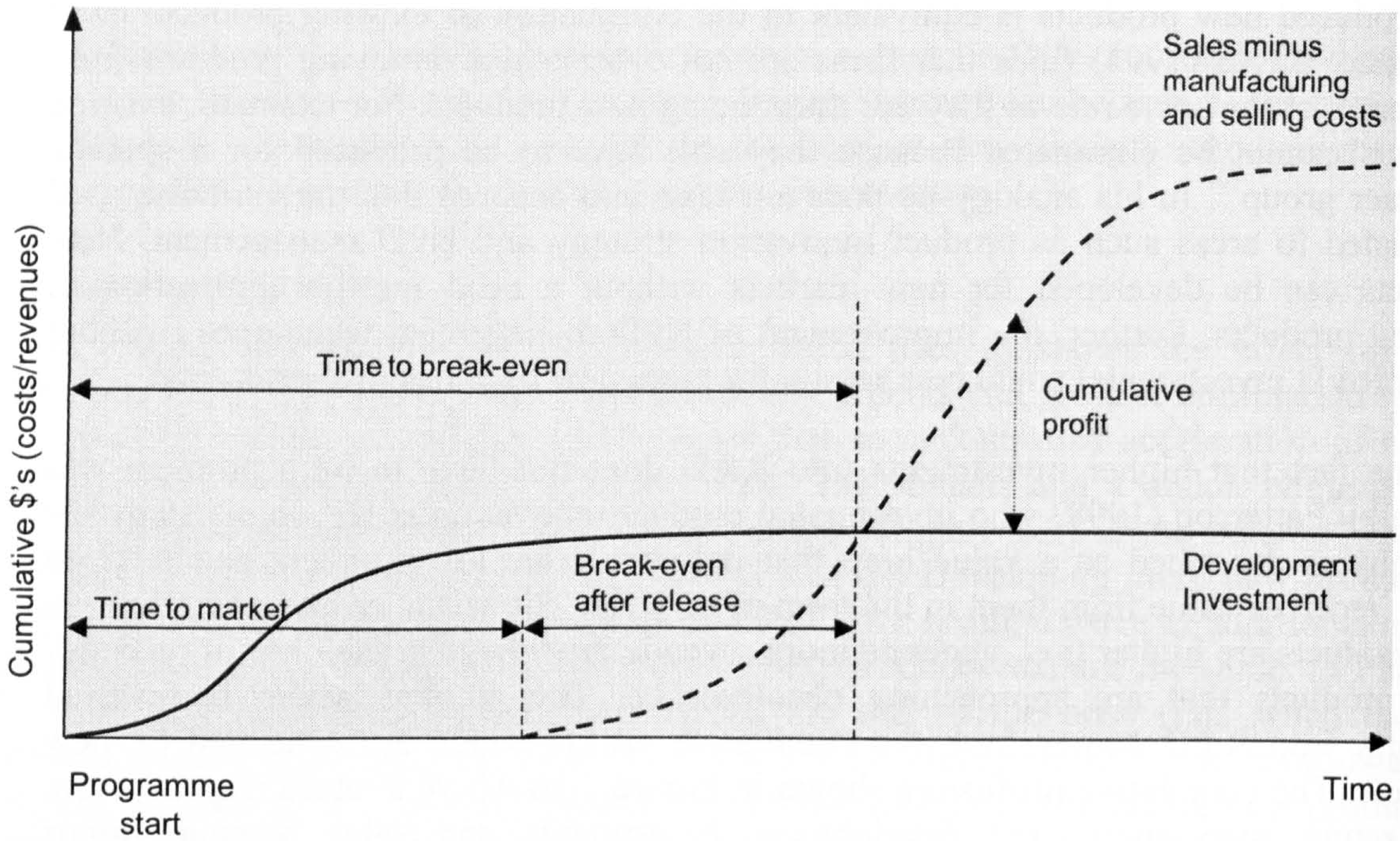
Although Braun's model works in theory, empirical research studies show that the analogy he presents is difficult to transfer into practice. His conclusion that the number of introduced new products is equivalent to the elimination of existing products lacks substance. Bayus (1994) finds that firms are not consistently removing products from the market at the same rate as they are introducing new products. For example, existing products cannot be eliminated because they still have to be produced for a specific customer group[19]. In his analogy he does not take into account that the variables used are related to areas such as product innovation strategy and NPD management. New products can be developed for new markets without a need for the elimination of existing products. Further, the improvement of NPD management techniques (without higher R&D investments) could be a reason for more new products in shorter time.

The fact that higher investments into R&D does not have to be a problem was shown by Patterson (1998) who investigated product innovation at HP. In his study the company is described as a value loop that delivers value to customers and then, in return, receives value from them in the form of revenue. The revenues gained from these new products are higher (i.e., generate more revenue growth) than the drop in revenues from products that are approaching obsolescence. The amount which is invested regularly into R&D comes from the cumulative profits which are generated by new products. The cumulative profits are shown in Figure 2.10 where a return map is given. This return map shows the development investments and sales revenue minus manufacturing and selling costs over the lifetime of a product.

In Pattersons view higher revenues and higher cumulative profits from new products are directly linked to their organisational (e.g., effective distribution and sales operation) and management performance (e.g., effective NPD management processes and executive leadership) – which is not investigated in his study. Overall, this phenomenon is summarised by Patterson as follow: "While HP's profit growth has not kept pace with revenue growth rates, annual profits are vastly greater now than they were when this transition began".

[19] In the case studies (Phase 3) one business unit was identified (BU 3) with a huge number of existing products, which are produced in low numbers for specific customers (i.e., for customers with long term contracts and guarantees for delivering spare parts for a 10 years time period). The fact that they do not automatically eliminate an existing product with the introduction of a new product led to a low product innovation rate. However, about 60% of their turnover came from products younger than three years. The case study of this business unit is given in Appendix B (Case Business Unit 3 'Break Systems').

Figure 2.10: Return Map (Beaumont, 1996)



As the example HP has shown, it is no problem for big companies to finance higher R&D efforts with their cumulative profits. However, how this is possible for small and medium companies is not clear. Further, it is still open how company profits are related to higher investments into R&D. This was investigated by Morbey (1988) who found that higher investments into R&D do not automatically lead to higher profitability. He investigated annual reports across many industries as well as the relationship between R&D expense levels (i.e., investments into R&D) and company profits. He found that R&D expense levels predict growth, but not profitability. However, both the studies of Patterson and Morbey do not take into account characteristics of the business environment nor does he look at factors in the management areas organisation and human resource management. Because of this limitation their studies should be repeated by using a more complex research design. This in turn leads to the conclusion that Braun's (simple) "acceleration trap" does not seem to be useful for explaining the (complex) relationship between R&D investments and the percentage of obsolete products.

Product innovation outcome

A further stream of investigations into product innovation strategies investigates the influence of strategies on innovation outcome as revenues, profits and company growth. De Meyer and Pycke (1996) find, that on average, new products generate nearly thirty percent of manufacturing companies' revenues. This finding is qualified by Firth and Narayanan (1996) who investigated the influence of different strategies with regard on return (e.g., revenues from new products, ROI) and risk (i.e., classification by capital markets). They profiled the new product strategies of 18 large companies (selected from the Fortune 500), based on a study of 459 new products introduced during a five-year period. They find, that "although firms may effectively focus their new product strategies in several ways [i.e., newness of embodied technology, newness of market applications and innovativeness in the market], the absence of strong focus appears to enhance the riskiness of firms". Further, they find that companies that emphasised market innovativeness in their new product introductions register higher return without a concomitant increase in risk. One limitation identified is that the paper does not explore the firm's reasons for pursuing certain innovative strategies on a deeper level. Further, the study does not investigate other areas than business environment and organisational factors. However, this seems to be necessary because these areas could be related to return and risk, too. Therefore, further longitudinal research in this area is required by taking a more complex view.

Investigations over time are important for showing how companies adapt their strategies to the quickly changing market demands. Geroski and Machin (1992) took a long-term approach and analysed 539 UK manufacturing firms over the period of 12 years (1972-1983). In their study they find that innovating firms (defined as companies with at least one product innovation sometime during the period 1972-1983) are both more profitable and grow faster than non-innovators (defined as companies with no product innovation during the period 1972-1983). Although the differences between innovation and non-innovation firms are extremely small, the observation over time led to an interesting result. They found that innovators substantially outperform non-innovators in recessions, but differentials narrow considerably in booms. In order to avoid the worst effects of recessions, innovative firms have the internal capabilities to respond quickly to new technological developments, and to match changing technological possibilities with changes in consumer needs. This is the reason why innovating firms appear to outperform non-innovators. In particular the approach of Geroski and Machin to investigate companies over a longer time period seems to be important in finding out the reasons for and effects of product innovation activities on product innovation outcome.

One main factor for staying competitive over a longer time period is to grow with new products. This is investigated by Hax and Majluf (1991) who find that companies have the possibility to grow with new products. Similar findings are made by Zarah (1993b) who point out that firms can emphasise new product development activities as a means for achieving growth and profitability. Further, he finds company growth is also possible by entering new markets. Companies that pursue a growth strategy (i.e., increase of revenues) are likely to develop and introduce products frequently, often before competitors, exhibiting considerable commitment to entrepreneurialship (Covin and Slevin, 1991). Another study in this field was performed by Brenner (1994) who investigated growth on the basis of a database of hundreds of new air products produced from 1980 to 1994 in the U.S. They investigated new product sales and found that new products grow far more rapidly than older ones, potentially providing a large boost to a company's growth rate. They found that 40% of the organisation's sales growth came from products that did not exist five years ago.

To show how the relationship between existing and new products are used as an instrument for strategic planning, two examples from industry are given. The first one is the Black&Decker company which has the aim of developing at least one major new product line every 18 to 24 months (Graber, 1996). The second example shows how the percentage of revenues gained from new products is used to generate a continuous stream of new products. At 3M in 1994 30% of revenues must come from products less than four years old. Further, they set the goal for 1997 to achieve 10% from products less than one year old (Anonymous, 1995a). As this strategic goal only gives the framework for product innovation activities, it would be interesting to show how the whole product portfolio is managed, i.e., the elimination of existing products. However, the two cases do not give further background information on this aspect.

A personnel view on how product innovation and growth are related is given in a case study of Bomardier (Baghai et al, 1997). Bomardier has achieved rapid growth (20 per cent per annum over the past 10 years) by making acquisitions in unrelated industries and focusing on product innovation. Bomardier's strategy is to be close to customers and develop and produce what they want. However, for the managing director the costs of producing new products are the critical point. He points out that independent from the business a company is in, new products have to be manufactured "at a competitive cost". In the case study the board of management was interviewed and the statements were proved through information from further informants and background information. However, not every interview with managing directors gave such detailed and valid information as shown next.

Further, insights into the growth of a company are given in an interview with Paul Cook (Taylor, 1990). The founder of the Raychem Corporation (a company in the electronics industry) put pressure on innovation to achieve company growth. Cook argues, that the only way to increase the company from $1 million to $5 million without big acquisition efforts is "to get more and better products out of the door faster". He points out that the best way to avoid competition is to sell products that rivals cannot touch. In Cook's view a key driver of innovation is the size of a business unit. In his view, a business unit will not innovative effectively if it has more than a few hundred people. His conclusion is that "every company is innovative or else it isn't successful". This interview shows the view of a single managing director. As this interview was published in a well-known business journal (Harvard Business Review) it can be concluded that the single view reflects reality. However, to strengthen the reliability of this interview, most of his statements need to be qualified in an in-depth study. Another example for company growth with product innovation is given in an interview made by Prokesch (1993). He questioned Ed McCracken, the chairman of Silicon Graphics about the importance of innovations for his company. In this interview, Ed McCracken points out that product innovation is the key for achieving competitive advantage. He states that "whatever market we're in, we want to manufacture only the products that give us a 50% gross margin, which we think we need to stay on the leading edge of innovation". To achieve this he points out that a broad product line is important. For him such a broad product line is important to avoid a company position in niche markets only. In such niche markets he argues, it is difficult to get the payoff[20]. Ed McCracken's view of

[20] Ed McCracken's view that mass markets are important to generate high cross margins is not conclusive. Several studies found that niche markets have a high potential for high profits (e.g., Simon, 1996; Rommel, 1991; Janz et al, 2001). In the current study one case (BU 8) made 31% profit within a niche market (Refer to Appendix B, Case Business Unit 8 'Ultrasound').

strategy at Silicon Graphics is interesting, however to check the validity of his statements information from other sources would be needed.

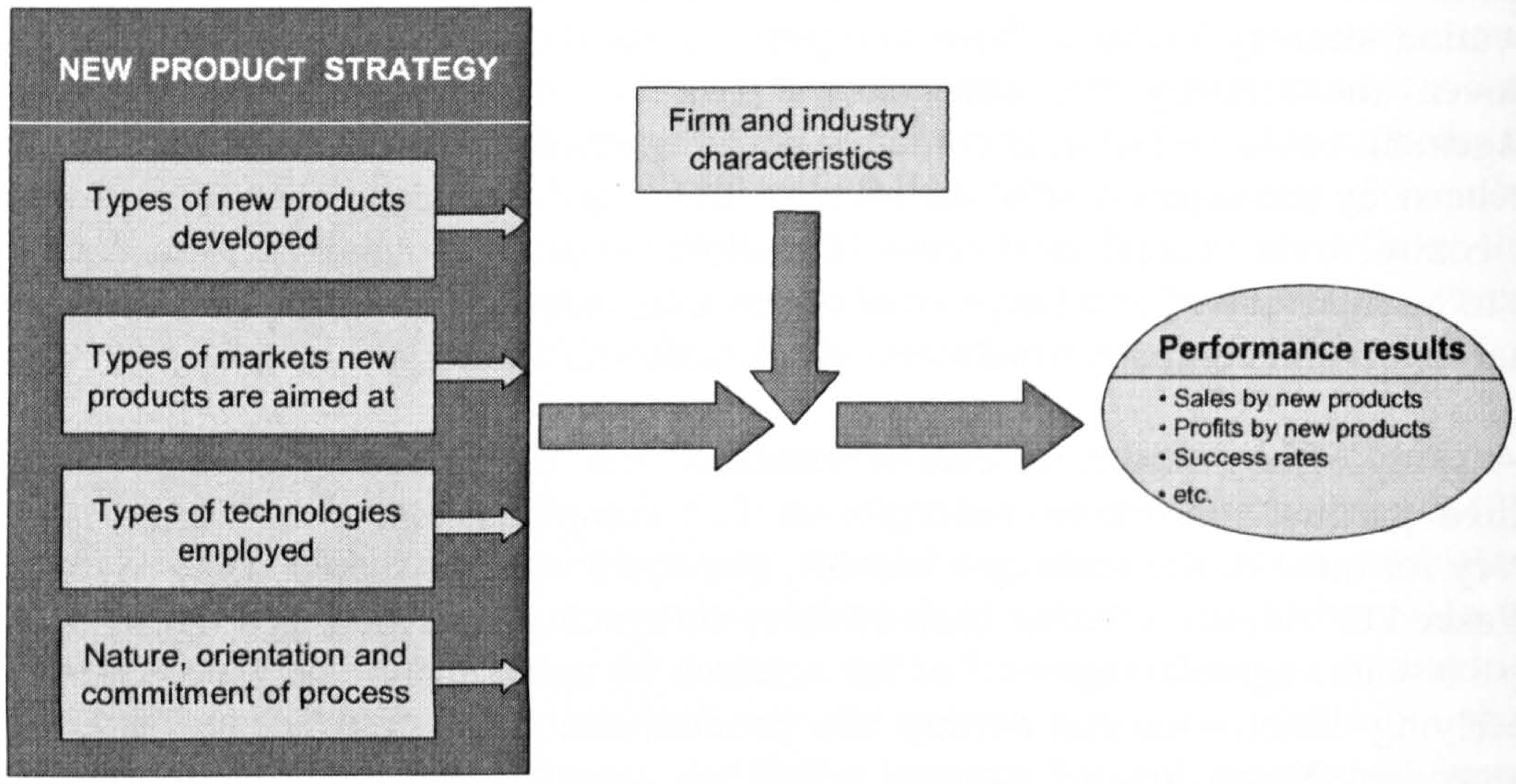
Interviews with CEO's are very helpful to get insights into a company's product innovation strategy because these key persons set the goals and strategic guidelines. However, the strategy literature shows that the strategy fixed by the board of management could be not in accordance with the strategy lived. For example, it can be influenced by managers below the level of the board of management (i.e., by groups with control over critical resources). Therefore, several managers within a company have to be interviewed and (as pointed out earlier) information from other sources (e.g., annual report and company brochures) needs to be analysed also.

A study of how strategies can be measured was conducted by Cooper (1984). He studied product innovation strategies at 122 companies using 66 variables. In his survey for most of the strategy variables, managers were presented strategy statements and asked to indicate whether each of these statements described their company (using 0 to 10 scales agree/disagree). For his research he used cluster analysis to identify the underlying dimensions that portray new product strategy. The result was a total of 19 independent dimensions of strategy which were categorised into four groups (Figure 2.11). The groups are types of new products developed, types of markets, the aim of new products, types of technologies employed and nature orientation and commitment of process. These groups are related to the companies' and industry characteristics and influence performance[21] (e.g., percentage of revenues from new products, failure rates, importance of the programme in generating sales and profits).

Using this model, Cooper identifies five different strategies. The first one he identifies is the balanced strategy which is described as the best one to achieve good values for every performance criterion. Low-budget strategy, the second one is characterised as having a good success rate and profitability but low impact on the company. The third strategy is technology driven having high percentage sales of new products, but low success rates (e.g., poor profitability and short-fall of programme objectives). The fourth one is defined as the technologically deficient strategy. This strategy is identified as having poor performance on most performance measures. The fifth strategy is the high-budget diverse strategy with poor performance on most measures. Although Cooper offers a systematic research design, it is difficult to understand, how the 66 variables are related and what the drive behind them is. To understand this, some case studies would be helpful. However, the research of Cooper shows a possible way to identify and explain product innovation strategies. Further, the research shows, that strategic issues can only be answered by the combination of variables and questions capturing different management fields. In his study, two critical points have to be noted. Most variables are ranked via rating scales. Therefore, they contain no information about the value of these measures. Further, he did not ask several manages within one company. However, this seems to be important to improve the validity of the results. Therefore, similar research should be carried out with (personal) interviews of several managers within one company and the analysis of information from other sources.

[21] Performance measures were asked for the for the last five years.

Figure 2.11: The Conceptual Framework for the study: New Product Strategy is Defined by Four Blocks of Strategy Variables (Cooper, 1984)



In summary, most papers with focus on product innovation strategy do not investigate the product portfolio as a whole. Especially the balance between existing and new products has not been investigated with in-depth studies. For example, Clement et al (1998) and Tellis and Golder (1996) investigated pioneering effects and their influence on market success and found that new products often result in the elimination of existing products. However, information about the product portfolio as a whole (i.e., the relationship between existing, new and eliminated products) are not given in their (and other) studies on product innovation strategy. From the literature it get clear, that an uncontrolled introduction of new products does not automatically lead to higher profit and higher growth. For example, Brockhoff (1993) recommend that factors such as product range, product differentiation and elimination of products have to be taken into account. A further problem of too many new products is given by Kenny and Quelch (1994). They find that unchecked product-line expansions can weaken a brand image. Overall, these studies show that the right balance between existing and new products (a product portfolio which seems to be the best one to stay competitive) can be a vital factor. However, although many studies recommended planning the relationship of existing and new products carefully, most studies on product innovation strategy do not address this problem. Therefore, research activities in this direction seem to be necessary.

Further, the research shows that product innovation strategy is related to the other three main areas of product innovation on company level (i.e., business environment, organisation and human resource management). However, such a view is not common in research activities of product innovation.

2.3.6 Comprehensive Studies of Product Innovation at the Company Level

Studies which investigate different areas of product innovation at company level are presented in this section. The first study presented was conducted by Simon (1996). In his book *Hidden Champions*, he describes the strategies and practices of small and mid-sized German companies that create highly successful products and services. In his definition, a hidden champion company is number one or two in a world market or number one in the European market. It has no more than $1 billion in sales revenue and should have low public visibility (in his sample, the size of a typical hidden champion is reflected in median annual sales revenues of $130 million). The methodology of his research is based on five categories of data. Public information, company published material, survey data from 457 questionnaires (122 questionnaires were usable for analytical purposes), more than 100 interviews with managers and contacts in the context of consulting assignments. This research was conducted between 1993 and 1995. Although he concentrated his research on both, manufacturing and service companies his findings are particularly interesting. He finds, that almost all companies in his sample have achieved world market leadership. He sees the reason for this in the fact that at some point they pioneered essential aspects of technology or business practices in their markets. This finding is an interesting one, because other researchers (e.g., Cramp, 1994; Lambkin, 1998) found, that pioneering is not always the best way to act within a market. Another finding of Simon is that innovation in these companies is clearly stated in company guidelines and intensively communicated. Although this is not a new result (this was also found by researchers such as Senge, 1990; Kaplan and Norton, 2001 and Tidd et al, 1998), it shows that communication within a company is essential for being innovative.

A further finding of Simon is that creativity, commitment, staff quality, corporate culture and a deep and comprehensive understanding of a customer business and problems are a basis for continuous and gradual innovations. Almost three-quarters of the respondents of his questionnaire said that their leading market position is based on technological know-how and innovation. 57% said that they are driven by the market and technology, 32% naming the market, and only 11% citing the technology as the dominant driver. He points out that their R&D spending does not appear to be particularly high – on average they invest 6.3% of sales[22]. Looking at technology and market he argues that the hidden champions are strong in both dimensions. He also finds that in small companies all personnel continually interact with people in functions and professions other than their own. Therefore, they are closer to the end result of the work and achieve a better integration of technology and market.

An interesting result of Simon's study was that some hidden champions had to overcome substantial customer resistance against breakthrough innovations. He concludes that sometimes customers are conservative or unable to act to their long-term advantage[23]. Simon points out that the hidden champions achieve this by having an

[22] In contrast to Simon's finding R&D investments in the case business units were particularly higher. On average they invest 9.8% of the revenues into R&D activities (Section 7.5.3 'Product Innovation Strategy').

[23] The finding that customers sometimes have to be convinced is discussed in Section 2.5.1 'Source of Ideas'. In the case studies 2 business units reported, that they have to convince their customers (BU 1 and BU 8). The case study of BU1 is given in Chapter 7 and the case study of BU8 is presented in Appendix B.

overall strategy. Taking the definition of Johnson and Scholes (1999), their strategy formulation is based on both logical incremental/rational command and muddling through. With regard to NPD processes he finds that although the NPD teams are surprisingly small, their achievements are impressive. In several firms he found a single, solitary, outstanding figure responsible for NPD. This is an expert who has focused on the problems of the company for years and produced most of the innovations. However, the focus on one person may be a possible way for smaller companies, but does not work in greater organisations[24]. The concentration on only one outstanding expert could be dangerous when this expert is not the owner of the company. When this person leaves the company the whole knowledge is gone, too. Although product innovations are the main topic in his study he does not investigate the relationship between existing and new products on a deeper level. With regard to the innovativeness of companies he uses the number of patents per hundred employees as an indicator. He takes this measure although he states "that some of these figures may not be absolutely accurate". However, the approach of Simon to investigate the success factors of hidden champions is remarkable because he looks at different areas within companies. In a further research it would be interesting to analyse Simon's data with regard to the individual product innovation rates (positions) of the hidden champions.

A further study which investigated product innovation activities on company level was carried out by Griffin (1997a). She investigated 383 companies with both product and service innovations[25] who are part of the Product Development&Management Association (PDMA). Her survey is in line with prior best practice studies of other researchers (e.g., Anonymous, 1994, 1995b; Booz and Hamilton, 1982; Mello and Vernette, 1995). In her survey she investigated success outcome variables (i.e., market measured as "position in your industry" and financial success measured as the degree relative to their program's objective) and process and organisation variables (i.e., strategy, product development process and organisation). Further, she analysed demographic variables as the type of customers, industry participation and firm size. Although many of the variables were measured via ranking scales and predefined answers were given (from which the respondents had to choose the most appropriate ones) the results are particularly interesting. On average, the NPD processes for 55.6% of the sample included a specific NPD strategy (e.g., line planning, commercialisation). To achieve the strategic goals 53% of the firms used more than one structure for organising innovative NPD projects (e.g., within function, venture group, NPD staff department). Further, she found that NPD reporting structures for best practice firms do not differ from reporting structures for the rest of the firm. This indicates that the organisation form on company level and project level is closely related[26] which was also found by other researchers (e.g., Brown, 1991; Schoonhoven and Jelinek, 1997; Liversay et al, 1996). Another finding was that innovative projects used multi-functional

[24] Such an outstanding person was identified in two business units (BU1 and BU 7). In both cases the owner played an important role in developing new products. However, both owners have recognised that their R&D activities have to be implemented into their companies more systematically. Therefore they had built up R&D departments over the last few years. The case study of BU1 is given in Chapter 7 and the case study of BU7 is presented in Appendix B.

[25] In Griffin's article 'product' refers to both manufactured goods and services. When physical products are considered separately from services, she referred to as manufactured goods.

[26] The relationship of organisational structures and product innovation is discussed in Section 2.3.2 'Product Innovation and Organisation'.

teams more extensively than less innovative projects. This again is in line with findings from Anonymous (1996b) and Larson and Gobelli (1988).

With regard to product development measurement Griffin found that 75.6% of the sample did develop formal financial objectives against which actual performance (i.e., revenue growth, revenues from new products) is evaluated. However, even though objectives were set, only 50% of the respondents went back and evaluated actual performance. In general only 46.5% of the sample used the variable revenues from new products as a target. This is confirmed by Anonymous (1994) who finds that only 50% of higher-performing firms track NPD performance while only 28% of the lower-performing firms track NPD performance. Selected performance variables investigated by Griffin are presented in Table 2.5. Overall, the success rate of those new products which make it to market across the sample was 59% (manufacturing companies 59.6%). The percentage of products categorised as financial successes is given with 54.6% (manufacturing goods = 55.3%). Manufacturing companies make 34% of their revenues with new products and achieve 32.4% profits. This was achieved with 10% products categorised as new-to-the-world and 20% new-to-the-firm – all other new products (70%) were improvements or cost reductions.[27] It has to be noted that although she investigated product innovation outcome variables, no precise information about the whole product portfolio, i.e., product innovation rates is presented. However, to get a comprehensive view into product innovation outcomes this should be measured in further research projects, too.

Table 2.5: Average Successes by Demographic Category (Griffin, 1997)

	Success Rate[1] (%)	Profit Success[2] (%)	NP Sales[3] (%)	NP Profit[4] (%)
Full Sample	59%	54.6%	32.4%	30.6%
The Best	79.8%	78.0%	49.2%	49.2%
The Rest	52.5%	47.1%	25.2%	22.0%
Manufactured Goods	59.6%	55.3%	34.0%	32.4%
Services	58.2%	52.7%	24.1%	21.7%

[1] Success Rate: % of products commercialised in the last 5 years categorised as successes.
[2] Profit Success: % of products commercialised in the last 5 years categorised as financial successes.
[3] NP Sales: $ sales of products commercialised in the last 5 years as a% of total sales.
[4] NP Profit: $ profits of products commercialised in the last 5 years as a% of total profits.

Another comprehensive study which covers a wide range of factors was conducted by Berth (1997). On basis of 463 interviews with managers (managing directors, marketing managers, R&D managers and production managers) and data from 137 companies he investigates the drivers for product innovation of German companies. In Table 2.6 overall results of product innovations investigated by Berth are given. Most innovations need four years development time. He finds that, on average, a German innovation needs five years to achieve the break-even with 2.1% profit and a return of capital with 3.6%. However, profits increase up to 9% in the ninth year after product launching and after the ninth year profits decrease. Berth differentiates between

[27] According to the definition of Iansiti and Clark (1994) products categorised as new-to-the-world and new-to-the-firm new can be described as transformational product innovations. All other new products can be defined as incremental ones.

incremental and transformational[28] innovations. He finds that the breakeven-point with transformational innovations is achieved after a six year period. Further, he finds that the profits in the following years (year six to nine) are higher than with incremental innovations. The sample he uses includes a mixture of products in the start-up phase and new products which have not reached the break even. These new products are compared to existing products of more than eight years old. The comparison of these two types of products shows that with old products profits are 6% while with new products profits are only 0.2%. The interviewed managers estimated lower profits with old products (decrease down to 1.3%), while profits with new products are estimated to increase up to 9%. However, an estimation of future profits does not show realistic data. Therefore, the method of looking back into the past and using real data would be the better way.

In a further step Berth compares companies with different strategies and different product portfolios. He finds that traditional companies which maintain their existing products and introduce new products occasionally achieve 5.1% profits and 6.5% return on investment. Companies which try to both hold on to existing products and to be very innovative only achieve profits with 3.7% and a return on investment of 4%. In strong contrast, young companies with new products and highly innovative activities achieve profits of 6.4% and return on investment of 9.1%.

Table 2.6: Average over all Innovations Investigated by Berth (1997)

	Development Time				**Product Introduction**				**Break-even**				**Pay-back**
Years	**-4**	**-3**	**-2**	**-1**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Turnover (Euro)					49.6				845		1,264		1,669
Profit (Euro)					-134.4				17.9		84.4		143.7
Accumulated profits (Euro)					-296				-413		-175		46
Capital investment (Euro)					163.6				497		755		891
Profit (%)									**2.1**		**6.7**		**9.0**
Return of capital (%)									**3.6**		**11.2**		**28.5**

Although his data analysis does not give a detailed insight into the whole product portfolio, he presents the profits on an average of the whole product range. However, for analysing the profits it would be necessary to know the product portfolio (e.g., product innovation rate) of the case companies. In summary, it can be concluded that his results only show tendencies. One reason for this is the mixture of data from the manufacturing and service industries in his data analysis. Another questionable approach is the use of a time period of nine years to investigate the profits from new products. This is not comprehensible because other studies show that a nine year period is too long for investigating product innovation due to the fact that life cycles of products are shorter (e.g., Anonymous, 1995a; Graber, 1996; Griffin, 1997c;

[28] In the definition of Berth, transformational innovations are more than just product adaptations. However, a more detailed definition is not given.

Anonymous, 1999a; Jantz et al, 2001[29]). It has to be noted that Berth's approach as a consultant is to develop an innovation self-assessment guide for managers. Therefore, the aim of his research activities is to underline the importance of product innovation and not to investigate specific research questions in-depth.

A further stream of studies on a company level are large surveys. Roper et al (1996) analysed data of over 1,700 UK and 1,300 German manufacturing companies. The detailed analysis shows that companies with new products generate higher revenues and achieve higher growth. The survey finds that companies' main objectives with product innovation are to increase market share and improve product quality. Another survey was performed by Rommel (1991) and McKinsey who surveyed 40 German mechanical engineering companies and identified large differences in performance. He finds that successful[30] companies exhibit better growth and return-on-sales and have narrower product ranges, lower product complexity, closer relationships with their suppliers and better NPD processes. Further, researchers from the McKinsey consulting company (Kluge et al, 1996) investigated approximately 40 electronics companies from different countries. They find that "many German electronics companies urgently need to improve the productivity of their innovation efforts". In comparison to companies from other countries, German companies did not set targets for sales growth from new products, had problems with the integration of cross-functional teams and did not use enough analysis methods to identify customer needs. The two studies were based on the opinions of the authors and information about the research methodology and data analysis were poor. In summary, both studies can be sorted into the category "anecdotal".

Annual surveys are another kind of research on company level. In Germany the Fraunhofer Institut für Systemtechnik und Innovationsforschung surveyed over 800 small companies and found that nearly 50% of companies, which earn more than 25% of their revenues from new products also experience growth (Kulicke et al, 1997). Based on the survey data other researchers found that many German manufacturers have not yet applied new methods such as teams and just-in-time production (Lay et al, 1996; Kinkel and Wengel, 1997). Another major study is the annual ZEW survey on innovation. Many German companies responded in 2000, covering a range of industries (Janz et al, 2001). The survey showed that the investment by manufacturing companies in product innovation has increased by 16.8% since 1993. This measure was qualified with the variable investments into product innovation in proportion to the turnover which only increased from 4.6% in 1996 to 4.7% in 1999. However, as a result of increased investments into product innovation turnover with new products in manufacturing industry increased from 38% in 1993 to 45% in 1999. In summary, the study shows that new products play a key role in achieving revenue growth.

For capturing the complexity of product innovation on company level, innovation audits can be used as a framework. A research team at the London Business School developed such a guideline for an innovation audit (Chiesa et al, 1996), which is in line

[29] Jantz et al (2001) analysed the life cycle of products for the German manufacturing industry from 1992 to 1999. They found that life cycles in the E&E engineering sector decreased from six years in 1992 to five years in 1999. In the automotive industry product life cycle decreased from eight years in 1992 to seven years in 1999. In their study they measured the average over three years for products with the highest revenues.

[30] The study does not explain success and does not define factors for success.

with Majaro (1988). The audit is based on a set of questions with focus on innovation processes within a company, e.g., concept generation, NPD, process innovation, and technology acquisition. The user gets information about his entrepreneurial thinking and leadership and recommendations as to how he can improve innovation activities within his company. The audit is based on predefined answers, which have to be rated on a scale of one ("poor") to five ("world class"). Although the results are based on a self-estimation of managers which are strongly influenced by the personal view of innovation, the audit helps them to think about nearly all aspects of innovation. On the basis of this audit they can identify weaknesses and strengths and are able to optimise their innovation processes. Innovation audits have also been recommended by other consultants, e.g., Feige and Crooker (1998) and Wind and Mahajan (1997). However, measuring product innovation via ranking scales is problematic. They are a good instrument for showing tendencies, but for in-depth investigations variables need to be measured absolutely.

Although there have been several studies of product innovation activities at a company level over recent years, data of product development practice and performance at this level are rare (Oliver, 2001). Because product innovation research at this level is in its infancy, the need for further research is given. It has been found that most studies do not differentiate between the degree of new products. However, this is important when comparing product innovation activities of companies. A further gap identified in the research papers at company level is the focus on new products without taking the whole product portfolio into account. This is surprising as several writers have stressed that the development of new products cannot be divorced from the management of existing products (e.g., Johne and Snelson, 1988; Brockhoff, 1993; Kenny and Quelch, 1994). Such a view will become increasingly important for companies to make well-informed decisions on product introductions, design changes, and end of life situations (Ryan and Walter, 1996).

Overall, the literature review at company level shows that product innovation is influenced by many factors from different areas. Therefore, many researchers have focused their research activities on the project level.

2.4 INVESTIGATIONS AT THE PROJECT LEVEL

At the project level researchers have focused on various topics with main areas being

- Source of ideas
- The new product development process
- Time-to-market
- Comprehensive studies of product innovation at the project level

2.4.1 Source of Ideas

Much research into product development management has treated the issue of creative problem-solving implicitly, when dealing with how to improve time, cost and quality (Jannson et al, 2000). Often, the new ideas are based on new combinations of existing knowledge from internal or external sources (Pleschak and Sabisch, 1996). Internal sources are for example, research activities on a specific area, suggestions from employees or from quality control activities. External ideas come for examples from customers or activities of competitors. Independent from the source an idea could be generated by accident, e.g., 3M Post-it notes (Trapp, 1997) or could be created in a formalised process (e.g., Pleschak, 1997). For supporting creativity and idea generation, many companies have set up innovation programmes in the conviction that creativity is one key to competitive survival (e.g., Houlder, 1996a; Tersko, 1996; Rueter, 1999).

The literature on the source of ideas comprise:

- Creative thinking
- Spring of ideas
- Structured methods to develop new products

Creative thinking

Creative ideas emerge from many conscious and unconscious working processes within the human brain (Zimmer, 2001; Lynn et al, 1996). The challenge is to structure these working processes and to offer a climate accelerating the generation of ideas from employees working on NPD projects. Although creativity is seen as an important factor for generating product innovations, Kelley and Littmann (2001) point out that very little attention is given to developing the creative thinking skills of individuals within organisations. In an empirical study they identify four elements for developing personal creativity of individuals. The first element is the understanding of the process of creative thinking followed by the identification of blocks to support creative thinking and the skills individuals can use to increase creative response. The third element is the usage of methods to get fresher ideas and solutions more often. The identification of a personal creative drive and a lifelong vision that can help individuals achieve their personal and professional goals is the fourth element. One possibility for increasing the idea output is the usage of creativity techniques. Well known methods are for example, brainstorming, brainwriting, morphologic analysis, synectic and crossing (Geschka, 1986; Geschka, 1996; Schlicksupp, 1989; and Koestler, 1964). Brainstorming is characterised by the open exchange of ideas while brainwriting uses written ideas based on the thoughts of others. Morphologic analysis is based on the systematic break down of the problem into smaller elements. Synectic is the search for analogies in other areas, e.g., biology and crossing uses the combination of different thoughts from different viewpoints. All these methods can be used by companies to generate ideas for new products in a systematically way.

Creative thinking refers to how people approach problems and solutions – their capacity to put existing ideas together in new combinations (Amabile, 1998). However, to be able to do this, employees need time as Jonlee (1996) find. He identifies time pressure as a creativity killer. Further, employees should be able to make mistakes (Golemann et al, 1999). Therefore, Krohe (1996) concludes that creative people need to be managed differently from those who do the day-to-day work. This in turn is related to the corporate culture within a company which gives the framework for how employees handle their ideas. One further key factor for generating new ideas is an appropriate infrastructure. For example, Mabert et al (1992) find that the installation of a "war room" with collects market information is helpful to develop ideas further. These findings indicate that companies need a suitable corporate culture and infrastructure for generating a permanent stream of new product ideas.

That the creation of ideas must be an ongoing process is shown by Tabrizi and Walleigh (1997) who analysed 28 NPD projects at 14 high-tech companies. They investigated the development of next generation products (platforms) and found that new-platform products can create marketplace gaps – competitors can quickly take possession of this market gap. They conclude that this is the case "when a company treats the successful launch of a new product platform as an isolated event rather than part of an ongoing process". To create such an ongoing process of product innovations the internal cultures and processes have to be oriented towards the creation of new derivative products.

To be able to generate such an ongoing stream of product ideas the latest technologies need to be implemented into the idea generation process. This is stated by Iansiti and West (1997) who investigated 87 development projects at 30 companies in the US and Japan. They find that the main challenge for companies is to choose among the vast array of technologies. The integration of new technologies into the idea generation process can result in new products (applications). Taking their findings into account, new product ideas are related to market information about the latest tendencies in technology.

Spring of ideas

Independent of creativity techniques, the first stimulus for new ideas often comes from customers. Kim and Mauborgne (2000) find that managers often have difficulties estimating the profit-potential of (transformational or radical) new ideas. In such cases, they argue, it is necessary to identify the customer benefit. Hippel (1982, 1988) supports the message that the customer is an extremely valuable source of innovative ideas. Based on many examples, he sees the innovation process as "distributed across users, manufacturers, suppliers, and others". One stream of his research focuses on *lead users* who are defined as customers who "face needs months or years before the bulk of the marketplace encounters them". He argues, that firms in rapidly-moving fields that have trouble identifying future user needs might wish to consider studying lead users. Riggs and Hippel (1993) investigated 64 innovations in two US scientific instrument manufacturing companies. They found that innovations with high scientific importance tend to be developed by users, while innovations having high commercial importance tend to be developed by manufacturers. These findings show that different viewpoints of users and manufacturers lead to different new products. It can be concluded that the aims of the two groups are different: the instrument manufacturer wants to sell the new products successfully while the user develops an instrument for a specific internal application. However, the combination of both views can lead to new products with a high market potential.

The view that customers are a main source for new ideas is not shared by all researchers. Leonard and Rayport (1997) find that customers often do not have an understanding of all relevant aspects. They conclude that a customer's ability to guide the development of new products and services is limited by their experience and their ability to imagine and describe possible innovations. Therefore, both views should be taken into account for the generation of ideas. This view is also taken by Pawlak (1996) who notes that "technology development is a team sport". Such a team involves the researcher, product engineer, manufacturing engineer and supplier. Therefore, information from all partners is necessary to develop "successful new products".

However, new products can be based on the ideas of single persons, too. A case study at IBM (Hammel, 2000) showed that innovations can be connected closely to persons and their enthusiasm to create something new. In the beginning of the seventies a single person was convinced that information transfer with the internet technology can be an important instrument to strengthen the competitive position of IBM. He infected others with his ideas and found a group of colleagues who shared his visions. At the end a process was started (from one person) which transformed IBM to a dominant service provider.

The product innovation literature shows that ideas can be based on several sources. To guide the idea generation process systematically, several methods have been developed which integrate company internal and external information sources. These methods are presented next.

Structured methods to create new products

In the product innovation literature several systematic methods for the idea generation process are offered. One of the most commonly used product planning methods is quality function deployment (QFD). QFD is an instrument for a systematic integration of customer demands into design, product and manufacturing processes (Akao, 1990). The whole QFD process consists of four quality charts which are built up on each other. The key element of the whole method is the first matrix, the "house of quality". In this matrix customer requirements and design features are related (this is the foundation on which the products are designed). In the second matrix, the key design features are related to part characteristics. The third matrix (process planning), helps to identify process characteristics of the final product. In the final matrix, the equipment requirements are translated into operation requirements. The four stages of the QFD method helps to translate customer requirements into product specifications by using the full source of information within a company. A model which goes in the same direction was developed by Noritaki Kano (Matzler and Hinterhuber, 1998). It offers a framework for how customer satisfaction and the degree of achievement is related The model considers that a customer expects any product to have certain basic attributes and to be reliable. It can be used to check out the relative importance of product ideas that customers seek. This in turn is helpful for both the identification and improvement of product ideas in a systematic way.

A method where information from users and developers is used was created by Herstatt and Hippel (1997). They presented a new approach to developing new product concepts via the *lead users method.* The process begins with the identification of a small sample of sophisticated users. These users are drawn into a process of joint development of new producer service concepts with manufacturer and personnel. In the next step the developed product is tested against a population of more ordinary users. Herstatt and Hippel tested this method at Hilti AG with a low tech product for the construction industry – a pipe hanger (a device to fix water/gas pipes to the wall or ceiling). A group including the marketing manager, the product manager and three specialised engineers worked together to design a new pipe-fastening-system. The fastening system developed was then tested successfully by a sample of 12 routine users. In comparison to their conventional research methods they reduced their development time from 16 to nine months and their costs from $100,000 to $ 51,000. Although this method worked well in their case study, they recommend that this new method is tested in further studies, especially in the high-tech field.

The lead users method offers a systematic framework for how new products can be generated with the involvement of producers and users. This method was developed further by Lemasson and Magnusson (2002). Although their method focuses on service innovation, their approach is interesting. Their method, which is called the *generative model revision,* has unveiled new potential contributions through user involvement. In their model the designers have a central role in supporting the users to create new ideas. With this support users are able to explore completely new innovation opportunities.

A more general method – value analysis – is offered by Müller and Stolp (1999). This method offers a framework of two stages for achieving higher values for the end-users. In the first stage the functions of products are analysed (analytical phase). In the second stage designs are developed which offer higher value for the end-user or lead to lower costs of the products. A similar method is the Failure Mode and Effect Analysis (FMEA). It consist of five elements starting with the analysis of the function of products (Ebeling,1988). Other parts of the method provide for the identification of failures, investigation of the reasons for failures, estimation of the effects of failures on product performance, and the creation of suitable product designs.

A further technique as to how product ideas can be created systematically is given by Herb et al (1998). They describe the "theory of inventive problem solving (TIPS)" which was developed by Genrich Altschuler in the 1950s. This technique assume that comparable problems have been solved before and therefore "thousands of patents" can show how similar problems have been solved. Although this structured method may help to develop new products ideas, it is questionable if it is useful for generating transformational and radical new ideas. A similar approach is taken by (White, 1996) who calls his method "cognitive coaching". His method is based on the assumption that research scientists have to be guided to think innovatively. This can be achieved by using metaphors and analogies or a description of how the process might operate.

The last method presented is the Robust Design method, also called the Taguchi Method (Taguchi, 1989). Taguchi's approach allows experiments to be performed and prototypes to be tested on multiple factors at once so that the product/process becomes insensitive to use-conditions and other uncontrollable factors. The first stage of the method is definition of target functions (system design). In the second stage disruptive factors with influence on the target functions are identified (parameter design). The last stage called tolerance design aims to identify the optimum of costs to eliminate most of the disruptive factors. By consciously considering the noise factors (environmental variation during the product's usage, manufacturing variation, and component deterioration) and the cost of failure the method helps to develop products and processes which work trouble-free in their area of application.

The methods presented help to identify and select such ideas which can be transferred into sellable products. However, having ideas which lead to new products requires a corporate culture which supports creativity. Further, it was shown that only an ongoing stream of new product ideas lead to competitiveness in the long term. Therefore, information from company internal and external sources needs to used for the idea generation process. However, although many researchers investigated creativity techniques and gave recommendations on how new products can be generated, only a few ideas can be transferred into successful products (i.e., in term of market acceptance and profits). Page (1993) finds that 11 new product ideas are required to generate one success (100 new ideas lead to 9.4 successes). Similar findings are made by Griffin (1997a) but on a higher level. In her sample 100 ideas led to 15.2. successes (one success for every 6.6. ideas). However, she also finds that most of the NPD projects are eliminated in an early phase of the NPD process, where less time and money has been spent on any particularly idea (i.e., in the phase of idea screen and business analysis).

In order to minimise the failure rates of new products, ideas need to be analysed and optimised in an ongoing process over the whole product generation process. Therefore, the idea generation and selection process need to be a part of the whole NPD process. Studies with focus on the NPD process are presented in the next section.

2.4.2 The New Product Development Process

Much has been written about the need for a clear product development process which defines the responsibilities of different functions, such as R&D and marketing, at different phases of the project. Hippel (1990) states that "project managers specify tasks and their interrelationships so that they can distribute innovation effort across people and organisations". The close interaction of NPD projects with people makes it necessary for teams to be well organised to reduce the failure of NPD projects (Bowen et al, 1994b). The literature dealing with the NPD process is rich. As this research project is not directly focused on NPD processes only an overview will be given, covering four areas:

- NPD methods
- Costs, resources
- Promotors for innovation
- Learning from previous projects

NPD methods

Today new products are normally developed in a structured manner using project management tools. The emergence of project management methods is described by Cooper (1994) who discusses the development of the NPD processes that are in use today. These processes originate from activities of the American National Aeronautics and Space Administration (NASA) which developed the first generation of structured NPD management tools – the NASA Phased Project Planning. This method was developed further into the Stage-Gate NPD process which has been widely adopted by industry.

The characteristics of this process are a conceptual and operational road map for moving a new-product project from idea to launch. It is an NPD process that divides the effort into distinct time-sequenced stages separated by management decision gates (Cooper and Edgett, 2002). Multifunctional teams must successfully complete a prescribed set of related cross-functional tasks in each stage prior to obtaining management approval to proceed to the next stage of product. The whole Stage-Gate process is divided into five key stages. In the first stage (scoping) the assessment of the technical merits of the project are determined. Product and project are defined, justified and planned in the second stage (building the business case). Then, the manufacturing or operations plan is mapped out, the marketing launch and operating plans are developed, and the test plans for the next stage are defined in Stage 3 (development). The purpose of Stage 4 is to provide final and total validation of the entire project testing (validation). Finally, the commercialisation of the product is carried out in Stage 5 (launch).

The NPD process, has been investigated by many researchers who identified clear techniques to improve the management of NPD projects. Further, problems companies have in the NPD process are addressed. For example, Kim and Mauborgne (1997) and Gobelli and Brown (1993) find that successful companies have a well thought-out project organisation and execution. Basis for this is the detailed definition of each stage in the whole NPD management process. A good project organisation is required, because projects are becoming more complex and team members from different departments (e.g., team members from R&D, marketing, production, suppliers) have to be managed. Such cross-functional teams help to develop new products more efficiently and increase the success of new product introductions (Pitta et al, 1996; Song and Parry, 1999; Gerwin, 1994). The fact that the team is an important factor for well running NPD projects is also identified by Cooper and Kleinschmidt (1994). Further, factors they identify are the product definition and the up-front homework as key factors which will lead to pioneering success. However, Smith and Reinertson (1992) mention that cross-functional development teams are common and therefore they are losing their bite as a means of obtaining competitive edge in NPD. As they do not offer other possibilities for managing NPD projects more effectively, their argument lacks substance.

One important step in the whole NPD process is the selection and definition of an NPD project. In order to generate competitive products in terms of design, quality and price, the chosen NPD project (product) needs to be fit into the product portfolio. In other words: it is about making strategic choices which markets, products, and technologies companies will invest in (Cooper et al, 1999). A possibility how NPD projects can be evaluated, selected, and prioritised is the Arthur D. Little approach (Lee-Mortimer, 1995). With this method NPD projects are checked on a number of qualitative characteristics such as: suitability with corporate strategy, competitive impact of technologies, probabilities of success, financial reward, and investments required. A further possibility to screen NPD projects is offered by Wheelwright and Clark (1992). They offer a project map to measure how product and processes change over the running time of a project. Such a framework is helpful for managers to decide if existing projects may be accelerated, killed, or de-prioritised and if resources need to be allocated (or reallocated) to the active projects. Especially the number of NPD projects running in parallel and the time resources of team members need to be planned and checked carefully. Therefore, portfolio management for new products is a dynamic decision process wherein the list of active products and NPD projects is constantly revised (Cooper and Edgett, 2002).

An investigation into the use of portfolio management methods in 205 US manufacturing companies was carried out by Cooper et al (1999). Their research based on a survey including some open questions and ratings on one to five linkert-type-scales. Companies were clustered into four groups to identify benchmark companies. For example, the top performers (42% of the sample size) were identified to have a strong strategic alignment, the right balance of projects and the right number of projects.

They found that benchmark companies employ a very formal, explicit method to manage their portfolio of projects (i.e., they have well-defined portfolio procedures). Their finding that strategic aspects are important for portfolio management process implies that activities on project level are closely related to strategic aspects on company level. As their aim was to investigate portfolio management of NPD projects, a linkage to management methods for the whole product portfolio (i.e., the relationship between existing and new products) is not given. However, to stay competitive the whole product portfolio needs to be attractive for customers. Therefore, further research activities in this direction are necessary.

Costs, resources

Portfolio management of NPD projects is closely related to costs and human resources. To achieve a well running NPD project (i.e., in terms of quality and time) the team members have to be released for these projects. However, because of costs and limited personnel resources, team members are often involved in several NPD projects. This often results in low motivation within the team, low quality and to a postponement of the product launch. This was found by Goffin and Pfeiffer (1999) and Cooper (1999) who identify problems with NPD projects when too many projects are running in parallel. This is the case when companies overestimate their R&D capacity. As a result many of their NPD projects are badly managed (Kulicke et al, 1997). In consequence, the advice is to concentrate on a few selected projects. The factors required to run NPD projects optimally were investigated by Murmann (1994a and 1994b). He analysed the German mechanical engineering sector and found, that reducing time-to-market and resources is achievable by reducing product complexity. A lower complexity is a basis for a better management of individual projects and better management of priorities and conflicts between projects. However, in Murmann's study one limitation is identified. He asked managers how they would improve their projects with regard to reducing time-to-market and costs. As managers were asked a hypothetical question, it is not clear if the suggested measures would work in reality. However, the findings are comprehensible and give hints on improving NPD management.

One further critical point in the management of NPD is project termination. A study of Balachandra et al (1996) showes, that in most cases the decision to terminate NPD projects comes too late and that the implications for employees are often neglected. This indicates that employees have to be involved closely in the planning of NPD projects. Within these planning processes the time resources and the tasks within the project team have to be fixed. This was investigated by Adler et al (1996) in six companies (GM, HP, AT&T, Ford, Raychem, Motorola). They found that the capacity required for projects has to be compared to the available resources. Further, it was shown that fewer projects can lead to a shorter time-to-market. In his study one limitation is identified. They do not give insights on how time resources are managed by the individual case companies. However, this would be important to help managers to manage their NPD projects more efficiently. Another study with focus on scheduling NPD projects was made by Gupta et al (1992). For their research in German manufacturing companies they used the structure of a previous US study (Rosenau, 1989). They found that differences exist between the perceptions of R&D, marketing and manufacturing on project schedule and costs. The limitation identified is the measurement of perceptions of managers working in different management functions in different companies. For example, they compared the perception of NPD projects of a marketing manager from one company with the view of an R&D manager from another company. To correct this limitation, the study would need to concentrate on one single company where all three managers are interviewed. Probably the comparison of three different perceptions within one company could lead to other results[31].

In contrast to the above findings where specific recommendations on how to run NPD projects are given, other researchers have not identified simple solutions for successful NPD. Zirger and Hartley (1994) find that one management technique alone is not enough to improve NPD processes. In their view the context and the way techniques are implemented play an important key role. This is also found by Tabrizi and Walleigh (1997) who state: "We have not discovered a magic formula for rapid, successful new-product definition". Further, Balachandra and Friar (1997) find that there is no universal model encompassing the success or failure of either new products or NPD projects. Consequently, they propose that the success and failure factors are related to the context. A wide variety of development practices in best practice companies is also found by Oliver et al (1999). They identify a number of company-specific factors (such as size, age and ownership) which influence the adoption rate of standardised practices. These findings indicate that NPD processes are embedded into the whole context of a company. One further element in the whole NPD process are individuals.

Promotors for innovation

The literature shows that individuals are an important factor in NPD projects. For example, Craig (1996) finds that in many cases, the people involved in the projects have difficulty in working together as a team. Therefore, the team members and the team leader need to be carefully selected. To lead NPD successfully it is necessary to have somebody who is convinced of the project's aims and gives it his personal full commitment. Such a person, often referred to as promotor, is the driving force behind a well running NPD process. Several researchers have concentrated their research activities on this aspect and investigated the role of promotors for product innovations on a deeper level (e.g., Mabert et al, 1992; Wildemann, 1993; Gemünden and Walter, 1995; Hauschildt and Kirchmann, 1997; Hammel, 2000).

Hauschildt and Kirchmann (1997) conclude that there are three individual promotors which have a key influence on the success of NPD: the management sponsor (a person who is empowered to allocate resources for the project), the technical specialist (a person who has know-how in the technology developed), and the product champion (a person from the board of management who promotes the smooth running of the NPD process). The fact that promotors are important individuals in supporting innovations is also shown by Wildemann (1993). He investigates the role of senior managers and finds that new processes can be introduced much faster with the support from senior managers. This in turn, shows that without the support of the managing director, it is more difficult for employees to be innovative. However, promoters may be necessary – but if they are too dominant, a team does not work because new ideas have no chance to emerge (Mabert et al, 1992).

[31] Hultink and Robben (1995) found that managers in different positions think in different ways. Managing directors have a long term thinking while R&D managers think in the short term. Therefore it can be concluded that the analysis of the different views (managers) within a company would increase the validity of the results.

The way in which product innovations can be promoted is also investigated by (Barczak and Wilemon 1989) who analyse 10 semi-structured interviews with R&D managers in leading positions. The interviews were selected from a larger study with a dataset of 99 interviews. They find that the interviewees view their position as a promotor as having four different roles: communicator, climate-setter, planner and interfacer. They conclude that "particular types of new product development teams may require both different skills and a different range of these skills". The findings show that promotors have an important role in accompanying employees and teams.

From the findings it can be concluded that a good balance between promotors and project team members is needed for an effective NPD project. However, there are other factors which make the introduction of major innovations problematic. When major innovations are introduced, people often resist the change for a variety of reasons, not all of which are rational or clearly articulated (Hauschildt, 1997). Therefore, it is essential that all team members are committed to the product idea of the project to be successful.

Learning from previous projects

One possibility to overcome resistance to change is learning from previous projects. This requires the availability of information about previous projects. But often NPD members have difficulties in reporting their project process as Wheelwright and Clark (1992) and Bowen et al (1994a and 1994b) identify. They find that team-members themselves do not write down their findings and therefore knowledge gained in a NPD project is not available to others. However, they conclude that one possibility to ensure a regular project documentation is the official auditing of NPD projects. Although formalisation is often seen as a handicap, it is crucial to write down the experience and make it available to other persons involved in NPD activities.

Existing knowledge only can be used in NPD projects which build up on previous ones. Therefore, the learning from previous projects is closely related to project familiarity (i.e., technology and markets). Robets and Berry (1983) and Cooper and Kleinschmidt (1993) find that project familiarity is linked to the success of NPD projects. Their researches show that failure rates of projects increase as the familiarity decreases. The reason is that the ability to leverage internal strengths and resources is particular relevant. Further, Maidique and Zirger (1990) find that technological synergies (i.e., the transfer of knowledge from well known technologies into new products) are important factors in running NPD projects successfully.

With knowledge from previous NPD projects it is possible to achieve the reduction of development time. Studies handling this specific phenomenon are discussed in the next section.

2.4.3 Time-to-market

One main focus of product innovation research at the project level are studies investigating NPD management techniques to reduce time-to-market (e.g., Datar et al, 1997; Kessler and Chakrabarti, 1996; Toepfer, 1995; Millson et al, 1992; Smith and Reinertson, 1992). Time-to-market can be defined as the total development time from the generation of the product idea to its manufacturing release (Nijssen et al, 1995). It is also called cycle time by some researchers.

The topics covered by the research are mainly:
- Measurement of time-to-market
- Influence of time-to-market on company performance

Measurement of time-to-market

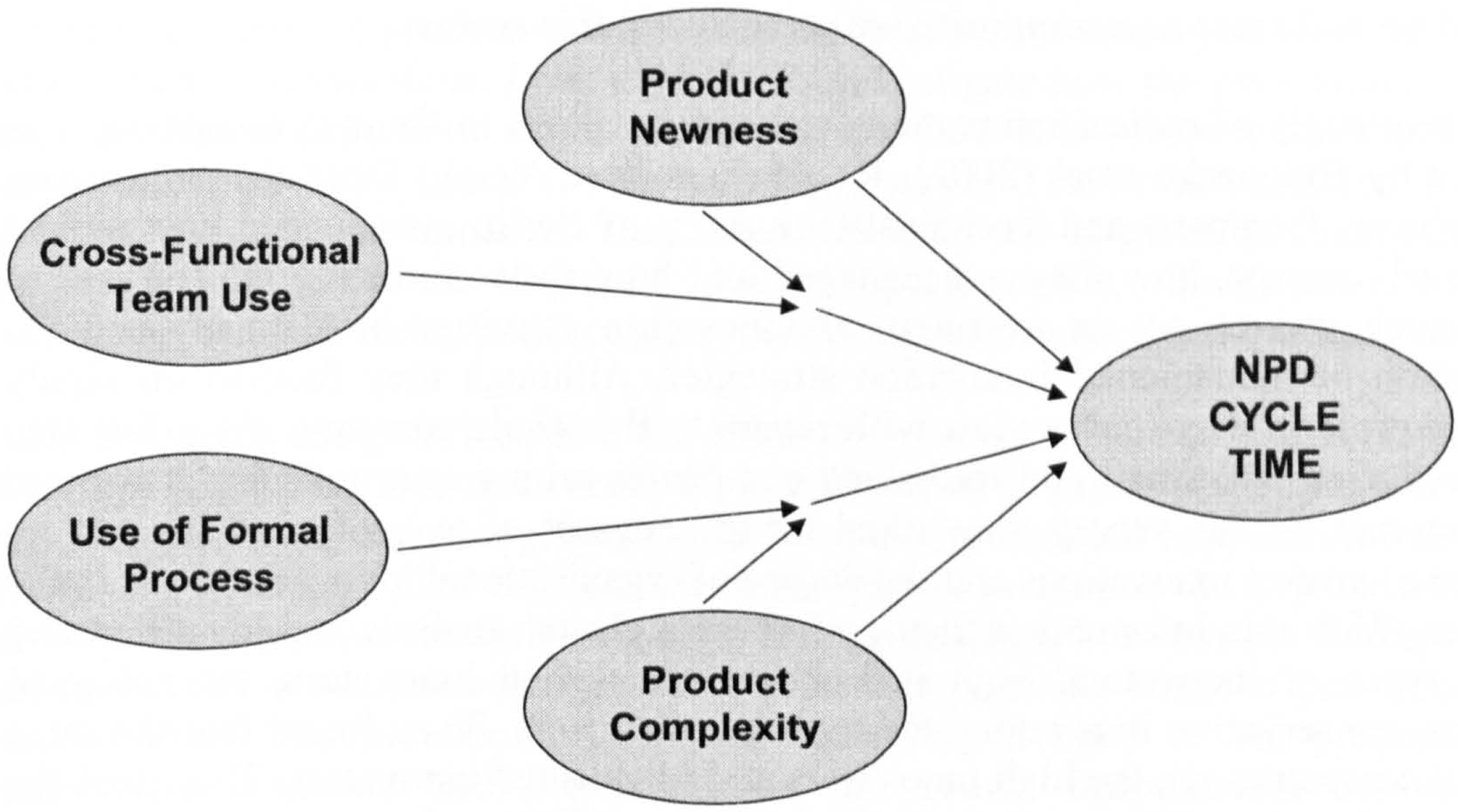
Many studies of time-to-market only give "anecdotal rather than real empirical evidence" (Cooper, 1995). The limitations of these studies are that the suggested techniques, in themselves, do not necessarily lead to faster NPD (Griffin, 1992). A study in the computer industry found that most prescriptions for cycle time reduction are based on little hard evidence (Datar et al, 1997). As no "hard" evidence in the computer industry was identified, it could be concluded that the same phenomenon exists in other industries, too.

Another example of the superficial nature of much of the research done in the field of time-to-market is shown in the study of Zirger and Hartley (1996). Although they point out that most of the literature discussing time-to-market is based on managerial experience, or studies with small sample, their study also has limitations. They interviewed seminar attendees with questions relating to a recent product. As managers from different companies (operating in different markets) took part in the seminar, the industry sectors of the investigated companies varied extremely. In their research they did not investigate the factors which influence time-to-market on a deeper level and therefore their study is believable in showing tendencies but the data is not useable for a deeper analysis.

A deeper investigation is made by McDonough (1993) who examined the importance of faster NPD of 12 companies with 32 NPD projects in the UK. He carried out interviews and used questionnaires to get information on how projects were working. He points out that "earlier studies suggest that the characteristics of individuals who work on a project play a crucial role in its successful development". He finds that routine work makes projects faster and he recommends that a classification into routine and radical tasks is useful when NPD processes have to be speeded up. His findings show that NPD processes are influenced by individuals and therefore he points out the selection of team leaders and team members differently. However, the project team and formal processes are not the only two areas with influence on time-to-market.

Griffin (1993; 1997b) and Griffin and Page (1993) made clear that an investigation into time-to-market needs a complex view. The process has to be investigated from different viewpoints in NPD process to guarantee that the time variable in each company is based on the same definition. They look at difficulties in measuring time-to-market and include a delimitation of different viewpoints in order to get comparable data. Figure 2.12 shows the viewpoints which are necessary to take into account. A valid measurement of time-to-market needs an investigation of following areas: product newness, cross-functional team use, use of formal processes and product complexity. Griffin points out that a lot of papers do not make such detailed distinctions in what they try to measure and consequently, they come to wrong conclusions. This drawback is also confirmed in a benchmarking study by Oliver et al (1997), who experienced difficulties in finding robust measures.

Figure 2.12: A Structure of Project, Process, and Cycle Time Relationships (Griffin, 1997b)



Influence of time-to-market on company performance

The reasons for research activities in this specific field is the assumption that with shorter cycle times more new products at lower costs can be brought into market. However, such a relationship is questionable as Ittner and Larcker (1997) and Griffin (1997c) found. They could not find a simple and direct relation between time-to-market and organisational performance either. Independent from the influence of time-to-market on company performance Bayus (1997) points out that there are at least two ways to overcome the high efforts on faster development times. The first one is the identification of large markets, thus supporting the increased expenditures required to accelerate development time. The second is the better understanding of the development time-cost trade off, i.e., to find the optimum relationship between time and cost in new product development.

The influence of time-to-market on company performance is questionable. As time-to-market is related to the NPD process (Griffin, 1997b), a company has to find the optimal relationship between their resources (e.g., personnel, providing technical infrastructure) and development time. The fact that the view on company resources is important for planning NPD projects efficiently is also shown by other researchers (e.g., Goffin and Pfeiffer, 1999; Kulicke et al, 1997). For example, the return on investment could be endangered because of given time windows that are either too short or too long. To fulfil a too short a time-to-market target it could be necessary to involve externals (which could be very expensive) or it could be that the daily work is blocked because too many employees are working in the NPD project. However, a too long a time-to-market target could lead to ineffective work and wasting of resources. In consequence, NPD projects have to be planned individually with regard to a company's resources[32].

2.4.4 Comprehensive Studies of Product Innovation at the Project Level

Many of the studies at the project level investigate specific research areas (i.e., source of ideas, the new product development process and time-to-market). Studies which examined several areas as a composite are presented in this section.

A recent study of radical innovations on a project level in German companies was conducted by Brennecke et al (2001). Researchers from Verein Deutscher Ingenieure e.V, McKinsey Company and Technical University of Berlin investigated how radical innovations[33] emerge, how they are managed and how their marketing is. The aim of their research was to get an overview of innovation activities in Germany and the identification of fundamental innovation strategies. Although they focused on highly innovative projects they took a view with regard to the whole company. As a first step they investigated 342 small and mid-sized companies with a questionnaire distributed via the internet. In this survey they asked for the degrees of technological innovation, the degree of market innovations and the degree of organisational innovations within the companies. With this information they performed a cluster analysis and identified five different types of innovators: high innovators, established innovators, technological innovators, conservative innovators and average innovators. They found that the most successful companies are the high innovators and established innovators. They used the percentage of revenues from new products as an indicator for success, i.e., more successful companies achieve a higher percentage of revenues with new products than less successful companies[34]. These successful companies, they found, have their focus more on technological leadership and time-to-market, while costs play a secondary role.

In a follow-up in-depth study Brennecke et al (2001) interviewed managers at 94 companies (with more than 100 employees) on a specific, highly innovative NPD project. They used a predeveloped questionnaire and interviewed project managers from R&D and marketing and other departments involved in the projects. The aim of this phase was to get detailed information about management techniques and the derivation of a guideline for managers. They measured the success of projects by the means of time, cost and quality (estimated by the managers) of a project in the NPD phases, prototyping, and marketing. Although they state that this method has limitations, they did not validate the answers through further information. The in-depth study

[32] In the current case studies the percentage of NPD projects running on time varied from 2% to 100% (the mean is given with 55%). This indicates that some companies have difficulties of managing NPD projects.
[33] Using the terminology of this PhD research, radical can be defined as highly transformational.
[34] In their research the percentage of revenues from new products younger than three years was defined as innovation rate. As no common definition of 'product innovation rate' exists it is dangerous to use this variable without defining it in advance. In consequence, studies using this term have to be checked as to what they are measuring.

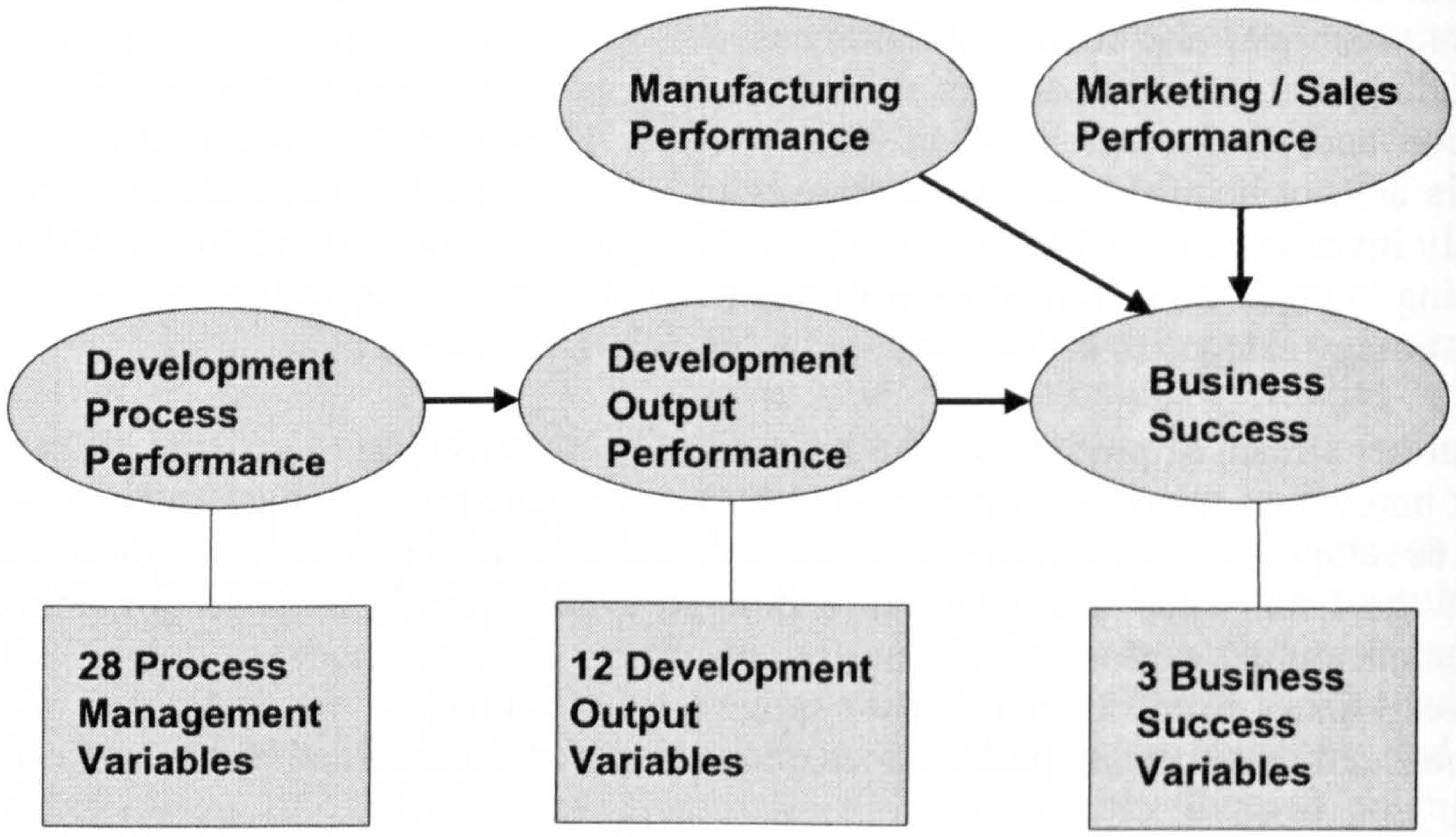
investigates the success-factors in the six strategy categories: organisation, team, NPD process, culture and business environment. Most of their findings are similar to those from previous studies[35]. For example, they find that most successful projects use a functional organisation form and teams are closely located in all phases of the NPD process (which was also found by Gassmann, 1997). However, one interesting result is their finding that external partners should not be involved in the first phase (i.e., idea generation and pure research) of an NPD process. They find that in this early phase externals are not helpful because the framework of the project is not clear enough. As they only investigated one highly innovative NPD project within companies it would be interesting to know-how companies with less innovative NPD projects operate (i.e., how the six strategy categories differ from the findings in their study).

A further stream of product innovation research activities on project level deals with product innovation measures. Loch et al (1996) investigate how the performance of the overall development function can be measured, and how it is connected to the success level of the firm. They use a Griffin and Page survey (1993) as basis for defining development output performance. The framework they use is given in Figure 2.13. It comprises data from development process performance, development output performance, manufacturing performance, marketing performance and business success.

Their research design is based on the 1992-1993 survey of 95 companies (Japan, US and Europe) from the electronics sector by McKinsey & Company, Stanford University and the University of Augsburg. Loch et al have a very detailed approach for defining variables in two stages. First they use factor analysis to determine the key variables and then they use regression analysis to look at the relationships between the concepts. The identification of development output performance dimensions leads to part of a five-factor solution. The first factor is market leadership defined as the proportion of products first-to-market and the proportion of product introductions representing significant innovations. The second measure is design quality defined as the quality of conformance in manufacturing or industrial design. Innovation rate, defined as the number of major new products introduced compared to the industry average and the overall number of product introductions normalised by the product life cycle in industry was given as the third factor[36]. The next factor identified is product line freshness identified by the proportion of sales from products introduced within the last three years. Finally, the design to cost, represented by the variable unit cost reduction makes up the last factor. The analysis emphasises development productivity as a very important driver for business success. However, Loch et al conclude that "development process performance is not an absolute concept, but rather depends on the nature of the competition in each industry". This result is in line with the findings of other researchers as Gupta and Wilemon (1990), Porter (1990) and Zarah (1993b). Although the research design covers aspects of different product innovation positions, their data analysis has one limitation. As they only analyse survey data, the answers should be checked through interviews or case studies. A further limitation of the study is that not all potentially relevant performance measures could be constructed from the data and that only larger companies are part of the survey. However, the variables used are a good basis for further research activities.

[35] Most findings of Brennecke et al (2001) are made by other researchers too. They are discussed in Section 2.3 'Investigations at the Company Level' and Section 2.4 'Investigations at the Project Level'.
[36] It can be seen that Loch et al (1996) use a different definition of product innovation rate from that of Brennecke et al (2001) and the definition used for the current research.

Figure 2.13: A Framework of Development Performance (Loch et al, 1996)



In further research Cooper and Kleinschmidt (1995) found that a classification of variables into project and company level is not as clear as it appears at first. For their research they sent a detailed questionnaire with 48 measures (gauged via one to five likert scales) to 161 firms from different industries. Within the questionnaire, 10 different performance measures were used (e.g., success rate, profitability relative to competitors, overall success). In their study, a distinction is made between new product success at the project level (which has been studied extensively in other investigations) and performance at the company level. They find that the importance of many of the issues at a company level, which cut across all projects, have to be considered as critical success factors. For example, in their sample the highest percentages of revenues from new products and highest success rate is not related to the highest profits. Companies with the highest performance metrics (e.g., profitability relative to spending, impact on company profits, profitability relative to competitors) are characterised with lower percentages of revenues from new products and a lower success rate. These findings indicate that performance measures at company level need to be related to performance measures on project level. Taking these findings into account, factors at the company level, i.e., organisation, human resource management, culture and strategy have an influence on how NPD projects run within a company and how people work together in NPD projects. This shows that both company-level and project-level measures need to be investigated within every research project. The number one driver in performance they identify is the existence of a high-quality NPD process. A clear and well-communicated new product strategy for the company is the number two driver followed by strategic focus, synergy and entrepreneurial climate for product innovation as the number three driver. Although they state that "companies who operate with new products in a market have a competitive advantage", no information is given about what relationship between existing and new products is the key for competitive advantage.

However, as this can be answered only with a case study approach, further studies should carry out such research projects.

The product innovation literature focusing on a project level shows, that explanations of product innovation are difficult to obtain by investigating only one specific area (e.g., source of ideas or time-to-market). Further, it is shown that performance measures at project level are related to performance measures on company level. Therefore, the need for a more complex view on product innovation is demanded by several researchers as Cooper and Kleinschmidt (1993, 1995), Tabrizi and Walleigh (1997), Balachandra and Friar (1997), Griffin (1997a), and Schoonhoven and Jelinek (1997). However, only a few studies have taken this approach. As activities of a whole company influence the product innovation output (e.g., product innovation rate, percentage of revenues from new product and profits), it will be necessary to carry out research studies going in this direction.

2.5 RESEARCH METHODOLOGY IN INNOVATION RESEARCH

As the literature review has shown, product innovation is complex and therefore "most innovations are the result of complementary processes [e.g. different processes running in parallel]" as stated by De Bandt (1995). Because of this complexity most researchers have only investigated one specific area of product innovation, e.g., team-working or product innovation strategy. Typically, each of these aspects have been investigated by researchers from different disciplines. Researchers from marketing and operations have concentrated on product innovation success or failure, whereas behavioural researchers have tended to study on teamwork or communication. Researchers from different disciplines tend to use different approaches in the research methodology – surveys or case studies.

The first research method discussed are surveys. Surveys are able to show, for example, the relationship between product innovation rate and the percentage of revenues from new products. They allow powerful investigations into product innovation – this is shown by the study of Roper et al (1996) where data from over 3000 companies was analysed. Because of the high numbers of companies investigated, external validity is high. However, surveys do not provide in-depth information on product innovation and cannot cover the most complex issues on product innovation. A further difficulty is the use of numeric scales to measure innovation variables. As these measures are based on managers' perceptions, such information has to be used carefully (because of a low internal validity). As factors inside organisations are a primary source of sustainable advantage, Rouse and Daellenbach (1999) argue that it is "essential to gain an in-depth knowledge and understanding of the organisation and its processes, too". From the literature it becomes clear that the only possibility of getting such information is to carry out interviews or case studies.

In contrast to mail surveys, cases are a method of exploring specific issues in-depth. With this research method company processes can be investigated and explained in detail. However, to gain (internal) valid data, case study visits have to be organised in detail and information from respondents has to be proved on validity. Many previous studies did not followed these regularities and therefore most of them were made in a superficial way (e.g., Taylor, 1990; Taylor, 1991; Prokesch, 1993; Mass and Berkson, 1995). To get meaningful results it is necessary to interview different persons within a company. This seems to be useful because managing directors tend to show their company in the best possible light and therefore the information has to be analysed carefully. A further reason that it is necessary to interview different persons within a company is the different view on product innovation and strategic aspects as Hultink and Robben (1995) find. To make the data as valid as possible they have to be proved by analysing other information sources such as company brochures and company reports. Questions have to be asked in a structured way and key aspects (i.e., research questions) have to be discussed intensively with the interview partners, to avoid anecdotal information.

One further problem (with regard to external validity) is the selection of case companies. Most researchers conducted their research on big well-known and highly innovative companies (e.g., Nevens et al, 1990; Cimento and Knister, 1994; Brennecke et al, 2001). Additionally, many studies have taken one company (e.g., Taylor, 1990; Patterson, 1998; Baghai et al, 1997). The findings from these studies are generalised with the assumption that the results can be transferred to other companies. In consequence, some of the recommendations identified are questionable because it is unclear how they work outside the companies studied.

It can be summarised that most studies use only survey or case study research. However, to capture the complexity of product innovation a combination of both methods appears to be a useful approach. Such a combination seems to be useful because the product innovation literature shows that it is difficult to make a direct link between particular innovation practices and market success (e.g., Balachandra and Friar, 1997; Griffin, 1993; Loch et al, 1996). To avoid these limitations, companies with different characteristics need to be selected at random.

2.6 CHOOSING A MODEL FOR FURTHER INVESTIGATION

The innovation literature shows, that many studies have investigated product innovation at the macro level and project level. Interestingly the company level has only been investigated by a few researchers. Further, it was recognised that only a few studies covered both the company and project level. However, researchers such as Cooper and Kleinschmidt (1995) argue that the investigation of product innovation must move from project level to the company project level of analysis. The need for further research in this direction is also stressed by Terwiesch et al (1998). They state that "interestingly, practically no one has tried to investigate product innovation on a company level".

In order to identify a suitable model for the further research activities several models from the product innovation literature are evaluated. This evaluation led to the selection of the Cooper and Kleinschmidt (1995) model.

2.6.1 Summary of the Key Models in the Literature

Overall six models are identified focusing on product innovation at the company level (Table 2.7). In the table for each model the key areas investigated, the advantages and the limitations are presented. It is known that most models focus on selected research areas within the company level. In summary the models can be described as follows:

- Cooper (1984) offers a model where the main focus is on product innovation strategy. However, other areas on a business unit level are not given in his model.
- The model Cooper and Kleinschmidt (1993) is created to explain the success and failure of selected NPD projects (products). Although it focuses on NPD projects it offers a comprehensive set of different areas including aspects from business environment, competition and company level.
- A classification of variables into project and company level is given by Loch et al (1996). However, variables focusing on business environment are not given in their model.
- In the model of Chiesa et al (1996) only aspects of how NPD can be managed are given.
- The model of Nadler and Tushman (1997) views the organisation as a system and offers areas which are important for analysing organisational problems. However, their model does not directly focus on product innovation.
- Terwiesch et a (1998) offers a framework for measuring the influence of NPD performance and business environmental factors on company profitability. The limitation of their model is that variables on an NPD project level are not included in their model.

It is shown that in the product innovation literature several models are given which identify different areas which influence product innovation activities (e.g., Loch et al, 1996; Terwiesch et al, 1998). However, most of these models concentrate on selected areas such as NPD project management, strategy or business environment. As the literature review shows a wide range of activities influence product innovation at a business unit level, such models covering only selected areas do not seen to be useful. A broad view is necessary because it is not clear which areas are the key drivers for varying product innovation rates and percentages of revenues from new products. A model capturing all areas (business environment, NPD project management, product innovation strategy, product innovation output) is offered by Cooper and Kleinschmidt (1993). Although their model was orginally used as a framework for investigating product innovation on project level, it can be used as a model for investigating product innovation on company level, too. Therefore, their model is seen as the most appropriate framework for investigating the key drivers for product innovation position (including the whole product portfolio).

Consequently, the comparison of the models given in Table 2.7 identified the Cooper and Kleinschmidt as the most appropriate one for investigating the key drivers of product innovation position systematically.

Table 2.7(a): Summary of the Key Models

Model	Key areas investigated	Advantages	Limitations
Cooper, 1984 New product Strategy is Defined by Four Blocks of Strategy Variables (refer to page 54)	• New product strategy - Types of new products developed - Types of markets new products are aimed at - Types of technologies employed - Nature, oriented and commitment of process • Firm and industry characteristics • Performance Results	• Based on product innovation strategy a framework for analysing product innovation performance is given.	• The main focus is on product innovation strategy. Other areas on business unit level are not given in the model.
Cooper and Kleinschmidt, 1993 A Conceptual Model of the areas Influencing New Product Outcomes (refer to the next Section 2.6.2)	• Market • Competition • The corporate environment • Nature of project , idea source • New product process • Strategy • Project outcome	• Offers a comprehensive set of different areas including aspects from business environment, competition and company level. • The model is used to investigate a set of different NPD projects (projects) within companies. Therefore it can be seen as a good basis for investigating the whole new product portfolio within companies, too.	• The model is created to explain the success and failures of selected NPD projects (products).
Loch et al, 1996 A Framework of Development Performance (refer to page 74)	• Development process performance • Development output performance • Manufacturing performance • Marketing/Sales Performance • Business Success	• The model offers a framework of how product innovation can be investigated on company level. • A classification of variables into project and company level is given.	• Business environmental variables are not given in the model.

Table 2.7(b): Continued

Model	Key areas investigated	Advantages	Limitations
Chiesa et al, 1996 Innovation – Your Move. A Self Assessment Guide (refer to page 59)	• Product innovation, product development • Process innovation • Technology acquisition • Market focus • Leadership • Resourcing innovation • Systems and tools • Innovation performance	• The user gets information about his entrepreneurial thinking and as to how he can improve product innovation activities. • The audit helps managers to think about most aspects of product innovation.	• Only aspects of how NPD can be managed are given. • The results are based on a self-estimation of managers which are strongly influenced by the personal view of innovation.
Nadler and Tushman, 1997 A Process for Organisational Problem Analysis (refer to page 30)	• Context - Environment, resources, history • Transformation process - Task - Informal Organisation - Formal Organisation agreements - Individual • Output - Organisation, group, individual	• The model shows how actual organisational output matches the output specified by the strategy (based on business environmental and internal factors). • The model views the organisation as a system and offers areas which are important for analysing organisational problems.	• The model does not directly focus on product innovation. • Variables measuring the areas offered are not given. • The model is developed for diagnosing organisational behaviour – especially how organisations can achieve long-term success.
Terwiesch et al, 1998 Framework for the Contingency Model (refer to page 29)	• Market environment - Industry profitability - Life cycle - Market growth - Market share • NPD Performance - Technical Performance - Market leadership - R&D intensity - Product line freshness - Innovation rate • Business unit performance - Profitability	• The model offers a framework of how product innovation can be investigated on company level. • Offers a framework for measuring the influence of NPD performance and business environmental factors on company profitability.	• Variables on NPD project level are not included in the model. • The variables chosen for describing the individual areas could be changed by sorting the given variables into other areas (e.g. innovation rate could be sorted into the area of business unit performance, too).

2.6.2 The Cooper and Kleinschmidt Model

As shown in the section above research of product innovation at the company level is not common. Further, a tested model capturing several areas (e.g., business environment, innovation strategy and NPD management) was not found in the literature. Therefore, a conceptual model was chosen which looked at success factors in product development by taking a broader view. Based on the results of their innovation research on NPD projects Cooper and Kleinschmidt (1993) created a model which shows the complexity of product innovation (Figure 2.14). One of their main findings was "that new product outcomes (success and failure) are the result of the interaction of the new product's strategy with both the new product's market and its competition". Their model shows the interaction of external and internal company factors by defining six different main areas.

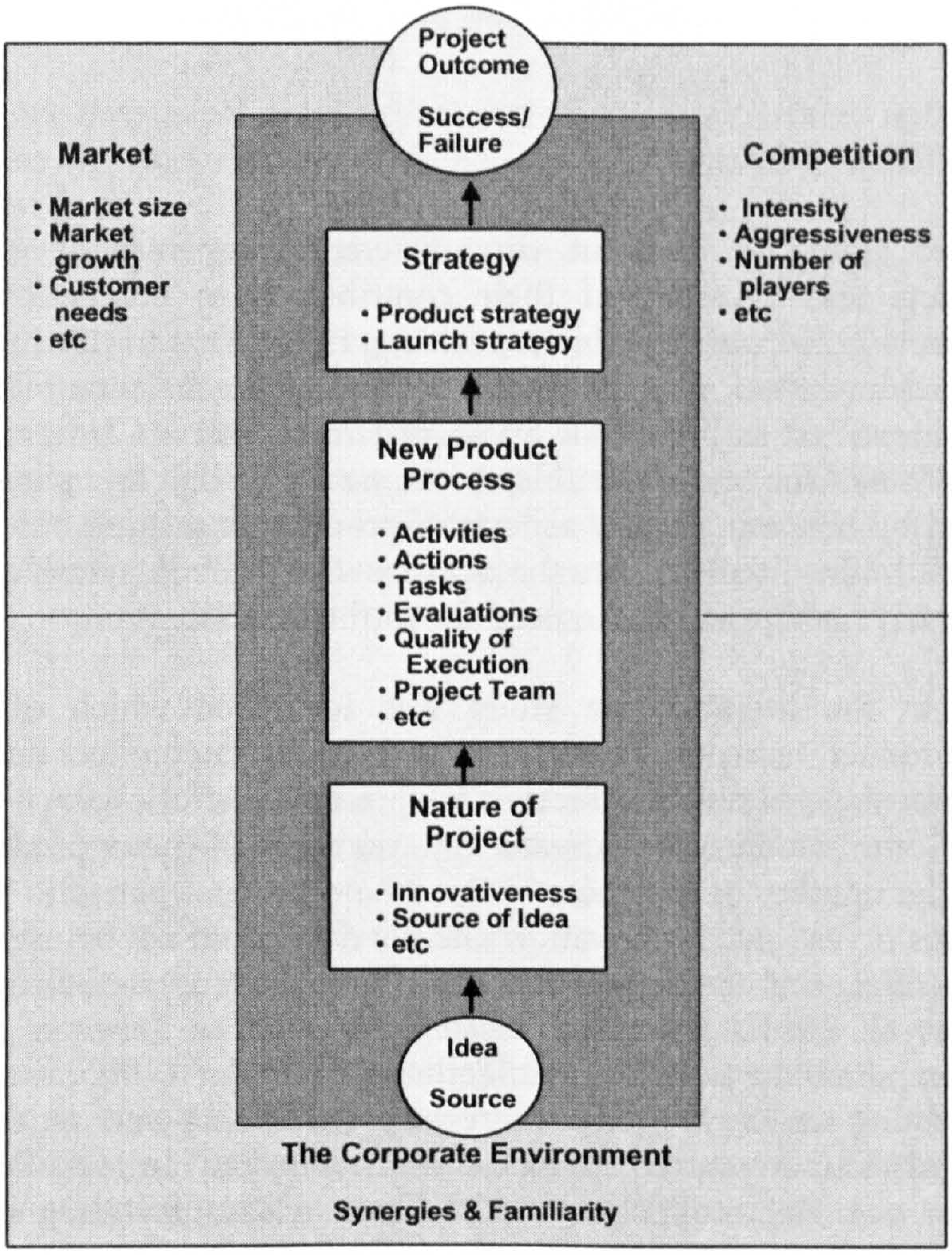
The areas are:

- Market
- Competition
- The corporate environment
- Nature of project / idea source
- New product process
- Innovation strategy

Cooper and Kleinschmidt explain the relationship of these six areas as follows: "The model postulates that new product outcomes [success and failure] are the result of the interaction of the new product's strategy with both, the new product's market and its competition... This strategy – the product and its launch – is the result of the new product process... The process commences with an idea (source) and is influenced by the nature of the project... Finally, this process takes place within a corporate environment consisting of resources, skills and experience in marketing, production, technology and management which may provide synergy and/or familiarity." In other words: all the six areas given in the model could have an influence on project or company outcome, i.e., product innovation rate and the percentage of revenues from new products.

As explained earlier, Cooper and Kleinschmidt use the model to explain the success and failures of selected NPD projects (projects running in the last five years and projects that had gone to market). They investigated 103 NPD projects in 21 companies (on average 4.9 projects in one company). Due to their approach of investigating a set of NPD projects (products) within companies, their model is seen as a good basis for investigating the whole new product portfolio, too. However, as the main aim of the current research is to investigate the relationship of varying product innovation rates and percentages of revenues from new products only, selected product innovation variables were chosen for further research. In order to answer the research questions, other variables from the product innovation literature (e.g., Loch et al, 1996; Griffin, 1997a; Terwiesch et al, 1998) were identified as important also.

Figure 2.14: A Conceptual Model of the Areas Influencing New Product Outcomes (Cooper and Kleinschmidt, 1993)



Taking the findings from the literature review into account, some limitations of their model were identified. The first one is the classification of innovation strategy at the end of a complex innovation process. In their model all arrows are oriented in one direction – from the bottom to the top. In consequence, it can be concluded that all of the areas are related, e.g., the nature of project influences strategy but strategy does not influence the nature of new products. In contrast the literature review, identified strategy as one of the most important drivers for product innovation with influence on every management area. Therefore, a better model would be one, where all areas are related to one another. In consequence, the arrows should be directed in two directions to show the dependency of each area on one another. Another result of the literature review was the identification of human resource management and culture as important factors for product innovation. But Cooper and Kleinschmidt do not show these areas separately (in their model this area is included in the area "New Product Process"). In an enhanced model, this area needs to be more strongly brought out.

Despite the recognised limitations, the model provides a useful framework for collecting data on product innovation at the company level. It is used to explain the reasons for varying product innovation positions. However, to understand how the model is applied, the set of research questions derived from the product innovation literature review need to be presented.

2.7 RESEARCH QUESTIONS

Only a few studies aimed to find out why different companies develop different numbers of products and investigated their contribution to competitiveness (e.g., Geroski and Machin, 1992; Zarah,1993b; Henderson, 1994). Due to this an explanation of different product innovation rates is not given, although a balance of existing and new products was identified as important by several researchers (Clement et al, 1998; Tellis and Golder, 1996). One reason for this shortage may be that this phenomenon can only be investigated by observing many aspects of product innovation on company and project level. Overall, the literature on the reasons for different product innovation positions is inconclusive and prompts the need for further investigation.

Consequently, in the literature no study was identified which offers detailed information about product innovation rates. As stated earlier, the product innovation rate is defined as the percentage of new products in the product portfolio which are less than three years old. Some studies investigate the number of new products but no information about the number of products in the whole product portfolio is contained. Although two studies investigated innovation rate the data could not be used – on closer inspection it became clear that the dataset was based on a different definition (Loch et al 1996; Brennecke et al, 2001). However, researchers such as Johnson and Scholes (1999), Bowman and Faulkner (1997) and Tellis and Golder (1996) found that the balance of both existing and new products are important to operate in a competitive market. Because previous research studies have not asked in detail for product innovation rates, an own data collection in the German manufacturing industry was necessary.

To make the research as valid as possible, product innovation rates have to be collected in two industry sectors. The two chosen industry sectors were engineering and E&E engineering[37]. Such a clear differentiation into two industry sectors was seen as necessary to be able to generalise the results. In the literature several papers were identified focusing on one industry sector (e.g., Ciemento and Knister, 1994; Loch et al, 1996; Terwiesch et al, 1998). Additionally, several papers were found with a mixed dataset with manufacturing companies and companies from the service sector (e.g., Simon, 1996; Berth, 1997; Brennecke et al, 2001). It can be concluded that generalisation of the findings from these studies is difficult. In the literature the engineering and E&E engineering sectors were identified as the two sectors where product innovation plays an important role. To get valid information about product innovation rates, in these two industry sectors it was necessary to define the unit of analysis at which the data are collected. As a unit of research the *business unit*[38] was chosen. This unit of analysis was also taken by Terwiesch et al (1998). They broke

[37] A detailed overview about the two industry sectors engineering and E&E engineering is given in Section 3.5 'The Industry Sectors E&E Engineering and Engineering'.
[38] The detailed definition of the business unit as a unit of analysis is given in Section 4.2.3 'Business Unit of Analysis'.

down their research from company level to the business unit level which was seen to be the most appropriate level for their research activities on product innovation. The findings above lead to the first research question (RQ 1):

RQ 1: *What are the typical product innovation rates of business units in the German engineering and electrical & electronics engineering (E&E engineering) sectors?*

As new products play an important role in today's business, revenues from new products play an important role, too. One possibility to measure revenues from new products with regard to the whole product portfolio is the measurement of the percentage of revenues gained from new products (e.g., Brennecke et al, 2001; Terwiesch et al, 1998). Although this measure has been investigated in several studies it is not clear how revenues from new products are related to product innovation rates. Therefore, this question still needs to be answered. This leads to the second research question:

RQ 2: *How are product innovation rates and the percentage of revenues from new products related (defined as product innovation position)?*

Research question two asks for the product innovation position including the measured percentage of revenues from new products. However, revenues do not automatically mean profit. As business units have to earn money to survive it is important to know, how much they earn with their products. In this context it is necessary to investigate, if business units act with the most profitable combination of existing and new products (product innovation rate). This is asked in the third research question:

RQ 3: *How are product innovation positions and*
a) profits with the whole product portfolio, and
b) profits with new products related?

Having the typical product innovation rates and percentages of revenues from new products (product innovation positions), it is now possible to investigate the reasons for the different product innovation rates and percentages of revenues from new products. To investigate this question on a deeper level, the model of Cooper and Kleinschmidt (1993) was chosen as a basis for the research activities. As previous research studies did not directly focus on the reasons for different innovation positions on a business unit (company) level, the fourth research question closes this gap:

RQ 4: *Why do different manufacturing business units in the industry sectors engineering and E&E engineering act with different product innovation rates and why do they achieve different percentages of revenues from new products (i.e., why do they act with different product innovation positions)?*

The identified research questions give answers to aspects which have not been investigated by previous researchers with in-depth studies. The key findings of this chapter are summarised in the following section.

2.8 SUMMARY

The literature review showed that the main problem in investigating the drivers of product innovation rate is the complexity and the overlapping of many factors. Therefore, many studies have focused on a more clearly defined division issue such as NPD projects, human resource management, etc. They assumed that the reasons why companies introduce new products are clear and therefore they concentrated their research activities on innovation management. Many researchers implicitly assumed that companies want to introduce new products faster and cheaper with more focus on customer demands. Further, most studies investigated the number of new products without taking the whole product portfolio into account. Therefore, the questions about why business units act with varying product innovation rates and why business units achieve different percentages of revenues from their new products are still open. These questions still remain unanswered and require further investigation. Therefore, for further research the following points should be considered:

- The identification of the drivers for product innovation rates is still open.
- To understand the drivers, innovation research will have to move from a project to the company (business unit) level.
- As product innovation is difficult to investigate on a company level, a more defined unit of analysis has to be chosen. Such a clearer unit of analysis is the business unit level.
- To adequately investigate all aspects of product innovation within a company, it seems to be necessary to combine two research techniques such as survey and case study research.
- Cases should be selected scientifically, rather than being chosen because they are well known.

To handle the complex field of product innovation, a methodology was chosen which covered the findings from the literature. The research with the worked out methodology focused on German manufacturing engineering and E&E engineering companies. To get a comprehensive view of the drivers for product innovation positions it is useful to give an overview of the latest innovation tendencies in German manufacturing companies. In the next chapter a detailed profile about product innovation tendencies in Germany's manufacturing industry and the two chosen industry sectors is given.

CHAPTER THREE

PRODUCT INNOVATION IN GERMAN INDUSTRY

3.0 INTRODUCTION

This chapter shows the importance of product innovation in German industry and compares Germany's innovation activities to activities in other countries. This chapter has the following characteristics:

- Information from German governmental institutions is summarised in order to show tendencies in German industry[39].
- International studies (i.e., from the European Commission and the OECD) are used to show the international position in the world.
- Information from industrial branch associations is analysed in order to give an overview of the two industry sectors engineering and E&E engineering.
- A practicioners workshop is analysed in order to show the importance of product innovation in German companies.

In the first section (3.1) the history of the German industry is summarised. Then, a short overview of the economical context and the general economic situation is discussed. In Section 3.2 the challenges for product innovation in German manufacturing industry are presented. An explanation of the *Standort Deutschland* debate (Germany as a location for manufacturing industry) is given in Section 3.3. This covers the ongoing discussions in business politics and society about the role of innovation in Germany. Some statements about the German *Mittelstand* (medium-sized companies) and Germany's ability for world-wide competition follow in Section 3.4. The German industry sectors engineering and E&E engineering are described in the following sections (Section 3.5). In the next section (3.6) a practicioners workshop is analysed for showing the challenges facing the case companies. Finally, a summary is given (Section 3.7).

As pointed out above, the first section summarises the historic situation of the German industry

3.1 HISTORY OF GERMAN INDUSTRY

The Deutsche Taschenbuch Verlag Lexicon (DTV, 1997) gives information about the history of Germany's industry. The first step for creating a common economic arena was the foundation of the Deutsche Zollverein (toll society) in 1833 which turned into the foundation of the Deutsches Reich (1871). The toll society was important, because at the beginning of the 18th century Germany was characterised by many different independent countries with their own governments and with individual tax systems. In the same period, Germany changed from an agrarian society into an industrial country.

[39] The term industry is related to the whole manufacturing activities of a country. The industry is separated into different sectors (e.g., engineering and E&E engineering). This definition is based on the interpretation of the Federal Statistic Office of Germany.

One foundation for this development was the fast growth of the population from 35.1 mill (1850) to 64.9 mill in 1910. This growth was a result of improved living conditions (i.e., better feeding and healthcare). The industrialisation was based on three key industries – mining and steel industries were concentrated in the Ruhrgebiet (a region in the centre of Germany) and the chemical industry was located along the Rhine.

In addition to the basic industries mining, steel and chemical industries further industries arose. Over the years engineering and electrical industry gained importance, too. The fast development of the industry was characterised by the net home product proportion of industry and manual working, which grew from 20.4% in 1854 to 44.6% in 1929. Additionally, the proportion of employees in industry increased from 24.3% in 1910 to 38.9% in 1939. At this time coal and iron ore were the most important raw materials, and both are found in Germany. However, most other raw materials had to be imported and it became clear that the strength of the German industry was (and is) to refine (imported) raw materials by producing innovative products which are sold all over the world. In 1938 seventy percent of all manufactured goods were exported to foreign (European) countries. This high export rate showed the dependency of the German industry on liberal trade conditions for selling their products.

Going back to the historical chronology, the first big event with influence on the economic situation of Germany was the First World War (1914 to 1918). At the end of the war German industry was dismantled and reparations prevented economical recovery. With a new currency, the Reichsmark, which was introduced in 1924, the German economical situation improved. However, with the beginning of the world economic crisis in 1929, unemployment increased rapidly again. As a result of this world-wide recession, Germans became resigned and this helped the national socialism to gain power. In the time of the Second World War (1939 to 1945), Germany's industry broke down for a second time. As a result of the war, Germany was separated into two parts – West Germany (Federal Republic of Germany) and East Germany (German Democratic Republic).

For supporting the regeneration of the West German economy, the US government started a development programme – the European Recovery Program (in Germany this development programme is named after Marshall, the initiator of this measure). In total 1.7 billion US-Dollars were transferred to German industry. With this support it was possible to build up an industry which became one of the key players in the world market. The result of the support programme was a rapid growth of German industry between 1950 and mid 1960 – this period is called "Wirtschaftswunder". The foundation of the European Community (Euratom) – in 1967 was a further basis for continuous industrial growth, and in the first half of the 1980s Germany held a world-leading position with technological products. However, from the mid-80s until the mid-90s, the turnover in German companies with new products decreased from one third to one fourth of the overall turnover (Kaltenbach, 1998).

In comparison to West Germany where a social market economy was the basis for free trade, the East German economy was built up as a planned economy. This economy was based on the model of the Soviet Union. The East German economy was characterised by attributes such as public ownership of production units, central planning of economic processes, and administrative fixing of prices and wages. The aim to take production units into public ownership is reflected by the low percentage of privately owned companies. From 1950 to 1976 the percentage of this kind of company decreased from 43.2% to 3.4% (DTV, 1997). More than a half of East German products (i.e., brown coal, agricultural products and electrical and electronic products) were exported to the Soviet Union. Although the economic growth was the highest within the union of communist countries, it was much lower than in West Germany. The dissatisfaction of the East Germans with both their economy and political situation, led to the elimination (peaceful revolution) of the German Democratic Republic in the late 80s.

Based on the elimination of East Germany a further key event in the German history emerged in 1991 – the reunification of West and East Germany. Billions of Euros were invested into the East German industry and in building up a new infrastructure. However, over the past 12 years the East German economy has not grown as expected. A report of the German Department of Education and Research characterises the technological performance of Eastern and Western Germany as follows: "All in all, there has been little convergence in the behaviour or patterns of technological performance in East and West Germany over the last 10 years. It must be assumed that the differences between the levels of technological development in Germany's eastern and western countries will continue to exist for some time to come" (Anonymous, 2000a).

In addition, to the economical difficulties in Eastern Germany another phenomenon influenced the technological performance of Germany's industry. In the 1990s, Germany had difficulties keeping up to par with the R&D activities in other countries. Sweden, Finland, The Netherlands, and especially the US increased their R&D expenditures more quickly than Germany. One reason for this development was the ability of these countries to take up the new challenges of information and communication technologies (Legler et al, 2001). Further, the mid 1990s were characterised by the restraint of Germans against innovations. This was summarised in a few sentences by the then President, Herzog, who stated that a major problem was that Germans are too negative about new products and new technologies. "Obviously each new product brings new problems but our attitude is to look only at the problems and not at the opportunities or the dangers that arise if we do not keep pace with a new development. In recent decades many things have been developed in Germany but not produced in Germany or exported from Germany. Put simply, top management in many companies has lacked imagination and an awareness of problems" (Norman and Studemann 1996).

However, since the mid 1990s the constraints on R&D investment in Germany appear to be over. Many more German companies are developing new products since 1995. R&D expenditures have increased in two figures, after years of stagnation. From 1995 to 1997 R&D expenditures had a growth rate of 11.8%. And in the years 1998 to 2001 a further rate of increase of about 23% was achieved" (European Commission, 2001b; Anonymous 2002a). Further, "two of every three industrial companies reported that they have developed a product or processes innovation in the last three years". The positive development is also shown in international rankings. In the 1996 ranking of the World Economic Forum (WEF) Germany was listed at position 25 with regard to its ability for world-wide competition (Vogel 1996). Another ranking comes from the International Institute for Management Development (IMD) in Switzerland. This ranked Germany in position 14 in 1996, but eighth place in 2000 (Garelli et al, 2000). Currently

German companies are investing more in R&D activities and product innovation is gaining importance (Anonymous, 2000a). However, because of structural problems in financing the German welfare state, high taxes and high national debts, Germany was downgraded to 15th place in 2002 (IMD, 2002).

Although there have been a number of positive developments, German industry has still to see a sustained consolidation of its innovative power in the global technology arena. Measured in terms of turnover however, industry's spending on innovation is still lower than the level reported in the early 1990s" (Legler et al 2001). This is also shown by a benchmark study of German and British manufacturing companies (Goffin et al, 2001). Although German Engineering companies are known to be highly innovative (e.g., Rommel, 1991, Gründler, 1996) the "data did not support the proposition that German engineering plants are more innovative than their UK counterparts". The same findings were made for the E&E engineering sector, where no significant differences were identified. Goffin et al point out that "these findings are somewhat surprising since German plants are often thought of as being more innovative than UK plants."

As the current German economical and technological context has influence on this research, the latest economical trends are summarised in the following section.

3.2 CURRENT INNOVATION TENDENCIES IN GERMAN INDUSTRY

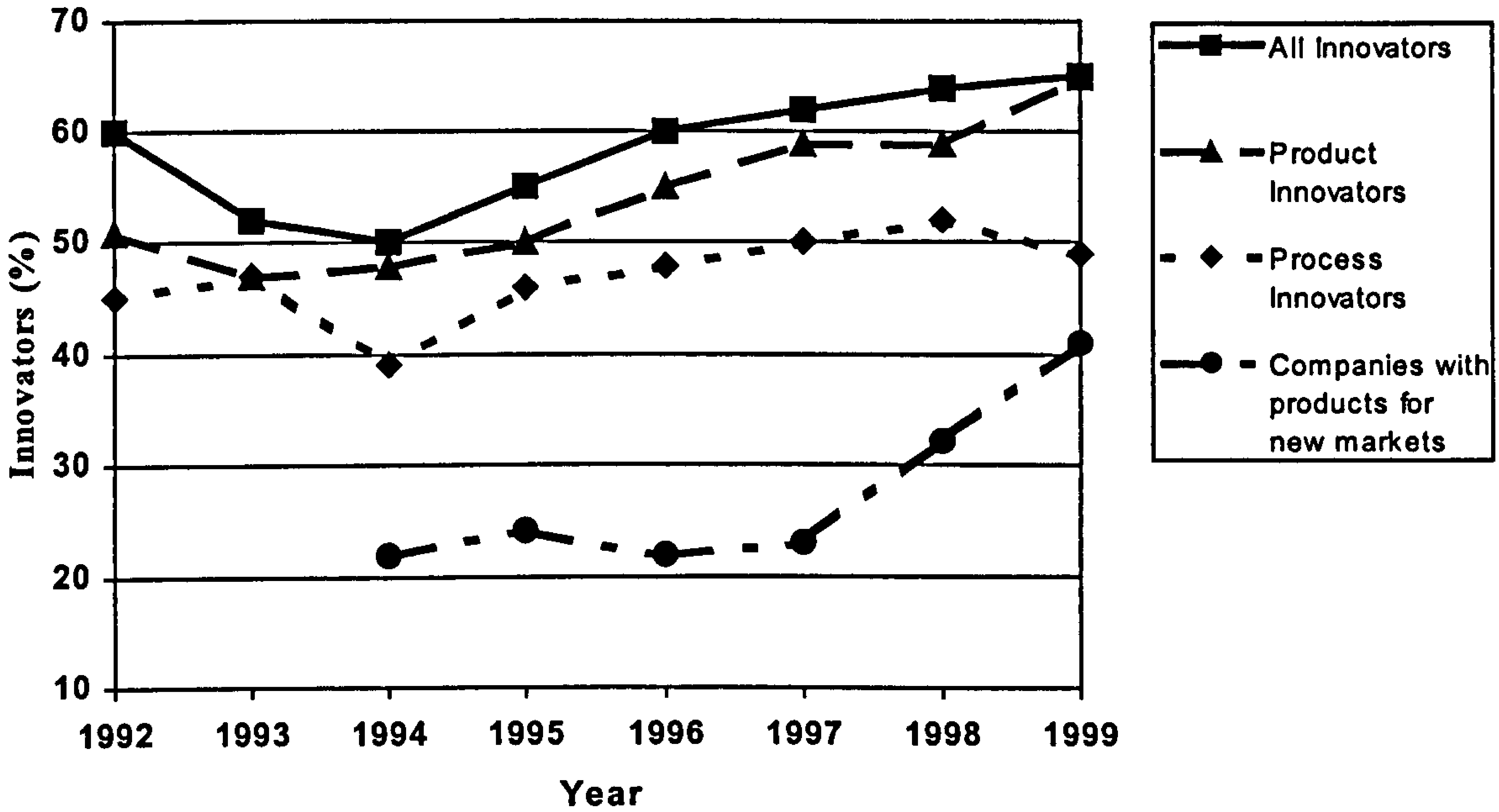
With a strong specialisation in high-level technologies such as machinery, automobile and electrical engineering, product innovation plays a crucial role in Germany's manufacturing industry (Strassberger et al, 1999). The current trends in German manufacturing industry with regard to product innovation are summarised by Szwejczewski et al (2000) as follows: "Innovations are being intensively and systematically pursued in order to gain a competitive edge and win new market segments, especially abroad." Further, they point out that the "aim for many companies is to achieve 80% of turnover from products less than five years old to avoid layoffs by increasing sales".

A major survey which was conducted for the German Federal Ministry for Education and Research shows the importance of new products for German companies (Legler et al 2001). Figure 3.1 shows the percentage of innovators[40] broken down into product innovators, process innovators and companies with products for new markets. Up until 1994 the percentage of German companies with new products was decreasing. However, companies recognised that they needed to develop high quality and highly innovative products to stay competitive in the world market, as stated by Legler et al. From 1994 to 1999 companies which reported innovative activities increased from 50% to 65%. A high rate of increase can be observed with product innovations. From 1994 to 1999 the percentage of product innovators increased from 48% to 65%. One interesting point is the high increase in the number of companies from 1997 to 1999 who introduced products for new markets. Now, more than 40% of companies have developed new products for new markets. The number of companies with process

[40] Innovators in the definition of Legler et al are companies which introduced at least one new product or process into market in the last three years.

innovations increased also – from about 40% in 1994 to 50% in 1999. In summary, this diagram shows that innovation has gained importance in the German industry. Legler et al explain this phenomenon with the ability of German companies for structural change and innovation.

Figure 3.1: Innovators (%) in German Production Industry 1992 to 1999 (Legler et al, 2001)

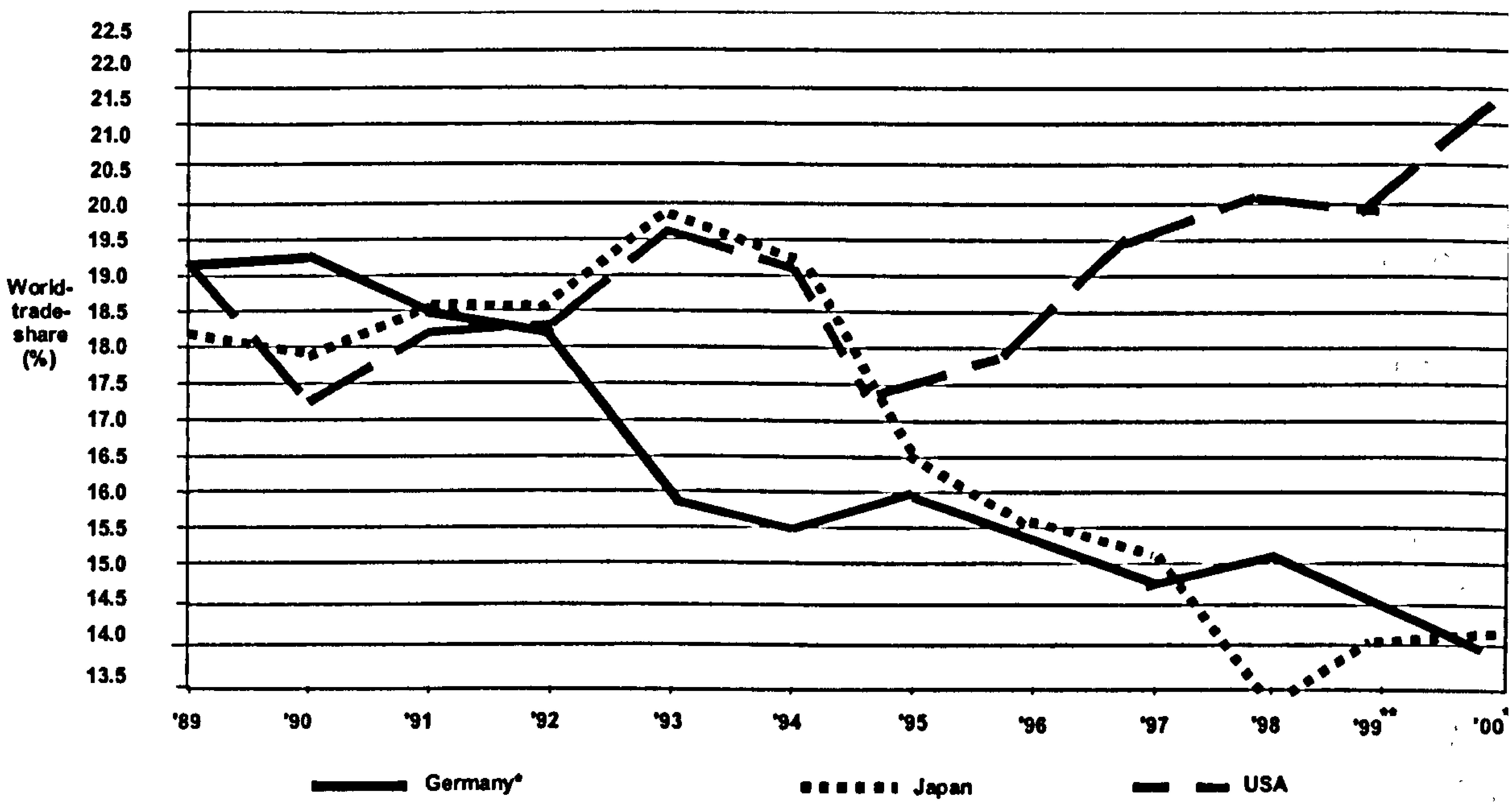


The report about Germany's technological capability for innovation summarises the actual situation of German R&D activities. This yearly report is carried out by six German economic research institutes which analyse national and international data to show the technological performance of Germany. In summary, the following findings are given in the report:

- Germany's R&D intensity (i.e., investments into R&D from both government and industry) began increasing again in 1996. This increase accelerated some in 1999. The country's R&D intensity currently tops 2.4% – for the first time since 1992.
- The sustained increase in the number of patents with world market potential which began in 1994 (i.e., the increase of inventions for which patent applications have been submitted in Europe, the USA and Japan) has continued.
- Foreign markets continue to provide the opportunity for economic growth in R&D-intensive branches of industry, accounting for nearly three quarters of these industries' gaining turnover. In the year 2000, foreign markets accounted for 54% of the turnover generated by R&D-intensive industries, compared to 45% in 1995. The depreciation of the Deutsche Mark was a major factor in stimulating export trade.
- The density of companies in East Germany is much lower than in West Germany.

The increased innovation activities of German industry have been commented on in newspapers and business magazines. The Frankfurter Allgemeine Zeitung (Anonymous, 1996a) stated that the "high German capital export to foreign countries indicates that German export goods are competitive". In 1998 the Frankfurter Allgemeine Zeitung (Anonymous, 1998a) pointed out that "German industry has again discovered the importance of innovation" and concluded the "innovation engine [of Germany] was running at top speed" (Anonymous, 1998a). The VDI Nachrichten argued in the same direction and concluded that the automotive industry has "made massive research efforts" and is now seen as stimulating many new products (Mock, 2001).

Figure 3.2: World-Trade-Share Germany, USA and Japan for R&D Intensive Goods 1989 to 2000[1)] (Legler et al, 2001)



1) Data for 1989 to 1994 is calculated on the basis of information from OECD
*) Reduction in 1993 because data basis was changing - trade between EU countries is not fully counted
**) Rough estimation

Nevertheless, R&D investments have to increase further because "in comparison to other countries, investment in R&D activities is low" (Anonymous, 2002a). In Figure 3.2 the share of world-trade R&D intensive goods[41] developed in Germany, Japan and the US is given. The Diagram shows that from 1992 to 2000 the German and Japanese market share with R&D intensive goods decreased from 18.25% to 14.0%. In contrast US companies increased their market share from 19% to 21% in 2000. As the US is a strong competitor for R&D intensive goods, the German industry has to invest further in developing R&D intensive goods.

[41] The term R&D intensive branch is not related to the degree of product innovation. It is related to the intensity (i.e., investments) of industries into R&D. R&D intensive industries are differentiated into industries with top technological products (costly R&D activities) is carried and industries with high technological products (above-average R&D activities). These two industries are compared to industries with no R&D intensive technologies (i.e., industries with average R&D activities).

The fact that Germany has problems to keep pace with other countries is also shown by a study of the European Commission (2001b). A comparison of seventeen factors (e.g., qualification of employees, R&D expenditures, patents for high-technology products and productivity) ranked Germany at number seven out of all the countries within the European Union. The study points out that Germany has difficulties in offering services in combination with a high technological products. Further, it is one of the nations where the inhabitants have difficulties in learning something new, i.e., have problems in the process of lifelong learning. However, lifelong learning is one of the most important abilities to stay competitive. Professor Gmünden from Berlin University states that "the innovation gap is not dependent from lower R&D investments or from a lower number of patents – the difficulty is the ability to transform the knowledge into new products, services and processes" (VDI, 2001).

This section has given an overview of the German competitive position. Now, it will be interesting how the German themselves see their position in the world-market. The discussion about Germany as a competitive location for the manufacturing industry is discussed in the next section.

3.3 THE "STANDORT DEUTSCHLAND" DISCUSSION

The economic position of Germany in comparison with other industrial countries has been a key topic of discussion in the media over recent years. This discussion is often referred in the German press as the *Standort Deutschland* discussion about Germany as a location for manufacturing industry . High production costs which are the result of both high labour costs (Brinker et al, 1997) and tax levels, have led many companies not to make further investments in Germany (Henkel, 1997). Together with France, Germany exhibits the highest taxes world-wide – 37% effective tax burden for German companies compared to 20.1% in the UK (Werner, 1998).

The framework conditions given above are reflected in the labour market. Companies are not willing to take on new employees. As a result of this unemployment has increased from 5.1% in 1991 to 9.7% in 1998. With more than four million people out of work in 2002, the rate of unemployment has achieved one of the highest level since the period after the Second World War (Zydra, 2002). It can be concluded that these facts are no invitation for companies to invest in Germany.

The degree to which Standort Deutschland has been discussed in Germany is demonstrated by the fact that many articles discussing it were published in leading national papers during the past years. In these articles the economic and social position of Germany in comparison to other industrial countries is discussed. Mück and Linke (2001) from the Handelsblatt state that the "Standort Deutschland debate does not fade away". They point out that "in comparison to other European countries the high corporate taxes of more than 40% are a clear disadvantage for foreign investors" – the situation has not changed with the latest tax reform. This view is not new as an article from 1998 in the *Frankfurter Allgemeine Zeitung* (Anonymous, 1998b) shows. In this article it is pointed out that the US Government is concerned that the competitiveness of Germany will continue to be inhibited by high corporate taxes compared to Europe. The fact that Germany has difficulties staying competitive is also stated by Fred Bergsten, director of the *Institute for International Economics* in Washington who says that "not everything is bad in Europe, but the biggest national economy (Germany) is ailing" (Anonymous, 2002b). In his view, the inevitable structural reforms are not realised. This is supported by Horst Sieber, director of the *Institute for World Economics* in Kiel (Grosser, 2002). He demands reforms in the education system, tax system and social system. Further, he refers to the speech held by the then President Herzog in 1996 (Norman and Studemann 1996). In this speech President Herzog pointed out that many Germans are not willing to realise reforms. Norman and Studemann state that at the end of the 1970s, the Americans had enormous difficulties, too and that they made an effort themselves. However Grosser states that "in Germany still no push forward has been recognised".

This situation is also summarised by Michael Porter. He states in an interview with Haacke (1999), that "Germany needs a better environment for innovations. In the past this was the strength of Germany". He concludes that Germany needs radical changes. To achieve this, the Germans have to change their mentality. Entrepreneurialship and a new spirit for innovations have to be created as Lothar Späth (chief of the board of Jenoptik) points out (Späth, 1999). Späth emphasises that "in Germany Bill Gates would be committed for trial while it was proved how it could be that someone can earn so much money – in such a decent state".

Due to the pressure on German manufacturing arising from their high labour costs, innovation is seen by 80% of managers as the area on which to focus (Janz et al, 2001). In understanding the role innovation plays for German companies, it is important to note that both large and small to medium companies are affected. Small and medium sized enterprises (SMEs)[42] – also called Mittelstand – have traditionally been a major driver of the economy.

3.4 THE GERMAN MITTELSTAND

The German Mittelstand plays an important role because only this branch has created new jobs in the past. Therefore, both the German government and the European Commission offers many support programmes to improve product innovation in these companies (European Commission, 2000, 2001a, 2001b). Especially fast-growing high research-intensive firms in key-technologies (e.g., bio-technology) create new jobs. However, there are also many low-tech companies which operate as employers. According to a survey conducted by the Bonn-based Institute for SME Research, 89,653 of the total 91,585 (97.9%) purely industrial enterprises in Western Germany are small to medium sized operations (<500 employees). These companies employ 41.6% of all industrial workers and account for more than one third (36.1%) of industrial sales (Paulgerg, 1999). While 422,000 jobs were lost from March 1996 to March 1998 in big companies, the German Mittelstand, created 46,000 new jobs (IWD, 1999b).

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[42] Dependent on the researchers, this definition is related to different variables. In the definition of the European commission SMEs have fewer than 250 employees, have either an annual turnover not exceeding 40 million Euro, or an annual balance-sheet total not over 27 million Euro (European Commission, 2002). Other institutions (e.g., Federal Ministry of Trade and Commerce) define SMEs as having less than 500 employees (e.g., Paulgerg, 1999).

Most of German SMEs are focused on niche products and are often market leaders world-wide (Simon, 1992; Wever and Allen, 1992). Their main strategy is to create and exploit new market niches through innovative new products (Simon, 1996). A study from the Zentrum für Europäische Wirtschaftsforschung (Legler et al, 2001) shows that innovative activities in the German Mittelstand increased from 1997 where it was 30% of the whole R&D expenditures in German industry to 40% in 1999. The strategy focus on new products was shown by a study of approximately 36 SMEs. This showed that for 69.7% innovation plays an important role and 36.4% of all products they offer are less than 3 years (Kukat, 1998).

To stay competitive German SMEs are always looking for new ways to increase their performance. The study by the Institute for SME Research, conducted in 1,044 SMEs[43] shows that 20.3% of small and medium German enterprises want do develop more new products to increase their competitiveness (Paulgerg, 1999). Another possibility to stay ahead are co-operations with other small and medium sized companies – dynamic and unpredictable markets are forcing the companies to work together. A study by Groothuis (1999) found out that two-thirds of SMEs have experience in working together with their competitors, whereas only 33% do not have strong networks.

A significant part of SMEs operates in the industry sectors engineering and E&E engineering. Many of these companies work as suppliers for greater companies (e.g., for automotive companies) or operate in niche markets (Anonymous, 1999b). The importance of the two industry sectors for the German economy is shown in the next section.

3.5 THE INDUSTRY SECTORS ENGINEERING AND E&E ENGINEERING

To perform a meaningful investigation of product innovation, the current study focuses on two different industrial sectors. This means that the results can be compared, and possibly, broader lessons for German industry can be identified. The two industry sectors chosen were engineering and electrical and electronic engineering (E&E engineering) for the following reasons:

- Engineering and E&E engineering companies are known to be innovative – as this study investigates product innovation this is an important point.
- Both industrial sectors have broad range of sizes of companies.
- Engineering and E&E engineering play an important role in Germany's gross national product.
- Products from both industry sectors are exported all over the world.
- Engineering and E&E engineering are important industries in other countries too, e.g., in UK and USA. Therefore, the results of this research will be interesting for foreign managers too.

The following section gives an overview of the two sectors and shows their importance. For each sector the actual economic situation in 2000 and 2001 and the

[43] SMEs from the manufacturing and service sectors; Turnover per year at least Euro 127.8 thousand (service Euro 255 thousand) and number of employees < 500.

latest tendencies in R&D are described. (As the main phase of this research was carried out in 2000 and at the beginning of 2001, the economic situation after the terrorist attack on the Word Trade Center on 11 September 2001 is not described.)

3.5.1 Industry Overview

Both industry sectors are characterised by different kinds of companies – in size, products and customers. Especially engineering includes manufacturing companies with products from different branches[44]: track vehicles; mechanical engineering; street vehicles; sheet metal and metal goods; synthetic material goods. Further, both industry sectors have a reputation for being a fast moving and innovative field with a strong need for product innovation. For example, Rommel (1991) chose mechanical engineering because "Germany's reputation for product innovation, engineering and styling, and high quality is legendary".

A look at the turnovers achieved in the two industry sectors underlines their importance (Federal Statistic Office, 1999). Table 3.1 shows the turnovers of the whole of Germanys manufacturing industry in detail. 44% of the total turnover was achieved with products in the engineering sector and 12% with products in the E&E engineering sector. In summary, 55% of the whole turnover in the manufacturing industry was created by the two sectors chosen for the current study.

Table 3.1: Turnover Manufacturing Industry for the Year 1998[1] (Federal Statistic Office, 1999)

Industry Sector and Branches	Turnover (billion Euro)	Percentage (%)
Whole manufacturing industry	**1,161,053**	**100**
Engineering		
Rubber and plastic parts	47,713	4.1
Metal processing	52,552	4.5
Manufactures of metal goods	71,395	6.1
Mechanical Engineering	145,846	12.6
Motor vehicles	189,991	16.4
Summary Engineering	**507,497**	**43.7**
Electrical & Electronics Engineering		
Bureau equipment and processing goods	14,055	1.2
Equipment for electricity producers	65,027	5.6
Television and radio	31,157	2.7
Measuring and steering instruments, medicine, optic	28,702	2.4
Summary E&E	**138,941**	**11.9**

[1] Assembly of industry sectors analysed in the PhD research project

[44] Industry sectors includes a set of different branches (e.g., engineering includes branches as motor vehicles, mechanical engineering, manufacturer of plastic parts and metal processing and manufacturers of metal goods). This definition is based on the definition of the Federal Statistic Office of Germany.

Both industry sectors play an important role in German exports. Based on data from the Statistical Yearbook (Federal Statistic Office, 1999), Table 3.2 shows the export/import-balance in 1998. Germany has comparatively few raw materials and lives from its exports of innovative products and 51% of all exports are from engineering and E&E engineering. The picture is clearer when viewing the export-surplus. On an average over all industries the export surplus was 16.7% in 1997, but with goods in engineering and E&E engineering a surplus of 63.8% was achieved.

Table 3.2: German Imports and Exports Listed by the International Goods Register for the Year 1998 (Federal Statistic Office, 1999)

Industry Sector	Import (billion Euro)	Export (billion Euro)	Export surplus within sectors (%)
Whole manufacturing industry	**416,206**	**485,792**	**16.7**
Σ Engineering and E&E engineering	**151,293** (36.35%)	**247,745** (51.00%)	**63.75**
• Engineering	89,801	186,679	208
• Electrical & Electronics engineering	61,492	61,066	~0

Key economical data and information about R&D activities in each sector are presented in the next sections.

3.5.2 Engineering

Developments in engineering started with the invention of the first industrial usable steam driven engine in 1765 by J. Watt. Based on this engine new methods were developed for both spinning and weaving (1787) – this invention marked the start of the industrial revolution (DTV, 1997). A further step was the development of internal combustion vehicles and the electric motor in the late 19^{th} century. With the electric motor the production of mechanical products was possible (an overview about the E&E engineering sector is given in the next section). Further, the first automobile was developed in the late 19^{th} century. These products helped to run automative processes and to develop engines for new areas of applications. Examples are belt production installations, motorised lathes, press machines. Over the years engineering split into different branches. The main ones presented in this section are:
- Mechanical engineering
- Motor vehicles
- Metal processing and manufactures of metal goods
- Plastic parts

These branches have similar production processes and all are closely related. For example, companies from rubber and plastic and manufacturer of metal goods are often suppliers to the automotive or mechanical engineering companies.

Mechanical engineering

German mechanical engineering companies are having a comeback. In the past companies in mechanical engineering had problems with product design, customer orientation, flexibility and costs. But since 1997 important markets were regained and in 2000 a world-market share of over 20% is expected (Rogowski, 1998). This tendency was confirmed in the latest report of the Federal Department on Education and Research. In the last two years the German engineering industry dominated the world market and with Euro 153.4 billion turnover in 2001 a record year was achieved (Anonymous, 2002a). In summary, 935,000 employees are working in mechanical engineering and companies have partly difficulties in finding skilled workers (Reuther, 1999). Especially the machine tool industry has a strong position in the world market – in this specific branch, 65,700 German employees achieved a turnover of Euro 0.61 billion (1998). Japan and Germany together produce 45% of the machines world-wide and both are also leaders in the export of machine tools (Kapp and Klingelnberg, 1999).

Mechanical engineering is the construction and manufacturing of machines and production plants. As pointed out earlier, engineering started in 1787 when spinning and weaving processes were automated. It provides the infrastructure to produce products such as cars and metal and plastic parts. Key developments since 1900 were the automation of processes and the development of (electronic) control engineering techniques.

To survive in the international market German mechanical engineering companies need a strong customer orientation. Gerhard (1999) investigated products and services and found that world-wide customers are reducing their number of suppliers. To stay attractive for customers, German mechanical engineering companies have to expand their product range. The branch has taken up this challenge as shown by Verband Deutscher Maschinen- und Anlagenbau e.V. VDMA (German Machinery and Business unit Manufacturer's Association). Based on new products and services they see their branch in a very good position to achieve high growth rates in the next years (Kriegbaum, 1999).

As customer demands have changed, mechanical engineering companies are forced to be more flexible and to concentrate their activities on these new customer demands (e.g., short delivery times, flexibility in market adjustment, and quality). This was investigated by Leyendecker and Bünting (1999) who surveyed 158 companies in mechanical engineering. The study shows that companies have changed their activities from achieving cost reduction to time and process optimisation. The number of employees in administration was reduced from 40% in 1983 to 30% in 1998. Further, new processes like group working, external production planning and production control were installed. And since 1995 the manufacturing added value has increased by 10% to Euro 110 per employee and working hour. The study of Leyendecker and Bünting shows an interesting phenomenon in the outsourcing activities of companies. Although 20% of the production in the last three years was outsourced, some companies increased their vertical range of production. The reasons for insourcing were problems in quality of suppliers, delivery time and free own capacities

Motor vehicles

The annual report of Verband der Automobilindustrie e.V. VDA (Automotive Industry Association) shows the trends in the German automotive industry (Gottschalk, 1999). Gottschalk states that sales in the German automotive branch amounted to almost Euro 160 billion in 1998, 16% more than 1997. In the last five years, the German automotive industry branch achieved average nominal rates of growth of almost 10%, accounting for some 16% of industrial sales generated in the whole of the German economy in 1998. In 1998, vehicle imports amounted to some Euro 46.5 billion, resulting in a trade surplus of Euro 50.6 billion and exceeding by far the foreign-currency spending of German tourists abroad (Euro 38.3 billion). In 1998 the gross value added from the development, manufacture, sale and use of motor vehicles accounted for almost a fifth of the national product of Germany, generating Euro 102 billion in tax revenue. The close link between motor transport and growth in Germany's national product is first of all revealed in the increase in the vehicle population. Since 1960, GDP has risen threefold. Over the same period, car ownership rose from 4.5 million in 1960 to 42 million cars today.

Nowadays the automotive industry is one of the key branches in the German economy – in 1998, some 710,000 people were employed – almost 40,000 more than 1997. 392,000 were employed in manufacturing vehicles and engines, 280,000 worked as manufacturers of parts and accessories, and 38,000 worked in the group manufacturing trailers, bodies and containers. Thus, every seventh job in the Federal Republic of Germany is directly or indirectly dependent on the manufacture, sale and use of motor vehicles.

The beginning of motorised vehicles was 1885/1886 in Germany – Carl Benz and Gottlieb Daimler developed the first automobile. The success of the automobile was supported by further inventions which improved the operation, security and comfort of cars. In 1888 the air-tyre was invented by J.B. Dunlop and Robert Bosch developed the first spark plug in 1903. In 1908 Henry Ford started to produce cars as mass produced articles (Frankenberg and Neubauer, 1995). Over the years Germany became one of the most important locations for car production. Companies like DaimlerChrysler, BMW, Volkswagen, Audi, Porsche, Opel have their headquarters and significant production facilities in Germany.

Ever since the 1992/1993 recession (Gottschalk, 1999), there have been two distinct trends in the automotive branch in Germany. On the one hand, exports have risen by almost 60% to 3.5 million vehicles, but on the other, new registrations within Germany during the same period only rose by just under 17% to four million. This difference between the figures for exports and for domestic sales has been particularly striking during the last two years. However, the dynamics of exports are the basis for the automotive business (VDA, 1999) and with more than Euro 204 billion exports in 2001 an export-record was achieved (Anonymous 2001). German vehicle manufacturers now have over 120 production and assembly facilities in more than 40 countries.

The successful comeback (after the 1992 recession) of the German automotive branch is based on innovative products, modern production methods and consequently, an export orientation (IWD, 1999a). While in 1998 the automotive production world-wide decreased by 2.6%, German automotive manufacturers produced 14.3% more vehicles than in the year before. This is not surprising, however, as the annual VDA report pointed out, that the German automotive branch is investing heavily in research.

The trends in R&D during the 1980s and 1990s, were that the automotive branch considerably increased its expenditure on research and development – which in turn accelerated the pace of innovation in the branch. As automobile manufacturing's importance for the German innovation system has grown steadily over the last 20 years, this sector accounts for more than one quarter of the industrial sector's R&D spending (Anonymous, 2002a). It also provides the chemical, electronics, electrical, engineering and telecommunication industries an important impetus for technological innovation." (Anonymous, 2000a). However, as cars are produced and sold internationally, German car makers expend approximately 20% of their R&D spending in countries abroad. The level of R&D is reflected in the number of patent applications made. In 1996 2,940 patents were registered by the German automotive branch – 31% of all the 9,342 automotive patents registered world-wide. "Global orientation, the ability to innovate and the willingness to offer additional products and services are the key factors for profitable growth. The strategic positioning of suppliers vis á vis their customers has three dimensions – contribution to development processes, to assembly activities and to integration" (Gottschalk, 1999).

However, the VDA report shows that innovations were only possible with co-operation between independent manufacturers over individual products. The supply industry is playing an increasingly prominent role in enhancing the attractiveness of German motor vehicles and making them more competitive on world-markets. Suppliers have taken on new tasks both in the fields of development and production. In addition, to this, they have pushed ahead with the new development of safety features in German cars, e.g., chassis stabilisation systems, anti-lock systems and airbags.

Metal processing and manufactures of metal goods

The Eisen, Blech und metallverabeitende Industrie e.V., EBM (Association of Steel, Sheet Metal and Metal Processing Industry) estimated their economical situation as follows: after a stagnated market in 1999 a market growth on a low level is expected. With about 244,000 employees a turnover of Euro 28.5 billion was achieved in 1999 (EBM, 1999)

For thousands of years metals have been used for the production of tools and weapons. Iron, aluminium or zinc are important materials for manufacturing, e.g., cars, ships, machines and engines. In this sector many companies are spezialised in the production of specific metal parts.

Manufacturers of metal goods often work as suppliers for the automotive or mechanical engineering industry branch. And as explained earlier, they have to offer new services and products to their customers. The ability to develop new products within their own organisation and to offer complete solutions to the customers give them very good chances in this highly competitive market.

Manufacturers of plastic parts

For the manufacturing synthetics branch the Gesamtverband kunststoffverarbeitende Industrie GKV (Synthetic Processing Industry Association) estimated moderate growth rates in the next years (Puttkamer, 1999). In summary, the 2,700 German synthetic processing companies achieved a turnover of Euro 36.4 billion. 274,000 employees worked in this industry branch. Compared to other branches the synthetic branch is ranked in seventh place in the processing branch in Germany. Puttkamer points out that typical companies in this branch are privately owned with an average of 100 employees per firm – most are SMEs.

The first synthetic materials which were used for mass production were developed in 1930/1935 (e.g., PVC, Polystyrol). Further, new synthetic products were introduced in the 1950s and 1960s. Synthetic materials were available from the 1930s, but the replacement of metal parts for mechanical applications started about 20 to 30 years ago. Nowadays more and more synthetics are used in the industry sectors mechanical engineering, E&E engineering and construction. As many application fields for synthetics exist, the European Production Statistic divides this industry branch into four big sub-branches (GVK 1999a): films and plastic profiles, consumer goods and supply parts, construction goods, and refining.

A basis for growth were innovative products for medicine, automobiles, computers, mobile phones, etc. It is interesting to know that also in this industry branch producers of synthetic processing machines are included. However, innovation is an important factor in this branch. An innovation report showed that 69% of all companies are introducing a fluent stream of new products (GVK, 1999b).

3.5.3 Electrical & Electronics Engineering

With Euro 130.4 billion turnover and about Euro 7.7 billion expenditure for R&D, electrical is one of the three main sectors of industry in Germany besides mechanical engineering and motor vehicle construction (Graß and Reischman, 1999). More than half of the products made in Germany and of services provided by the E&E industry are exported, 60% of which go to Western Europe. In Germany about 850,000 people work in the industry sector. Outside Germany, a workforce of more than 300,000 is employed in all parts of the world by German electrical and electronic companies (ZVEI, 1999a,b).

With the discovery of electromagnetic induction by M. Faraday in 1832, the basis for the development of the first electric motor by J.Ph. Wagner (1836) was made. In 1866 Werner von Siemens developed the first dynamo. Siemens constructed the first electric train in 1879 and Th. A. Edison put the first power station into operation. The modern telecommunication technologies are based on techniques developed after the Second World War when electronics engineering was boosted from the invention of the transistor technology (the technology of transporting electrons in metals). Especially the development of the semiconductor technology was the basis for computer chips and electronic parts for a wide application field. On the basis of this technology information and communications technology was revolutionised via internet, mobile phones and digital technology. Nowadays the spectrum covers electronic components as well as turnkey production business units, comfortable household appliances and complete telecommunication systems, programmable controllers and state-of-the art medical systems for diagnosis and therapy (ZVEI, 1999a). The focus always is on innovative custom-tailored solutions. Formerly separate products now converge into systems and networks. Services like project engineering, software development, business unit operation and servicing are of growing importance for economic success.

The German ZVEI (1999b) characterise their branch as one of the most research-intensive and innovative ones of industry. The German E&E engneering industry spends Euro 5.6 to Euro 6.1 billion per annum on business units and equipment in Germany. Investments of more than Euro 7.2 billion – around one fourth of all R&D expenditure of the private industry – make it the most research-intensive sector of the German economy. Its turnover in 2000 was running at Euro 153.4 billion (VDI, 2000).

Although R&D activities increased over the last years, research and development in this area is no longer one of Germany's special strengths. Germany accounts for less than 5% of world-wide R&D expenditure in the IT hardware field and not quite 8% in the telecommunications field. By comparison, the entire industrial branch is responsible for 10% of world-wide R&D expenditure. Invention activity in some areas of information and communications technology has shown signs of an improvement in recent years. It would, however, be too early to speak of a turnaround (Anonymous, 2000a).

A study of the VDE (1999a) Verband der Elektrotechnik Elektronik Informationstechnik (German Association of Electrical and Electronic Information Technology) estimates a doubling of the world market for micro-electronic parts in 2003 to US$ 265 billion. For example, the world market for flat screens will increase from $14 billion in 1998 to $26 billion by 2004 (VDE, 1999b). In Germany Euro 1.9 billion of the whole GNP are based on the Euro 7.2 billion market of microelectronics which is a base for production of E&E pieces of equipment with a value of Euro 44 billion. And this again is a base for capital goods with a value of Euro 473 billion in the industry branches mechanical engineering, electrical and electronic engineering, automotive, precision engineering and optic, and bureau and data technology.

3.6 THE CHALLENGES FACING THE SAMPLE COMPANIES

The previous section identified the main challenges facing German industry. However, the question remains whether these challenges are those that the sample companies face. To check this, a practitioners workshop was conducted before the main phase of the research started with companies from the sample[45].

As to how the challenges for product innovation can be overcome by German companies was investigated in a workshop run at the benchmarking conference "International Best Factory Awards Germany 1997"[46]. These companies face many of issues to those described earlier in this chapter. For example the creation of new markets through innovative new products and the development of new products for strengthening the international market position. 59 managers from different German

[45] The data used for the research based on the German dataset International Best Factory Awards. Therefore the practitioners workshop gave first hints into the challenges for product innovation of the sample companies. A detailed description of the dataset is given in Chapter 4 (Section 4.3.3 'Sample').
[46] Most of the managers who had taken part at the conference "International Best Factory Awards 1997" were from the case companies studied.

manufacturing companies (and different industry sectors) were asked to gave their opinions on the most important needs for product innovation. The model from Sheth and Ram (1987) was used as the basis for this workshop (refer to Section 2.3.1). To collect the participants views on product innovation, they were asked to fill out cards which were collected and categorised using the Metaplan–Technique (Anonymous, 2002d). First, they were asked to write down the challenges which forces their companies to be innovative. According to the areas of the model, all cards were sorted and every manager had the ability to rate the factors. Second, they were asked for possibilities of how these drivers could be overcome – all answers were sorted and ranked. Although informed in its approach – the approach of the workshop can be described as a litmus test – the finding of the workshop offer some insights into how product innovation is perceived in German manufacturing industry.

3.6.1 Challenges for Product Innovation

An overview of the most important challenges for innovation is given in Table 3.3. From the four given areas the managers saw customer requirements as the most important challenge (51%). In this area "specific customer solutions" were reported as the main challenge. However, to achieve a speedy reaction to customer requirements the workshop participants had seen the need to offer different product varieties and to be very flexible. Further it was commented that changing customers means that traditional segments are disappearing or fragmenting and companies will need to adjust their product ranges accordingly. For example, Mercedes offers a car in a new customer segment – with the A-Class they produce a car for young families.

The next driver is technological advantages which was seen by 21% as the most important one. New technologies are creating new industries and forces companies to act with shorter developing and manufacturing lead times. For instance, information Technology is changing the face of the buying. Most consumer goods (e.g. books and compact disks) can be ordered via the internet. Similarly electronic point-of-sale bar-code technology has radically changed the management of supply chains by enabling almost instant feedback on sales to manufacturers.

17% of the managers saw intensified competition as one of the most important challenges – globalisation of procurement, production, and sales are growing rapidly. The process of concentration of companies leads to more competition in the future. Interestingly this area was not seen as the most important challenge and was ranked in third place. As an increasing number of large and medium sized enterprises have a global presence and international management their thinking has to change – therefore it was recommended that managers have to think in more global terms . Companies may also face competition from sources normally outside their industries. One given example is the mobile phone industry. For example Mannesmann was a successful engineering company which started to build up an own mobile phone net. A industry sector which has grown rapidly in the late 1990s.

Finally changing business environment was ranked bottom (11%). Price pressure, location and political dependencies were the most answered challenges for innovation in this area. World-wide, markets are becoming more open as the market economy is embraced by most governments and through the efforts of trade groupings such as the

EU and NAFTA in reducing tariffs. Although market are becoming more open, political dependencies such as licences and taxes were seen as critical. One effect of open markets is the circumstance that home markets formally thought of as safe, can be quickly threatened by competitors from abroad.

Table 3.3: Necessities and Challenges for Innovation (workshop results)

Challenge	Examples	Frequency of Mention (%)
Customer Requirements	• Specific customer solutions • Varieties • Flexibility	**51 %**
Technology	• Shorter Development Times • Shorter manufacturing lead times • To be ahead of technology	**21 %**
Competition	• Globalisation – the world gets smaller • Processes of concentration • Customer oriented innovations	**17 %**
Business Environment	• Price pressure • Location • Political dependencies	**11 %**

3.6.2 Solutions for Overcoming the Challenges

For the four drivers the managers were then asked to give strategies on company level as to how they can be overcome. The results are dividedd into four main groups which are based on the analysis of the workshop results (Table 3.4).

- corporate culture and human resource management
- customer focus
- NPD management
- organisation

The most important solution to overcome the drivers for innovation is the implementation of an employee-oriented corporate culture. 48% of the solutions presented in the workshop can be categorised in this area. Especially team work, problem solving groups and continuous process improvement companies were seen as important. The discussion showed that for most of the managers motivation and entrepreneurial thinking of teams form a base for innovation.

The next area was customer focus – with 28% it was ranked in second place. It was recommended that customers and their requirements are changing. In the next 10 years Germany will have an older population than nowadays. Because older customers will have other requirements than young consumers, companies have to offer customer specific products. Further the trend for individualisation is growing. This factor was given by several managers with regard to their ability to become more customer focused for gaining customer loyalty.

Both new product development processes and organisation were ranked third (12%). Faster development times were seen as an important element to overcome the challenges for more innovation. As more and more innovative products include high-tech features it was stated that co-operation (in terms of organisational challenges) with universities and research institutes are important.

Table 3.4: Solution to Overcome the Drivers for Product Innovation (workshop results)

Area	Strategies	Frequency of Mention (%)
Human resource management and corporate culture	• Team work • Problem solving with conversation processes between people • Employee oriented organisation • Continuous improvement of processes	**48 %**
Customer focus	• Customer orientation • Customer oriented innovations • Communication with customers	**28 %**
NPD process	• Faster development time • Co-operations with universities and research institutes • Creativity	**12 %**
Organisation	• Process oriented organisation structures • Optimisation of processes	**12 %**

3.6.3 Link to the Research Questions

The workshop has shown that product innovation is seen as a key for staying competitive. For the managers who had taken part at the workshop, changing customer requirements are seen as the most important driver for product innovation. New technologies, intensified competition and business environment are not seen as such important drivers. However, in summary all drivers given in the model of Shethh and Ram forces companies to develop new products. Dependent on a company's market position some of these factors seem to be more or less important. Consequently this could be a reason why companies are operating with varying product innovation positions.

For achieving more innovation they are beginning to improve their human resource management and corporate culture more. Although in the product innovation literature NPD project management is given as a key area for developing new products it was not seen as the most important challenge to get more innovative. From this finding it can be concluded that the individual product innovation position of companies is not related to NPD management techniques but in different areas inside and outside a company. As the key drivers for varying product innovation position are still open a model capturing all these different areas should be used for any further research.

Overall the results of the workshop show that the development of new products is a key issue in German manufacturing companies in the International Best Factory Awards sample. Although the approach taken in the workshop was simple, the evidence is sufficient to indicate that product innovation is worth further (more systematic) investigation. Consequently the number of German companies developing new products has increased over the last few years (refer to Section 3.2).

3.7 SUMMARY

After a recession at the end of the 1980s and the beginning of the 1990s, German companies in the engineering and E&E engineering sectors have a strong focus on product innovation. With the replacement of existing products by new ones they regained their strong competitive position. This finding is reflected in the practitioners workshop presented in the section above. It is shown that managers see product innovation as a key factor for staying competitive. In summary, the tendencies in German manufacturing industry and the challenges facing companies can be summarised as follows:

- Product innovation plays a crucial role in German manufacturing industry . From 1993 to 1999 the proportion of companies which are introducing new products increased from 45% to 65%.
- German managers are looking for new ways to become more innovative. A workshop with managers found that corporate culture, human resource management, customer focus, NPD management and the optimising of organisational structures are important areas to improve their competitive position. It has to be noted that the improvement of NPD management techniques is not seen as the most important challenge.
- Although R&D expenditures in German industry increased over the last 10 years, Finland, Japan, US, Switzerland and South Korea are ranked higher.
- 53% of the whole turnover in the manufacturing industry was created by the engineering and E&E engineering sectors.
- The high export rates (58.73%) show that products from these two industry sectors are competitive world-wide.
- Both industry sectors belong to Germany's most research-intensive and innovative sectors.
- Companies in Engineering and E&E engineering have production and assembly facilities all over the world. Therefore, an investigation of product innovation activities would be interesting for both German and foreign managers.

This chapter has shown that product innovation is one of the most important key issues in Germany, especially in the sectors engineering and E&E engineering. In the next chapter the methodology of the research will be presented.

CHAPTER FOUR

RESEARCH DESIGN

4.0 INTRODUCTION

This chapter explains the methodology used for the research into the reasons why business units have different product innovation rates. In addition, the relationship between product innovation rates with percentage of revenues from new products (product innovation positions) was investigated. In summary, the research design:

- Addressed four research questions which were identified from an intensive review of the literature.
- Was based largely on a model from Cooper and Kleinschmidt (1993). This model links factors related to the business environment to product innovation output.
- Handled a complex topic, and so the research was divided into three phases. Phase 1 identified the typical product innovation rates of business units in German companies. In Phase 2 errors in measuring product innovation rate was corrected and Phase 3 investigated the reasons for varying product innovation positions.
- Used a combination of survey and case study methods. This helped to avoid some of the limitations of previous research into product innovation, and helped to make the results more generalisable on the one hand, and more in-depth on the other. The research was carried out in phases, so that the survey data at stage two informed selection of cases for stage three.
- Used the dataset of the German International Best Factory Awards. This contains detailed benchmarking data on performance of over one hundred manufacturing business units including data on their product innovation.

All these points are discussed in this chapter, which is divided into six main sections. In the first section, the phases of the research are presented. Then, an overview about the research methodology is given (including a discussion of the philosophical and pragmatic perspectives, and a presentation of the unit of analysis). In the following three sections, the individual Phases 1, 2 and 3, are discussed in detail, including the research questions and the methods used. Further, the samples and the problems encountered are presented. Finally, a summary is given.

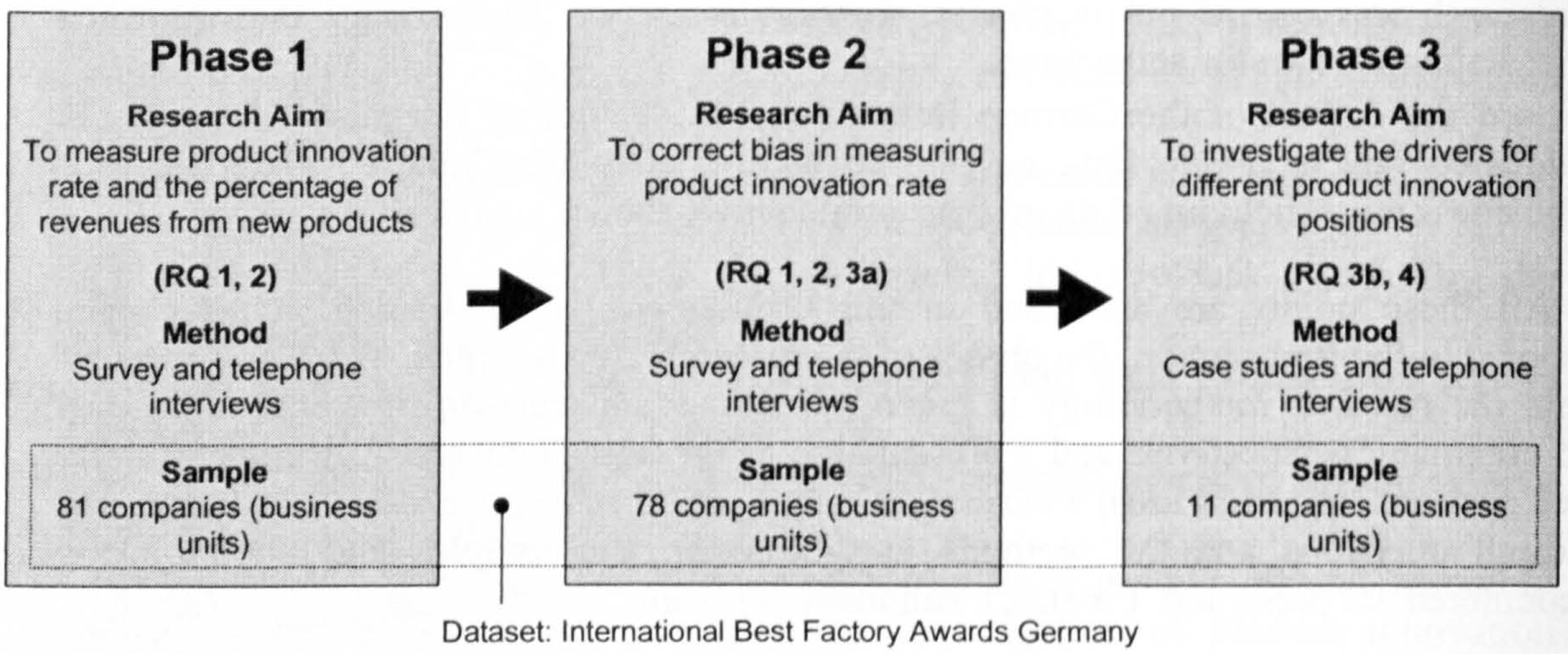
4.1 PHASES OF THE RESEARCH

In order to get clearer insights about significant factors of product innovation positions, (defined as the relationship between product innovation rate and the percentage of revenues from new products) a combination of different research methods was applied in this study. This approach was chosen after the review of limitations of previous studies. In order to enhance the quality of the research outcomes, sample sizes of some 80 firms were used in stages one and two, and 11 cases selected in stage three.

The research was designed in three phases as shown in Figure 4.1. The three phases can be summarised as follows::

- *Phase 1.* This phase measured product innovation rate (RQ 1). Further, the percentages of revenues from new products were investigated (RQ 2). A combination of survey analysis (with a sample of 81 business units) and telephone interviews (eight sample business units) was used in this phase. Phase 1 also led to the identification of measurement errors in the survey.
- *Phase 2.* In this phase the errors in the measurement of product innovation rate were corrected. To develop a more detailed response, a combination of a one-page survey and telephone interviews were conducted – altogether, a dataset of 78 business units was collected. Based on the corrected product innovation rates (RQ 1) the relationship to the percentage of revenues from new products was investigated (RQ 2). Further, the relationship between product innovation rates and the percentage of profits with the whole product portfolio was analysed (RQ 3a).
- *Phase 3.* The research in this phase focused on the question why business units operate with different product innovation positions (RQ 4). In order to answer this question 11 business units were selected from the analysis of Phase 2 because they showed 'off diagonal' results in terms of product innovation rates and/or percentage revenues from new products. Phase 3 also investigated how product innovation position and profits with new products are related (RQ 3b).

Figure 4.1: Overview of the Three Phases of the Research



As the research was run over three phases and each had different attributes, a more detailed overview is given in Table 4.1. In the table for each phase the research questions, the aim of the phase, the methodology, the sample used, the problems encountered and the conclusions are presented.

Table 4.1: Research Method Overview

	Phase 1	Phase 2	Phase 3
Research question	• **RQ 1**: What are the typical product innovation rates of German business units in the engineering and E&E engineering sectors? • **RQ 2**: How are product innovation rate and the percentage of revenues from new products related (defined as product innovation position)?	• **RQ 1** • **RQ 2** • **RQ 3a:** How are product innovation positions and profits with the whole product portfolio related?	• **RQ 3b:** How are product innovation positions and profits with new products related? • **RQ 4**: Why do business units within the same industry sector have varying product innovation rates / percentages of revenues from new products (i.e., product innovation positions)?
Aims of phase	• To investigate product innovation rate and the percentages of revenues from new products. • Identify a reliable method for measuring product innovation rate.	• To collect valid data on product innovation rate and the percentage of revenues with new products from a wider sample in the industry sectors engineering and E&E engineering.	• To investigate the business units' position on diagram product innovation rate and the percentage of revenues from new products. • To investigate the drivers of product innovation rate (lower and high) and revenues with new products (lower and high).
Methodology	• Survey • Investigation of two variables on basis of the International Best Factory dataset (Questionnaire see Appendix C) • Telephone interviews (1 hour).	• Improved survey • Investigation of three variables on basis of five questions (Questionnaire see Appendix D) • Telephone interviews (10 hours).	• Case studies selected on the basis of high / low product innovation rates and high / low percentages of revenues from new products with two to three interview partners • 29 variables (13 qualitative + 16 quantitative)
Sample	• Germany / manufacturing / engineering and E&E engineering sectors IBFA 1997 81 business units (IBFA data) 8 telephone interviews (1999)	• Germany / manufacturing / engineering and E&E engineering sectors (in 1999) IBFA 1997/1998/1999 148 bus. units (postal questionnaires) 78 bus. units (= 53% respondent rate) 34 telephone interviews (1999/2000)	• Germany / manufacturing / engineering and E&E engineering sectors IBFA 1997/1998/1999 78 business units 11 case bus. units (2000/2001)
Problems encountered	• Survey limitations: misunderstanding of the questions.	• Survey limitations: misunderstanding of the questions. • Difficulties in understanding what is a new product.	• Complexity: capturing of different areas which could have influence on product innovation position.
Conclusions on each phase	• Errors identified in measuring product innovation rate. • Combination of survey and telephone interviews is useful.	• Valid data on product innovation rate and the percentage of revenues from new products collected, as a basis for the further research. • In the E&E engineering sector business units with higher product innovation rates generally generate higher profits. In engineering such a relationship is not given.	• Detailed explanation why business units operate with different product innovation positions. • Product innovation position do not show how innovative a business unit is, because it is related to the context (i.e., market, competition and product innovation strategy).

4.2 RESEARCH METHOD OVERVIEW

For the research project a combination of qualitative and quantitative methodological approaches was adopted, which are in the positivistic and objective tradition. Due to the complexity of the research questions, the research project focused on the business unit as the unit of analysis. As described earlier, the research investigated product innovation rate and its relationship to the percentage of revenues from new products on a business unit level. As these variables are a main basis of this research, the usefulness of the combination of these variables is discussed in detail. The individual product innovation position (i.e., relationship between product innovation rate and the percentage of revenues from new products) was investigated using a model from Cooper and Kleinschmidt (1993). Based on this model an overview of all product innovation measurement variables chosen for this research is presented. In summary, the key characteristics of this section comprise:

- Philosophical perspective
- Pragmatic perspective
- Ethical issues
- Business unit of analysis
- Product innovation rate and percentage of revenues from new products
- Product innovation measurement variables

4.2.1 Philosophical Perspective

Blaikie (1993) identifies two key influences on the choice of a research strategy. It can be made for pragmatic reasons to try to match a strategy to the *nature of a particular research project* and the kind of research questions which have been selected for consideration. Or it can be made for in terms of how the various approaches which can be taken relate to the *world view of the researcher*, that is their personal preference for a certain philosophical position on the nature of social reality. These two influences direct the selection process of which philosophical perspective is most appropriate for a given research project and a given researcher.

In management research there has traditionally been a debate about the value of a positivist versus a phenomenological approach to research (Glaser and Strauss, 1967; Cohen and Manion, 1989). Taking a positivistic approach assumes that social reality exists, it can be objectively observed and is subject of cause and effect in much the same way as the natural world. In contrast, the phenomenological approach is a subjective domain of meanings and interpretations created by social actors, substantially different from the world of nature. An extreme example using a phenomenological approach is action research which "demands an integral involvement by the researcher intent on changing the organisation" (Eden et al, 1996).

These two approaches can lead to different research methods. Researchers following the positivist approach tend to favour quantitative methods (e.g., Moser and Kalton, 1971; Finch, 1987; de Vaus, 1986) while researchers with an interpretivist approach use qualitative methods (e.g., Lofland and Lofland, 1984; Geertz, 1973; Okely 1994). However, for management research, this 'either-or' mentality is often inappropriate. Both approaches in combination can offer advantages when investigating social phenomena. This position is supported by Glaser and Strauss (1967) who state that there is "no fundamental clash between the purpose and capacities of qualitative and quantitative methods or data" and pointed out that "in many instances, both forms of data are necessary – not quantitative used to test qualitative, but both used as supplements".

Consequently, a combination of quantitative and qualitative research is used in this study. Both methods allow the researcher to question people about their own behaviour (and possibly that of others) and their attitudes to and perceptions of various aspects of their work environment. Looking at the surveys as a research method, Bryman (1989) states that clearly defined variables are important because "unlike the experimental researcher, the survey practitioner does not manipulate what is deemed to be the independent variable...". However, it has to be taken into account that there are some areas of social reality, such as values and beliefs, which statistics cannot measure. This is pointed out by Silverman (1993) who believes that trying to count attitudes in surveys is a flawed approach to research. "Do we all have coherent attitudes on any topic which await the researcher's question?", he asks. This statement shows that surveys have serious limitations for explaining social phenomena. Therefore, in-depth qualitative studies have to be carried out. Hartely (1994) describes qualitative research as "a detailed investigation, often with data collected over a period of time, of one or more organisations, or groups within organisations, with a view to providing an analysis of the context and processes involved in a phenomenon under study". For Miles and Huberman (1994), qualitative research is conducted through an intense and/or prolonged contact with a "field" or life situation. They point out that the researcher's role is to gain a "holistic" (systemic, encompassing, integrated) overview of the context under study: its logic, its arrangements, its explicit and implicit rules.

Qualitative research can be conducted by using several research methods. One of the most important sources of information for qualitative studies is the interview. As Yin (1994) points out, interviews may take several forms. Most commonly, case study interviews are of an open-ended-nature, in which the researcher can ask key respondents for the facts of a matter as well as for the respondents' opinions about events. This way of carrying out interviews can be described as using a phenomenological approach. A second type of interview is constituted by focused interviews, in which a respondent is interviewed for a limited period of time. In such cases, the interviews may still remain open-ended and assume a conversational manner, but the structure is more likely to follow a certain set of questions derived from the case study protocol. A third type of interview, is based on more structured questions, along the lines of a formal survey.

Looking at the philosophical perspective a further criteria has to be discussed. The way in which the samples were chosen is crucial for later analysis. Samples can be chosen in an objective or subjective way. Miles and Huberman (1994) stated that qualitative researchers usually work with small samples of people, nested in their context and studied in-depth – unlike quantitative researchers, who aim for larger numbers of context-stripped cases and seek statistical significance. However, taking validity issues into account, the sampling strategy should be carried out in a structured way and should follow an objective sampling strategy. Such a research strategy was used in this research project.

The sample investigated in the survey was based on an anonymous database (database of International Best Factory Awards). From this database engineering and E&E engineering business units were chosen. The sampling for the case studies was based on a systematic selection by using the variables product innovation rate and percentage of revenues from new products. Because of this anonymous and systematic selection of both the survey sample data and the case studies, the philosophical position of this research project can be clearly classified as objective.

Additionally to the philosophical approach there are pragmatic reasons for adopting a mixture of qualitative and quantitative approaches. This pragmatic approach is discussed in the following section on the basis of a systematic comparison of variable-oriented and case-oriented research activities in the social sciences.

4.2.2 Pragmatic Perspective

This research project set out to address four different research questions, each of which needed to be operationalised in different ways. Clearly, a mix of different research methodologies would be needed. In order to inform the selection process, a useful contrast of the strength s and weaknesses of quantitative and qualitative research approaches is given by Ragin (1987). The quantitative approach has been characterised as 'variable-oriented' – accurate, but leading to broad, general conclusions with an 'unreal quality' about them. The qualitative approach is characterised as 'case-oriented' – short on generalisability but with a rich and elaborate dialogue between theory and evidence.

As Table 4.2 shows, variable oriented research is normally based on large datasets with the scope on broad empirical generalisations based on heterogeneous samples. The data is analysed in an analytic way and the link to actual empirical processes is marked. Consequently, the conclusions from this data are vague and abstract and therefore more concrete questions do not receive the attention they deserve. In contrast, case-oriented research focuses on smaller samples and is based on multiple methods to establish different views which seek to account for all deviating cases. Cases are a very good instrument for handling the complexity but it is difficult to sustain attention to complexity across a large number of cases. Therefore, the relevance is narrow because the findings are specific to the cases examined.

Taking Ragin's conclusion on variable-oriented and case-oriented research into account, both methods are useful for answering specific research questions. The variable-oriented research approach is best suited for analysing large datasets by means of statistical methods. This research strategy was identified as the most appropriate method for analysing many datasets with multivariate statistical techniques, i.e., for investigating the relationship between product innovation rate and the percentage of revenues from new products (RQ 1, RQ 2). With this research method product innovation rate and the percentage of profits with the whole product portfolio can be investigated, too (RQ 3a). However, the conclusions could be vague and abstract. Therefore, as the main aim of the research project was to investigate the reasons for varying levels of product innovation rate and percentage of revenues from new products (RQ 4) and the profits with new products (RQ 3b), a case-oriented strategy is the most appropriate.

Table 4.2: Variable-Oriented and Case-Oriented Research in the Social Sciences (after Ragin, 1987).

	Variable-oriented	Case-oriented
Basis of Research	• Quantitative • Multivariate statistical techniques • Many data sets	• Multiple methods to establish different views • Qualitative quantitative • Few datasets
Scope	• Wide categories • Broad empirical generalisations based on heterogeneous samples • Comparability ignored/skirted	• Narrow classes of phenomena • Several combinations of conditions may yield a certain outcome
Causality	• Disaggregated into variables & distributions • Based on analysis of entire population or sample	• Probabilistic relationships not accepted • Must account for all deviating cases
Conclusions	• Vague & abstract • 'Unreal quality' of conclusions • More concrete questions do not receive the attention they deserve	• Few general conclusions • Separate context
Theory/data link	• Radically analytic • Strictly a priori • Link between research & actual empirical processes marked	• Rich & elaborate dialogue • Strong link between research & actual processes
Aggregation	• Breaks into parts – variables which are difficult to reassemble into wholes. Not combinatorial.	• Holistic: parts related to context of whole
Complexity	• Average influence across a wide variety	• Sensitive to complexity & historical specificity. But difficult to sustain attention to complexity across a large number of cases.
Relevance	• Broad: general statements linked to abstract theoretical ideas about generic properties	• Narrow: findings specific to few cases examined

The evidence from both a philosophical and a pragmatic perspective suggests that the reason for varying levels of product innovation rate and percentage of revenues from new products is most likely to be gained by taking a positivist and objective stance and a mixture of a qualitative and quantitative approach to research.

4.2.3 Ethical Issues

As the managers interviewed gave detailed insights into management practices used, the information gained in the case study visits has to be handled confidentially. Especially information about strategy, profits, revenues and organisational issues have to be processed carefully. This was achieved with regular information to the interview partners about the latest developments of the current research project. As explained next, this was expected to be achieved with a set of actions.

First the informants were asked if they were agreeable to having their statements recorded on tape. After the case study description were made, the drafts were sent to the interview partners and they were asked for their comments. This was carried out in order to offer the interviewed partners the possibility of making corrections. Further, they had the possibility of giving comments how the information could be used. In the research all business units were given anonymity and therefore the danger that some could be identified by direct competitors was minimised. To minimise this danger as much as possible was demanded by one MD. The discussion with him is given in order to show how the data are used in the current research project.

The MD of this business unit made clear that the whole strategy had been revealed in the interview. In his opinion their competitors are very interested in their future strategy. Therefore, he pointed out that this information must not be allowed to go further. He demanded this information to be used in an anonymous way. To be able to control this it was important for him to read the case study description of his business unit in advance of publication. Further, he asked for papers which are in preparation for publication. His fear was removed and it was agreed to inform him regularly. Further, it was explained how the data are presented and what information is included in the thesis. After the explanation of the way as to how the data are presented, he agreed to have his data used for further analysis.

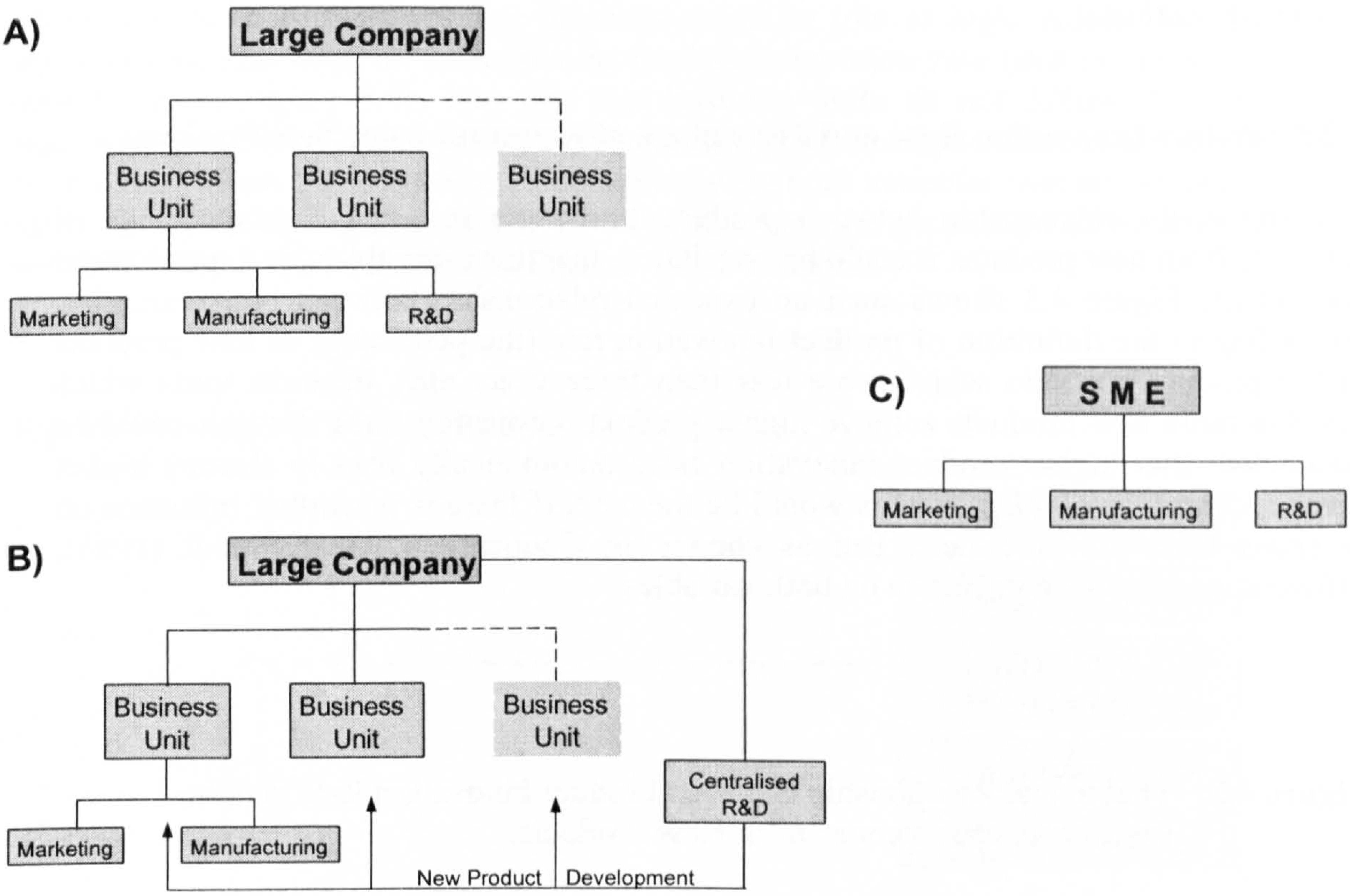
This example showed that it is important to make sure that all information is used confidentially. Consequently, all business units are and will be informed when publications are planned. Finally, it has to be noted that no direct competitors are included in the sample size. If this should be the case, the way as to how the data are collected and analysed would be discussed with both competitors in detail.

Based on the analysis of confidential information from the interviewed partners the current research focused on the analysis of business units which are defined next.

4.2.4 Unit of Analysis

To obtain comparable data of product innovation rates and percentages of revenues from new products the unit of analysis had to be defined clearly. As a unit of analysis the production unit was considered but rejected. One problem of taking the production unit is the concentration of its activities on manufacturing. Therefore, the influence on R&D activities is weak. As the current research focuses on product innovation, only limited information can be gained from such "production units". Therefore, a more appropriate terminology was chosen – the "business unit".

Figure 4.2: Types of Organisations and the Unit of Analysis of the Research



A business unit is more independent than a production unit. It has its own manufacturing, marketing and is involved into all R&D activities. Figure 4.2 shows three different kinds of business units. In large companies there are typically several business units, each of which has a full range of business activities, including marketing, R&D and manufacturing (A). In other cases, some functions could be centralised (e.g., R&D) and therefore a business unit is only responsible for marketing and manufacturing (B). On the one hand, in this case the business units are deeply involved in NPD projects dealing with their product lines. On the other, there could be business units which represent the whole company (C) – this is the case with small and medium sized enterprises (SMEs). Taking the three different types of organisations into account, the terminology "business unit" is characterised by the following attributes:

- The unit of analysis is strongly involved in all R&D processes
- The unit of analysis has its own production and it has influence on the product portfolio they produce
- The unit of analysis is engaged in marketing activities

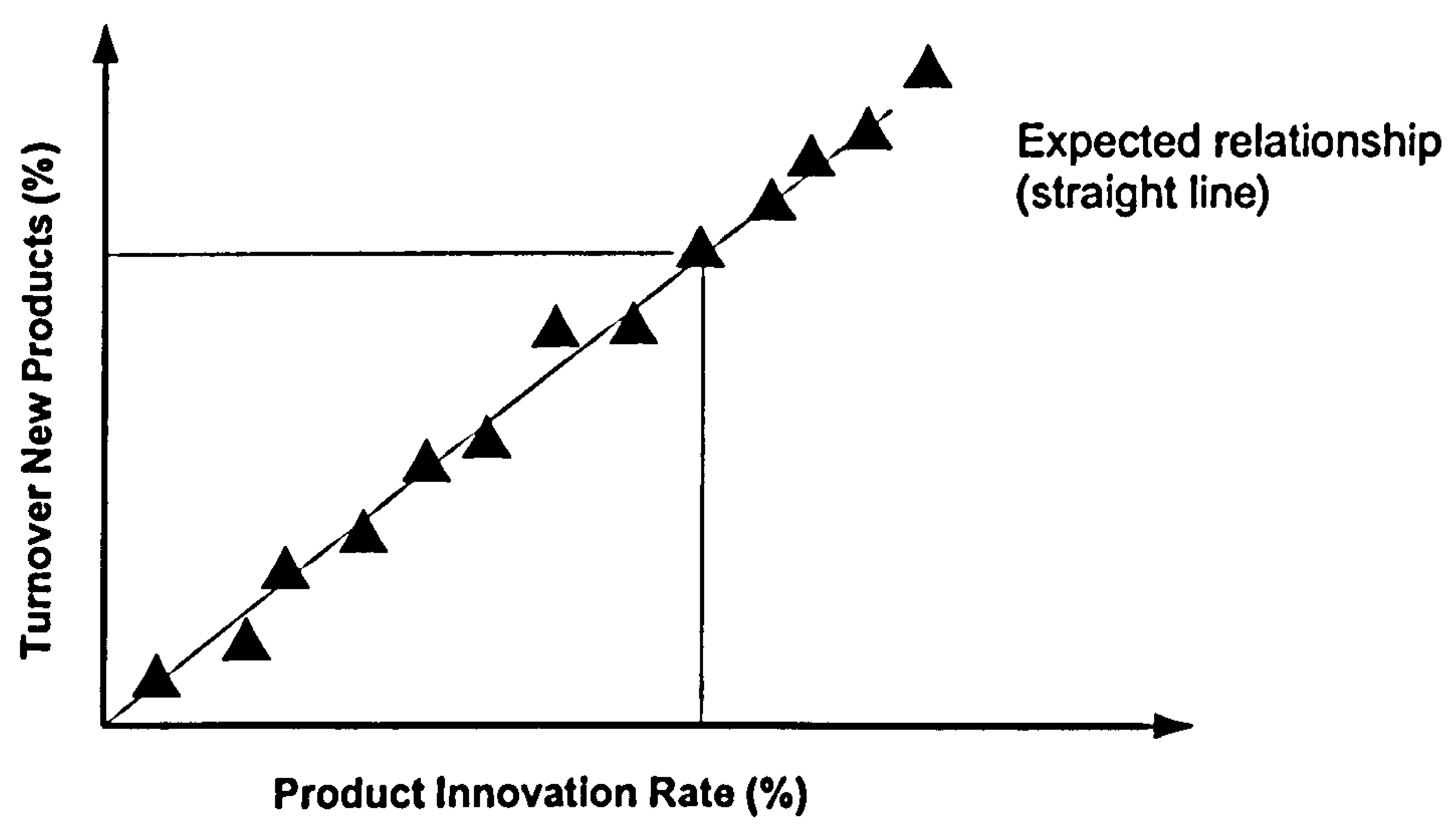
The chosen unit of analysis (business unit) made it possible to investigate the research questions in a systematic way. The literature review identified product innovation rate (e.g., Terwiesch et al, 1998; Goffin and Pfeiffer, 1999) as a measure showing the innovativeness of companies. Further, the percentage of revenues from new products (e.g., Cooper and Kleinschmidt, 1993 and 1994; Griffin, 1993 and 1997a; Hultink et al, 1997; Chiesa et al, 1996; Loch et al, 1996; Terwiesch et al, 1998;

Brennecke et al, 2001) was identified as a measure showing the ability of companies of converting new products into revenues. Consequently, the relationship between these two measures is chosen as a hypothesised measure to investigate product innovation on a business unit level. Therefore, the usefulness of these two variables is discussed in the following section.

4.2.5 Product Innovation Rate and Percentage of Revenues from New Products

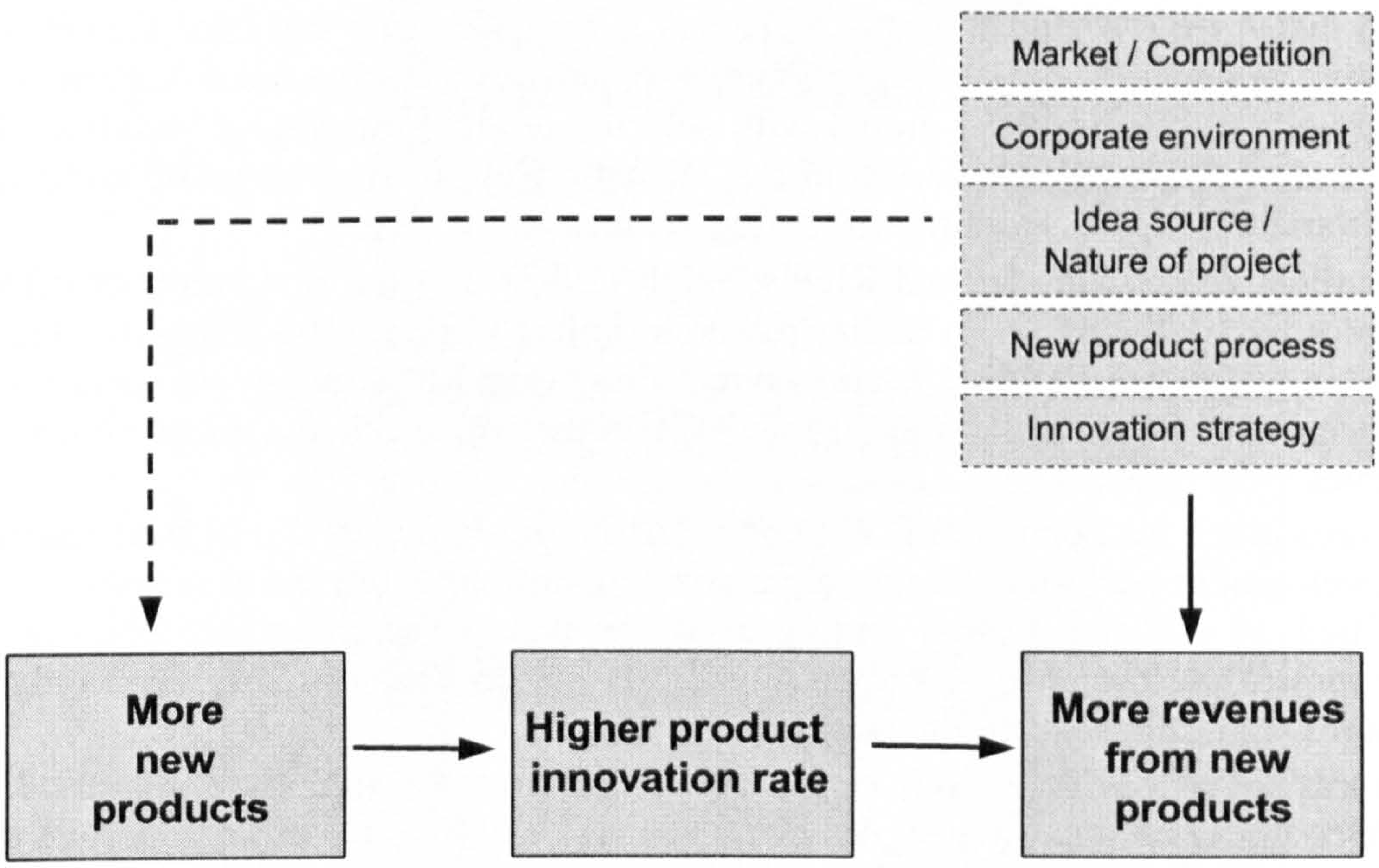
Looking at the relationship between product innovation rate and the percentage of revenues from new products it could be concluded, that these variables are dependent on each other. Figure 4.3 shows such an expected relationship between both variables. According to the definition of product innovation rate (the percentage of new products in the product portfolio which were less than three years old), business units which develop more new products achieve higher product innovation rates. Now, it could be concluded, that higher product innovation rates automatically lead to (linear) higher revenues from new products. This would be the case, if there is no further influence on revenues from new products. But as shown by Cooper and Kleinschmidt (1993), different areas have an influence on both variables.

Figure 4.3: Theoretical Relationship Between Product Innovation Rate and the Percentage of Revenues from New Products.



The areas identified by Cooper and Kleinschmidt (i.e., market, competition, corporate environment, idea source, nature of project, new product process, innovation strategy) directly influence the product innovation position. Therefore, the expected relationship as shown in Figure 4.3 is questionable. Dependent on these areas the percentage of revenues from new products could be low or high. Additionally, these areas in turn also have an influence on product innovation rate (this is shown by the dotted line in Figure 4.4). The fact that business units do not follow the expected regularity given in Figure 4.4, makes it interesting to investigate these two variables. In the research Phase 1 and 2 the relationship between both variables was investigated. The factors influencing both product innovation rate and the percentage of revenues from new products were investigated in Phase 3 of the research.

Figure 4.4: Effect of Product Innovation Rate



As pointed out earlier, the basis for the research was the Cooper and Kleinschmidt model which describes the influence of different management areas (external and internal) on product innovation rate and the percentage of revenues from new products. How their model was used as a basis to measure and explain a business unit's product innovation position is presented in the next section.

4.2.6 Product Innovation Measurement Variables

The literature review showed a range of different variables to measure product innovation activities. It also showed, that the measurement of product innovation is problematic, because detailed knowledge about product innovation processes within a business unit may be necessary. For example, Griffin (1993) showed that the variable 'time to market' needs a detailed definition and investigation of product development processes within a business unit in order to obtain valid data.

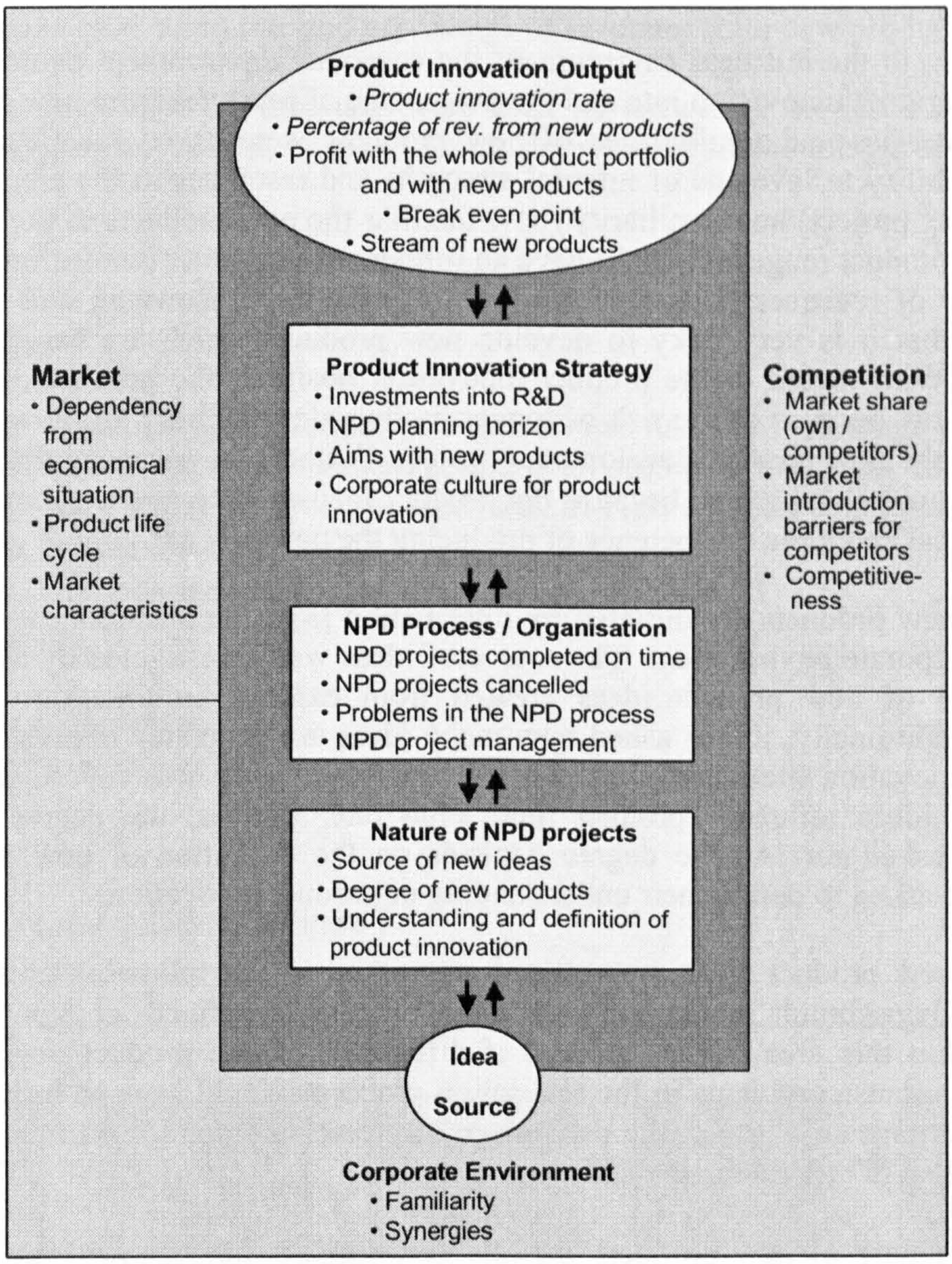
To obtain a reliable measure of new product innovation performance, Griffin and Page (1993) recommended that managers should measure at least five variables: two market acceptance measures (sales and market share), one financial measure (return on investment) and two product performance measure (quality and technical performance level). Although such a limited set of variables is usable for managing companies, the identification of the reasons for different product innovation positions need further variables. Therefore, a set of suitable variables (according to the model of Cooper and Kleinschmidt and based on the findings from other researchers) were chosen to explain the reasons for different product innovation positions.

The analysis of the literature has shown that problems occur when measurements are carried out via ranking scales. It also showed that variables need to be clearly defined in order to ensure that they are comparable. Therefore, each was tested in a pilot study and discussed in detail with the managers interviewed. All variables identified in the literature are sorted according to the areas given in the Cooper and Kleinschmidt model – Figure 4.5 shows their model with selected product innovation variables. The variables and measures were selected in a systematic way. In summary, the systematic choice of variables are based on the following sources:

- Measures given by Cooper and Kleinschmidt (1993). In their research they offered variables for each area. In an earlier research project Cooper (1994) investigated 66 variables which resulted in 19 independent dimensions of strategy elements which had been categorised into four groups. From their research the most significant variables were selected.
- Measures given by Loch et al (1996) and Griffin and Page (1993). In their research 43 development performance measures were identified. From these measures they identified 14 which are most widely used. As their research project investigated development performance on project level (and not on business unit level) only 10 measures were selected from their study.
- Measures given by Terwiesch et al (1998). In their research they identified 10 variables from previous studies. As their research was identified as an important step into research of product innovation performance on company level, all 10 variables were chosen for this research project.
- Measures given by other researchers. Researchers as Chiesa et al (1996), Simon (1996), Berth (1997), Griffin (1997), Brennecke et al (2001), Roper et al (1996), Janz et al (2001), Boag and Rinholm (1989), used a set of measures for their research in the field of product innovation. From these measures the most used were selected in a systematic way.
- Measures based on own conclusions. Based on the literature review and the experience made in the pilot study in Phase 3, own measures were identified as being important for answering the research questions.

The systematic selection of variables and questions from the product innovation literature contributed significantly to the reliability and quality of the research. As stated earlier, the model of Cooper and Kleinschmidt (1993) was chosen as a framework for the research. The reworked model with some of the chosen measures is given in Figure 4.5. The model was discussed intensively in Chapter 2 and it has to be mentioned that each area could have influence on product innovation rate and the percentage of revenues from new products themselves. Therefore, the arrows in their model are changed to point into two directions (this is in contrast to their original model, where all the arrows are in one direction).

Figure 4.5: Product Innovation Research Measures/Questions within the Cooper and Kleinschmidt Model (1993)



To show how the model and the chosen variables and questions were used for answering the research questions, the variables given in Figure 4.5 are explained in detail. According to the model of Cooper and Kleinschmidt a business unit (grey shaded areas of Figure 4.5) is embedded within the business environment (market and competition). Variables identified in this area were market share and product life cycle. Market share (competitiveness) was asked for both their own products and for their most important competitors. It was chosen, because several researchers found that higher competition forces companies to develop more new products (e.g., Gupta and Wilemon, 1990; Porter, 1990; Zarah, 1993b; Loch et al, 1996). As different product life cycles could have an influence on the product innovation rate this variable was also asked for in the case study visits. Further, the managers were asked to give information about their dependency upon economical situations. With this information environmental effects and their influence on product innovation positions were identified.

In addition, to the business environment the corporate environment could have an influence on product innovation rate and the percentage of revenues from new products. Therefore, synergies and familiarities of new products were asked for. The role of synergy (the ability to leverage of internal strengths and resources to the advantage of the new product project) and familiarity (how familiar the new products to the business units existing product range are) could have an influence on product innovation rate and the percentage of revenues from new products. For example, Bowman and Faulkner (1997) argue that it is very risky to develop new products which are based on new competences. With regard to the product innovation position, the product innovation rate could be low because of the risk of longer product development times or a higher failure risk of the new product development project. Further, the revenues from such a new product could also be low, because the product focuses on a new customer group who are sceptical about the competence of producing the new product.

Ideas for new products are initiated by information from the business environment or from the corporate environment. The source of ideas was investigated by asking for the percentage of new product ideas created from external information (e.g., by customers). Additionally, it was asked how many ideas are generated internally. Since the product innovation literature gives contradicting findings, it was investigated how the source of ideas influence product innovation rate. Further, the degree of new products was asked for. As the degree depends on the definition of new products, managers were asked to define their understanding of product innovation.

How the new product ideas are realised was asked in the following area. In the Cooper and Kleinschmidt model the realisation process is defined as "new product process". Within this area it was checked if difficulties in the product development process exits, because problems in the realisation processes could have an influence on product innovation rate. Further, the percentage of projects completed on time and the projects cancelled in the last three years were measured.

Both, the nature of new products and the new product development process are influenced by strategic issues. Although the literature review showed that innovation strategy is an area that is as complex as the product innovation process itself, it was investigated intensively. Managers were asked to explain their product innovation strategy. As a framework for measuring strategy, the model of Johnson and Scholes (1999) was used. Further, the variables investments into R&D activities, product planning horizon and the percentage of new products introduced with the strategy first to market were measured. Additionally, company brochures and statements of the interviewees were analysed to get information about the corporate culture supporting product innovation.

The management activities of a business unit together with environmental effects have an influence on product innovation outcome. The most important measures in this area were the variables on product innovation rate and the percentage of revenues from new products. Further, the profits with the whole product range were measured and the break-even point for new products was asked for. Additionally, the managers were asked to describe their stream of new products (e.g., waves, continuous stream). Finally, the managers were directly questioned to explain their business unit position within the diagram product innovation rate and percentage of revenues from new products.

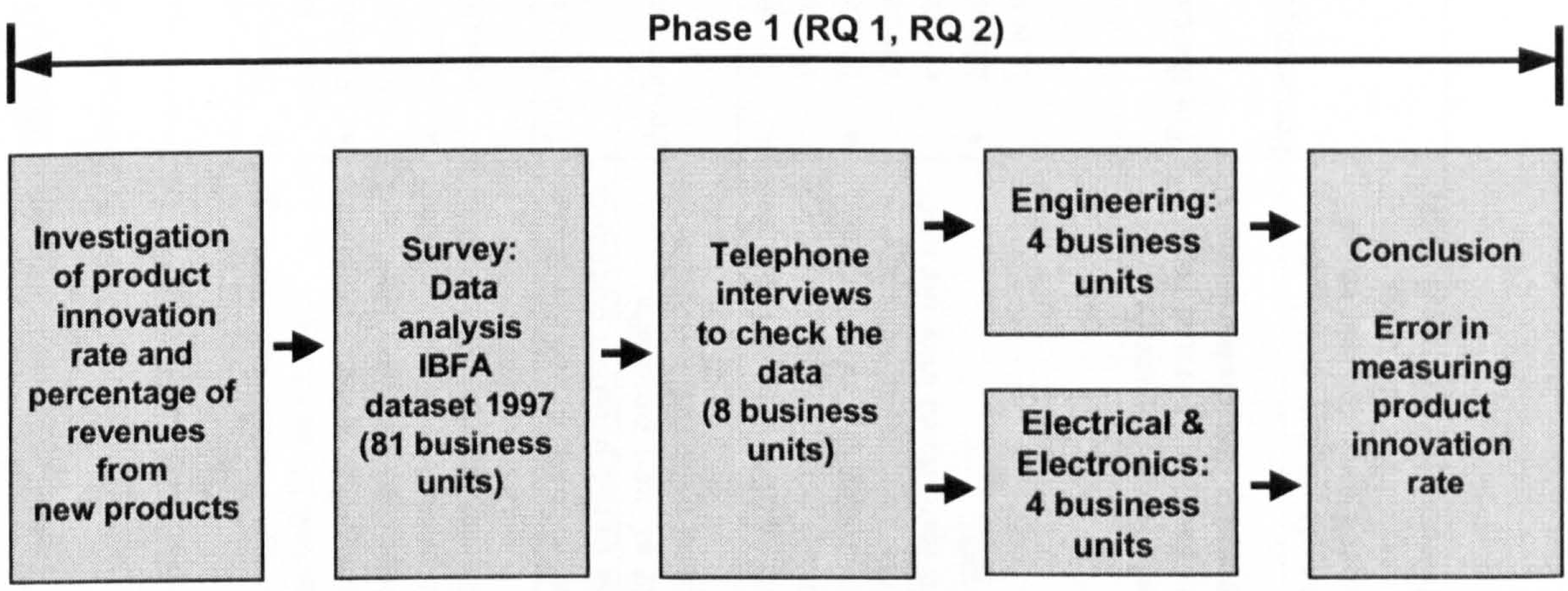
The ways as to how the measures were used for answering the research questions are given in following sections which present the research methodology of Phase 1, 2 and 3 in detail.

4.3 PHASE 1

Phase 1 aimed to investigate product innovation rates and the percentage of revenues from new products in German engineering and E&E sector. In this phase the dataset of International Best Factory Awards was analysed. In Figure 4.6 an overview of Phase 1 is given. This section discuss:

- Research questions and aims
- Methodology
- Sample
- Problems encountered
- Conclusions on Phase 1

Figure 4.6: Research Design - Phase 1



4.3.1 Research Questions and Aims

In Phase 1 the research questions were:

RQ 1: What are the typical product innovation rates of business units in the German engineering and electrical & electronics engineering (E&E engineering) sectors?

RQ 2: How are product innovation rates and the percentage of revenues from new products related (defined as product innovation position)?

To answer the questions the quantitative variables (marked with a "QT") used are given in Table 4.3. For each measure the definition and the advantages and limitations using this measure are given. In the last column the source is listed. From this table it can be seen that both product innovation rate and the percentage of revenues from new products are calculated on basis of two sub-variables. In the IBFA dataset the variable product innovation rate was not asked directly and was calculated on basis of the two variables 1a and 1b. The variable percentage of revenues from new products was asked directly and a calculation with the variables 2a and 2b was not necessary (business units calculated this variable by themselves).

Table 4.3: Variables Investigated in Phase 1

VARIABLES INVESTIGATED IN PHASE 1				
#	Variable	Advantages	Limitations	Source
1 (QT)	**Product innovation rate (average over the last three years)** *Average number of main products introduced over the last three years, expressed as a percentage of the total main product range.*	• Shows how the product range was renewed over the last three years. • Shows if a business unit has the aim to react to market demands with new products. • Shows the ability of a business unit to transform ideas into new products.	• Measurement problems to get valid data. • Says nothing about the quality of the products. • Says nothing about the success of products. • Says nothing about the reasons why product innovations were made / or not made.	Goffin (1997b); Terwiesch et al (1998), Goffin and Pfeiffer (1999).
1a	**Number of main products in the business unit's product portfolio**	For the calculation of product innovation rate the two variables given in 1a and 1b were necessary.		
1b	**Number of new products introduced over the last three years.**	Product innovation rate per year (%) = $\left\{\dfrac{\text{Number of new products introduced over the last three years} \times 100}{\text{Number of main products in the business unit's product portfolio}}\right\} / 3$		
2 (QT)	**Percentage of revenues from new products** *The percentage of sales reported for the last year made with new products introduced over the last three years.*	• Shows the importance of new products in the product portfolio. • Shows how new products are accepted by the customers, i.e., if their development is customer oriented. • Shows if the distribution of new products is working or not.	• Turnover does not automatically mean profits. • It does not say anything about the turnover of specific products. Therefore, one product could be a bestseller while the others are unsaleable items. • Maybe three years are too short for the acceptance of new products to generate significant turnover.	Cooper and Klein-schmidt (1993, 1994); Griffin (1993, 1997); Hultink et al (1997); Chiesa et al (1996); Loch et al (1996); Terwiesch et al (1998); Brennecke et al, (2001).
2a	**Revenues from the whole product portfolio earned for the most recently completed budget year.**	For the calculation of the percentage of revenues from new products the two variables given in 2a and 2b were necessary.		
2b	**Revenues from new products (introduced over the last three years) earned for the most recently completed budget year.**	Percentage of revenues from new products (%) = $\left\{\dfrac{\text{Revenues from new products (introduced over the last three years)} \times 100}{\text{Revenues from the whole product portfolio}}\right\}$		

4.3.2 Methodology

Surveys can include mail and telephone interviews. Kalsbeek (1995) states that "mail, telephone interview, and in-person interview surveys are the most common". Surveys are characterised by questions which are asked from the researcher in a formal manner and a systematic record is made of their responses (Bryman, 1989). The questions could be asked in two different ways. The respondents have the choice of answering the questions in their own way (open-ended questions) or the response choices are pre-provided (closed questions) as Bryman points out. To avoid difficulties in understanding, they have to be asked precise and unambiguous questions, so that all respondents will understand them in the same way. Further, the questionnaire should not be too long because of the limited time of the respondents. Often, the respondents do not take much time to read the questions very carefully and therefore it could be that the questions are misinterpreted. In consequence, the given answers are wrong (Markóczy, 1997).

In order to increase internal validity, Phase 1 combined a survey (IBFA data from 1997) and telephone interviews. A total of 81 questionnaires were analysed in order to get a suitable dataset of product innovation rates. The analysis showed statistically low product innovation rates for all business units. Therefore, the product innovation rates were checked via telephone interviews at eight business units – four business units from engineering and four business units from E&E engineering. Interviews were held with the manager named as the respondent on the IBFA questionnaire. In most cases it was the quality manager who was responsible for answering the IBFA survey within a business unit. However, in some cases the managing director was interviewed. In all interviews product innovation rates were discussed intensively.

Table 4.4: Reliability

#	Validity issue	Action taken in research
1	Adopt or adapt questions that have been used successfully in other surveys (Markóczy, 1997)	Data from questions of International Best Factory Awards were analysed.
2	Check data via telephone interviews (Bryman, 1989; Markóczy, 1997)	Data from International Best Factory Awards were checked for eight business units via telephone interviews (one hour).
3	Use time periods that are related to the importance of the question (Bryman, 1989; Markóczy, 1997)	Product innovation rate and the percentage of revenues from new products were asked for over the last three reported years.
4	Have the questions reviewed with an expert (Bryman, 1989; Markóczy, 1997)	The questions were discussed intensively with managers from eight business units in Phase 1. On the basis of these telephone interviews the questions were improved and were asked in the second (improved) survey (Phase 2).
5	Ask a limited number of questions to increase respondent rate (Kalsbeek,1995)	In the telephone interviews the two variables product innovation rate and percentage of revenues from new products were asked.

To achieve as strong a set of data as possible the chosen research method survey (which includes a mail survey and telephone interviews) had to follow some regularities. Therefore, the reliability issues are given in Table 4.4. For each validity issue identified in the literature the source and the action taken in the research is given.

4.3.3 Sample

The validity of the research is closely related to the sample chosen for the research. Bryman (1989) states that "an important phase in the collection of data is the selection of the units to which the data relate". He suggests the method of probability (or random) sampling to avoid a selection bias, whereby certain units are overrepresented. In order to avoid this limitation, the research used the dataset of the International Best Factory Awards Germany. In this dataset business units from different industries are included. Further, the profile of entrants shows a wide range of business units, including well-known international ones and also small and medium size enterprises (SMEs).

The International Best Factory Awards have been running successfully in Germany in their current format since 1997. The purpose of the award is to recognise and reward management processes. Previous winners and finalists have been described in e.g., Plüskow (1997, 1998) and Anonymous (2002c). However, in addition, to recognising manufacturing excellence, the programme collects detailed benchmarking data on performance from over a hundred manufacturing business units each year. Most of the IBFA participating business units returned the completed questionnaire together with further information such as product-information brochures, business unit reports or special business unit analysis (turnover of product ranges, etc.). This has enabled the creation of an extensive database, against which individual manufacturing business units can be judged. The award is open to any manufacturing "company" and companies can enter more than one business unit for the award and each business unit is treated as a separate entity.

The survey data is used to identify good performance in each of the two chosen industry sectors and a number of business units are selected for visits by a team of judges. These visits are used to audit the top performers who will receive awards. The IBFA programme has played an important role in creating an interest in the manufacturing industry and offers a key benefit for participating business units – they all receive a confidential benchmarking report comparing their performance to other business units in the same sector. The award, the publicity and the benchmarking reports all motivate business units to enter and typically about 100 different business units participate in the programme each year. In order to ensure confidentiality, business units are only identified by a reference number in the database. This database has evolved into a major research tool for the study of manufacturing performance and a range of papers has been published (for further details see: New and Szwejczewski, 1995; Goffin et al, 1997a; Szwejczewski et al, 1998; Pfeiffer et al, 1999; Goffin et al, 2001).

It should be noted that business units in the IBFA databases are not necessarily representative of the German industry as a whole. This is because they are self-selective in their participation in the award programme. It could be assumed that the business units which enter are only those who think they have a chance of winning. However, experience shows that the majority of business units enter because they are interested in benchmarking their performance against similar business units. The fact that the entrants are interested in benchmarking does, of course, indicate that they are aware of the advantages of this practice and so may tend to be better informed business units.

The IBFA questionnaire includes approximately 200 questions in all areas within a business unit – ownership, size, employees, product range, cost structure, market information, business unit branch, etc. Table 4.5 shows some examples of data which are used for gaining some background information on the business units analysed.

Table 4.5: IBFA Data for Product Innovation Analysis (Example Background Data)

Example Factors	Questions	Notes
Ownership, size, employees	A1, A2	Background detail on the profile of the manufacturing business unit.
Product range	B3a	Number of different products currently being produced.
Cost structure	C1, C2	Details of the manufacturing costs; materials, labour, etc.
Product innovation	F1, F2, F3	Refer to Appendix C for a full listing of the IBFA product innovation questions.
Market information	H1 -H5a	Description of products, market positioning, etc.

From the over 200 questions which are asked in a 23 page questionnaire, one page focuses specifically on product innovation and so gives an opportunity for investigating product innovation. The main data collected on product innovation comprises (Appendix C):

- The speed with which new products are developed (termed *cycle time* or *time-to-market*).
- The number of new products launched over the previous three years.
- The percentage of new products which are extensions to existing product ranges and the percentage of products which constitute totally new ranges.
- The number of new products planned over the next three years.
- The total number of products in a manufacturing business unit's portfolio. This figure can be compared with the number of new products to calculate the *product innovation rate* – the percentage of new products in the portfolio which are less than three years old.

As pointed out earlier, Phase 1 involved the investigation of the product innovation data of 110 IBFA entrants from 1997. In this year 78 business units from engineering and 20 business units from E&E and were listed in IBFA. But because of missing data, it was only possible to use the dataset from 63 business units from engineering and 18 business units from E&E engineering of the IBFA dataset (the totality of 81 business units).

Finally, it has to be noted that most of the business units which have taken part in the benchmarking programme International Best Factory Awards are willing to co-operate in further research. Therefore, the database is a good basis to select case business units for conducting in-depth studies. Consequently, this database formed the basis for all three research phases.

4.3.4 Problems Encountered

The main difficulty in this phase were the problems encountered in measuring product innovation rate. The telephone interviews confirmed that the IBFA survey data led to inaccurate product innovation rates. The detailed results of Phase 1 are given in Chapter 5.

4.3.5 Conclusions on Phase 1

Phase 1 was necessary to get an overview of product innovation rates in German manufacturing industries. Referring to the research aims the findings in Phase 1 were:

- To measure product innovation rate and the percentage of revenues from new products of a suitable set of business units.
- Inaccurate measure of product innovation rate. The questions asked in the IBFA questionnaire led to the wrong calculation of product innovation rate.
- Combination of survey and telephone interviews is useful.

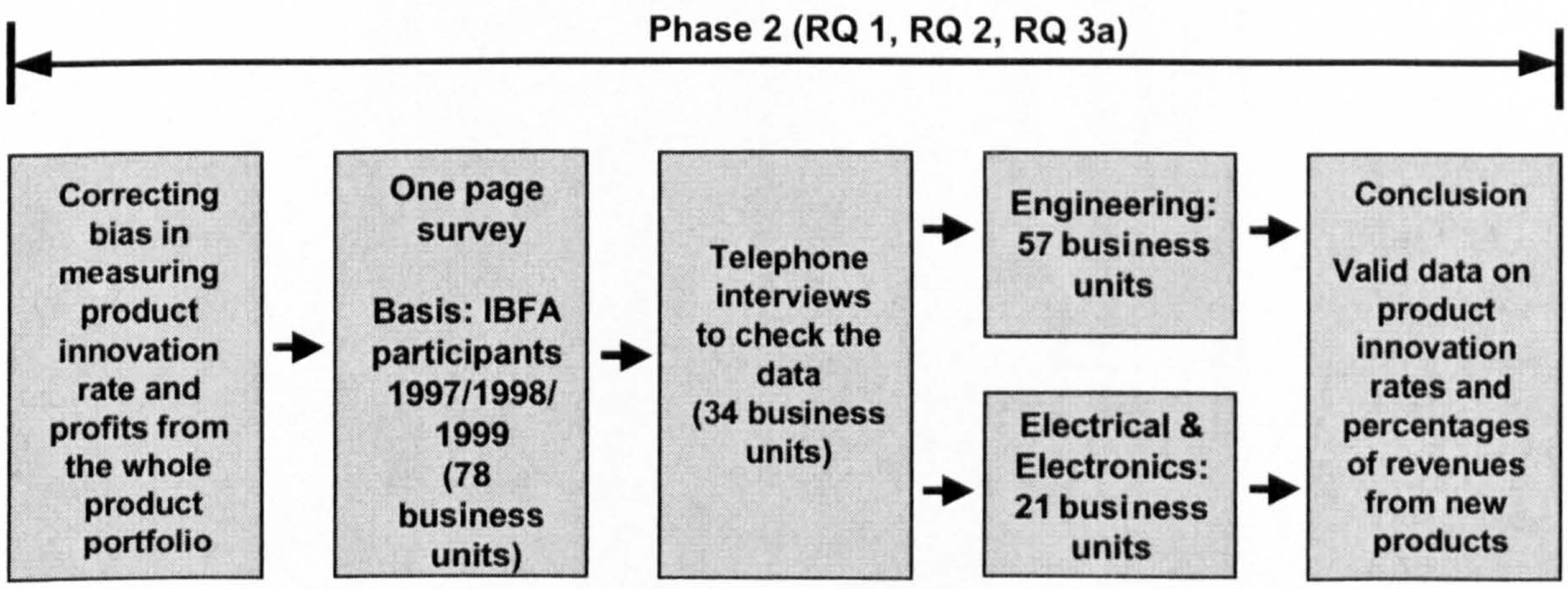
The wrong product innovation rates led to Phase 2, in which the error in measuring the product innovation rate was corrected. The research methodology of Phase 2 is presented in the following section.

4.4 PHASE 2

The most important result in Phase 1 was the identification of the errors in measuring the product innovation rate from survey data. To correct this in Phase 2, a one page postal survey was sent to IBFA participants and telephone interviews were carried out to correct the data. The corrected product innovation rates and percentages of revenues from new products collected in Phase 2 formed the basis for an in-depth investigation of varying product innovation positions (Phase 3). Figure 4.7 gives the first overview over the research activities in Phase 2. This section comprises:

- Research questions and aims
- Methodology
- Sample
- Problems encountered
- Conclusions on Phase 2

Figure 4.7: Research Design Phase 2



4.4.1 Research Question and Aims

The main aim of Phase 2 was to collect valid data on product innovation rate and the percentage of revenues from new products from a sample in the industry sectors engineering and E&E engineering (*RQ 1 and RQ 2*). With the corrected data it was also possible to answer research question three partly:

RQ 3a: How are product innovation positions and profits with the whole product portfolio related?

The quantitative variables investigated in Phase 2 are given in Table 4.6 (marked with a "QT"). As in the same table in Phase 1, for each measure the definition and the advantages and limitations using this measure is given. In the last column the source is listed.

Table 4.6 Variables Investigated in Phase 2

VARIABLES INVESTIGATED IN PHASE 2				
#	**Variable**	**Advantages**	**Limitations**	**Source**
1 (QT)	**Product innovation rate (average over the last three years)** *Average number of main products introduced over the last three years, expressed as a percentage of the total main product range.*	• Shows how the product range was renewed over the last three years. • Shows if a business unit has the aim to react to market demands with new products. • Shows the ability of a business unit to transform ideas into new products.	• Measurement problems to get valid data. • Says nothing about the quality of the products. • Says nothing about the success of products. • Says nothing about the reasons why product innovations were made / or not made.	Goffin (1997b); Terwiesch et al (1998), Goffin and Pfeiffer (1999).
2 (QT)	**Percentage of revenues from new products** *The percentage of sales reported for the last year made with new products introduced over the last three years.*	• Shows the importance of new products in the product portfolio. • Shows how new products are accepted by the customers, i.e., if their development is customer oriented. • Shows if the distribution of new products is working or not.	• Turnover does not automatically mean profits. • It does not say anything about the turnover of specific products. Therefore, one product could be a bestseller while the others are unsaleable items. • Maybe three years are too short for the acceptance of new products to generate significant turnover.	Cooper and Klein-schmidt (1993, 1994); Griffin (1993, 1997); Hultink et al (1997); Chiesa et al (1996); Loch et al (1996); Terwiesch et al (1998).
3 (QT)	**Profits with the whole product portfolio** *The percentage of profits reported for the last year made with the whole product portfolio (new and existing products).*	• Shows how profitable the business unit is. • Shows if the product portfolio is balanced – in terms of having the most profitable product portfolio.	• Does not automatically show profits with new products.	Cooper and Klein-schmidt (1993, 1994); Berth (1997); Terwiesch et al (1998); Brennecke et al, (2001).

4.4.2 Methodology

To get reliable data it was necessary to improve the IBFA questionnaire. The one page survey used in Phase 2 differed from the IBFA questions in two respects. Firstly, it asked for main products and not merely for products generally. Secondly, the respondents were asked to calculate their product innovation rates themselves. The idea behind this self-calculation was that in this way, managers could see their own product innovation rate and thus had the possibility to check whether the numbers were realistic or not. Although the questionnaire was improved it was decided to make telephone interviews, because the experiences of Phase 1 had shown that a lot of managers had difficulties in giving valid figures for product innovation rate.

To obtain accurate data for product innovation rates, the one page questionnaire was sent out to IBFA participants from the engineering and E&E engineering sectors. The questionnaire (see Appendix D) was devised for obtaining information about:

- The total number of "main" products in a manufacturing business unit's portfolio.
- The number of "main" new products launched over the previous three years.
- The product innovation rate as the percentage of new products in the portfolio which were less than three years old (self calculation).
- The percentage of revenues achieved with new products launched over the previous three years.
- The profits made with the whole product portfolio (new and existing products) were taken from Section C of the International Best Factory Awards Questionnaire.

The experiences of Phase 1 showed that a lot of managers had difficulties in defining product innovations – although a definition had been given in the questionnaire: "A significantly new product is one which the business unit has not made previously and which represents more than a simple change of material, colour or design variant". Consequently, 34 telephone interviews (10 hours) were carried out to check the data and to get information from business units which had not replied. From the companies which replied, especially those with extremely high or low product innovation rates were chosen for the telephone interviews. The sample chosen for Phase 2 of the research is presented in the next section.

4.4.3 Sample

Once again the sample was obtained from the International Best Factory Awards. However, the Phase 2 one-page questionnaire was sent out to all companies in the engineering and E&E engineering sectors who participated between 1997 and 1999. Therefore, 148 business units were contacted and asked to give their actual data (reported for 1999). 78 business units replied (a 53% response rate). This high response rate indicates the high interest of the managers into the research.

Table 4.7 gives an overview of the survey respondents, sorted by their IBFA-participation over the years 1997 to 1999. It is interesting that some business units had only been IBFA participants for one year, while others had taken part two or three times. For example, in engineering, the same seven business units participated in IBFA 1997, 1998 and 1999. As some business units had taken part more than once, the answers in the IBFA questionnaires over the years could be compared. A comparison of some business unit's 1997 data with the 1999 data of the same business unit for instance allowed interesting insights about the change of the product innovation position over time.

This data was used to investigate how managers are able to prognosticate their future product innovation rate for their business units. In the IBFA questionnaire the prognosis on the number of new products for the next three years was asked for. For business units who took part in the years 1997 and 1999 the prognosticated product innovation rates can be compared with the real product innovation rates achieved three years later (in 1999).

Table 4.7 IBFA Business Units who gave their Corrected Product Innovation Rates; sorted by IBFA Participation over the Years 1997 to1999

Industry Sector	Participation in one year			Participation in two years			Participation in three years	Σ
	'97	'98	'99	'97/'98	'97/'99	'98/'99	'97/'98/'99	
Engineering	12	11	12	3	5	7	7	57
E&E	4	2	5	1	3	4	2	21
Σ	16	13	17	4	8	12	9	78

4.4.4 Problems Encountered

There are many problems which are encountered when investigating product innovation rates with surveys. Although the questionnaire had been improved in Phase 2, some respondents still had difficulties in understanding what a new product is. A few respondents mixed their number of variants over all products with their new main products. This resulted in the calculation of too low product innovation rates. However, this error was corrected in the telephone interviews.

4.4.5 Conclusions on Phase 2

Phase 2 produced an accurate dataset of product innovation rates and revenues from new products which could be used as a basis for the further research. With this dataset it was possible:

- To position all business units in a diagram with product innovation rate and percentage of revenues as the x and y axes, respectively.
- To investigate the reasons for different product innovation rates and percentages of revenues from new products on a deeper level.
- To investigate the relationship between profits with the whole product portfolio and product innovation rates.
- To select case business units with varying product innovation positions (i.e., low/high product innovation rates and low/high percentages of revenues from new

products) to investigate the reasons for varying product innovation positions on a deeper level.

The chosen research design for Phase 3 is given in the following section.

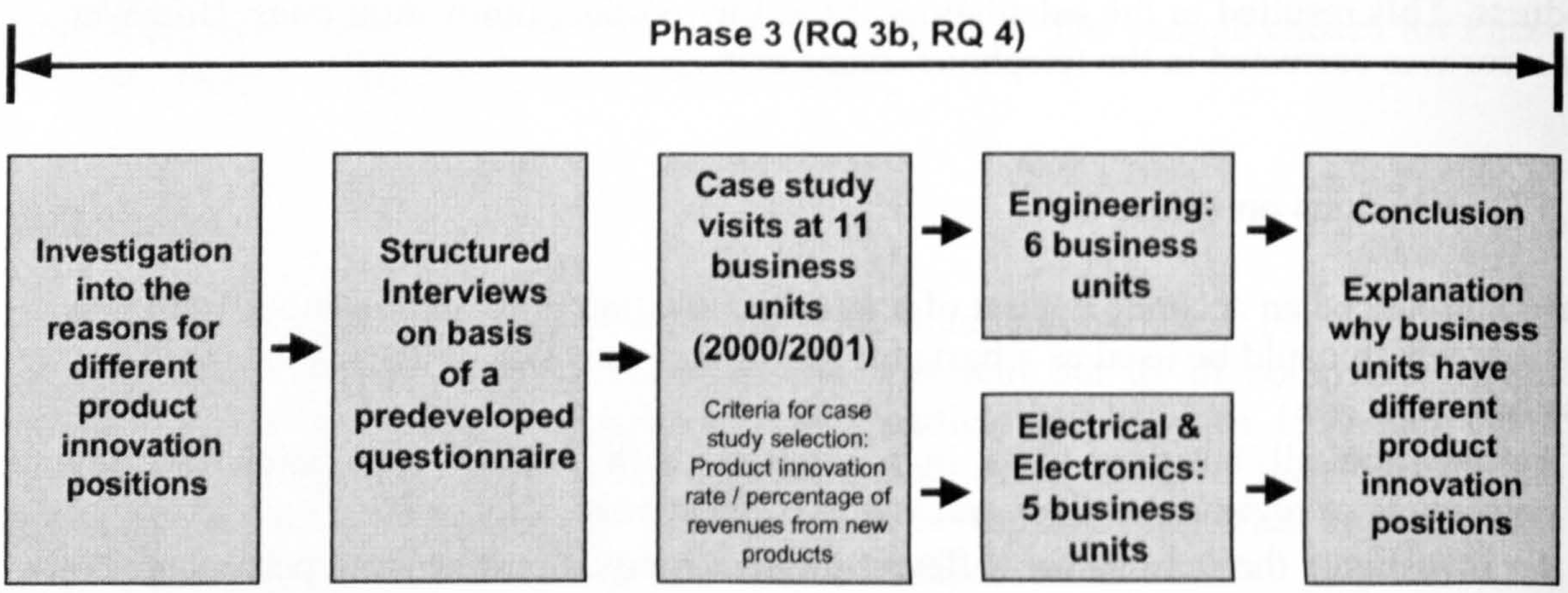
4.5 PHASE 3

Phase 1 and 2 analysed the relationship between product innovation rate and (a) the percentage of revenues from new products and (b) the profits from the whole product range. However, as these two phases used a quantitative approach, they did not give insights into the reasons for varying levels of product innovation rates and percentages of revenues from new products. However, the first two phases generated reliable data from which it was possible to select an appropriate number of business units for case study investigation. Figure 4.8 shows the different steps in the attempt to find answers to the reasons for different product innovation positions.

This section is divided into:

- The research questions and aims
- Methodology
- Validity issues in case study research Phase 3
- Data collection and data analysis
- Problems encountered
- Conclusions on Phase 3

Figure 4.8: Research Design Phase 3



4.5.1 Research Questions and Aims

The aim in this phase was to find out why different manufacturing business units in the same industry sector have different product innovation positions. In detail, the research questions for this phase were:

RQ 3b: *How are product innovation positions and profits with new products related?*

RQ 4: *Why do different manufacturing business units in the industry sectors engineering and E&E engineering act with different product innovation rates and why do they achieve different percentages of revenues from new products (i.e., why they act with different product innovation positions)?*

A diagram of the product innovation rate and the percentage of revenues from new products was used to select 11 business units for case study investigation (see Figure 4.10). These case studies investigated the drivers of product innovation rate (lower and high) and the percentage of revenues with new products (lower and high). For the case visits, a structured questionnaire was designed. During each visit, semi-structured interviews were held with managers with different functions. Holding on-site interviews with managers from various departments ensured that a comprehensive insight view of the reasons for higher and lower product innovation positions within the business units could be developed.

In addition, to qualitative information from the interviews, a set of quantitative data was collected at each case company. The qualitative measures of innovation performance used in the research were selected in a systematic way and are shown in Table 4.9. In summary, 16 (quantitative) variables and 13 questions for gaining qualitative information about the reasons for the individual product innovation positions were used in the case study visits. Quantitative variables are marked with a „QT" and qualitative questions are marked with a "QL'"[47]. For each variable the definition and the advantages and limitations is given. In the last column the source is listed. The selection of variables was based on the literature and a detailed list of all the variables identified from the product innovation literature (given in Appendix F). For each area given in the model of Cooper and Kleinschmidt at least two underlaying variables were identified. An overview of the kind of variables is given in Table 4.8. It has to be noted that the variables have to be discussed intensively with the interviewed managers to get valid information. The methodology used to find out the reasons for different product innovation positions is given in the next section.

[47] For both, quantitative variables (QT) and qualitative questions (QL) the term 'variable' is used. A specification of the variables is given with the acronyms QT and QL.

Table 4.8: Overview Quantitative and Qualitative Variables Investigated in Phase 3

#	Cooper and Kleinschmidt Areas	Number of Variables	
		Quantitative (QT)	Qualitative (QL)
1	Market	2	2
2	Competition	2	2
3	Corporate environment	---	2
4	Nature of Project	1	1
5	New product process	2	1
6	Product innovation strategy	3	3
7	Product innovation output	6	2
8	Σ (= 29 variables)	**16**	**13**

Table 4.9(a): Quantitative and Qualitative Variables used in the Case Study Research (Phase 3)

MARKET				
#	**Variable**	**Advantages**	**Limitations**	**Source**
1 (QT)	**Product life cycle** *Years of a product life from the beginning of market introduction to replacement by a new product.*	• It shows how fast customer demands change over time and how innovative a market is – on condition that a business unit reacts to market demands. • The product life cycle of a product directly influences the product innovation rate.	• Does not show if the cycle time of products is caused by the quality of a new product (good or bad) or by changing customer demands. • Hard to measure accurately	Terwiesch et al (1998).
2 (QT)	**Market growth** *Growth of an industry sector orea branch per year reported as an average over the last three years.*	• Shows how attractive an market is.	• Information from specific branches is difficult to obtain.	Zarah (1993b); Cooper and Klein-schmidt (1993, 1994, 1995); Terwiesch et al (1998).
3 (QL)	**Economical influence** *Are you dependent upon economic conditions (e.g., from branches)?*	• It is helpful to understand the strategy of a business unit • There could be specific economical tendencies with influence on product innovation rates (e.g., laws).	• Based on the personal estimation of the interviewed managers.	Porter (1980, 1990); Terwiesch et al (1998); Zarah (1993b).
4 (QL)	**Technology** *Do new technologies forces your business unit to introduce new products?*	• It shows how new technologies have influence on the replacement of existing products by new ones.	• Based on the personal estimation of the interviewed managers.	Sheth and Ram (1987)
COMPETITION				
5 (QT)	**Market share** *The world-wide volume for the product group in question, divided by world wide volume market size in the last reported year*	• Indicates own position in comparison with competitors.	• Market share data is difficult to obtain and often questionable in terms of accuracy. • Due to the possibility of wrong conclusions, reliability of this measure depends on the quality of the information reported by the respondents.	Cooper and Klein-schmidt (1993, 1994, 1995); Chiesa et al (1996); Voss et al (1996); Terwiesch et al (1998); Janz et al (2000).

Table 4.9(b): Continued

#	Variable	Advantages	Limitations	Source
COMPETITION				
6 (QT)	**Percent market share of the three biggest competitors** *The percentage of competitors sales in the market.*	• Comparing this variable with own market share, gives information about the market position of the investigated business unit. • Shows the competitive position within a market.	• The variable is difficult to obtain because information is often inaccurate. • To compare market shares, competitors have to operate with the same product portfolio. However, this is not always the case.	Cooper and Klein-schmidt (1993, 1994, 1995).
7 (QL)	**Market introduction barriers for competitors** *Are there barriers for new competitors to enter the market?*	• Helps to understand the market position and the innovativeness of new products. • Shows if the business units operate within specific niches.	• The market barriers could be over- or underestimated by the managers.	Cooper and Klein-schmidt (1993, 1994).
8 (QL)	**General competitive situation** *Influence of the general competitive situation on product innovation activities.*	• Shows how the competition in global markets is related to product innovation activities (i.e., the number of new products developed).	• Information is based on the personal estimation of the competitive situation by the respondents.	Gupta and Wilemon (1990), Porter (1990), Zarah (1993b), Loch et al (1996).
CORPORATE ENVIRONMENT				
#	**Variable**	**Advantages**	**Limitations**	**Source**
9 (QL)	**Familiarity** *How is the familiarity between new products and existing products in terms of product type, markets and technologies?*	• Shows how the new products are related to *existing products in terms of customer needs* and technology familiar to the firm. • Shows the focus on core competence.	• This variable has a strong relationship to the strategy field. Therefore, it has to be discussed intensively with the respondents.	Peters and Waterman (1982), Cooper and Klein-schmidt (1993, 1994); Griffin (1997a).
10 (QL)	**Synergy** *How are the synergies of the product innovation activities and the firms resource base?*	• Shows how the resources – internal strengths - within a business unit (marketing, salesforce, manufacturing and plant equipment) are used for new products.	• As most activities can be outplaced, this issue and its influence on product innovation rate has to be discussed intensively with the respondents.	Cooper and Klein-schmidt (1993, 1994).

Table 4.9(c): Continued

NATURE OF NPD PROJECTS				
#	**Variable**	**Advantages**	**Limitations**	**Source**
11 (QT)	**Source of new Ideas** *Percentage of NP ideas created internally (by employees) and externally (e.g., by customers)*	• Shows the ability of business units to fulfil customer demands • Sows the ability to create new products based on both internal and external idea sources.	• Often, is not clear as to where the ideas come from.	Cooper and Klein-schmidt (1993, 1994).
12 (QL)	**Degree of product innovation** *What is the degree of new product innovations[48]?*	• Shows how product innovation is defined within a business unit.	• Difficulty if the degree of innovation is really understood by the interviewed managers.	Iansiti and Clark (1994); Griffin (1997a).
NEW PRODUCT PROCESS				
#	**Variable**	**Advantages**	**Limitations**	**Source**
13 (QT)	**Percentage of projects on time** *R&D projects over the last three years which are on time in comparison to all running projects.*	• Indicator if the project management techniques used by a business unit work. • Shows if the board of management have a realistic view of the complexity of their R&D projects.	• Time goals planned on a large scale. Planned development time is too long – with better management techniques shorter development times are possible.	Adler (1996); Boag (1989); Cooper and Kleinschmidt (1995); Licht et al (1997); Terwiesch et al (1998).
14 (QT)	**Percentage of projects cancelled** *Percentage of R&D projects over the last three years which were cancelled.*	• Shows how good projects are planned or not planned and if the projects (products) are customer demanded or not.	• Does not say anything about the reasons why projects are cancelled.	Chiesa et al (1996); Griffin (1997a).
15 (QL)	**How is the NPD management process organised?** *How is the NPD process defined? What are the problems in the NPD process?*	• Discussing the R&D process with managers gives a better understanding of the relationship between the different Cooper and Kleinschmidt areas. • Especially for business units with low product innovation rates, the NPD process has to be investigated to show the influence on product innovation rate.	• It does not automatically have influence on new product success within a market in terms of turnover and acceptance by customers.	Cooper and Klein-schmidt (1993, 1994, 1995); Griffin (1997a).

[48] The degree of product innovations is discussed in Section 2.1.2 'The Degree of Product Innovation'.

Table 4.9(d): Continued

PRODUCT INNOVATION STRATEGY				
#	Variable	Advantages	Limitations	Source
16 (QT)	**NPD project planning horizon** *Length of time into the future in which new products are planned.*	• Indicator for strategic (long term) planning with regard to a balanced product portfolio.	• A problem involved in this measure could be that the future ideas represent unrealistic projects.	Boag et al (1989); Chiesa et al (1996); Griffin (1997a).
17 (QT)	**Investments into R&D** *The money invested into R&D activities divided by the revenues achieved with the whole product range for the last year reported.*	• Shows the amount of R&D investments which should lead to product innovation.	• Not clear if the money is used effectively. • Different definitions of what is included in R&D costs (i.e., tool construction)	Cooper and Kleinschmidt (1993, 1994, 1995); Boag (1989); Griffin (1997a); Licht et al (1998); ZEW (2000).
18 (QT)	**Percentage of products with the strategy first to market** *Products which are offered earlier in the market as same competitive products.*	• Shows the ability of a plant to transform new technologies into products faster than competitors. • Many business units try to be ahead of their competitors. In the context of this study, it is interesting to investigate whether the number of products with the strategy first to market influences the product innovation rate.	• Does not show if the products make profits. • Does not show if the products are accepted by the customers.	Cooper and Kleinschmidt (1993, 1994); Griffin (1997); Terwiesch et al (1998); Janz et al (2000).
19 (QL)	**Product launch strategy** *What are the aims with new products?*	• This question directly focused on the aims with new products, e.g., price- leadership or technological leadership could be possible strategies.	• Based on the personal estimation of the interviewed managers.	Cooper and Kleinschmidt (1993, 1994); Griffin (1997a).
20 (QL)	**Corporate culture and commitment of the board of management for product innovation** *How is product innovation supported within a business unit?*	• Shows how the board of management supports product innovation activities within a business unit • Shows how human resource management is related to product innovation position.	• The corporate culture is difficult to obtain.	Coopper and Kleinschmidt (1995); Senge (1996); McGourty et al, (1996); Zien and Buckler (1997).

Table 4.9(e): Continued

PRODUCT INNOVATION STRATEGY				
#	**Variable**	**Advantages**	**Limitations**	**Source**
21 (QL)	**Product innovation strategy** *What are the actual product innovation strategies? (Identification of strategies according to the model of Johnson and Scholes)*	• Systematic categorisation of strategies. • Comparison of strategies across-case business units.	• The "really used" strategy is difficult to obtain.	Cooper and Kleinschmidt (1993, 1994, 1995); Johnson and Scholes (1999).
PRODUCT INNOVATION OUTPUT				
#	**Variable**	**Advantages**	**Limitations**	**Source**
22 (QT)	**Product innovation rate (average over the last three years)** *Average number of main products introduced over the last three years, expressed as a percentage of the total main product range.*	• Shows how the product range was renewed over the last three years. • Shows if a business unit has the aim to react to market demands with new products. • Shows the ability of a business unit to transform ideas into new products.	• Measurement problems to get valid data. • Says nothing about the quality of the products. • Says nothing about the success of products. • Says nothing about the reasons why product innovations were made / or not made.	Goffin (1997b); Terwiesch et al (1998), Goffin and Pfeiffer (1999).
23 (QT)	**Percentage of revenues from new products** *The percentage of sales reported for the last year made with new products introduced over the last three years.*	• Shows the importance of new products in the product portfolio. • Shows how new products are accepted by the customers, i.e., if their development is customer oriented. • Shows if the distribution of new products is working or not.	• Turnover does not automatically mean profits. • It does not say anything about the turnover of specific products. Therefore, one product could be a bestseller while the others are unsaleable items. • Maybe three years are too short for the acceptance of new products to generate significant turnover.	Cooper and Klein-schmidt (1993, 1994, 1995); Griffin (1993, 1997); Hultink et al (1997); Chiesa et al (1996); Loch et al (1996); Terwiesch et al (1998); Brennecke et al, (2001).

Table 4.9(f): Continued

PRODUCT INNOVATION OUTPUT				
#	Variable	Advantages	Limitations	Source
24 (QL)	**Individual product innovation position** *How can the individual product innovation position be explained?*	• Respondents were directly asked to explain their product innovation rates and their revenues from new products.	• Based on the personal estimation of the interviewed managers.	Own Conclusions.
25 (QT)	**Profits with the whole product portfolio** *The percentage of profits reported for the last year made with the whole product portfolio.*	• Shows how profitable the business unit is. • Shows if the product portfolio is balanced – in terms of having the most profitable product portfolio.	• Does not automatically show profits with new products.	Cooper and Klein-schmidt (1995); Berth (1997); Terwiesch et al (1998).
26 (QT)	**Profits with new products** *The percentage of profits reported for the last year made with the new products*	• Shows how profitable new products are. • Shows how new products are used to generate profits.	• Does not automatically show profits of the whole business unit (i.e., profits from the whole product portfolio).	Cooper and Klein-schmidt (1995); Berth (1997); Terwiesch et al (1998).
27 (QT)	**Break-even-point (success rate*)** *Time when revenues for a typical new product exceed the investments (met of the financial objectives*).*	• Shows the period of time until a new product makes a profit and the investments are paid.	• The break-even for new products is not measured in every company.	Berth (1997); Griffin (1997a)*.
28 (QL)	**Stream of new products** *How can the stream of new products over the last 5 years be described?*	• Shows how products are introduced over time (waves, permanent stream).	• Based on the personal estimation of the interviewed managers.	Own Conclusions.
29 (QT)	**Business unit growth** *Business growth (given as the average percentile decrease or increase of the turnover) per year reported as an average over the last three years.*	• Shows the ability of a business unit to create new markets or to increase market share.	• Business unit growth dependent upon a good business environment and not from good products. • Turnover increases but profits decrease.	Griffin (1993); Loch et al (1996); Terwiesch et al (1998).

4.5.2 Methodology

The variables (quantitative and qualitative) asked in the case study visits were identified in the literature as useful for explaining the individual product innovation positions. However, before looking into the discussion of the validity issues of Phase 3, more general aspects of research strategies for qualitative research will be discussed.

The rationale for a qualitative approach is summarised in Table 4.10 which shows a set of research methods differentiated into five major research strategies (Yin, 1994). The implications of each strategy are shown on: (a) the type of research questions proposed, (b) the extent of control an investigator has over actual behavioural events, and (c) the degree of focus on contemporary as opposed to historical events. Yin (1994) argues that in some situations all research strategies might be relevant and in other situations two strategies might be considered equally attractive. Yin also points out, that there are situations, in which a specific strategy has a distinct advantage: "For the case study this is when a '*how*' or '*why*' question is being asked about a contemporary set of events over which the investigator has little or no control".

Table 4.10: Relevant Situations for Different Research Strategies (Yin, 1994)

Strategy	Form of research question	Requires control over behavioural events?	Focuses on contemporary events?
Experiment	How, ***why***	Yes	Yes
Survey	Who, what, where, how many, how much	No	Yes
Archival Analysis	Who, what, where, how many, how much	No	Yes / No
History	How, ***why***	No	No
Case study	How, ***why***	No	Yes

The approach of Yin (1994) can be used to explain the rationale for the case study approach used in Phase 3. The main aim of Phase 3 was to identify why business units have different product innovation positions. Yin suggests three different research strategies for '*why*' questions. In detail these three research strategies are:
- Experiment
- History
- Case study research.

Experiment

Investigations of management issues using an experimental approach are difficult because of their complexity and therefore time intensive and expensive. One possibility of examination of product innovation could be an observation of two business units – one which introduces new products and one which does not introduce new products into markets. However, in this case the results could not be generalised because the success (e.g., profits, market share) of each business unit is influenced by different factors (as shown by the areas given by Cooper and Kleinschmidt). For example, a non-innovative business unit operating in a specific branch could be more successful as an innovative company operating in a highly competitive market. A further difficulty is that experiments are constructed for specific research projects and are characterised by the strong involvement of the researcher. Therefore, the risk is high that the results are manipulated by the view (and actions) of the researcher. As this research investigates business units operating on the basis of their own decisions, experiments are not useful for answering the questions of this research project.

History

It is difficult to investigate innovation using historical data. One main problem is, that documentation within organisations is often full of gaps and managers who were involved in a product innovation project, could not be interviewed, because of a change of career or are working for other business units. Further, NPD management processes (e.g., difficulties) could not be investigated with in-depth studies. However, such an in-depth analysis is necessary to gain detailed insights into how product innovation outcome variables (e.g., product innovation rate) are influenced. Therefore, historic research in management often focuses on specific questions, where mainly quantitative data is collected, e.g., number of patents or number of R&D employees.

Case study research

One possibility to avoid the limitations of experimental and historic research is to carry out case studies. Decisions of managers are not manipulated and actual information can be gained from documents and managers. Case studies are able to take into account actual management tendencies, to help managers to understand specific management topics and to give recommendations which are helpful for their daily work.

From the research strategies suggested by Yin (1994) the case study approach was identified as the most appropriate method for investigating the reasons for varying product innovation positions. The particular factors which led to this decision include:

- Limitations of surveys. A postal survey of the issues was considered but rejected. Surveys have a number of limitations. These are for example, the possible ambiguity of questions, the lack of control over who actually answers the questionnaire and potentially low response rates (Moser and Kalton, 1971). Due to the complexity of some of the concepts of product innovation and their emerging nature, the possibility of ambiguous answers was considered to be high.
- Error in measuring product innovation rate. Phase 1 showed an error in measuring product innovation rate within the survey. The reason were the different definitions of new products by managers. Because the number of new products is given anonymously, the variable does not show these different views. This makes it necessary to interview managers for gaining a set of variables based on the same understanding of product innovation.
- Case study approach. Case studies have the advantage of investigating complex areas and they are seen as an appropriate way to address the problems of non-response and ambiguous answers. In this research they help to understand the individual product innovation position of business units, especially the relationship between product innovation rate and revenues from new products. Both variables are influenced by a set of management factors which have to be discussed with managers.

4.5.3 Validity Issues in Case Study Research Phase 3

Case studies take place in a real social world. Therefore, the researcher must be aware that accurate data on *what happened* in any particular situation (including what was believed and interpreted) is collected. To achieve a high validity of the research it is necessary to check the data in different directions. Consequently, validity issues have strong influences on the research design, because "the meanings emerging from the data have to be tested for their plausibility, their sturdiness, their confirmability – that is their validity. Otherwise we are left with interesting stories about what happened, of unknown truths and utility" (Miles and Huberman, 1994).

There are many issues to consider in achieving high-quality case study design but the main ones are construct validity, internal validity, external validity and reliability (Yin, 1994; Easton, 1995; Miles and Huberman, 1994). For the current study, one critical issue is the validity of collecting information about (product innovation) strategies from managers. Because much of the information must be obtained from few informants, it is extremely important that the data collected being as accurate as possible. Huber and Power (1985) offer guidelines, applicable to studies involving either interviews or written questionnaires. Together with the four case study issues identified by Yin, validity issues for strategy are discussed in the following paragraphs. For example, being aware of problems and limitations with retrospective reports can reduce inaccuracies and minimise misinterpretation of results.

These five issues identified above, have been commonly used to establish the quality of any empirical social research. "For case studies, an important revelation is that the several tactics to be used in dealing with these tests should be applied throughout the subsequent conduct of the case study, and not just at the beginning" (Yin, 1994). In this sense design work actually continues beyond the initial design plans Table 4.11 shows the five issues and gives a summary of case study tactics and the stage of research in Phase 3 in which the tactics occur:

- Validity of investigating strategy: Interviewing respondents with background knowledge of strategy to ensure that the data is realistic.
- Construct validity: Development of a sufficiently operational set of measures and usage of objective judgements to collect the data.
- Internal validity: Establishing a cause in the relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships (for explanatory or causal studies only, and not for descriptive or exploratory studies).
- External validity: Deals with the problem of knowing whether a study's findings are generalisable beyond the immediate case study.
- Reliability: The objective of this test is to be sure, that if a later investigator followed exactly the same procedures as described by an earlier investigator and conducted the same case study all over again, the later investigator should arrive at the same findings and conclusions.

Table 4.11: Tactics Adapted to Address the Five Design Issues based on Yin (1994), Power (1985), Miles and Huberman (1994)

Issues	Case study tactic	Stage of research in Phase 3 in which tactics occur
Validity in the strategy field	Choose informants who have knowledge about strategy	Research design
	Develop case study data base	Data collection
Constructive validity	Use multiple sources of evidence	Data collection
	Establish chain of evidence	Data collection
	Have key informants review draft case study report	Data composition
Internal validity	Do pattern matching	Data analysis
	Do explanation-building	Data analysis
	Do time-series analysis	Data analysis
External validity	Use replication logic in multiple case studies	Research design
Reliability	Use case study protocol	Data collection
	Develop case study data base	Data collection

The 'Strategy' Issue

Because of the complexity and involvement of many factors, strategy needs a well defined research method. Johnson and Scholes (1999) state that "strategic analysis is concerned with understanding the strategic position of the organisation in terms of its external environment, internal resources and competences, and the expectations and influence of stakeholders". Strategy research in the opinion of Tidd et al (1997) first concerns the practice of corporate strategy, which should be seen as a form of corporate learning from analysis and experience on how to cope more effectively with complexity and change. However, they pointed out that successful management practice is never fully reproducible. They stated that "in a complex world, neither the most scrupulous practising manager nor the most rigorous management scholar can be sure of identifying – let alone evaluating – all the necessary ingredients in real examples of successful management practice". For Kaplan and Norton (2001) strategies consist of hypotheses which are just assumptions about how the world works. They need to be continually tested for their validity and rejected when evidence accumulates that expected linkages are not occurring.

To achieve a high validity in the strategy field several models and guidelines are presented in the literature. For example, Huber and Power (1985) developed a guideline as to how interviews with managers can be used to gain information about a company's strategy. Other frameworks for identifying strategy are based on hypothesis testing (e.g., Hofer, 1975; Segev, 2000) or on cultural factors as symbols or rituals (e.g., the cultural web of Johnson and Scholes, 1999). The most important case study issues for strategy research are presented in Table 4.12.

Table 4.12: Validity in the Strategy Field

#	Validity issue	Action taken in Phase 3
1	Choose informants whose unique biases or lack of knowledge are likely to offset those of other informants (Huber and Power, 1985).	Interviews with three persons were held – managing director, R&D manager and marketing manager within a business unit.
2	Recognise that the person's emotional involvement with a topic or unit of analysis may either increase or decrease the accuracy of the responses (Huber and Power, 1985).	Key informants with different views and different involvement with the topic were chosen. Key questions were asked of all informants to gain as valid data as possible.
3	Motivate the informants to co-operate with the researcher (Huber and Power, 1985).	Usefulness of the research for their business unit was explained. Other managers got a summary of the results.
4	Consider how the framing of questions will affect the informant's responses (Huber and Power, 1985).	Questions based on empirical studies from other researchers. However, questions were proven in this direction.
5	Use questions that are pretested, structured and that impart an image of being rich in information content (Miles and Huberman, 1994)	Questionnaire was tested in a pilot study where it was ensured that the original questions were understood and the answers were complete.
6	Consider using tandem interviewing – suggested when a tape recorder is not used (Yin, 1994; Miles and Huberman, 1994)	All interviews were recorded on tapes.
7	Framework for categorisation of product innovation strategies (own conclusion)	The model "Directions for Strategy Development" offered by Johnson and Scholes, (1999) was used.

Construct Validity

Construct validity is concerned with how the chosen research method fits with the research aims, and how the method works to answer the research question. Further, it refers to the ability of the variables chosen for investigation to answer the research questions (Dane, 1990). Table 4.13 shows the key validity issues and the used research methods (actions) to achieve them

Table 4.13: Construct Validity

#	Validity issue	Action taken in Phase 3
1	Framework for the research (own conclusion)	Using the Cooper and Kleinschmidt model (1993) as a framework.
2	Does the research method and the variables chosen give answers to the research questions? (Miles and Huberman, 1994)	The research method was developed on basis of a systematic literature review. The variables were chosen in a systematic way from the product innovation literature.
3	Encouraging convergent lines of inquiry (Yin, 1994).	Using multiple sources of evidence. In the case studies information from two to three managers was collected. Additionally, business unit descriptions (e.g., brochures) were analysed.
4	Is the methodology clear and does the reader trust the research activities (Yin, 1994; Miles and Huberman, 1994)	Establishing a chain of evidence. Explanation of linkages between the Phases 1, 2 and 3 and the facts which have led to case study research. Detailed information on how the case studies were conducted and how the data was analysed.
5	Are the case study descriptions presented in clear and understandable way (Yin, 1994)	Draft case study reports were reviewed by key informants. Drafts were sent to the interview partners and they were asked for their comments.

Internal Validity

In order to maximise internal validity, multiple sources of data were used. The question is truth value: Do the findings of the study make sense? Are they credible to the people we study and to our reader? (Miles and Huberman, 1994). Table 4.14 shows some important actions to achieve internal validity.

Table 4.14(a): Internal Validity

#	Validity issue	Action taken in Phase 3
1	Does the account "ring true?" (Miles and Huberman, 1994)	Multiple sources of data were used - triangulation with informants views against organisation documentation.
2	Weighing the evidence - deciding which kind of data is most worthy (Miles and Huberman, 1994)	Triangulation; getting feedback from informants
3	Observer bias (Yin, 1994; Miles and Huberman, 1994)	Triangulation with several data collection methods – interviews and measures. It was asked for the feedback from informants – discussion of the interview summary.
4	Do patterns coincide? (Yin, 1994).	Pattern matching and explanation-building were made. Qualitative (open questions) and quantitative (variables) information was collected in the cases.
5	What is the time effect on the results? (Yin, 1994).	Case studies were conducted in 2000 and 2001. Therefore, the economical conditions for this time period (i.e., product innovation activities in German, situation in the two chosen industry sectors) are described in detail.
6	Handling the complexity (own conclusion)	One day visits, telephone interviews after the first analysis and if necessary, a further case visit was carried out. Interviews with two to three managers in each business unit.
7	Selection method of case studies (Miles and Huberman, 1994)	Business units were selected at random within the diagram "product innovation rate and revenues from new products".
8	Using independent variables (Cooper, 1984)	Concentration on 29 variables identified from he product innovation literature.

Table 4.14(b): Continued

#	Validity issue	Action taken in Phase 3
9	Establishing suitable operational measures for the concepts being studied (Miles and Huberman, 1994)	The questionnaire for data collection based on the experience gained in Phase 1 and 2 and on previous literature, i.e., the model of Cooper and Kleinschmidt (1993)
10	Checking the meaning of outliers; understanding every level of product innovation management (Miles and Huberman, 1994)	Extreme cases were selected, e.g., business units with high product innovation rates and low revenues with new products.
11	Checking of the results after a length of time (Miles and Huberman, 1994)	Careful documentation: Interviews were recorded on tapes and were written down.

External Validity

External validity handles the question whether the conclusions of a study have any larger import and if they are transferable to other contexts. Table 4.15 summarises some of these points.

Table 4.15: External Validity

#	Validity issue	Action taken in Phase 3
1	Possibility of generalising the results and transformation to other contexts (Miles and Huberman, 1994)	Investigation of two industry sectors and 11 cases: Engineering (six cases) and E&E engineering (five cases) to get meaningful results. Outliers were investigated.
2	Confirming survey data (own conclusion)	Data was checked in the case study interviews.
3	Confirmatory with prior theories (Miles and Huberman, 1994)	Investigation of the Cooper and Kleinschmidt model to show the relationship between different management areas to explain different product innovation positions
4	Is everybody able to follow the described research design? (Yin, 1994)	As many steps as possible were made operational – clear description of the research design.
5	Number of cases which would give confidence in analytic generalisation (Miles and Huberman, 1994).	"...Not more than 15 cases... because a study with more samples" can become unwieldy... there is too much data to scan visually and too many permutations to account for" (Miles and Huberman, 1994). For the research 11 cases were chosen.
6	Looking for negative evidence and ruling out superior relations (Miles and Huberman, 1994)	Outliers were investigated

Reliability

"The underlying issue here is whether the process of the study is consistent, reasonably stable over time and across researchers methods" (Miles and Huberman, 1994). In Table 4.16 some validity issues for reliability are given.

Table 4.16: Reliability

#	Validity issue	Action taken in Phase 3
1	Documentation (Yin, 1994).	Case study protocols were used. Interviews were held via taped and structured interviews. A case study data base was developed. Interviews were written down and collected within a word- document.
2	Are research questions clear? (Miles and Huberman, 1994)	Research questions were discussed with the review panel and managers.
3	Do findings show meaningful parallelism across data sources? (Miles and Huberman, 1994)	Statements from different interview partners within a business unit were compared. Information from brochures was checked with qualitative statements.
4	Were coding checks made and did they show adequate agreement? (Miles and Huberman, 1994)	Coding was carried out.

4.5.4 Data Collection and Data Analysis

In total 11 business units were visited and over 30 hours of interviews were transcribed in Phase 3. The managers interviewed were asked to supply background data about the business unit and to specify the immediate reasons for their product innovation positions. As a framework for the interviews a semi-structured questionnaire was used. Each case study visit was based on a 11 page interview-questionnaire. In all case study visits, 29 product innovation variables were covered. Further, background information of the business's product innovation activities were collected. This data was used to do in-depth-analysis. However, to get a detailed understanding about the context, general information about the business units were collected, too. Two to three managers in each business unit were interviewed:

- Managing director
- R&D manager
- Marketing manager (only if there was the possibility for an interview).

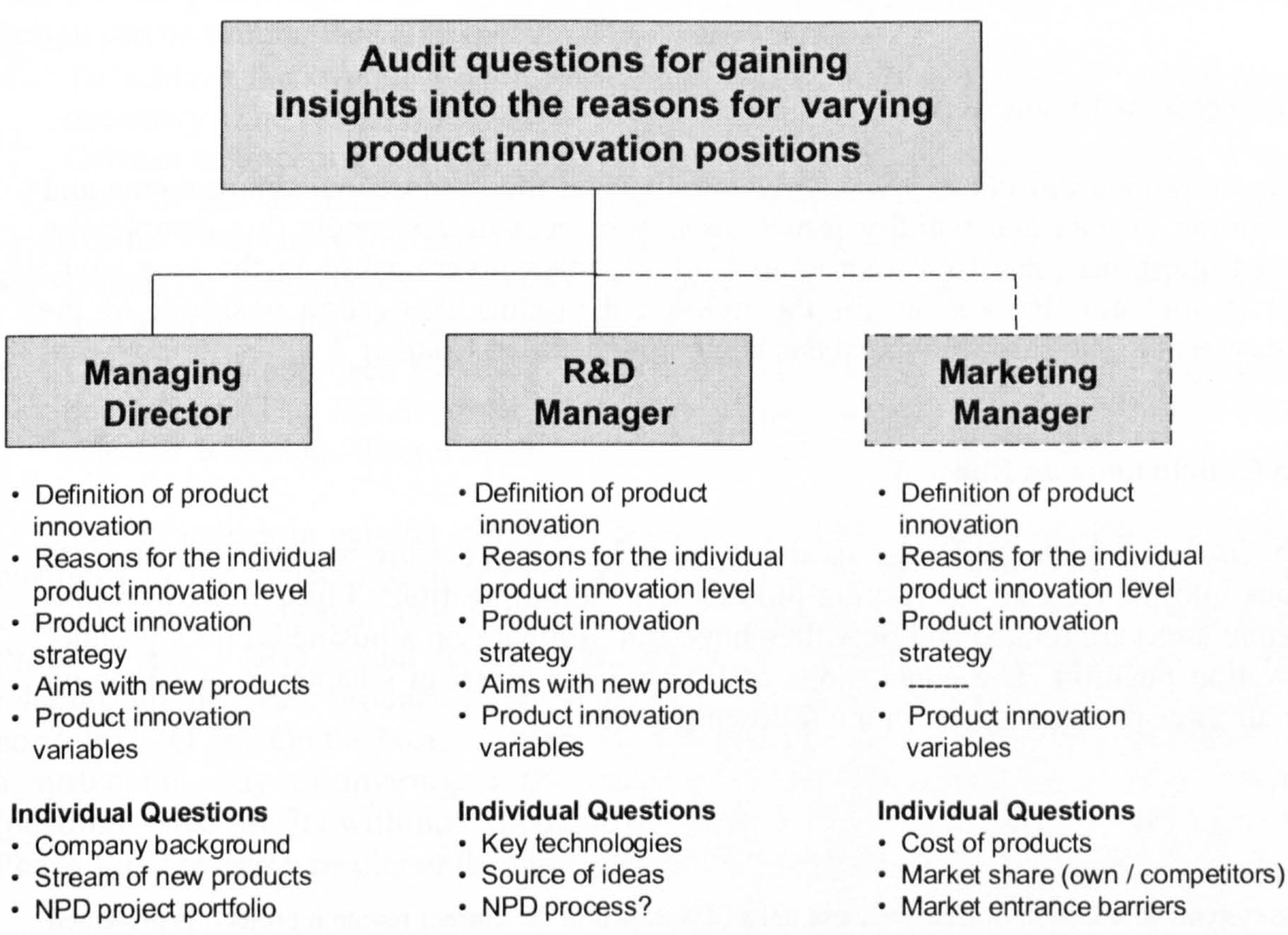
Based on the model of Cooper and Kleinschmidt (1993) the managers were asked a series of variables (Figure 4.9). To make the interview more efficient, the questionnaires with the quantitative variables were sent to the business units one week before the interviews took place. With this procedure the managers had the opportunity to collect the data without time pressure. In consequence, more time could be spent discussing the variables intensively.

Additionally, qualitative data was collected in the interviews (the structured questionnaire used for the case interviews is given in Appendix E). Due to the fact that the focus of this phase was on the drivers for product innovation positions, the managers were mainly asked to give the reasons for their product innovation rates, their percentages of revenues from new products and why they are introducing new products into the market. Further, they were asked to explain how the product innovation rates varied over time (i.e., increased, decreased or stayed at the same level). The framework for the audit is given in Figure 4.9, which indicates the questions asked of each of the three respondents (managing director, R&D manager and marketing manager).

All information from the various interviews had to be structured to identify the reasons for different product innovation positions. This was carried out in three stages:

1) *Within-case analysis.* Each case was reviewed separately and the data was analysed to give a complete picture of the business unit's approach to product innovation. To check the internal validity of the data, triangulation was applied: between different respondents; as well as between respondents' comments and business unit documentation. In certain cases, telephone calls to the original interviewees were necessary to double-check the data.
2) *Data reduction.* This was performed by writing two to three page case descriptions on each business unit. According to the Cooper and Kleinschmidt model the following main headings were used: *Business Unit Background; Product Characteristics; Market, Competition, Corporate Environment; Nature of Product Innovations; New Product Process; Product Innovation Strategy; Product Innovation Output; Key Drivers for the Individual Product Innovation Position.*
3) *Cross-business unit analysis.* Analysing the diagrams including the relation between product innovation rates and the percentage of revenues with new products, it was realised that different fields could be created. These fields were then compared to analyse the differences within the business units. The case descriptions were used as the basis for cross-case comparisons, to determine where similarities and differences existed (Yin, 1994; Miles and Huberman, 1994). In particular variables explaining specific product innovation positions were identified.

Figure 4.9: Phase 3: Framework for an Audit for Gaining Insights into the Reasons for Varying Product Innovation Positions



4.5.5 Sample

The sample size was 11 business units and Figure 4.10 illustrates the structure of this sample. The case business units were selected in systematic way[49] by separating the whole sample size into categories of low and high product innovation rates and low and high percentages of revenues from new products. The sample consisted of:

Six manufacturing business units in the engineering sector:

- Three business units identified as having high product innovation rate and high percentages of revenues with new products.
- One business unit identified as having high product innovation rate and a low percentage of revenues with new products.
- One business unit identified as having low product innovation rate and a high percentage of revenues with new products.
- One business unit identified as having low product innovation rate and a low percentage of revenues with new products.

Five manufacturing business units in the E&E engineering sector:

- Two business units identified as having high product innovation rate and high percentages of revenues with new products.
- One business unit identified as having high product innovation rate and a low percentage of revenues with new products.
- One business unit identified as having low product innovation rate and a high percentage of revenues with new products.
- One business unit identified as having low product innovation rate and a low percentage of revenues with new products.

4.5.7 Problems Encountered

The main problem in Phase 3 was the complexity of the product innovation theme and the volume of data and validity issues already discussed. To handle this complexity, focused questions (based on a structured questionnaire) were asked in the case study visits to find out the reasons for the individual product innovation positions of the business units. The case study analysis is given in detail in Chapter 7.

4.5.5 Conclusions on Phase 3

With the research methodology used in Phase 3 it was possible to carry out in-depth studies into the reasons for varying product innovation positions. Phase 3 showed how different areas are related and how they have can influence on a business unit's product innovation position. The conclusions of Phase 3 are given in Chapter 8. A summary over all three phases is given in the following section.

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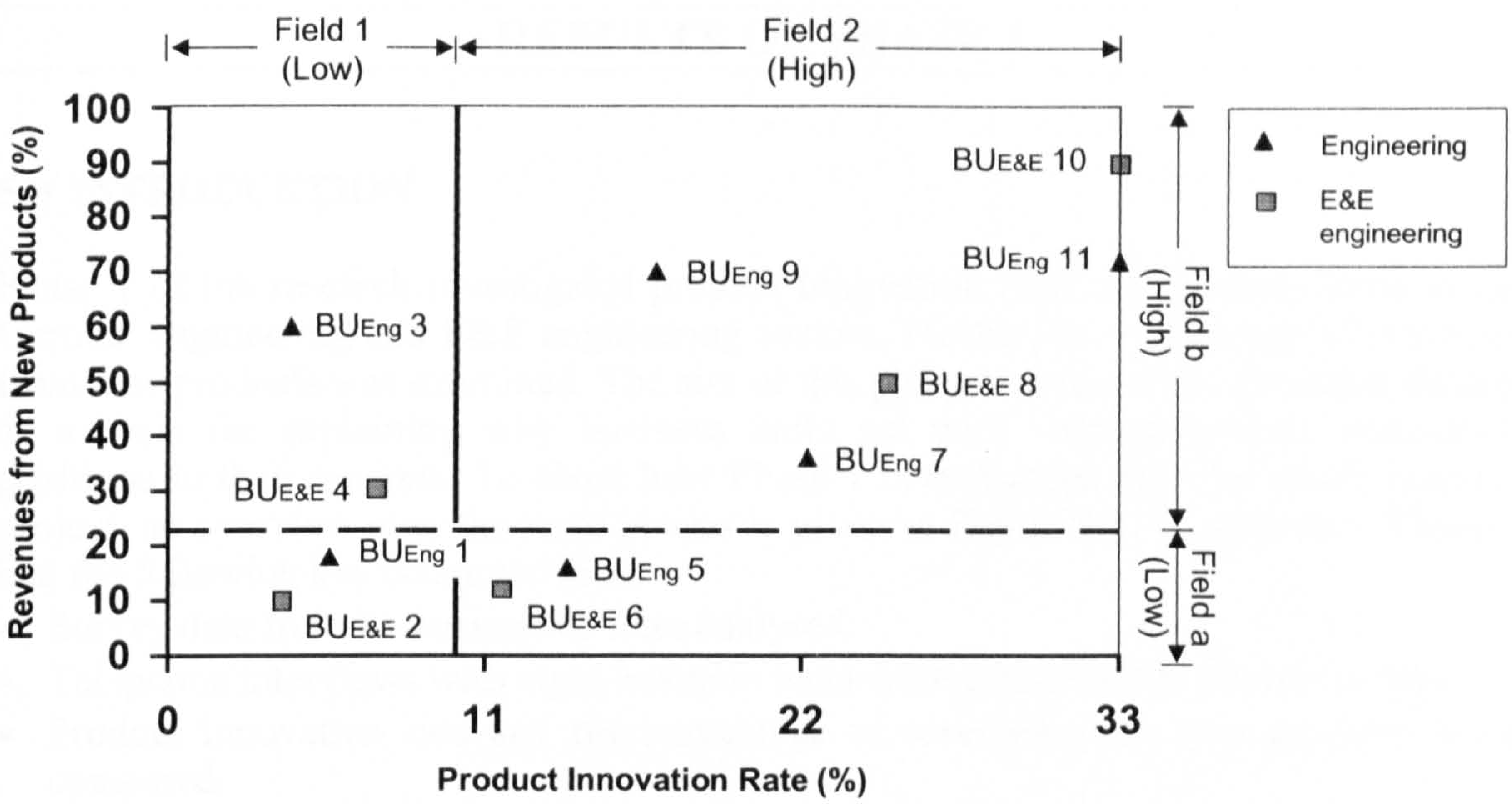
[49] The systematic selection of case business units (developed in the current research project) is presented by Harrison (2002) as a method to identify business units for deeper case-based research.

Figure 4.10: Sample Size for Phase 3



4.6 SUMMARY

In this study a strong emphasis was placed on developing an effective research design. This was necessary, because many management factors influence product innovation rate and the percentage of revenues from new products. Key elements of the research design can be summarised with the following three points:

- To achieve the overall project aims, a process extending over three phases was necessary. The research started with investigations of product innovation rates in German engineering and E&E engineering sectors, followed by a correction of the error in product innovation rates. The third phase focused on the question why business units have different product innovation positions.
- Overall, a combination of different research methods (surveys and case studies) was used to obtain insights on a comprehensive level.
- Overall, the approach of using quantitative and qualitative research methods is positivistic. The IBFA contained a broad dataset and case business units were selected at random. Therefore, the research had an objective approach.

The difficulties in gaining insights into the reasons for different product innovation positions in the industry sectors engineering and E&E engineering are shown by the complex research design. The corrected dataset of product innovation rates gained in Phase 1 and 2 (RQ 1 and RQ 2) were the basis for further investigations in the relationship between product innovation rates and profits with the whole product portfolio (RQ 3a). On the basis of Phase 2 it was possible to select case business units in a systematic way to investigate the reasons for varying product innovation rates (positions) and profits with new products in Phase 3 (RQ 3b and RQ 4). Starting with Phase 1, the research results of the three phases are presented in the following chapters.

PAGE

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CHAPTER FIVE

RESULTS OF PHASE 1

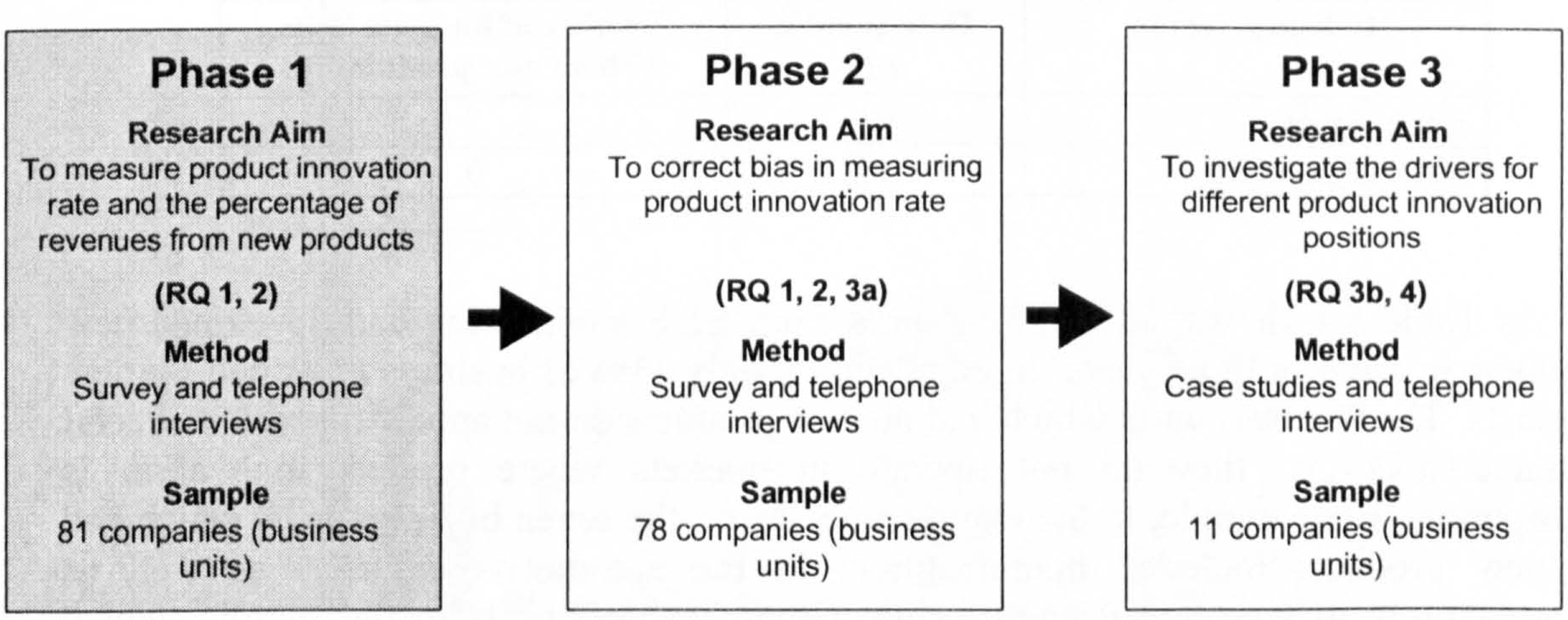
5.0 INTRODUCTION

Phase 1 of the research investigated product innovation rates for business units in the German engineering and E&E engineering sectors. Further, the percentage of revenues from new products was examined. The aim of this phase was to collect a suitable dataset as a basis for explaining why business units act with varying product innovation positions in their markets. To show how Phase 1 is embedded into the whole research project, an overview over the three phases is given in Figure 5.1. In summary, Phase 1 had the following key characteristics:

- Survey data from 81 businesses were analysed.
- Telephone interviews with eight business units were carried out to check the data.
- Product innovation rate and the percentage of revenues from new products were compared.

This chapter first describes the survey results based on the IBFA German database from 1997. In the next section, the main findings from the telephone interviews are presented – these interviews identified an error in measuring product innovation rate and this error was corrected for the eight business units where interviews were conducted. In the following section further information from the IBFA dataset was analysed. In the last section a summary of the results of Phase 1 is given.

Figure 5.1: Classification of Phase 1 within the whole Research Project



5.1 SURVEY RESULTS

The two sectors chosen for the study – engineering and E&E engineering – form an important part of Germany's manufacturing industry. The 1997 IBFA database that was used for this phase contains information from a total of 98 business units – 78 in the engineering sector and 20 in the E&E engineering sector. Of this dataset, only 81 business units answered all the questions in the IBFA section focusing specifically on product innovation. Therefore, only a sample of 63 business units in the engineering sector and 18 business units in the E&E engineering sector were available for this analysis. A broad range of business units in each industry sector were represented, both in size and product range. Following areas were investigated:

- Product innovation rate
- The percentage of revenues from new products
- The relationship between product innovation rates and the percentage of revenues from new products

5.1.1 Product Innovation Rate

Previous research by BMBF (2000) showed that 25% of the German manufacturing companies had not introduced any new products in the previous three years. In the IBFA dataset the number of business units with no new products is lower. The fact that only 9% of all of the business units taking part in the IBFA competition in 1997 had not introduced new products into the market (Table 5.1) shows that the importance of product innovation seemed to be recognised by most business units.

Table 5.1: Business Units without New Products in the Past Three Years (IBFA dataset 1997)

Industry Sector	Data sample (n)	Number of business units with no new products (n)
Engineering	63	7
E&E engineering	18	0

As Table 5.1 shows, all business units from E&E engineering had developed new products in the past three years. In engineering, only 11% of business units had no new products. The business units which had no new products do not appear to exhibit special characteristics i.e., they do not operate in markets where product innovation is unimportant. For example, in the engineering sector, the seven business units which had no new products included manufacturers in the automotive industry as well as manufacturers in mechanical engineering. Other business units in the sample, which operate in the same or similar markets, had all introduced at least one new product in the previous three years.

Figure 5.2: Product Innovation Rates (%), Engineering
(63 business units – data from 1997 IBFA database)

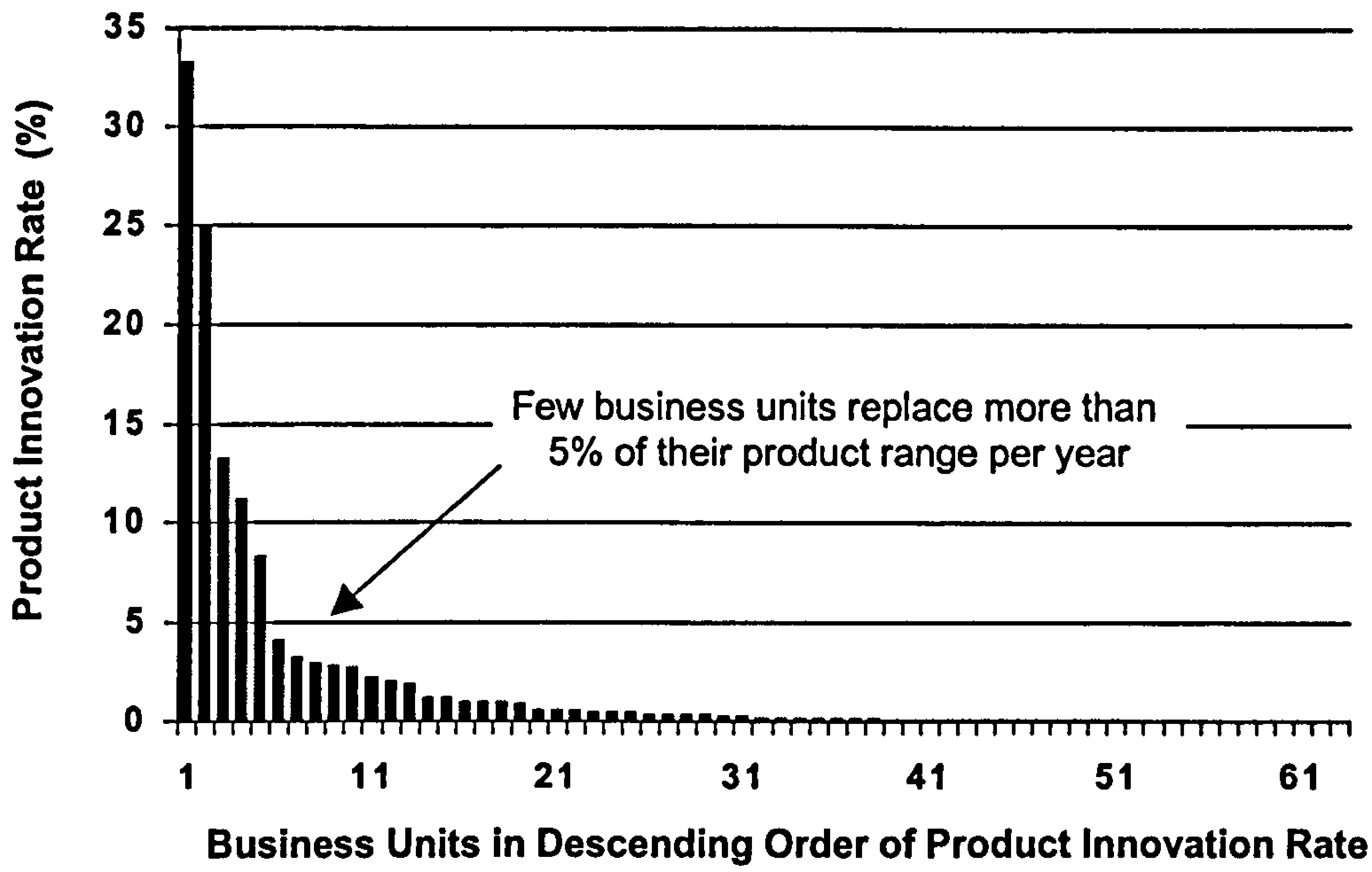
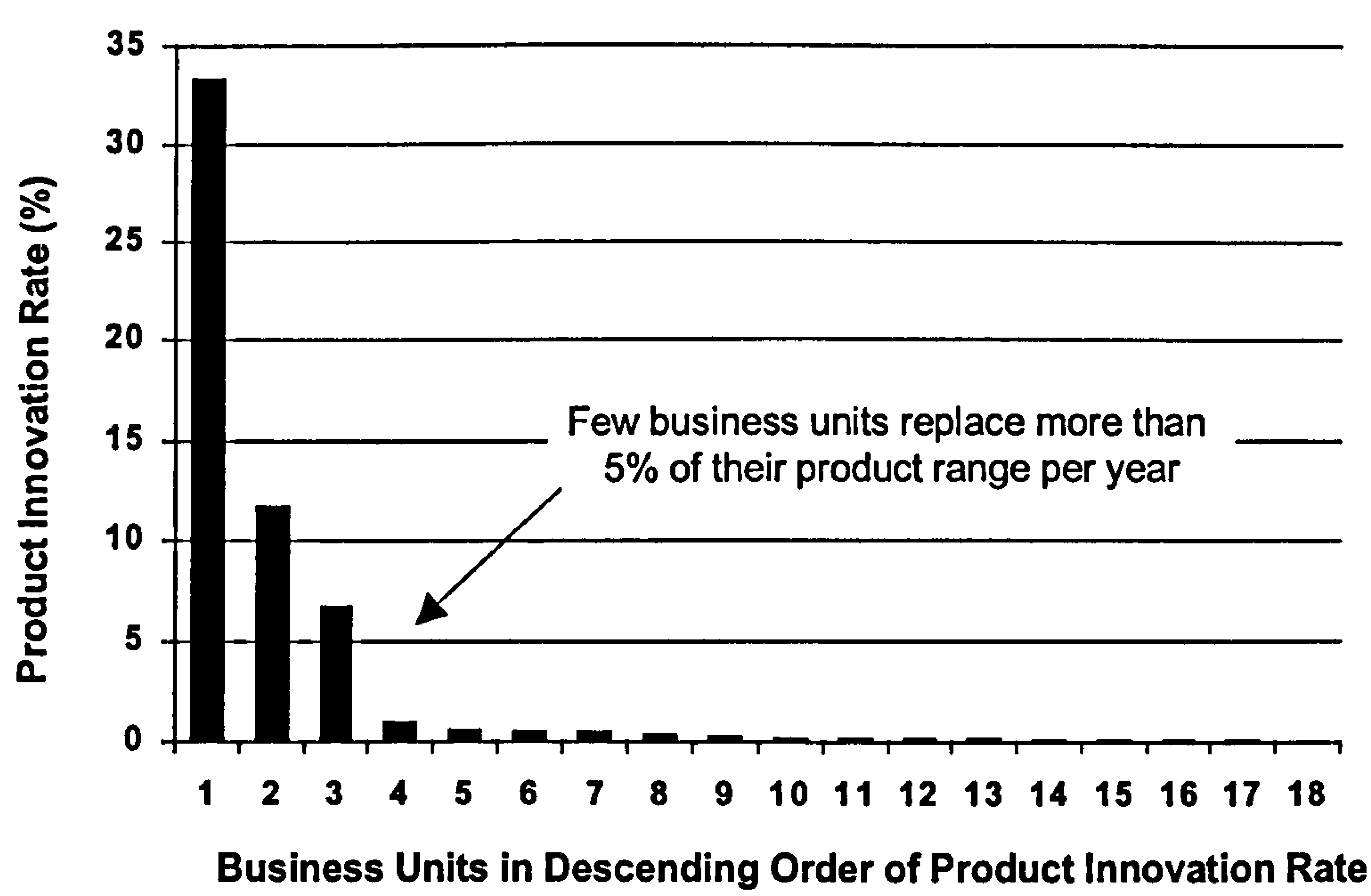


Figure 5.3: Product Innovation Rates (%), E&E Engineering
(18 business units from 1997 IBFA database)



Now, that it has been established that most business units in the IBFA sample had introduced new products, it is interesting to look at the rate of product innovation. *Product innovation rate* is defined as the percentage of new products in a business unit's product portfolio which are less than three years old. This figure can be calculated from the IBFA dataset given in the following two diagrams.

Figures 5.2 and 5.3 show the product innovation rates for each of the business units in the engineering and E&E engineering sectors respectively. In the diagrams, business units are shown with a descending product innovation rate along the x-axis, with product innovation rates given as the percentage per year of the portfolio that has been replaced over the previous three years (y-axis). The maximum product innovation rate for both industry sectors is 33%, corresponding to a business unit that has renewed its complete range of products over the previous three years. For the 63 business units given in Figure 5.2, it can be shown that only a few (five of 63) replace more than 5% of their portfolio per year. Figure 5.3 shows a very similar distribution, with three from a total of 18 business units innovating at a rate higher than 5% per year. Therefore, it would appear that many business units are not that innovative and product portfolios are, in most cases, only slowly replaced. Therefore, it was interesting to look at the role of new products in generating revenue.

5.1.2 Revenues from New Products

With rapidly changing markets and shorter product life cycles, many business units need to introduce more new products. In consequence, revenues from new products are fundamental. On average new products are responsible for more than a quarter of the revenues in the engineering sector. Table 5.2 shows that for the 63 business units for which there is data, an average of 26% of the revenues comes from new products. In the E&E engineering sector, the average earnings through new products are 31%. In comparison to product innovation rate (which is very low for most business units) the revenues gained with new products is very high. This indicates that new products contribute significantly to the revenues. Therefore, the implication of Table 5.2 is clear: business units need to focus strongly on developing a steady flow of new products to ensure their revenue streams.

Table 5.2: Revenues from New Products (IBFA database 1997)

Industry Sector	Sample Size (n)	Average Revenues from New Products (%)
Engineering	63	26%
E&E engineering	18	31%

It could be assumed that the business units that earn fewer revenues from new products are situated in slower moving, more conservative markets, in which case it could be argued that the importance of new products varies by market and that in certain markets it is not as important to develop them regularly. However, further inspection of the IBFA data shows that this is not the case. Similar business units operating in the same market exhibit vastly different revenues from new products.

Apart from the average values for revenues generated by new products (see Table 5.2), it is useful to look at the differences between business units. For the 63 engineering business units an average of 26% of revenues comes from new products. Figure 5.4 shows the revenues earned from new products for the 63 engineering business units (in ascending order along the x-axis). It can be seen that 23 business units earn more than 20% of their revenues from new products. Figure 5.5 shows a similar structure for business units in the E&E engineering sector. On average 31% revenues are generated from new products. Comparing the two graphs reveals that revenues from new products are equally important in each sector.

Although revenues from new products play a key role, the manner in which new products contribute to profits also requires further investigation. For example, it could be that business units with a low percentage of revenues from new products have higher profits than business units with a high revenue from new products. However, for an answer to this question a further inspection of the IBFA dataset is necessary. As Phase 1 concentrated on product innovation rates and the percentage of revenues from new products such an analysis was postponed until a later phase of the research (see Chapter 6)

The next step in the analysis was to look at the relationship between product innovation rate and the percentages of revenues from new products. It would seem logical that more new products would, providing they were successful, lead to higher percentages of revenues from new products. This relationship is investigated in the next section.

Figure 5.4: Revenues from New Products (%), Engineering
(63 business units – data from 1997 IBFA database)

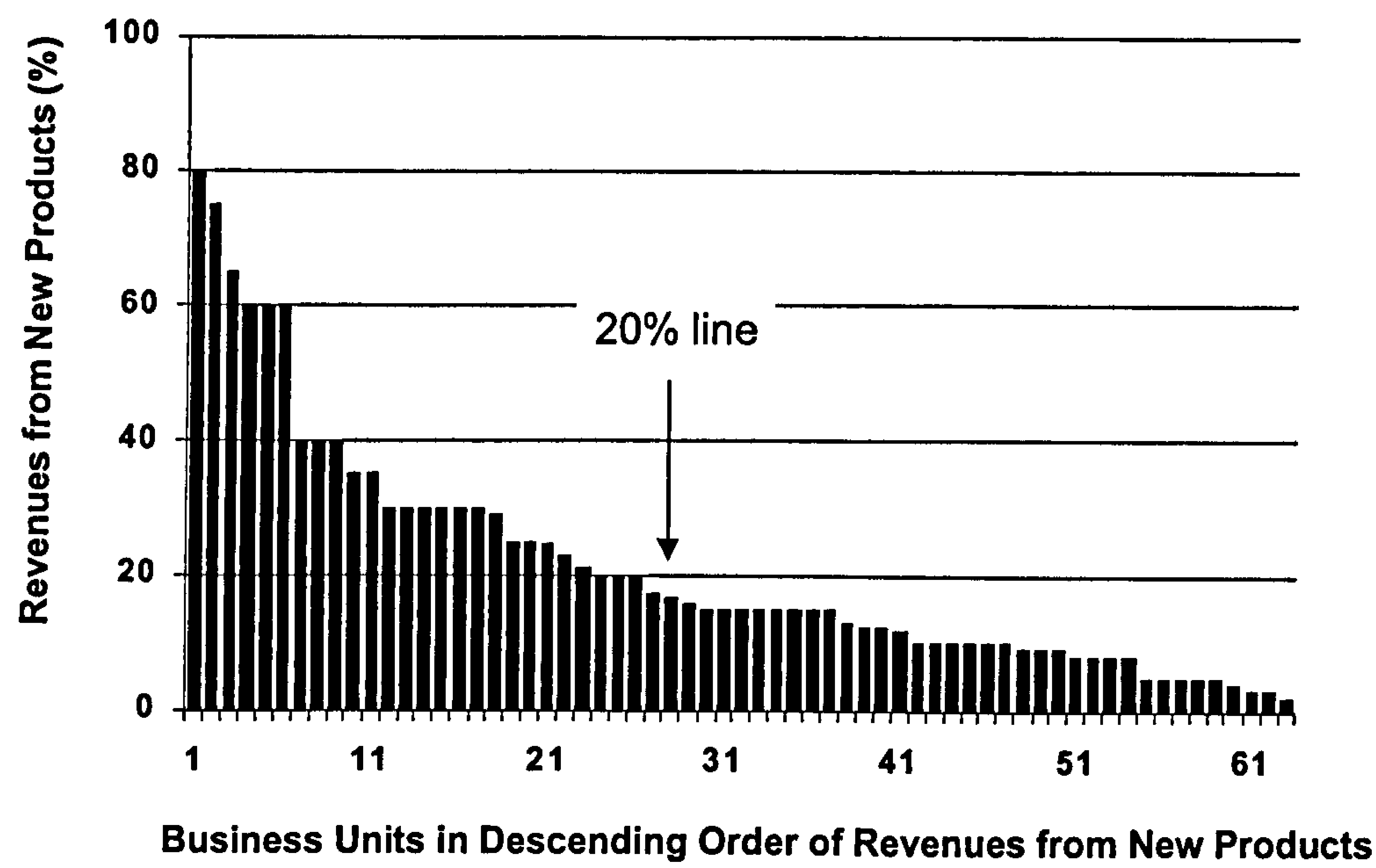
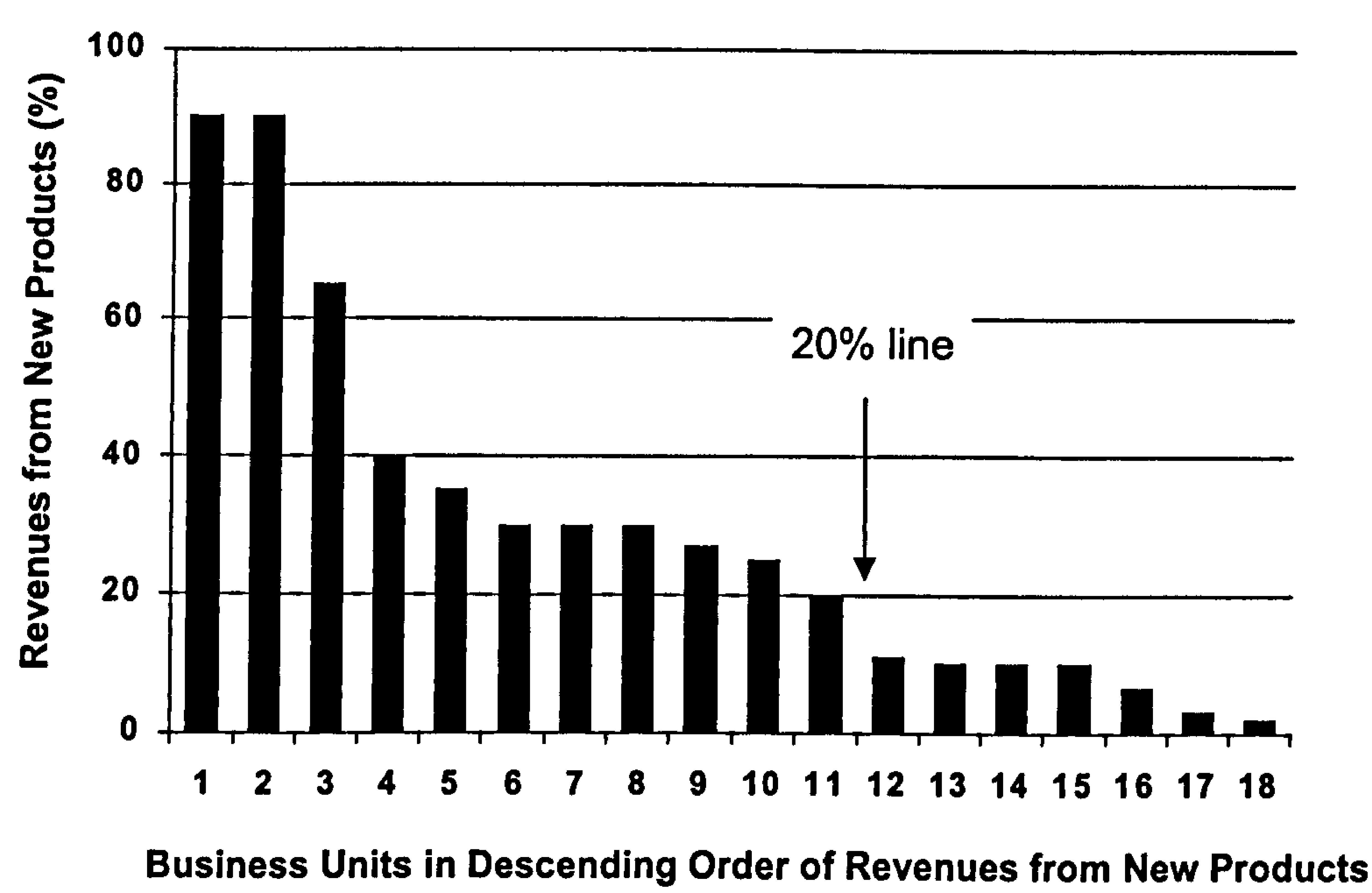


Figure 5.5: Revenues from New Products (%), E&E Engineering
(18 business units – data from 1997 IBFA database)



5.1.3 Product Innovation Rate and Percentage of Revenues from New Products

The survey allowed a detailed analysis of the relationship between product innovation rate and the percentages of product revenues to be obtained. In Figures 5.6 and 5.7 the data for the 63 business units from engineering and the data for the 18 business units from E&E engineering was combined to look for a relationship – which apparently shows no relationship.

Most business units in engineering (Figure 5.6) have very low product innovation rates (i.e., develop very few new products) but earn high revenues from the few new products they develop (as shown by the clustering of business units along the x axis line). Although the most business units have low product innovation rates the differences in percentages of revenues from new products are high. Some earn respectively low and some respectively high revenues. Further, one business unit is included with a very high product innovation rate but a low percentage of revenues from new products. Just as no relationship was found for the engineering sector, similar results were found for the 18 business units in the E&E engineering sector. However, from Figure 5.7 it appears that one business unit with a high product innovation rate achieves a very high percentage of revenues from new products.

Figure 5.6: Current Product Innovation Rate (%) / Revenues from New Products (%), Engineering
(63 business units – data from 1997 IBFA database)

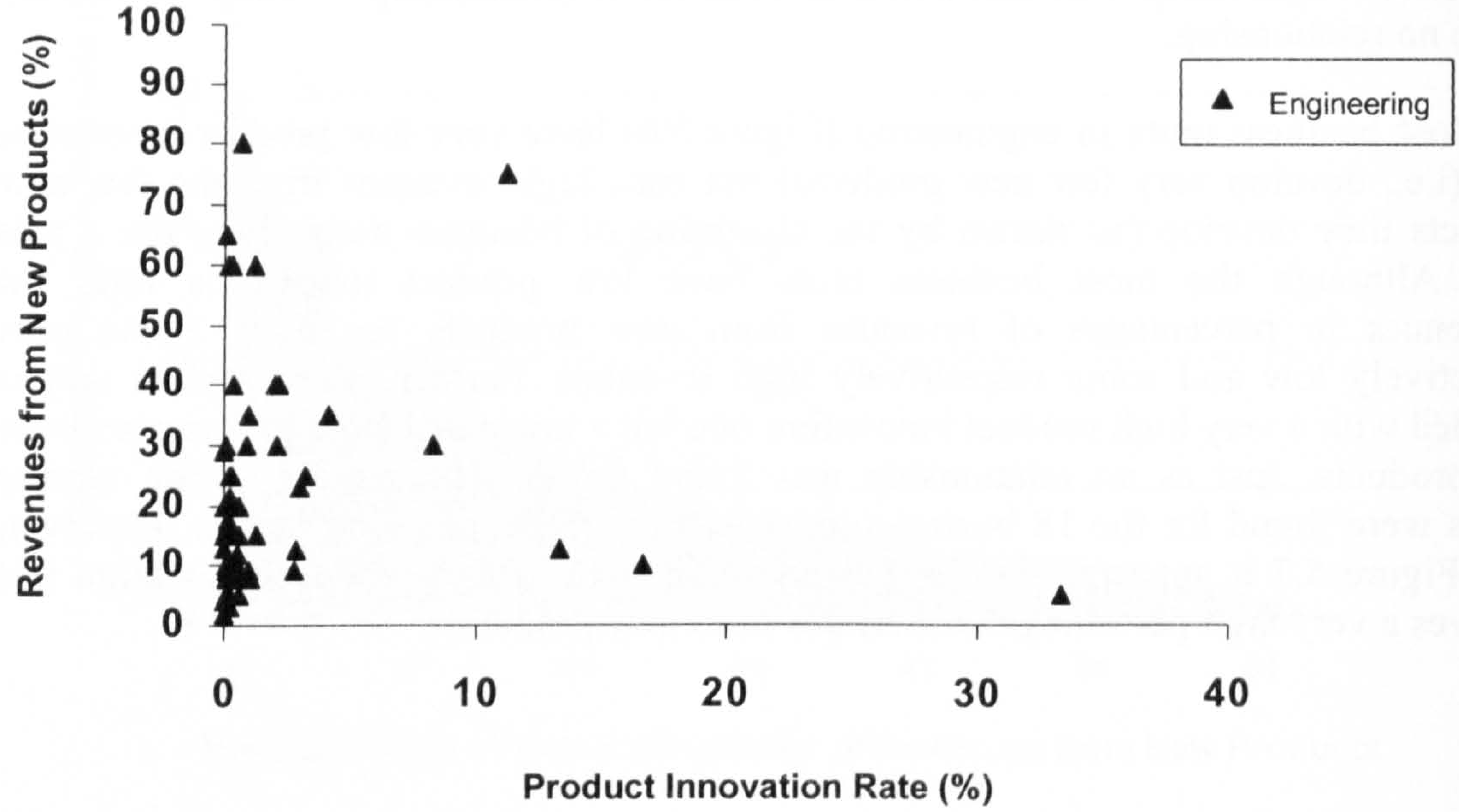
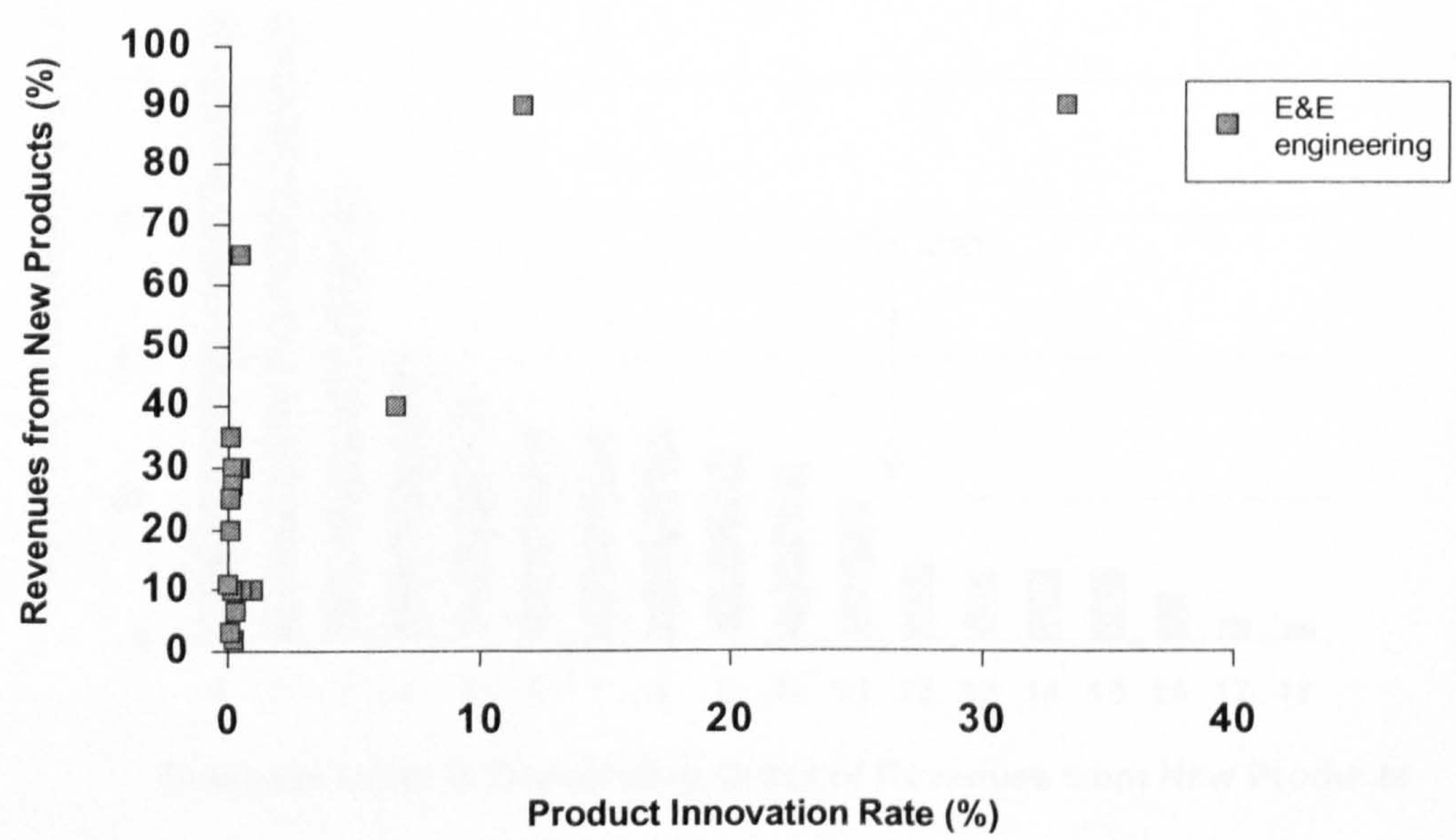


Figure 5.7: Current Product Innovation Rate (%) / Revenues from New Products (%), E&E Engineering
(18 business units – data from 1997 IBFA database)



The reasons for the varying positions could be the following points:

- Many business units have low product innovation rates but high revenues from new products because they concentrate their R&D activities on few new products. With these products they generate most of their turnover.
- Reasons for high product innovation rates and low percentages of revenues from new products are manifold. Firstly, it could be, that business units introduce new products only for strategic aims (e.g., completion of the product range). Secondly, it could be that revenues come later than three years after product introduction – in this case the definition of new products (younger than three years) has to be proved. Thirdly, it could be that these business units developed flops.
- Business units with high product innovation rates and high revenues from new products replace most products in their portfolio every three years – these new products generate most of their revenues.
- Innovation measurement is inaccurate. It could be that the respondents had a wrong understanding of new products or had wrong data of the total number of products and so the determination of the number of new products and existing products was wrong. As product innovation rate depends on the ratio of the number of new products to all existing products in the portfolio, product innovation rate could be too low or too high.
- Inaccurate sales revenues. The percentages of revenues for new products were only estimated and not calculated because no data was available.

To investigate the contradictory results of Figures 5.6 and 5.7, eight telephone interviews were carried out. From each industry sector four business units were chosen to check the data. The results of the telephone interviews are given in the next section.

5.2 TELEPHONE INTERVIEWS

The telephone interviews investigated manufacturing business units with different product innovation positions, i.e., product innovation rate and percentage of revenues from new products. Further, business units of varying size were selected because focusing on large business units exclusively might not give a representative[50] dataset. Four business units were chosen in each sector. The smallest business unit interviewed had 170 employees (including R&D; marketing; and manufacturing) and the largest business units employed 3,000 people. Three of the eight business units had less than 500 employees. It is important to note that four business units were part of large organisations, whereas in four cases the business unit studied constituted the whole company. Table 5.3 indicates the range of products produced by the business units within the two sectors, their organisational status, and their approximate revenues.

[50] Although a sample of eight business units is not representative for the German industry sectors at whole, a strong emphasis was put on getting a representative sample with regard to varying size.

Table 5.3: The Business Units Studied

Industry Sector	Types of products	Part of a larger organisation?	Revenues (1996)
Engineering (500 to 3000 employees)	Machine tools	No	10 M Euro
	Car components	Yes	200 M Euro
	Plastic assemblies	No	250 M Euro
	Industrial components	No	150 M Euro
E&E engineering (170 to 1600 employees)	Car electronics	Yes	350 M Euro
	Pump controls	Yes	550 M Euro
	Electric motors	No	15 M Euro
	Computer devices	Yes	750 M Euro

The interview partner was the manager who was named as respondent in the IBFA questionnaire. In most cases the interview partner was the quality manager who was responsible for the co-ordination of the survey within the business units. The variables discussed with the managers were equivalent to the variables concerned by the survey, which were:

- Product innovation rate
- The percentage of revenues from new products
- The relationship between product innovation rates and the percentage of revenues from new products

5.2.1 Product Innovation Rate

The telephone interviews allowed the cause of the innovation rate measurement error to be investigated. The eight telephone interviews gave the researcher the opportunity to discuss in detail what types of new products had been introduced in the past three years and how much of the total portfolio was new. Figure 5.8 and 5.9 are an adaption of Figure 5.2 and 5.3. Figure 5.8 shows the product innovation rate in decreasing order for the 63 business units in the engineering sector from IBFA 1997 (black columns). As the diagram shows, different values for product innovation rate were determined by the results of telephone interviews (grey columns). For example, business unit 'Eng 11' had a significantly larger product innovation rate because "the number of main products was not given correctly in the IBFA questionnaire" (Quality Manager, Eng 11). In three of the four business units interviewed, it can be seen that significantly different product innovation rates were found. A similar picture is given for the four business units interviewed in the E&E engineering sector (Figure 5.9). Three of four telephone interviews led to corrected product innovation rates.

Figure 5.8: Current Product Innovation Rate (%), Engineering (63 business units - data from 1997 IBFA database and corrected data telephone interviews)

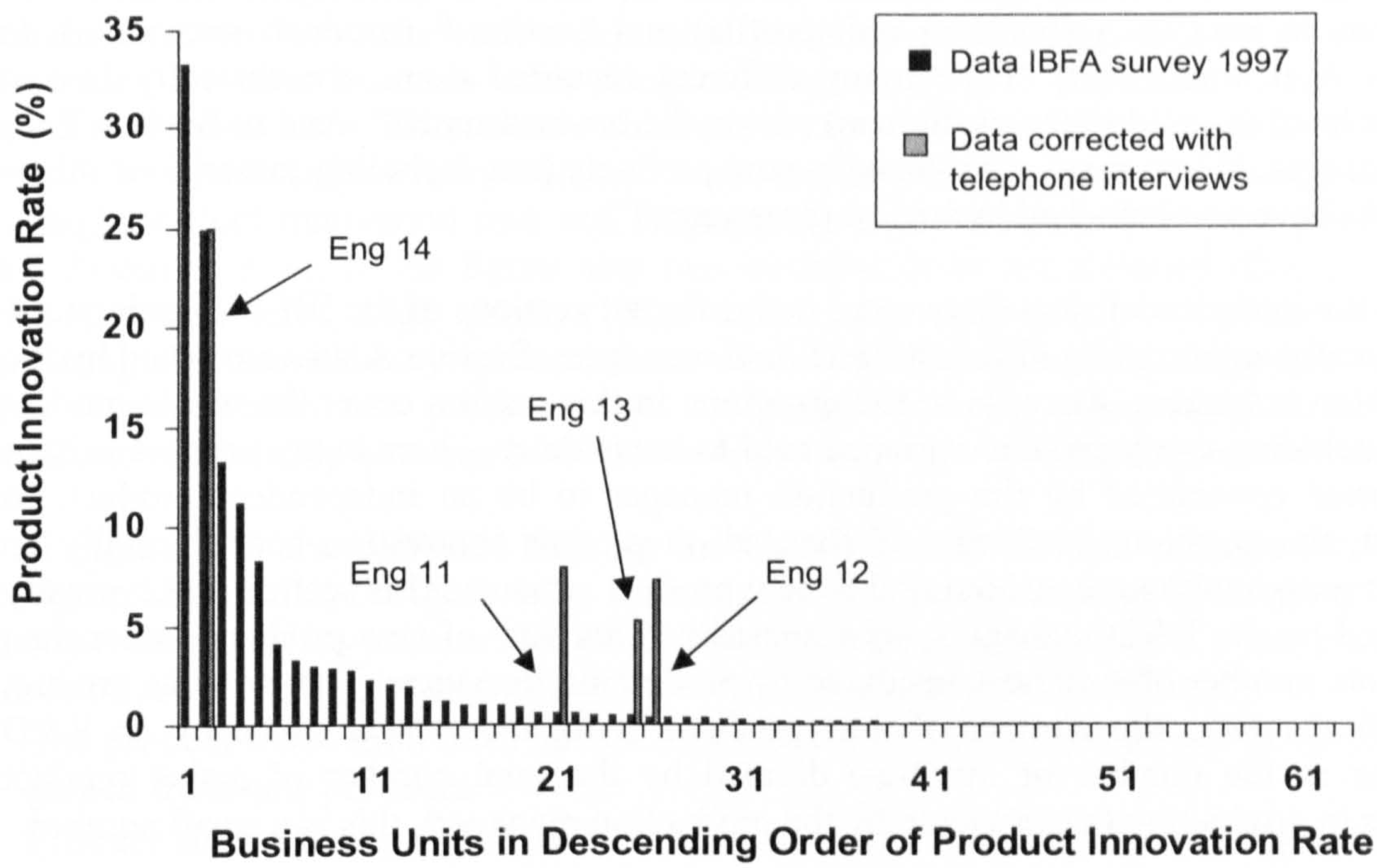
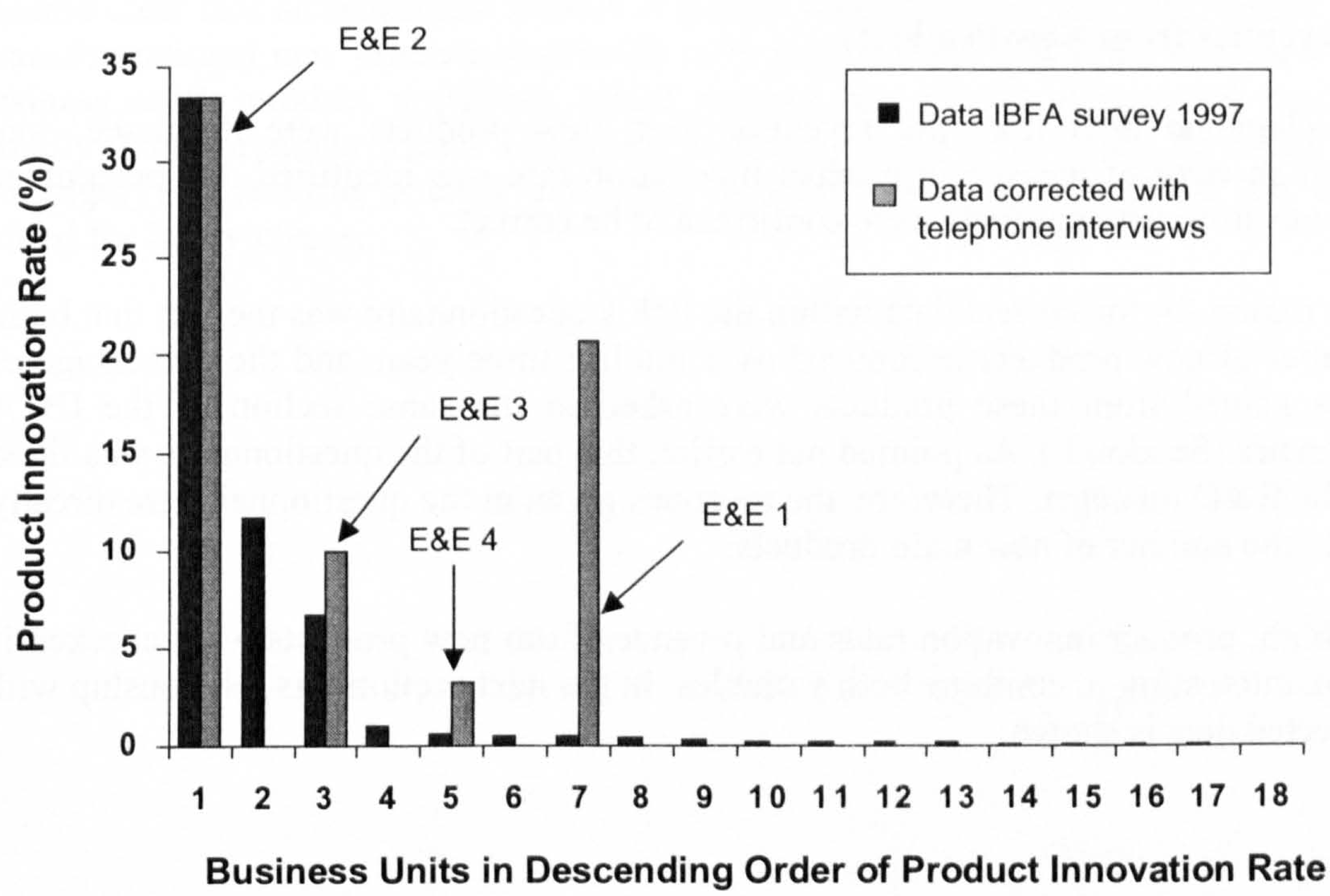


Figure 5.9: Current Product Innovation Rate (%), E&E Engineering (18 business units – data from 1997 IBFA database and corrected data telephone interviews)



However, the measurement error was only recognised in the process of checking the data in the telephone interviews. The reason for this error was, that the two variables used for calculating product innovation rate were derived from different section of the IBFA questionnaire and the content in which they were asked differed strongly. The basis for the calculation of product innovation rate from the IBFA questionnaire were questions in Section A (business unit profile) and Section F (product innovation). In Section A it was asked: "How many different recorded items are currently live at product level (as sold to the customers) within the business unit?". And in Section F the question was: "How many significantly new products (not including material or minor changes) have you launched in the last three years?".

In the interviews it was discovered that different sections of the IBFA questionnaire are typically answered by different functional managers. Section A was answered by the production managers. Answers to the questions in this section cover the whole product range including every product variance sold to a customer – here every product variant is reported considered by the production manager to be an independent product. In contrast, the questions in Section F focused on product innovation and especially on product ranges without considering different product variants. This section was typically answered by the R&D managers, who consider "families" of new products rather than the whole number of variants considered by production managers. Therefore, as product innovation rate is the number of new products (with the answer given by an R&D manager as the number of families) divided by the total number of active product variants in production (as answered by the production manager), this is a small number.

The finding of the interviews show that the collection of the data needs a different approach, in order to get accurate measures of product innovation rate (new products divided by existing products within the whole product portfolio). In addition to the product innovation rate, the percentage of revenues from new products was checked. The results are presented in the following section.

5.2.2 Revenues from New Products

In the telephone interviews the revenues from new products were discussed, too. Although an error of measuring product innovation rate was identified, the percentage of revenues from new products were confirmed to be correct.

The reason for the correct data within the IBFA questionnaire was the fact that both, the number of new products introduced over the last three years and the percentage of revenues gained from these products were asked in the same section of the IBFA questionnaire (Section F). As pointed out earlier, this part of the questionnaire was filled out by the R&D manager. Therefore, the revenues given in the questionnaire are directly related to the number of new main products.

As both, product innovation rates and revenues from new products were checked it would be interesting to combine both variables. In the next section this relationship with the corrected data is shown.

5.2.3 Product Innovation Rate and Percentage of Revenues from New Products

Overall, the eight telephone interviews allowed an accurate estimation of product innovation rate and the percentage of revenues with new products to be obtained. Figure 5.10 shows the relationship between product innovation rate and the percentage of revenues from new products with uncorrected variables for the two industry sectors. It can be seen that four business units (Eng 11, Eng 12, Eng 13 and E&E 4) have low product innovation rates but achieve revenues with new products. Further, one business unit with low product innovation rate and high revenues (E&E 1) and one business unit with high product innovation rate and respectively high revenues from new products (E&E 2) can be seen. In the figure also two business units are included (Eng 14 and E&E 3) which have high product innovation rates and achieve high revenues. Comparing the two industry sectors, three of four E&E engineering companies earn higher revenues from new products than companies from the engineering sector do. Overall, no relationship between both variables can be seen which seems contradictory.

In Figure 5.11 the corrected data for the eight selected business units are shown. The figure shows that business units with higher product innovation rates generate a higher percentage of revenues with new products than business units with a low product innovation rate do. The picture in Figure 5.11 could be explained as follows:

- The product innovation rates have a direct influence on the percentage of revenues gained from new products.
- Product innovation position in E&E engineering is higher than in engineering. Most business units in E&E engineering introduce more products and generate higher revenues with these products than business units in the engineering sector.

In the telephone interviews it was recognised that the managers had different definitions of product innovation (i.e., the degree of product innovation varied extremely). However, the degree of new products is important to get comparable information about product innovation rates from all business units. From the interviews it became clear that an inaccurate dataset is gained when one business unit counts only its transformational new products (normally only few products fulfil this criteria within a business unit's product portfolio), while another one counts incremental products (normally many products within a business unit's product portfolio can be sorted into this category). Therefore, a clear definition of what needs to be counted has to be provided for interviewees.

Figure 5.10: Current Product Innovation Rate (%) / Revenues from New Products (%), Engineering and E&E Engineering (eight business units – data from 1997 IBFA database)

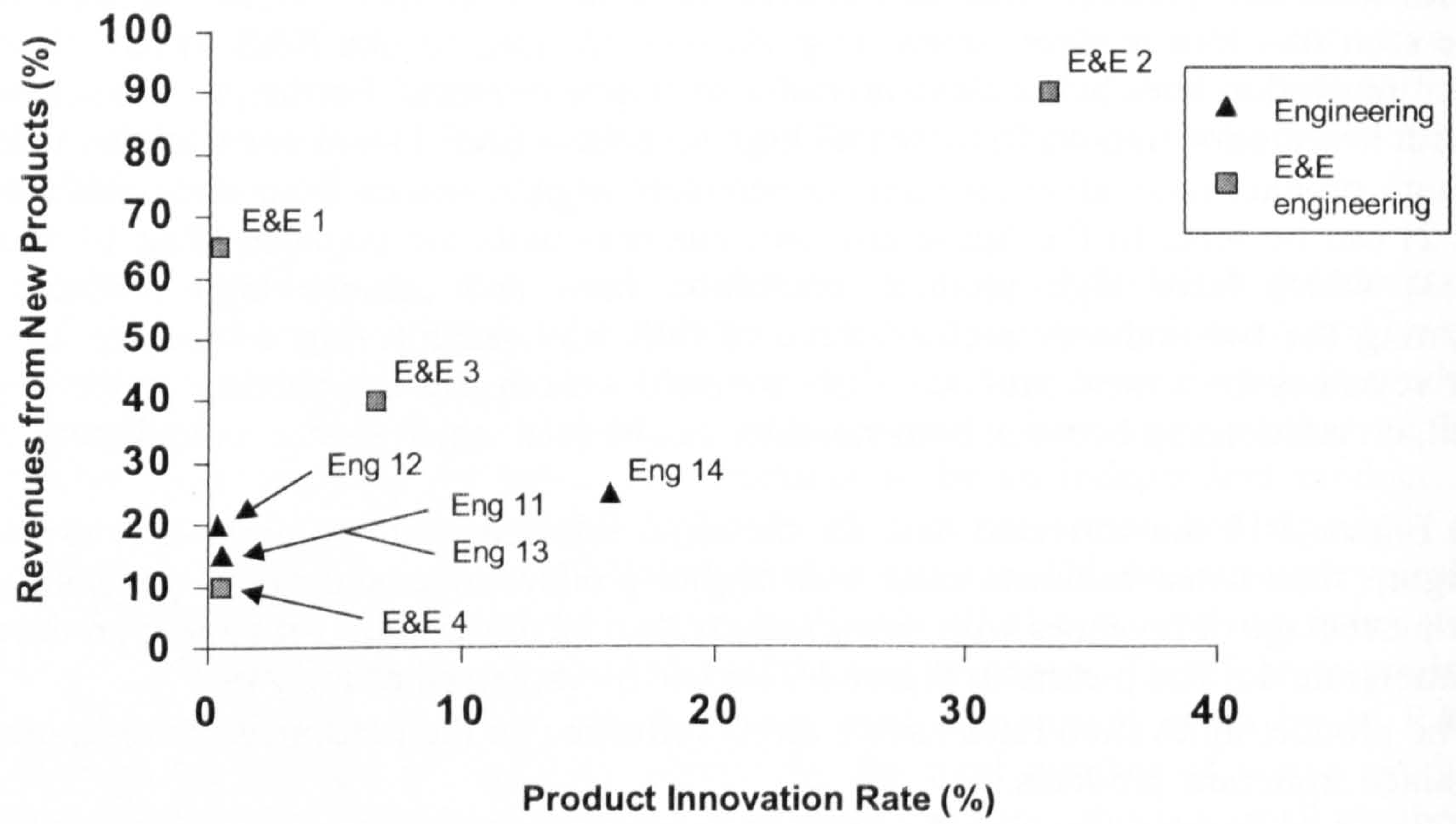
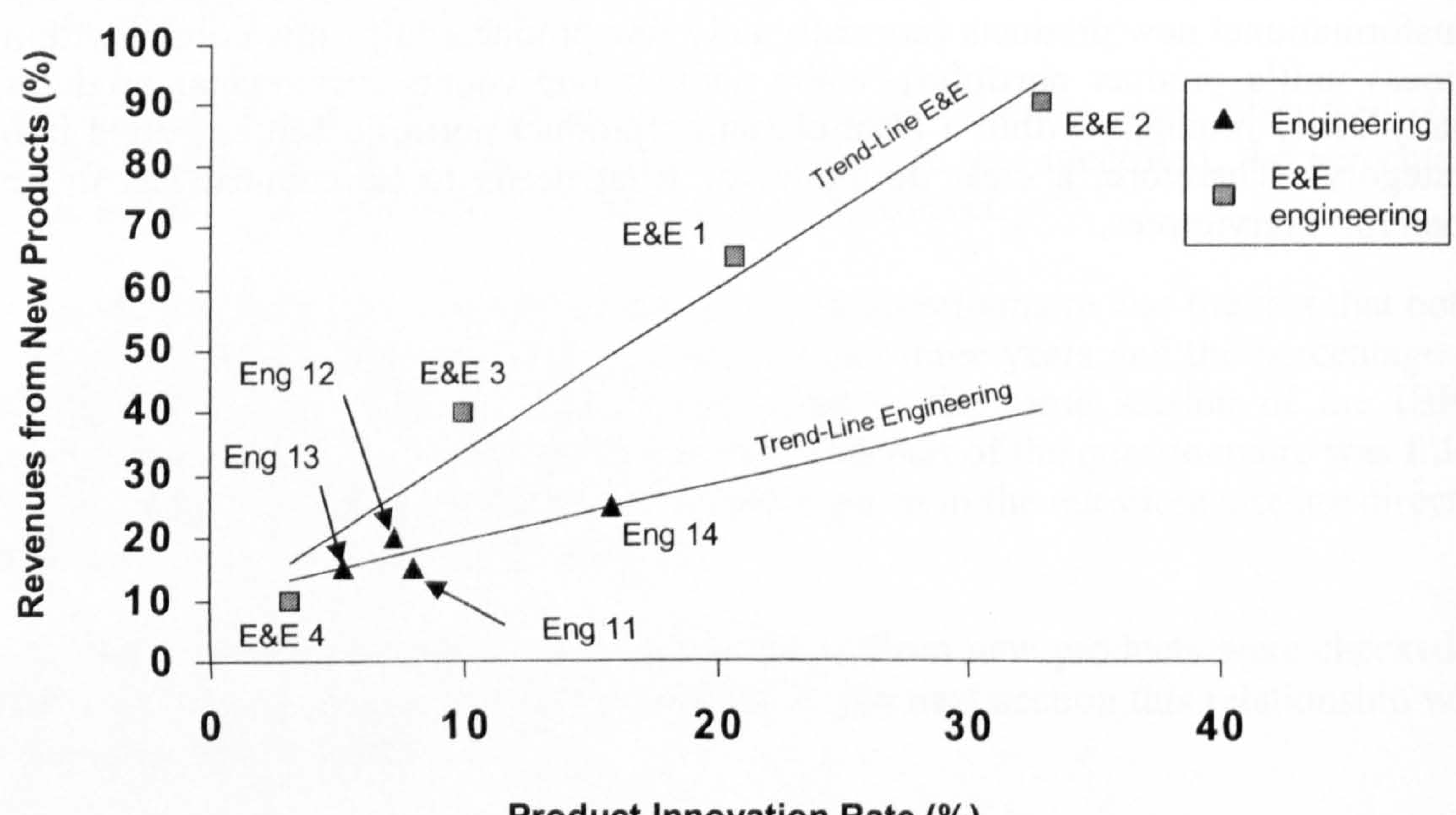


Figure 5.11: Current Product Innovation Rate (%) / Revenues from New Products (%), Engineering and E&E Engineering (8 business units – data from telephone interviews in 1999)



5.3 SUMMARY

For German business units in the two industry sectors engineering and E&E engineering, new products are important to generate revenues – 45% of all business units generate more than 20% of their revenues from new products. To achieve such high percentages of revenues from new products 91% of all business units introduced new products over the last three years. The key findings in Phase 1 were:

- It was identified that problems with the reliability of the survey data led to inaccurate estimation of product innovation rates. Eight telephone interviews were carried out to identify the measurement error and to obtain a correct dataset.
- For both industry sectors high differences exist in product innovation rates and the percentages of revenues from new products. This phenomenon requires a more detailed investigation by explaining the relationship between both variables.
- An apparent relationship between innovation rate and turnover with new products was observed using the corrected data for eight business units. However, to obtain a meaningful dataset, data for a larger dataset of business units need to be generated.

The results of Phase 1 showed that survey data are usable to show the relationship between product innovation rate and the percentage of revenues from new products. For the explanation of the reasons for different product innovation rates and revenues from new products in-depth studies have to be carried out. However, before starting the investigation into the reasons for varying product innovation positions, the error in measuring product innovation rate has to be corrected. This was done in Phase 2 by carrying out a further survey and telephone interviews.

CHAPTER SIX

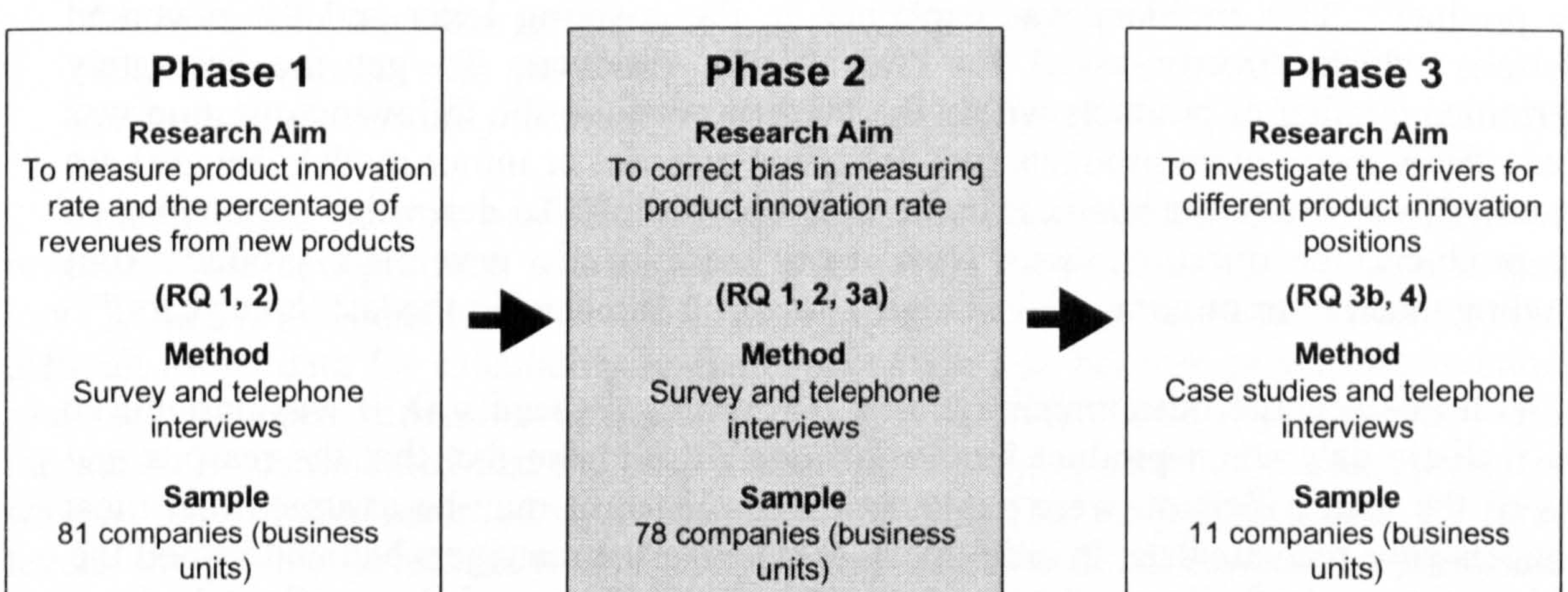
RESULTS OF PHASE 2

6.0 INTRODUCTION

Phase 1 showed that the IBFA survey had led to an inaccurate measurement of product innovation rates for many business units. Therefore, in Phase 2, all IBFA participants in the years 1997, 1998 and 1999 in the engineering and E&E engineering industry sectors were asked to check their actual data. Additionally, the figures of the current revenues from new products were collected. To get valid data, the questionnaire used in Phase 1 was updated and telephone interviews were carried out to verify the data (the reworked questionnaire is given in Appendix D). With the corrected dataset further investigations into the reasons for different levels of product innovation rate and percentage of revenues from new products were possible. To show how Phase 2 is embedded into the whole research project, an overview over the three phases is given in Figure 6.1. In summary, Phase 2 captured the following key characteristics:

- IBFA data from 78 business units was analysed.
- Telephone interviews with managers from 34 business units were carried out to check the data.
- With the corrected data it was possible to differentiate all business units into two groups – those with low and those with high product innovation rates. Further, the business units were divided into sub-groups with low and high percentages of revenues from new products.
- The corrected dataset made it possible to investigate the relationship between product innovation rate and profits with the whole product portfolio.
- The dataset of business units from 1997 to 1999 allowed the investigation of how the prognosis of product innovation rate works.

Figure 6.1: Classification of Phase 2 within the whole Research Project



This chapter starts with the presentation of the data collection process of the corrected product innovation rates. In the following two sections the corrected data on product innovation rates and the percentage of revenues with new products are presented. Both variables were combined within a diagram which formed the basis for the further research activities. The diagram, giving the corrected product innovation rates in relationship to the percentage of revenues from new products was then divided into fields with low and high product innovation rates. This separation is discussed intensively in the following section. On the basis of the corrected data it was possible to investigate actual product innovation rates with prognosis from the past. This analysis was made in the next section. Finally, a short summary of the findings is given.

6.1 DATA COLLECTION PROCESS

Phase 1 of the research showed that managers had difficulties in defining what a new product is. As the variables for calculating product innovation rate belonged to different sectors in the IBFA questionnaire, managers from different departments (production and R&D) answered the questions. Consequently, the data were not compatible and led to an inaccurate estimate of product innovation rates. To get a valid dataset, both variables were determined by one questionnaire and the managers were asked to calculate product innovation rate by themselves. How the data collection process was carried out is described in this chapter which captures:

- A description of the questionnaire used for the survey
- Information how the telephone interviews were carried out
- The structure of the business units investigated

6.1.1 Questionnaire

The difficulty of the differentiation between different degrees of product innovations is closely related to the definition of "main" products. In the questionnaire transformational innovations on the 'main' product level were asked for, which is in line with the definition of Iansiti and Clark (1994). Incremental changes of main products (i.e., another colour or very small technical differences) are not counted as an existing or new product[51]. This problem was explained in the covering letter and the reworked questions which directly asked for "main" new products. To get the accurately determined number of products within the product portfolio the following question was asked: "How many main products (not including material or minor model changes) are currently 'live' within the business unit product portfolio?" To determine the number of new products, the question was: "How many significantly new main products (not including material or minor model changes) have you launched in the last three years?"

With this specific questionnaire which is given in Appendix D, it was possible to gain realistic data about product innovation rate. Due to the fact that the reasons and aims of the data collection were explained in the letter, it may be assumed that most managers gave realistic data. In order to check whether the managers had understood the problematicness of the issue, 34 telephone interviews were carried out. The telephone interviews showed, that most managers had understood the problematicness of

[51] The degree of product innovations is discussed in Section 2.1.2 'The Degree of Product Innovation'.

calculating product innovation rate. However, there were a few managers who had difficulties giving realistic data. As the next section shows, variants and main products were again mixed in some cases.

6.1.2 Interviews

As pointed out in the section above, the interviews were designed to check if the managers had an appropriate understanding of what product innovation meant to make sure they had given their realistic product innovation rates. In the interviews especially those business units were checked, where product innovation rates and the percentage of revenues from new products seemed to be unrealistic (e.g., low/high product innovation rates but high/low percentages of revenues from new products).

At first sight it does not seem to be a problem to get realistic data about product innovation rates with the one page survey. But even if the right questions were asked, the answers could be based on very different assumptions of the managers. Problems were noticed in following areas:

- The number of main products often included variants, i.e., various types of the same main-product (e.g., different colours or different sizes).
- The number of new products was often calculated using different recorded items at the product level. Using this statistical data managers had difficulties identifying the correct number of new products and existing products.
- Managers had difficulties in understanding significant product improvements, as they were not clear about what exactly can be considered a significant product innovation.

To show the difficulties of managers in calculating product innovation rate, one example from a business unit in the engineering sector is given. In the one page survey, the manager gave the following data:

Number of new products (developed over the last three years):	*790*
Number of existing main products:	*6,162*
Product innovation rate (for three years):	*12.82%*
Percentage of revenues from new products:	*44.01%*

The manager of this business unit was interviewed because the percentage of revenues from new products was high (44.01%) while the product innovation rate was low (12.82%). The manager who had filled in the one page questionnaire stated: "It was difficult to get data for calculating product innovation rate because product innovation rate had not been measured before". When he was asked how the variables were measured, he commented that the basis on calculating the number of existing products was the list of items recorded within the business unit. This list was available for three levels: the product level, the manufactured component level and the bulk intermediate level. Having this data he stated, it was "no problem to identify the number of existing main products because the three lists only have to be added". As this calculation was seen to be wrong, he was asked whether the given number of existing products includes any variants. On this question he answered: "Every product with a different item number was counted". In the discussion of his calculation it became clear that he made no differentiation between main products and variants.

As the number of existing products were calculated on a wrong basis, he was asked how he calculated the number of new products. He pointed out that he used the internal releases in which the new products were reported to be manufactured. Within theses releases only main products are included. From this information it was evident that product innovation rate did not represent a realistic value for his business unit. The number of existing products included both main products and variants, while the number of new products was calculated on the basis of main new products. This mistake was corrected and the data for this business unit changed as follows:

Number of new products (developed over the last three years):	*790*
Number of existing main products:	*2,054*
Product innovation rate (for three years):	*38.46%*
Percentage of revenues from new products:	*44.01%*

The above example demonstrates the necessity of checking the postal survey later by interviewing managers – especially data which seems unrealistic needs to be examined. All in all, a dataset of 78 questionnaires with corrected product innovation measures were collected. 57 questionnaires in engineering and 21 questionnaires in the E&E engineering sector were useable for further investigations into the reasons for different product innovation rates and varying percentages of revenues from new products.

6.1.3 Sample Characteristics

In each industry sector investigated, a broad range of business units were represented, both in size and types of products produced. In the engineering sector, business units ranged in size from 19 to 3,038 employees (average 421); covering products such as trucks, pneumatic devices, synthetic parts for the car industry. Revenues ranged from Euro 1.5 million to Euro 300 million. In the E&E engineering sector, business units ranged in size from 11 to 2,622 employees (average 522); with a range of products covered including: printed circuit boards, communications, measuring devices, etc. Revenues ranged from Euro 5.5 million to Euro 1,709 million.

Figure 6.2 shows how the number of employees are distributed over the business units. In engineering, 21% have less than 100 employees (E&E engineering 14%). Most business units in both sectors (engineering 49% and E&E engineering 57%) have a number of employees between 100 and 500. 30% in engineering and 29% in E&E engineering have more than 500 employees. The high percentage of business units between 11 and 500 employees indicate that most business units represent the German Mittelstand[52]. Another indicator for this assumption gives an overview of the business unit owners.

[52] An overview about the German Mittelstand is given in Section 3.4 'The German Mittelstand'.

Figure 6.2: Overview Number of Employees, Engineering and E&E Engineering (78 business units – data from 1997, 1998, 1999 IBFA database)

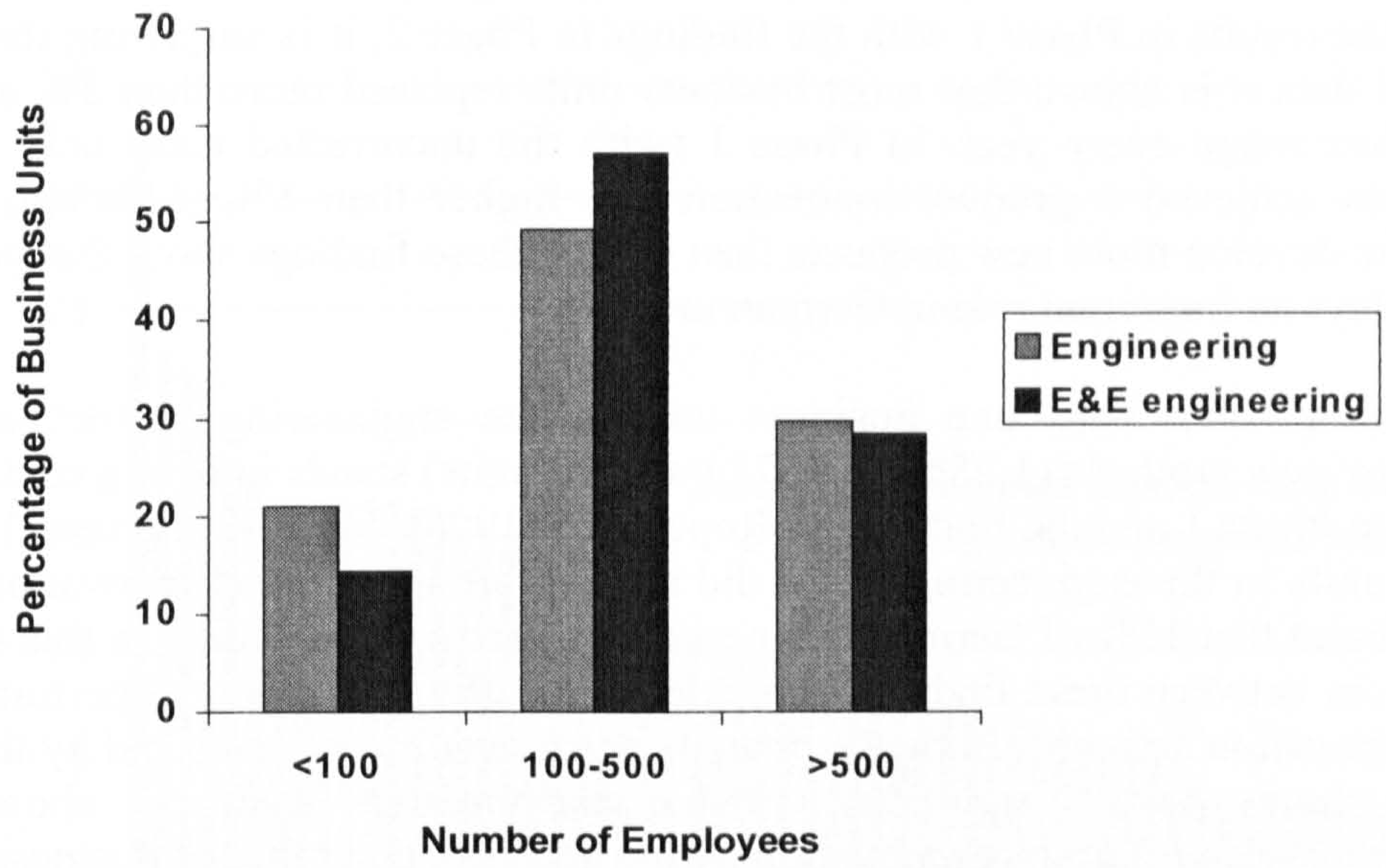
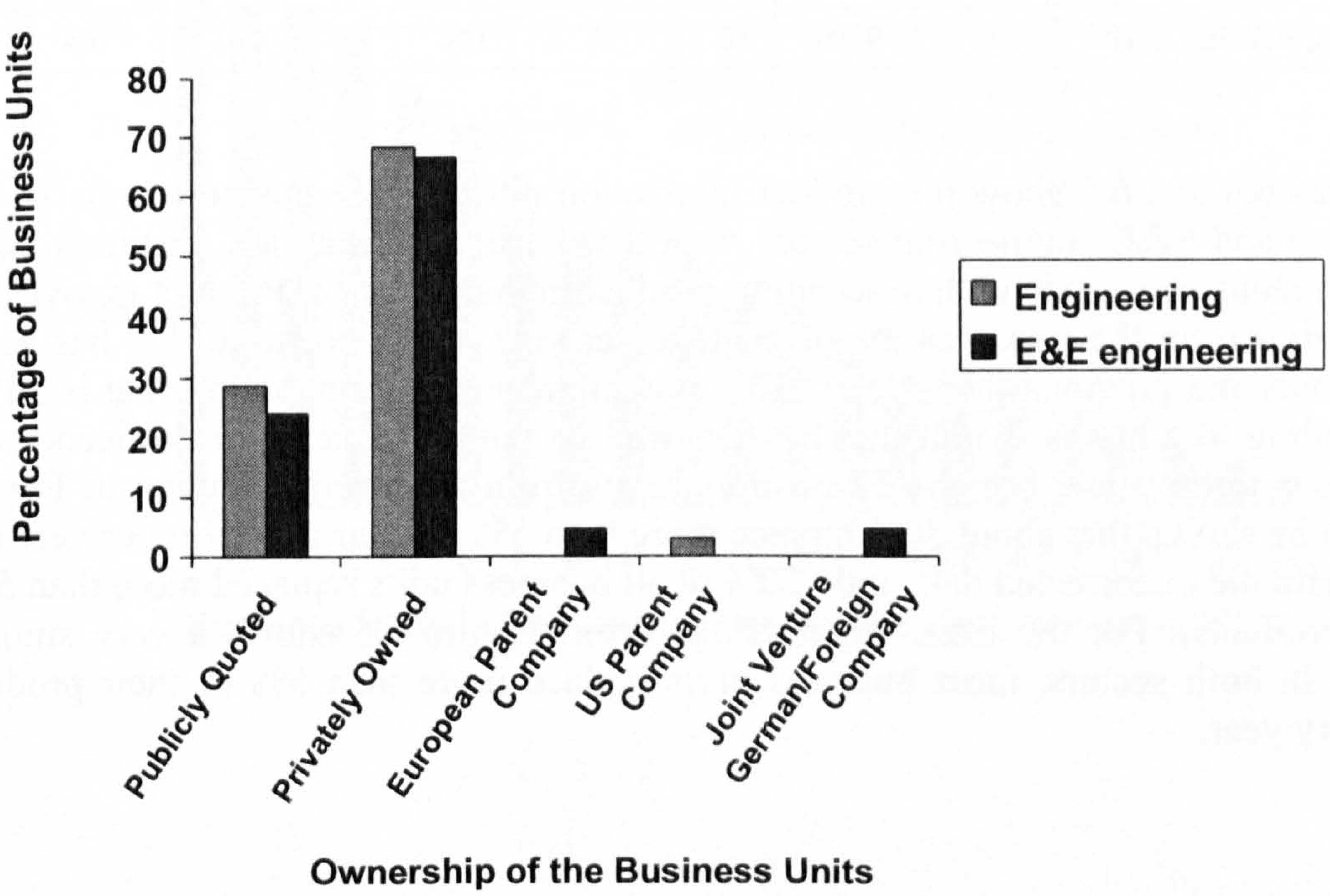


Figure 6.3 shows the structure of the business unit owners. 68% of all business units in engineering and 67% of all business units in E&E engineering have private owners. 29% in engineering and 24% in E&E are publicly quoted and only a few belong to European, US or other parent companies. Privately owned business units (companies) with a business unit size up to 500 employees can be characterised as German Mittelstand. Based on the presented sample characteristics product innovation rate is analysed in the following section.

Figure 6.3: Overview Business Unit Owners, Engineering and E&E Engineering (78 business units – data from 1997, 1998, 1999 IBFA database)



6.2 PRODUCT INNOVATION RATE

All business units (excluding one business unit in the engineering sector) had introduced new products and some had achieved extremely high product innovation rates. Comparing the results in Phase 1 with the findings in Phase 2, it is surprising that with the corrected data it is shown that most business units replaced more than 5% of their current product range every year. In Phase 1 (with the uncorrected data) only a few business units achieved a product innovation rate higher than 5%. Although some business units develop more new products than others, these findings show that product innovation plays an important role in German industry.

The findings that only one business unit in the engineering sector had not introduced any new products (1.28% of all 78 business units) stands in strong contrast to the findings in Phase 1 and the findings by Roper et al (1996). In the first phase, 11% of all business units in the engineering sector did not exhibit any product innovations and Roper et al found that 15% of German business units were not innovating in this sector. The differences between these findings can be explained by the improved performance of product innovation activities in the German industry over recent years and by the fact that IBFA entrants have a significantly better performance. Table 6.1 shows the increasing importance of product innovation by the decreasing number of business units without new products over the years. In the table, the results found by Roper et al, the data analysed in Phase 1 and the actual investigation with the corrected product innovation rates (Phase 2) are compared.

Table 6.1: Business Units without New Product Introductions in the Previous Three Years.

Industry Sector	**Roper (1994-1995)**			**Phase 1 (1997)**			**Phase 2 (1999/2000)**		
	n	No of bus. units with no new products		n	No of bus. units with no new products		n	No of bus. units with no new products	
		n	%		n	%		n	%
Engineering	407	61	15%	63	7	11%	57	1	1.75%
E&E engineering	106	10	9.5%	18	0	0%	21	0	0%

Figures 6.4 and 6.5 show the product innovation rates for the business units in the engineering and E&E engineering sectors respectively. In each diagram, business units are shown along the x-axis with descending product innovation rate. Product innovation rates are shown on the y-axis as the percentage per year of the portfolio that has been replaced over the previous three years. The maximum product innovation rate is 33%, corresponding to a business unit that has renewed its complete range of products over the previous three years. For the 57 business units from engineering shown in Figure 6.4, it can be shown that about 80% replace more than 5% of their portfolio per year (in Phase 1 with the uncorrected data, only 20% of all business units replaced more than 5% of their products). For the E&E engineering sector, Figure 6.5 shows a very similar situation. In both sectors, most business units replace more than 5% of their product range every year.

Figure 6.4: Corrected Product Innovation Rates, Engineering (57 business units – data from one page survey and telephone interviews 1999/2000)

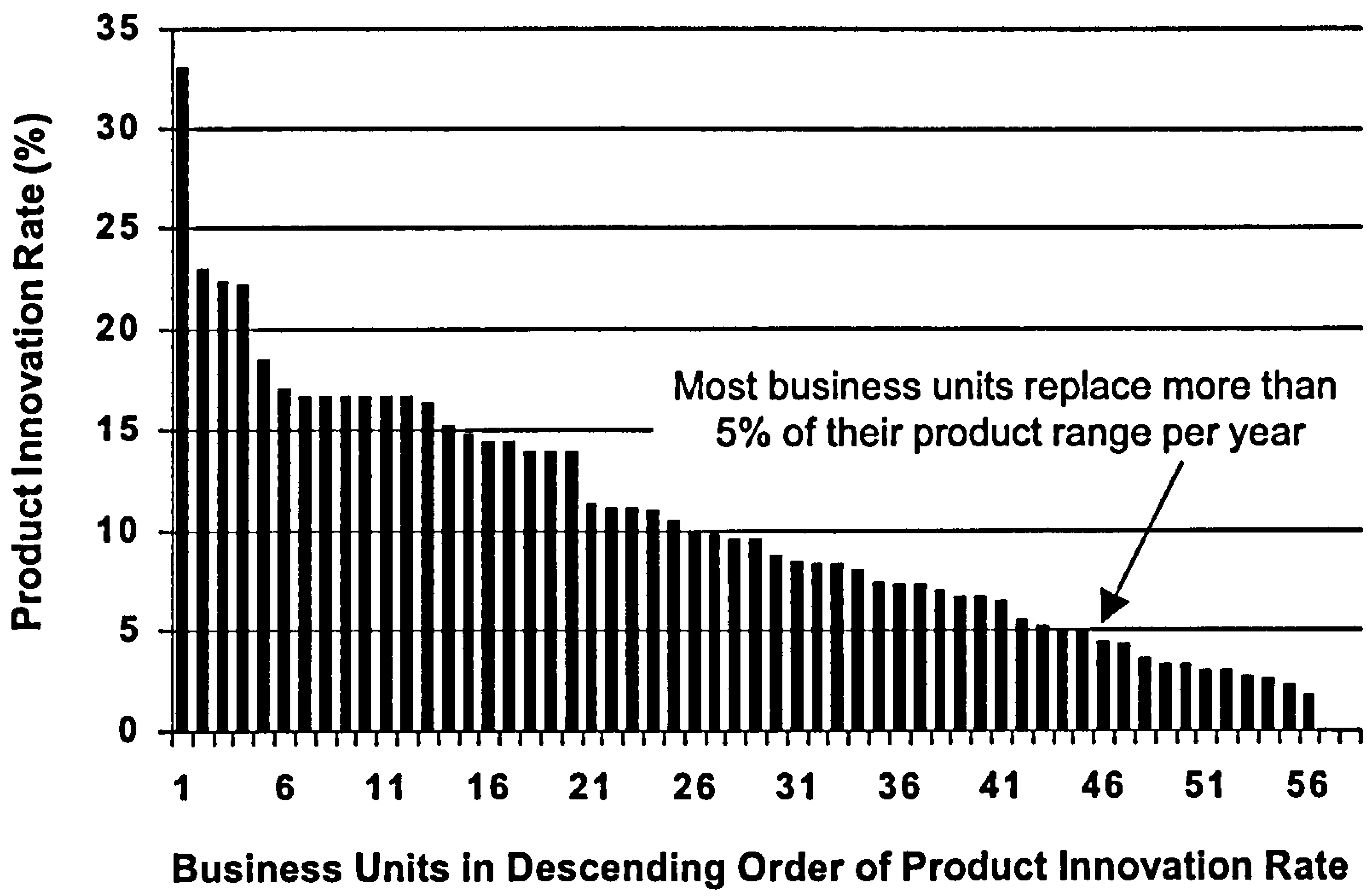
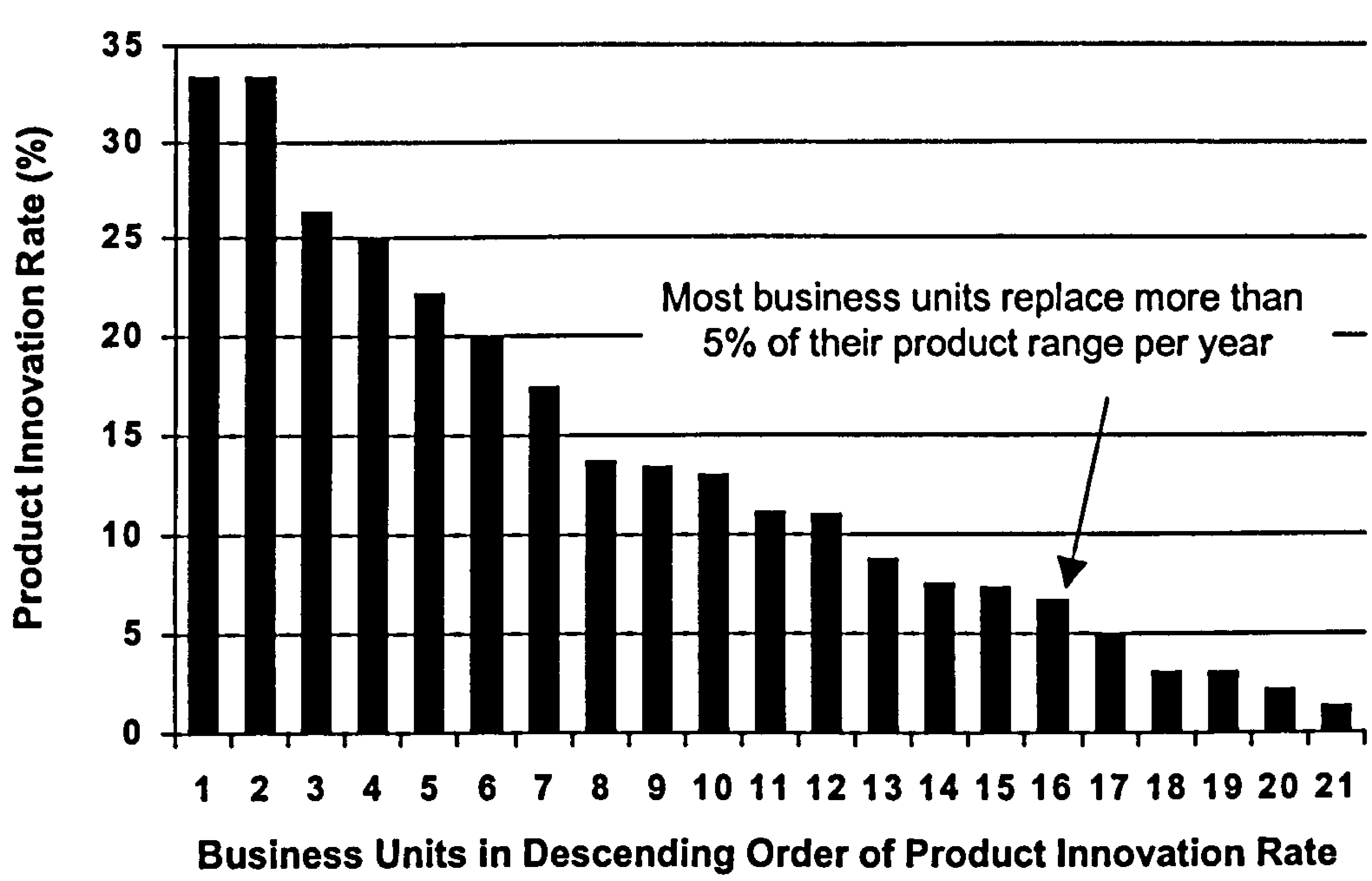


Figure 6.5: Corrected Product Innovation Rates, E&E Engineering (21 business units – data from one page survey and telephone interviews 1999/2000)



6.3 REVENUES FROM NEW PRODUCTS

Table 6.2 shows the percentage of revenues achieved by means of new products. For the 57 Engineering business units for which there is data, the average of the revenues coming from new products (28%) has not changed over the years. In E&E engineering, the average earnings from new products increased from 32% in 1997 to 37% in 1999. However, the implication of Table 6.2 is clear; business units need to focus on developing a steady flow of new products to ensure their revenue streams.

Table 6.2: Percentage of Revenues from New Products

Industry Sector	**Phase 1 (1997)**		**Phase 2 (1999/2000)**	
	n	Revenues (%)	n	Revenues (%)
Engineering	63	26%	57	28%
E&E engineering	18	31%	21	37%

Table 6.2 gives the average values for the percentage of revenues generated from new products. Furthermore, it is useful to look at the differences in performance between business units. Figure 6.6 shows the percentage of revenues earned by engineering business units by means of new products (for each business unit in descending order along the x-axis). Compared to Phase 1, the situation has not changed. It can be seen that more than half of the business units earn at least 20% of their revenues through new products. For the E&E engineering sector, Figure 6.7 shows a similar distribution. In about half of these business units, more than 20% of their revenues came from new products. Comparing the two graphs (Figures 6.6 and 6.7) one can see that the percentage of revenues from new products are important in both sectors. It can also be seen from the diagrams that in engineering one business unit does not earn any of its revenues through new products. All in all, the data clearly shows again the importance of new products for revenue generation.

With the valid dataset of 78 business units it is possible to show the relationship between product innovation rate and the percentage of revenues from new products. This relationship is discussed in the following section.

Figure 6.6: Actual Percentage of Revenues from New Products, Engineering (57 business units – data from one page survey and telephone interviews 1999/2000)

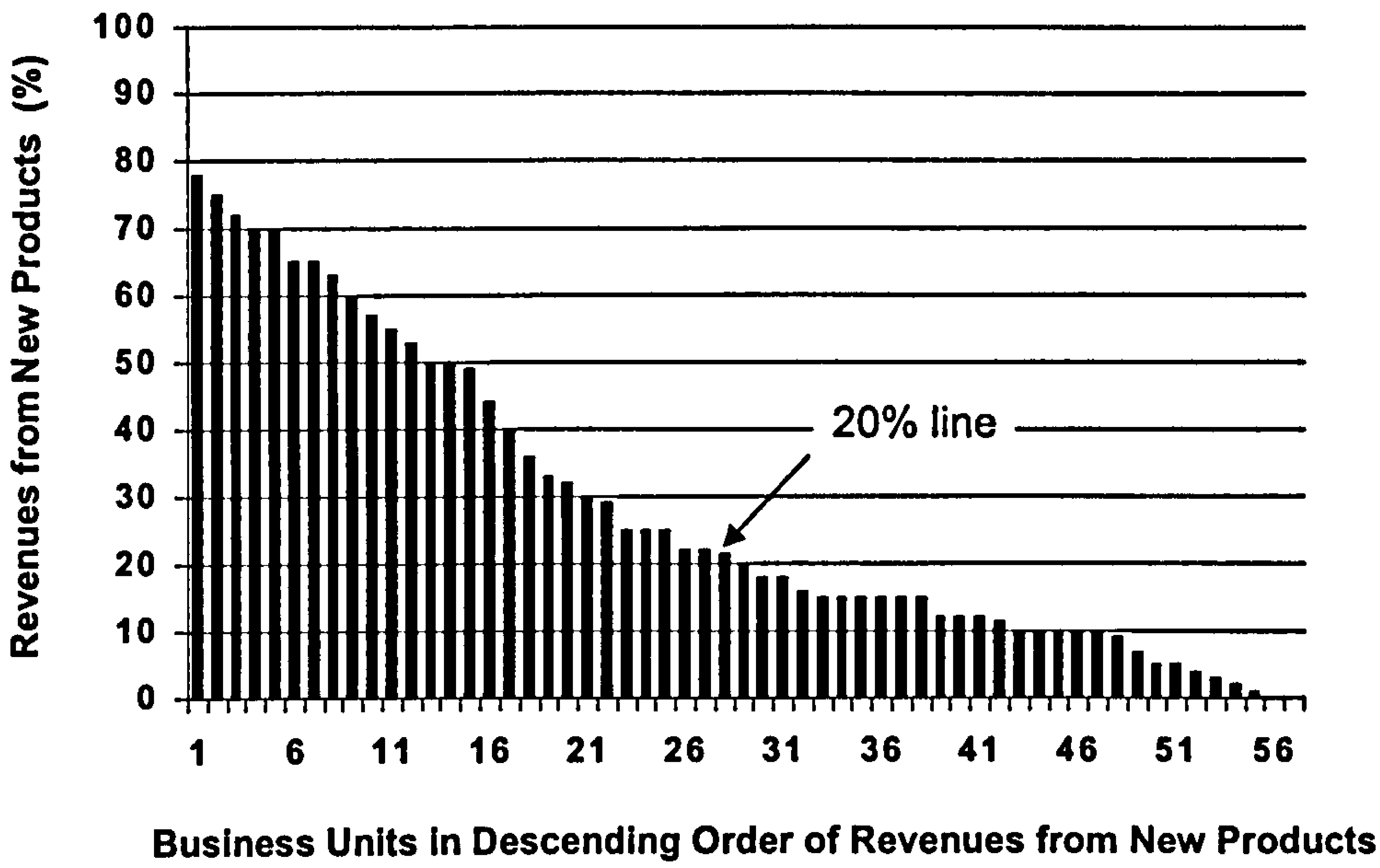
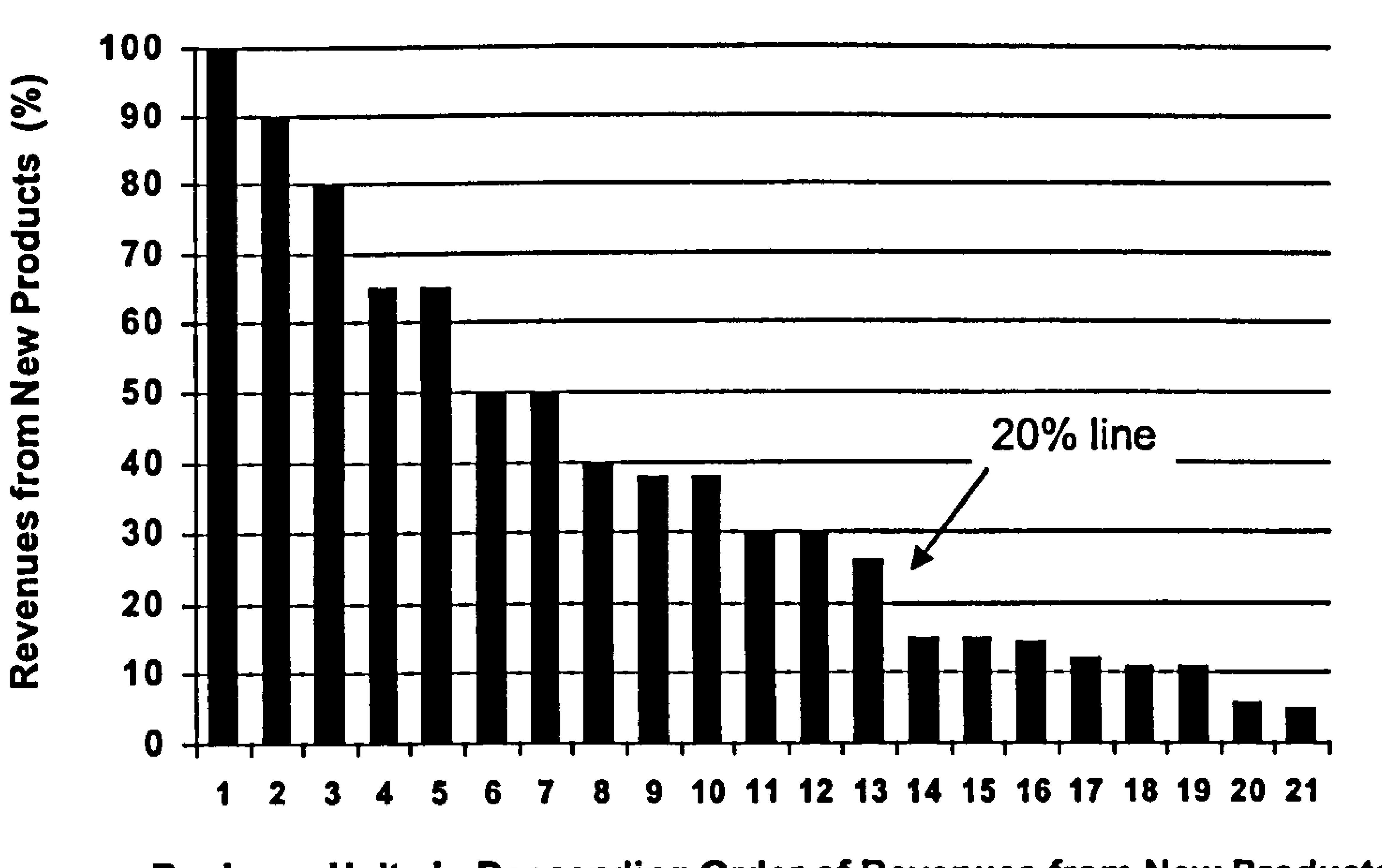


Figure 6.7: Actual Percentage of Revenues from New Products, E&E Engineering (21 business units – data from one page survey and telephone interviews 1999/2000)



6.4 PRODUCT INNOVATION RATE AND THE PERCENTAGE OF REVENUES FROM NEW PRODUCTS

With the combination of product innovation rate and the percentage of revenues from new products a detailed investigation into reasons for different innovation positions was possible. However, the relationship between both variables is not unproblematic and need to be discussed. In summary, the key characteristics of this section are:
- Product innovation position with the corrected dataset
- Advantages and limitations of the diagram

6.4.1 Product Innovation Position with the Corrected Dataset

The Phase 2 survey allowed a detailed analysis of the relationship between product innovation rate and new product revenues (product innovation positions) to be obtained for 78 business units. Figure 6.8 and 6.9 show the relationship for the engineering and E&E engineering business units without the corrected data and Figure 6.10 and 6.11 shows the relationship with the actual corrected data. As might be expected, the diagram with the correct data shows that business units, which introduce more new products, earn a greater percentage of their revenues from these. The different gradients in Figure 6.10 and 6.11 show this clearly.

The relationship between product innovation rate and revenues can be tested with the correlation coefficient (Bleymüller et al, 1996). Correlation analysis "is a means of measuring the strength or closeness of the relationship between two variables" (Fleming and Nellis, 2000). The most used test is the Pearson product moment correlation (Rosenthal and Rosnow, 1991) – the coefficient is given in Table 6.3. For the uncorrected data (Phase 1) for E&E engineering a correlation of 0.55 can be observed while for engineering there is a correlation of only 0.29 (0.41 for the whole sample). However, with the corrected dataset the Pearson moment correlation is 0.59 of all data points in engineering and 0.76 in E&E engineering. For the whole sample size the correlation is given with 0.44. Overall, the analysis shows a higher correlation for the corrected data than for the uncorrected data.

In order to interpret the Pearson product moment correlation the coefficient of determination can be used (Bryman and Cramer, 1994). The coefficient of determination is an indication of how far variation in one variable is accounted for by the other. Taking this definition into account the power of the corrected dataset in E&E engineering sector shows a high correlation (0.76) with a power (coefficient of determination) of 59%. This finding can be interpreted in the way that 59% of the variance in product innovation rate can be attributed to the percentage of revenues from new products. In other words, 41% of the variance in product innovation rate is due to variables other than to the percentage of revenues from new products. In comparison to E&E engineering the power of the correlation test in the engineering sector is lower. It is shown that the correlation coefficient of 0.59 has a coefficient of determination of only 34%. This shows, that for 66% of the data no correlation is given.

For any correlation based upon a sample it is necessary to determine whether the set of data pairs could have produced a correlation by chance alone. For the Pearson product moment correlation, this is the familiar t-distribution (Black, 1999). The power of the test is to show the probability that would correctly identify a statistically significant correlation coefficient. This seems to be necessary, because "statistical significance does tell us is the likelihood that a relationship of at least this size could have arisen by chance. It is necessary to interpret both correlation and the significance level when computing correlation coefficients" (Bryman and Cramer, 1994). From the data analysis the correlations are considered as significant. This finding can be interpreted in the way that a similar correlation coefficient would be given in another sample size, too.

Table 6.3: Correlation Coefficient

Measure		E&E engineering (21 bus. units)	Engineering (57 bus. units)	E&E + Engineering (78 bus. units)
Phase 1 (uncorrected dataset)	Correlation coefficient [r]	0.55	0.29	0.41
	Coefficient of determination [r^2]	30%	8%	17%
Phase 2 (corrected dataset)	Correlation coefficient [r]	0.76	0.59	0.66
	Coefficient of determination[r^2]	59%	34%	44%
	Significance [t]	Yes[1] (0.68)	Yes[1] (0.41)	Yes[1] (0.54)

[1] According to Cohen (1988) a significance at the 0.01 level is given for t = 0.59 (n=21), 0.331 (n=57) and 0.286 (n=78).

The variance in the industry sectors E&E engineering (59%) and engineering (34%) shows that a high number of business units without any correlation is included in the dataset. Consequently a detailed analysis of the business units' positions in the diagram product innovation rate and the percentage of revenues from new products shows a wide distance around the trend-line. For example, Figures 6.10 (engineering) and 6.11 (E&E engineering) show few business units which achieve high revenues with a low product innovation rate (e.g., business unit "A"), whereas others have a high product innovation rate but do not achieve high revenues from these new products (e.g., "B"). Another example are business units from the engineering sector (Figure 6.10) labelled "C" and labelled "D". Interestingly both business units have the same product innovation rates, but business unit "C" achieves 60% (E&E engineering 80%) and business unit "D" 35% (E&E engineering 50%) revenues with new products . Another interesting point is the close position of the gradient of both trendlines. In Figure 5.11 (Chapter 5) with the corrected data for case business units in Phase 1, the gradient between both trendlines was clearly different.

The detailed analysis of the diagram product innovation rate and the percentage of revenues from new products implies that an investigation of product innovation position with statistical methods (i.e., correlation analysis) is inadequate. Although the corrected survey data (Phase2) shows a correlation of 44% for both industry sectors, a causation is not given. Consequently, the conclusion that higher product innovation rates are automatically related to higher percentages of revenues from new products is lacking. In both industry sectors some business units do not follow this regularity. Therefore, case studies are necessary for investigating the reasons why a correlation is not given for every business unit.

Taking the arguments given above into account Figure 6.10 and 6.11 raise a lot of questions. For many business units, however, it is shown that increasing product innovation rates lead to higher revenues. The question is whether this is because the business units operate in different markets, in each of which there are radically different requirements for new products. Put another way, what opportunity is there for a business unit with a low product innovation rate and low percentage of revenues from new products to change? However, before going further it is necessary to discuss the advantages and limitations of taking the diagram product innovation rate and the percentage of revenues from new products for the further research.

Figure 6.8: Phase1 – Product Innovation Rate (%) / Revenues from New Products (%), Engineering (57 business units – data from 1997, 1998, 1999 IBFA database)

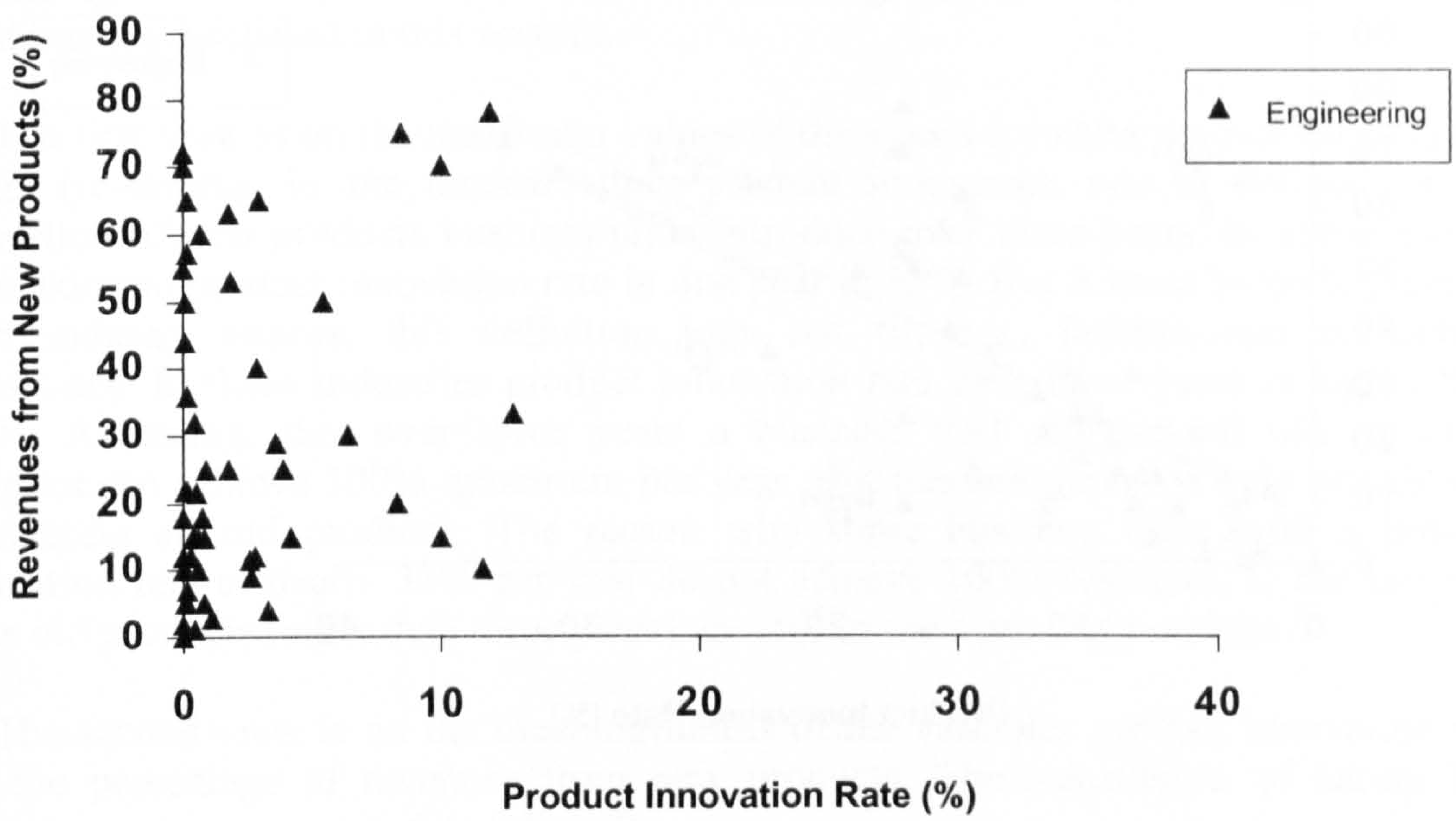


Figure 6.9: Phase1 – Product Innovation Rate (%) / Revenues from New Products (%), E&E Engineering (21 business units – data from 1997, 1998, 1999 IBFA database)

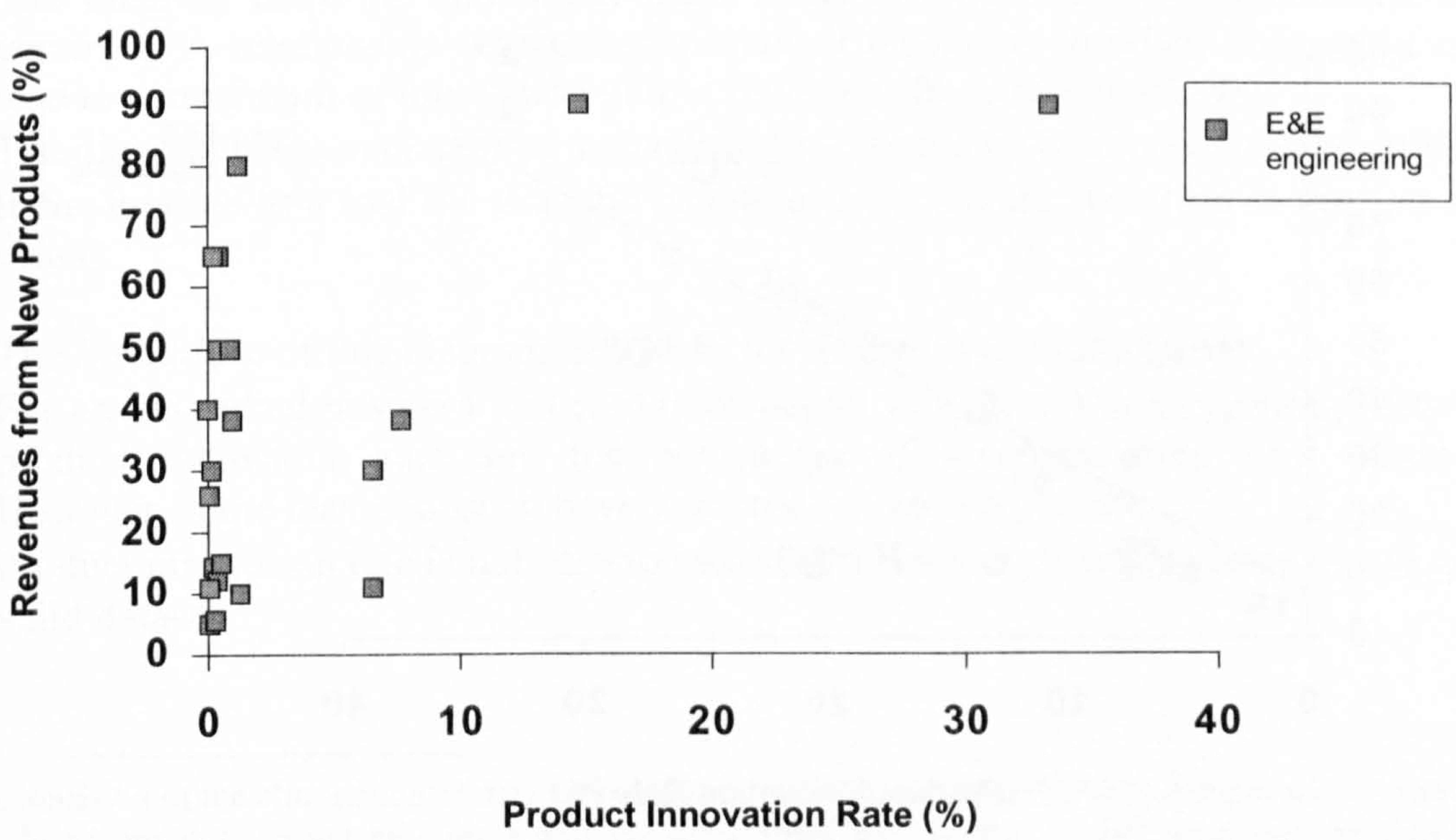


Figure 6.10: Corrected Product Innovation Rates (%) / Revenues from New Products (%), Engineering (57 business units – data from one page survey and telephone interviews 1999/2000)

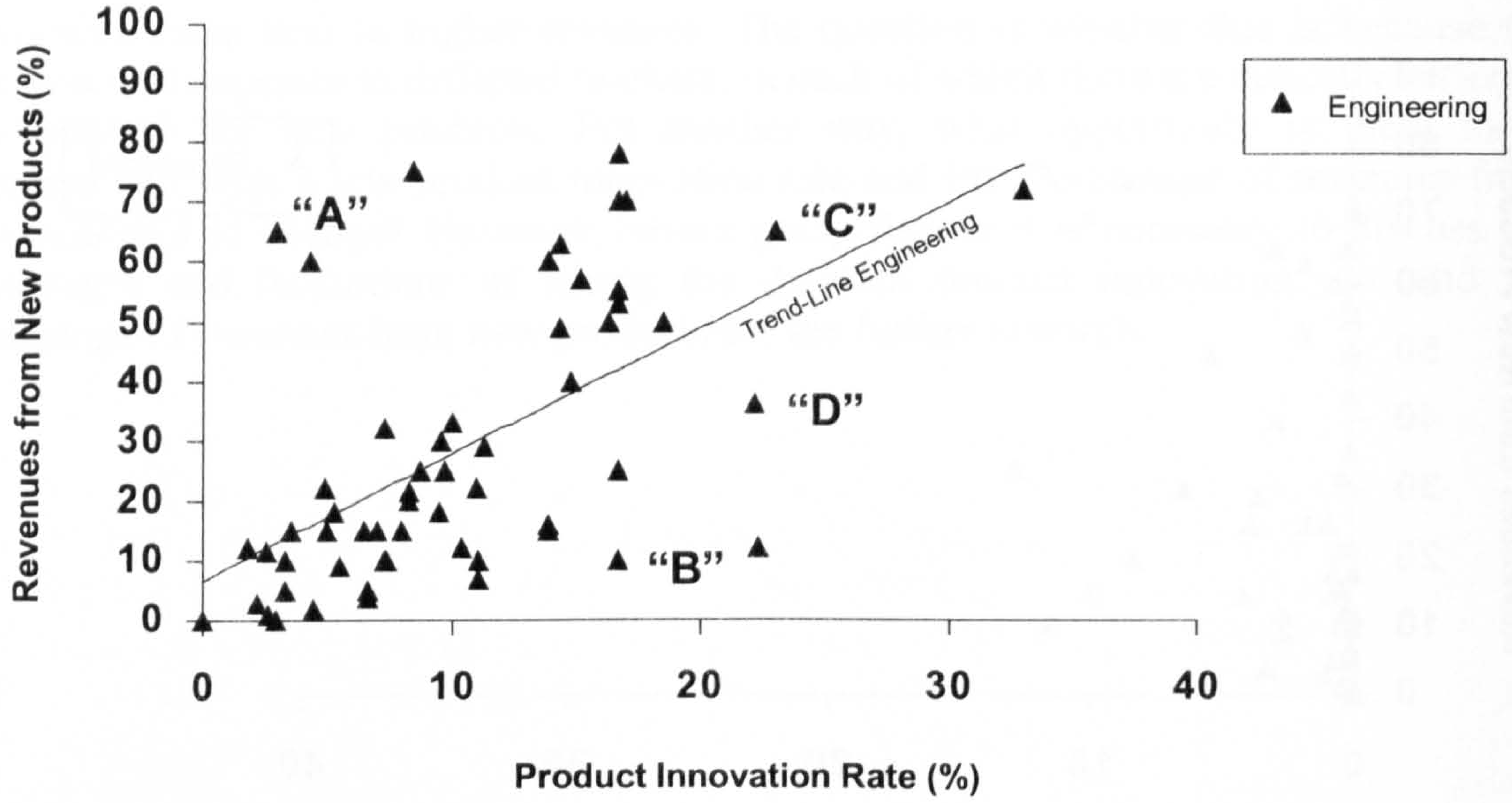
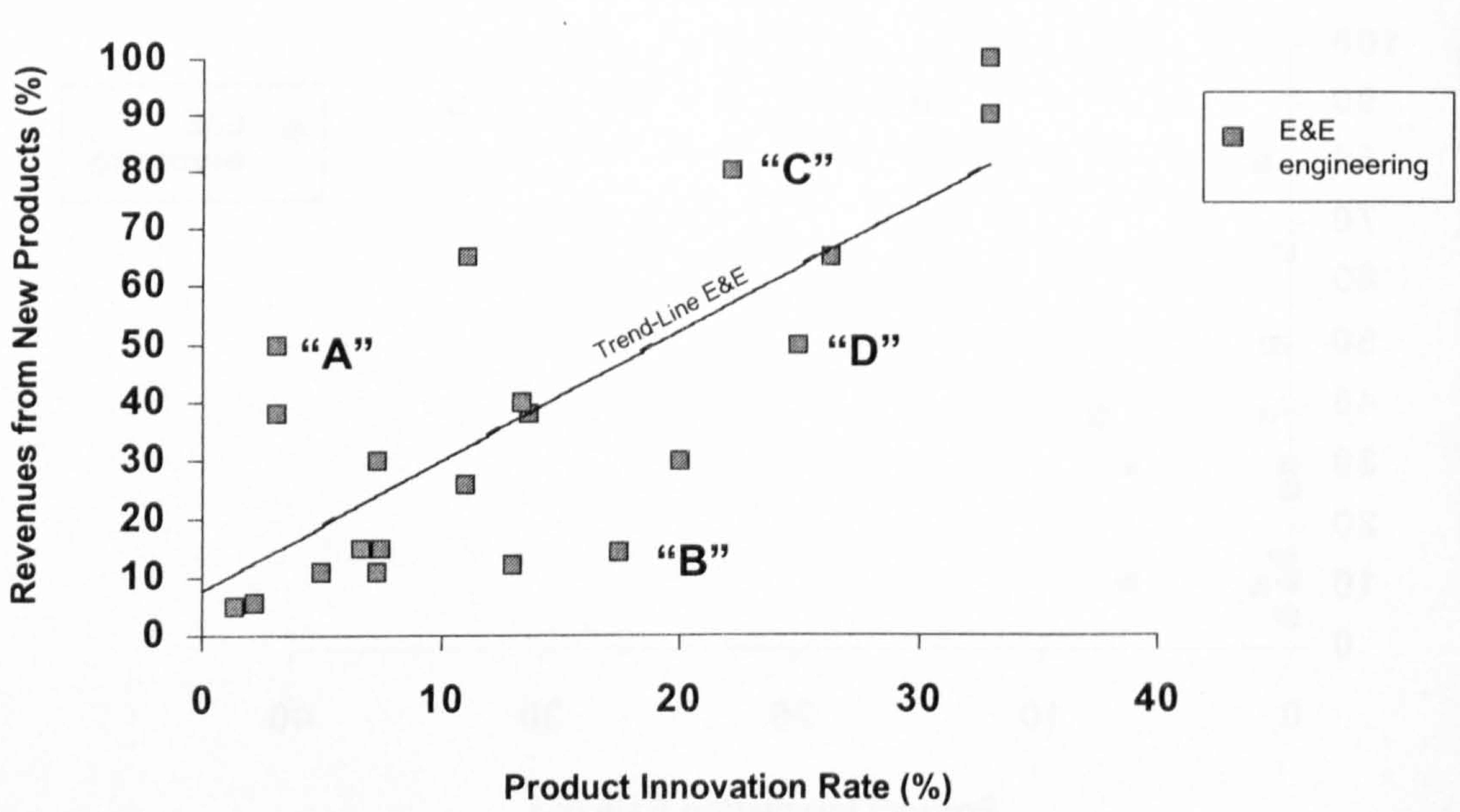


Figure 6.11: Corrected Product Innovation Rates (%) / Revenues from New Products (%), E&E Engineering (21 business units – data from one page survey and telephone interviews 1999/2000)



6.4.2 Advantages and Limitations of the Diagram

As the diagram with the corrected product innovation rate data shows, a relationship between product innovation rate and the percentage of revenues from new products can be observed for many business units. But what are the advantages and limitations of combining these variables and what is the meaningfulness of such a diagram? These questions are discussed in this section.

The first view is on the maximum values of the x-axis (product innovation rate) and y-axis (revenues). In the current study product innovation rate is defined as the proportion of new products business units introduce over three years. In consequence, the maximum product innovation rate in one year is 33%. But it must be noted, that for other industry sectors, this definition may not fit, e.g., fashion-wear or fashion accessories. In these industries product innovation rate over three years is higher than 100%. Assuming, that over three years a business unit replaces all old products, revenues can achieve 100% maximum per year. But this maximum is only possible by eliminating all old products. The reason why some business units with a product innovation rate of nearly 33% per year do not achieve 100% revenues, is the fact that some old products (older than three years) are still in their product portfolio.[53]

The second view is on the meaningfulness of the variables product innovation rate and the percentage of revenues from new products. The *advantages* of taking this diagram can be summarised as follow[54]:

- If there is a relationship between both variables the recommendations for managers will be clear – higher turnovers with new products will demand more new products (it is noted that higher revenues do not automatically mean higher profits).
- In combination with other variables, (i.e., profit and time to market) it can be explained if they have influence on the position within the diagram product innovation rate and the percentage of revenues from new products.
- The diagram helps to find out if there is an optimal relationship between both variables. A relationship where a minimum of resources (product innovation rate) lead to a maximum of innovation output (revenues from new products).
- The diagram helps managers to understand their actual level of product innovation.
- It can be used as a tool for strategic planning (i.e., expected position in three or five years).

The *limitations* of this diagram as a basis for further investigations are:

- For an individual business unit it may be useful to look at the relationship between product innovation rate and the percentage of revenues from new products. However, some may choose to have low product innovation rates.
- Product innovation rate is not easy to measure. Therefore, it is time intensive to get a valid dataset.

[53] A discussion of the elimination of new products is given in Section 2.3.5 (Product Innovation Strategy). That firms are not consistently removing products from the market at the same rate as they are introducing new products was found by Bayus (1994).
[54] The expected relationship of product innovation rate and the percentage of revenues is discussed in Section 4.2.5 'Product Innovation Rate and the Percentage of Revenues from New Products'.

- The diagram simplifies product innovation on company level and does not show the complexity.

It can be concluded that the diagram product innovation rate in combination with revenues from new products can help to understand why business units operate with different levels of product innovation rate and percentage of revenues from new products. As a starting point for further investigations on a business unit level, it seems to be an appropriate sampling framework. However, to be able to investigate the relationship between product innovation rates and the percentage of revenues from new products on a deeper level, some individual business units have to be chosen from the diagram. This was done in a systematic way by separating the diagram into fields. This is discussed in the next section.

6.5 A NEW APPROACH: SEPARATING BUSINESS UNITS INTO FIELDS

The research was based largely on investigating the product innovation position. Therefore, the diagram was divided into two fields – business units with low product innovation rates and business units with high product innovation rates. These two main fields were then separated into business units with low and high percentages of revenues from new products. The following sections discuss the separation of the diagram into fields in detail:

- Separation into fields
- Distribution of business units

6.5.1 Separation into Fields

The diagram product innovation rate and the percentage of revenues from new products shows a big variation of the business units (data-points). Although a business unit position within the diagram varies strongly, a concentration of data points within the diagram can be noticed. The highest accumulation of business units can be observed in the bottom left with low product innovation rates and low percentages of revenues. Another agglomeration is positioned in the centre of the diagram. These concentrations of business units could be accidental (the 78 business units do not represent the whole spectrum of the engineering and E&E engineering sector, respectively) or it could be that all these business units have the same characteristics. One possibility in the separation of the diagram into fields could be a separation of these two accumulations. However, such a separation is not based on strong arguments. To show a possible and systematic selection method, it is useful to look at the distribution of business units within the two variables product innovation rate and the percentage of revenues from new products.

Figure 6.12 (engineering) and 6.13 (E&E engineering) show the distribution of business units for the variable product innovation rate in increasing order. In the diagrams the number of business units with low product innovation rates is respectively higher than the number of business units with high product innovation rates. In engineering (Figure 6.12) most business units are placed in the sector between 7% and 12%. The rest is distributed from 12% to 33%. As the diagram does not show a normal distribution (i.e., normal distribution in order of Gauss) the mean is not useful as a separation variable – in consequence, the median is chosen as separation variable. Taking the median as separation line (9.5%), the number of business units in every field is the same (n = 28.5). The same picture is shown in Diagram 6.13 which shows the distribution of product innovation rate for the E&E engineering sector.

For the variable percentage of revenues from new products the distribution of business units is given in Figure 6.14 (engineering) and 6.15 (E&E engineering). In both industry sectors most achieve revenues from 0% to 30%, while the rest are placed between 31% and 100%. Therefore, the median was also chosen to separate the percentage of revenues from new products into two fields.

Figure 6.12: Distribution of Business Units for the Variable Product Innovation Rate (%) – Calculated within 4% Sectors, Engineering (57 business units – data from survey and telephone interviews 1999/2000)

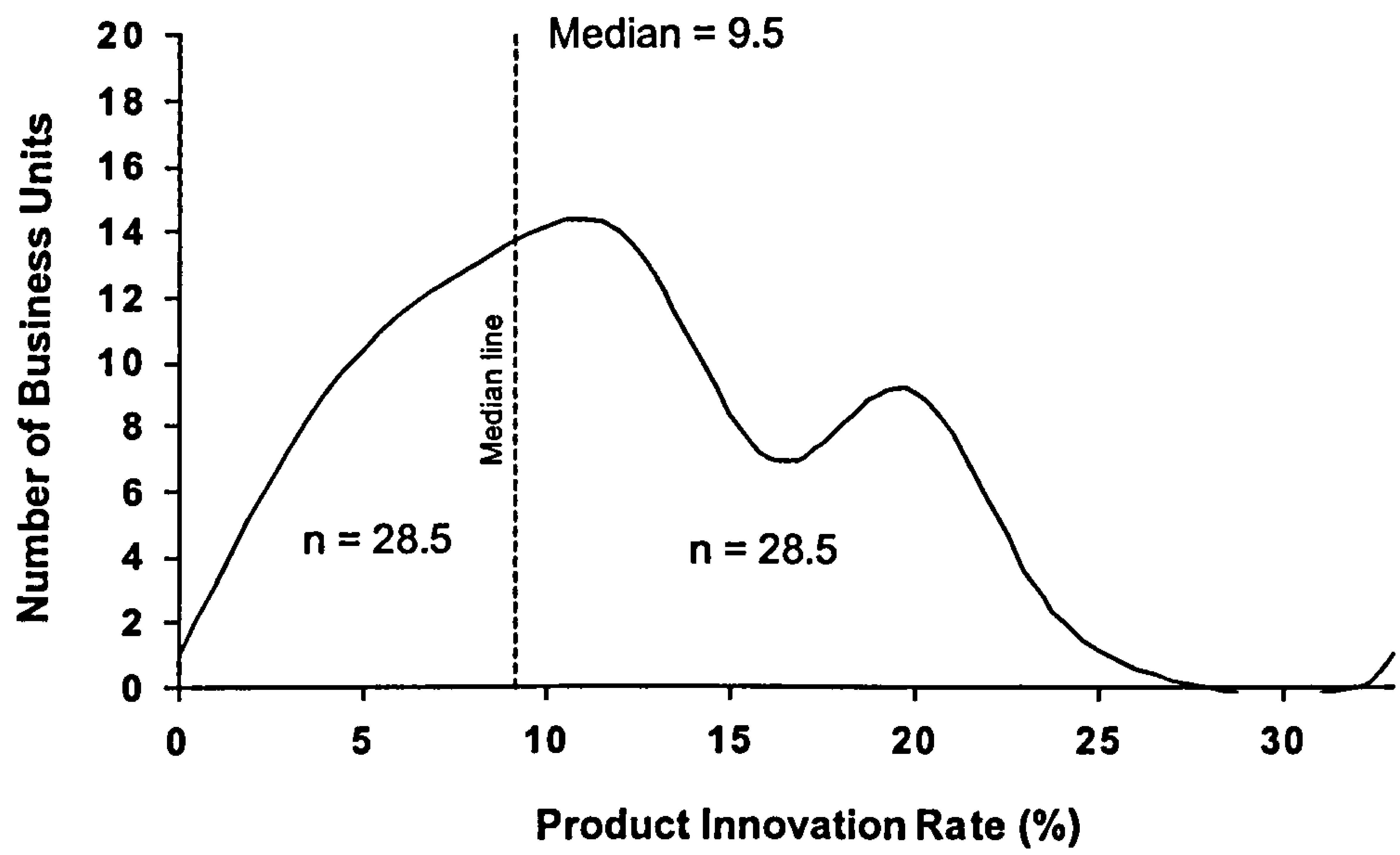


Figure 6.13: Distribution of Business Units for the Variable Product Innovation Rate (%) – Calculated within 4% Sectors, E&E Engineering (21 business units – data from survey and telephone interviews 1999/2000)

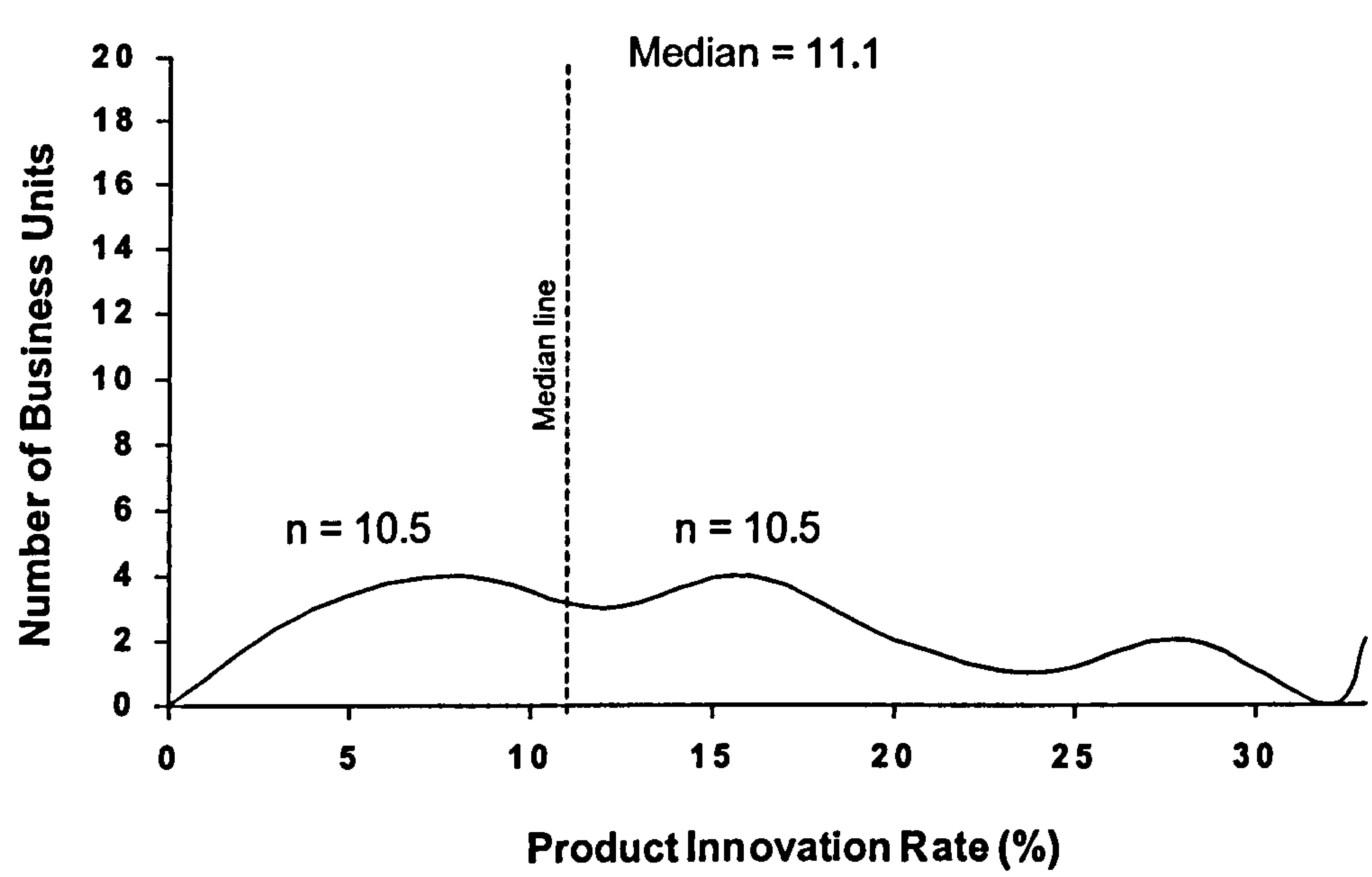


Figure 6.14: Distribution of Business Units for the Variable Revenues from New Products (%) – Calculated within 10% Sectors, Engineering (57 business units – data from survey and telephone interviews 1999/2000)

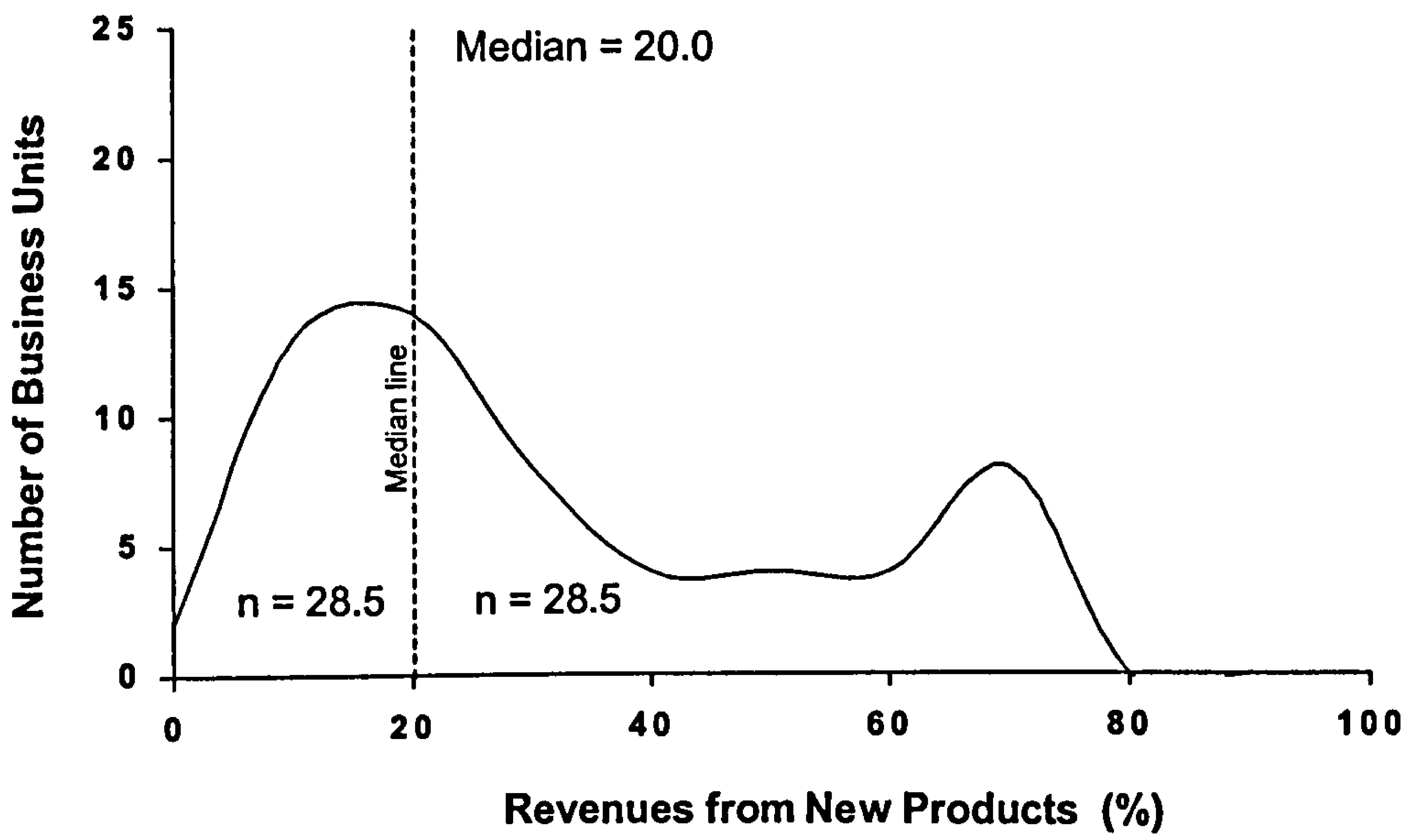
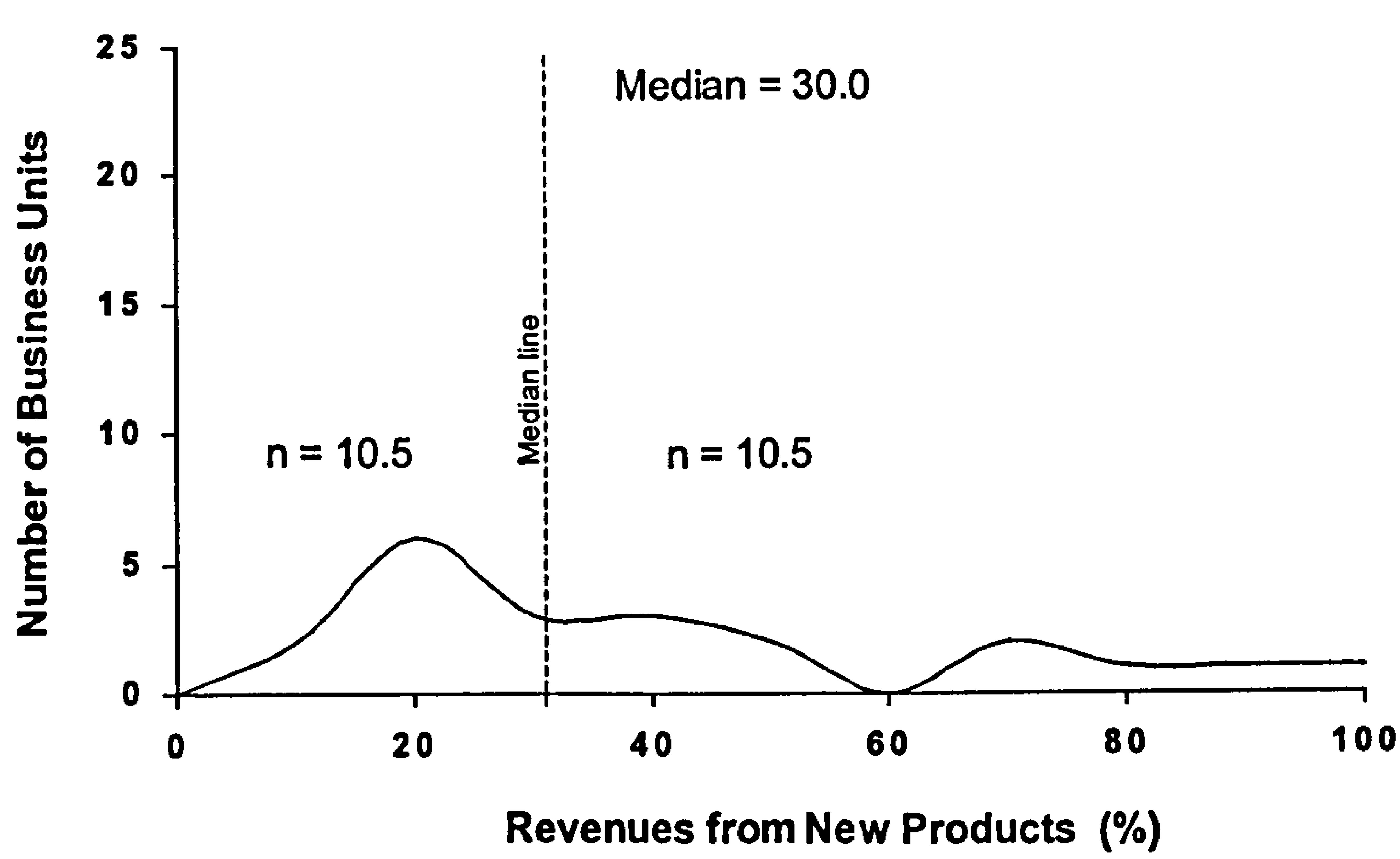


Figure 6.15: Distribution of Business Units for the Variable Revenues from New Products (%) – Calculated within 10% Sectors, E&E Engineering (21 business units – data from survey and telephone interviews 1999/2000)



The abnormal distribution of business units within the diagram product innovation rate and the percentage of revenues from new products is also shown by some statistical measures (Table 6.4). In each industry sector the variables are characterised by a high standard deviation and therefore the mean does not show a representative measure. This supports taking the median line as separation line.

Table 6.4: Statistical Measures

Measure	Engineering (57 business units)		E&E Engineering (21 business units)		E&E + Engineering (78 business units)	
	Product innovation rate	Revenues from new products	Product innovation rate	Revenues from new products	Product innovation rate	Revenues from new products
Mean	10.6	28.3	13.5	37.2	11.4	30.7
Standard deviation	7.4	13.0	9.8	27.4	8.2	24.4
Median	9.5	20.0	11.1	30.0	9.6	22.0

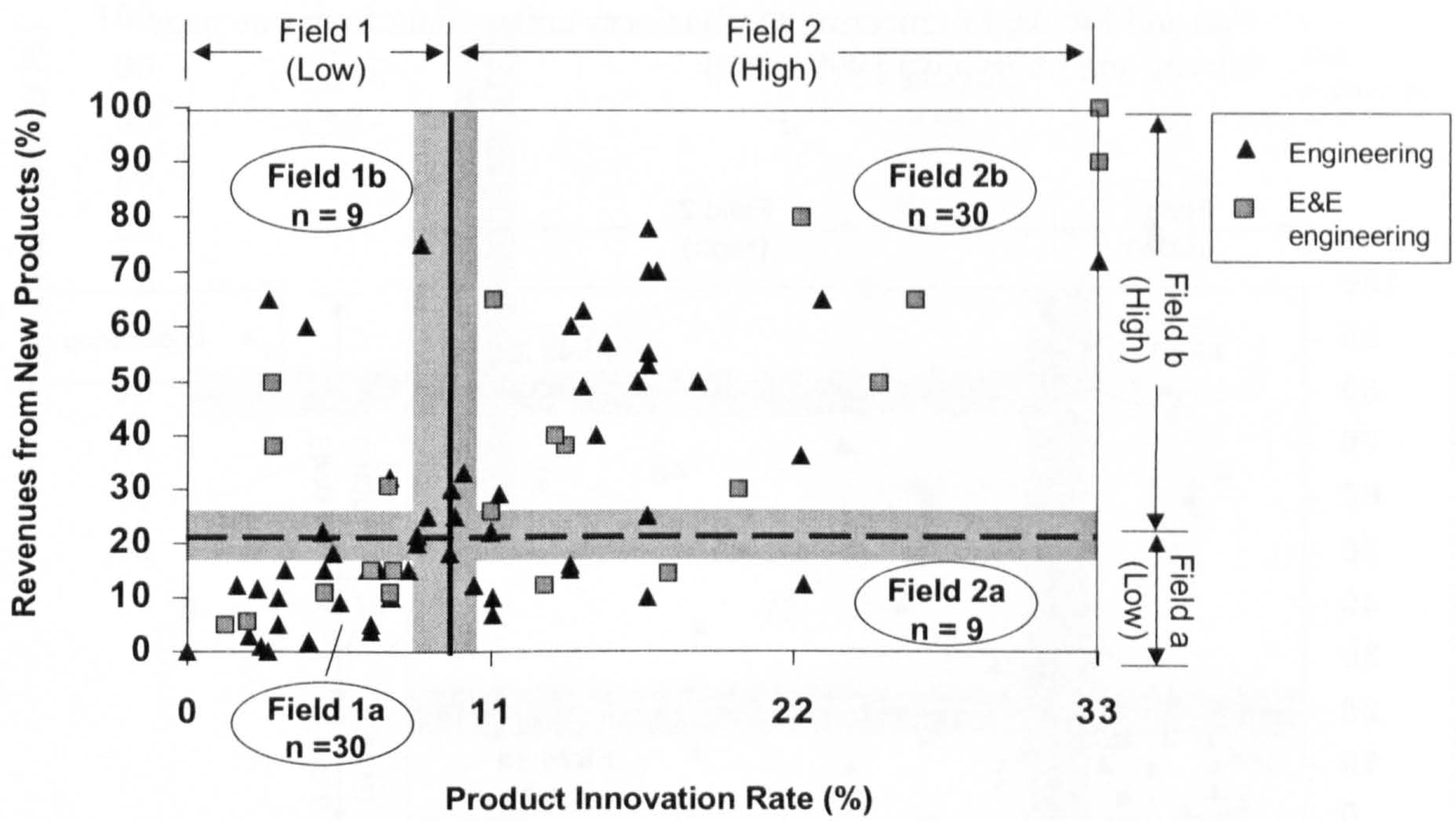
6.5.2 Distribution of Business Units

Taking all arguments into account, the most appropriate way is to separate the diagram product innovation rate and the percentage of revenues from new products by the median-lines. Figure 6.16 shows a categorisation of the whole sample size (industry sectors engineering and E&E engineering) into fields which are formed by the differentiation of the x-axis and y-axis in the medium lines. First the x-axis is divided by the median into "Field 1" (low product innovation rates) and "Field 2" (high product innovation rates). In the next step the y-axis is divided into "Field a" (low percentage of revenues from new products) and "Field b" (high percentage of revenues from new products). This differentiation into fields has the possibility that all business units are included in one of the four fields and the selection of cases can be made in a more effective way. Although it is clear that the division-lines can change by using another sample, the categorisation of all business units with this dataset can be summarised as follows:

- *Field 1*
  a: Includes business units with low product innovation rates (engineering <9.5%; E&E engineering <11.1%; engineering + E&E engineering <9.6%) and low percentage of revenues from new products (engineering <20.0%; E&E engineering <30.0%; engineering + E&E engineering <22.0%).
  b: Includes business units with low product innovation rates (engineering <9.5%; E&E engineering <11.1%; engineering + E&E engineering <9.6%) but high percentage of revenues from new products (engineering >20.0%; E&E engineering >30.0%; engineering + E&E engineering >22.0%).

- ***Field 2***
  a: Includes business units with high product innovation rates (engineering >9.5%; E&E engineering >11.1%; engineering + E&E engineering >9.6%) but low percentage of revenues from new products (engineering <20.0%; E&E engineering <30.0%; engineering + E&E engineering <22.0%).
  b: Includes business units with high product innovation rates (engineering >9.5%; E&E engineering >11.1%; engineering + E&E engineering >9.6%) and high percentage of revenues from new products (engineering >20.0%; E&E engineering >30.0%; engineering + E&E engineering >22.0%).

Figure 6.16: Corrected Product Innovation Rate (%) / Revenues from New Products (%) and Fields, Engineering and E&E Engineering (78 business units – data from one page survey and interviews 1999/2000)



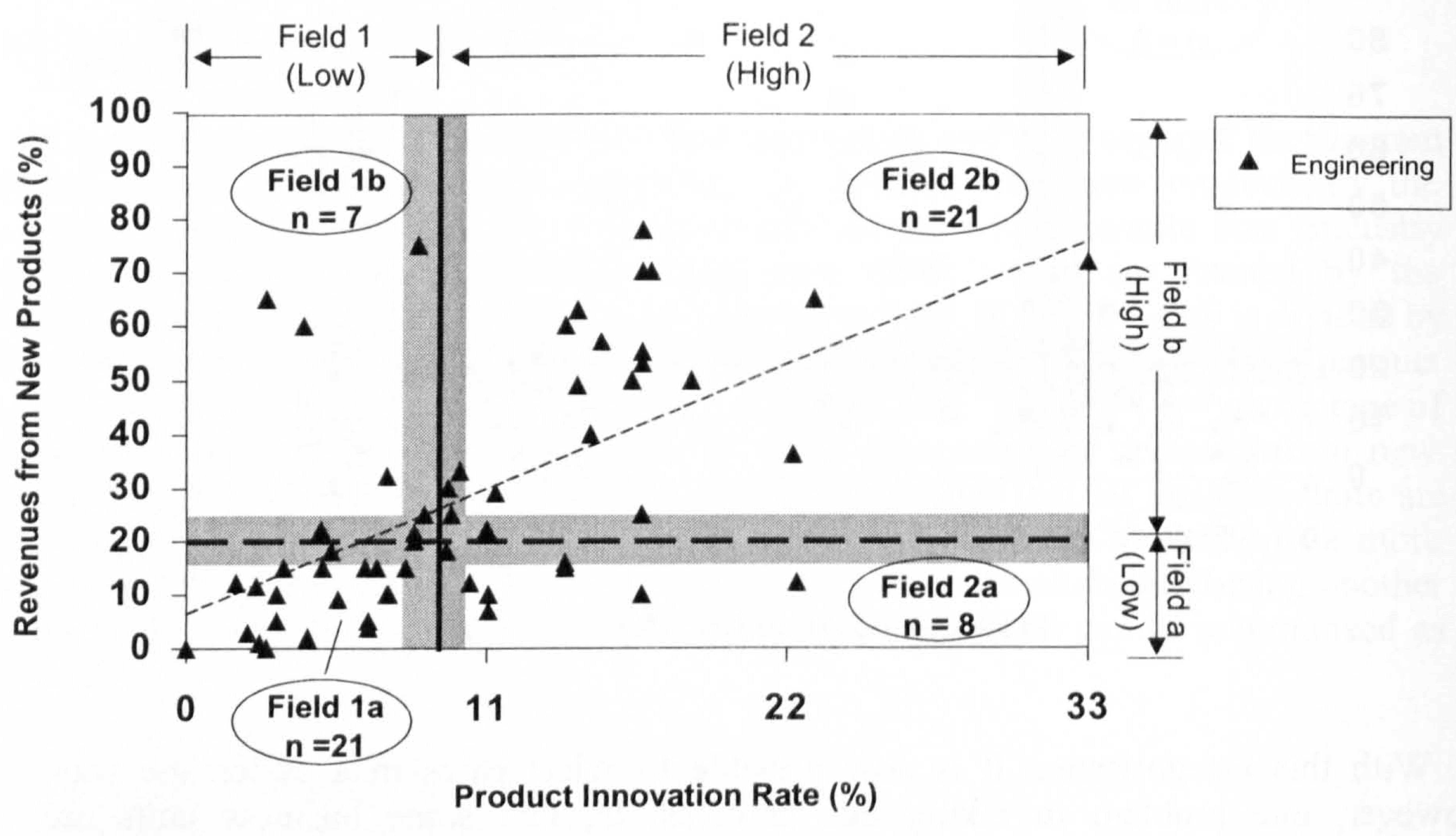
With this categorisation it is now possible to select cases in a systematic way. However, one problem in taking this approach is, that some business units are positioned nearly or directly on the separation-lines. As for these business units it is not clear in which field they can be sorted, a transmission area is given in the diagram. The grey beams show, that the position of these business units is open – dependent on the sample, the lines could change.

As Figure 6.16 shows the separation lines for the whole sample size (engineering and E&E engineering) the distribution of business units in industry sectors are given next.

Distribution of Business Units in the Industry Sector Engineering

For Engineering, Figure 6.17 depicts the same situation as for the whole sample size (engineering + E&E engineering). As has been explained previously, the diagram is differentiated into the two main fields and two sub-fields. The grey beam in the diagram marks the transition areas between two different fields. In Field 1a, most business units do not achieve positions higher than the trend-line. And some business units with a product innovation rate between 8% and 9.7% achieve only few revenues. In Field 1b, one business unit with a product innovation rate of only 8.5% makes 75% of its revenues from new products. On the one hand, in Field 2a one business unit with a product innovation rate of 22% achieves only 12% of its revenues by means of these new products. On the other hand, there are also several business units in Field 2b which achieve high revenues (up to 78%) with product innovation rates between 14% and nearly 33%.

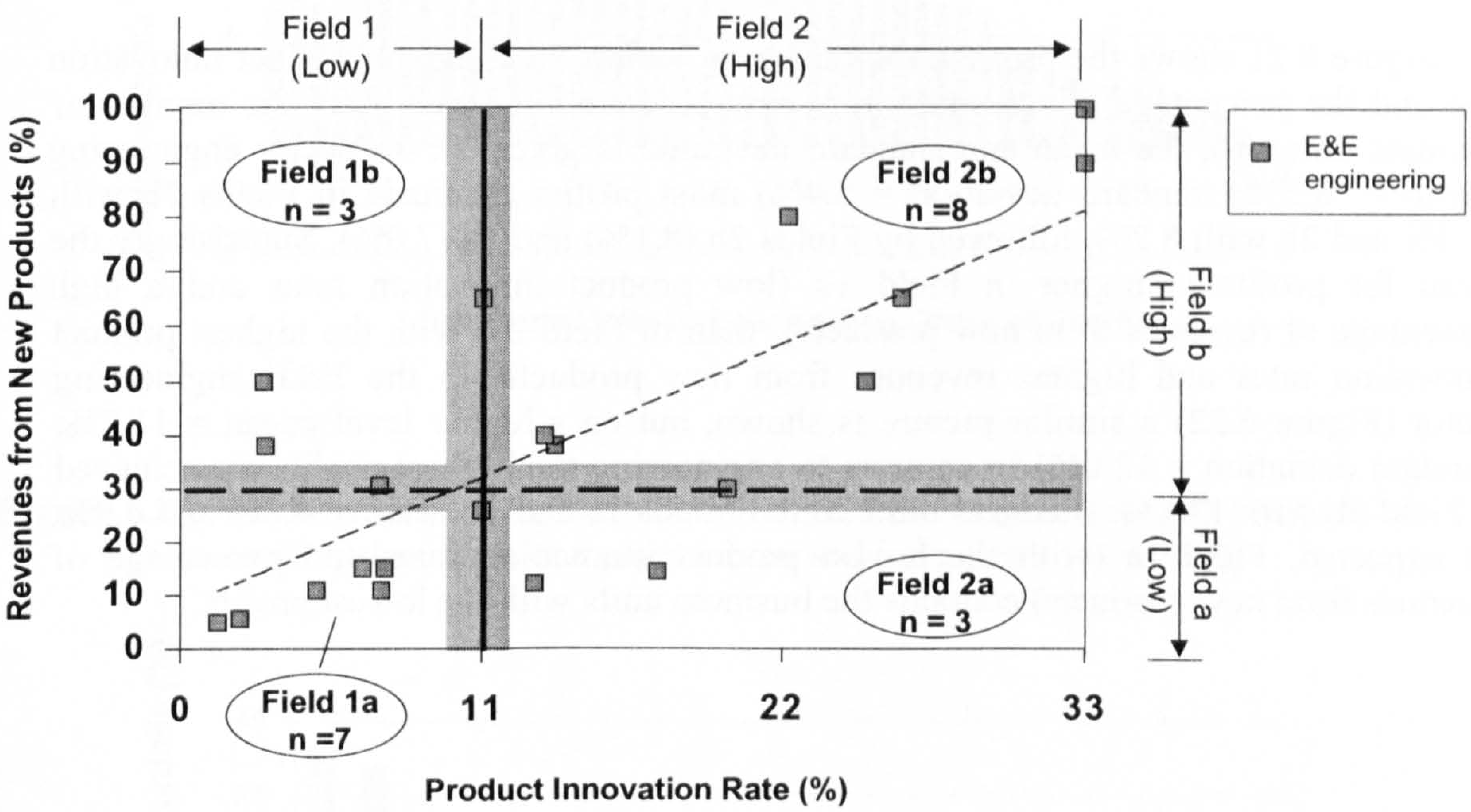
Figure 6.17: Corrected Product Innovation Rate (%) / Revenues from New Products (%) and Fields, Engineering (57 business units – data from one page survey and interviews 1999/2000)



Distribution of Business Units in the Industry Sector E&E Engineering

Figure 6.18 shows the distribution for the E&E engineering sector. In Field 1a only one business unit achieves 30% revenues with 7.3% product innovation rate. Two business units have product innovation rates with 1.38% and 2.2% and achieve revenues with 5.0% and 5.7%. Some others achieve 10% revenues with product innovation rates between 4% and 8%. Another interesting point is that all business units in this field are positioned underneath the trend-line. In Field 1b, one business unit achieves 50% of its revenues with a product innovation rate which is slightly higher than 3%. One business unit in Field 2a does not achieve more than 14.4% revenues although it has a product innovation rate of 17.4%. In Field 2b two business units achieve a product innovation rate of nearly 33%. From these two business units only one generates 100% of its revenues from the new products, while the other one achieves 90% revenues from the new products. These highly innovative business units are able to transform their innovation activities into revenues.

Figure 6.18: Corrected Product Innovation Rate (%) / Revenues from New Products and Fields, E&E Engineering (21 business units – data from one page survey and interviews 1999/2000)



The correct product innovation rates in the engineering industry and E&E engineering industry show that product innovation plays an important role in these industries. The data collected in Phase 2 was a good basis for further investigations. For both sectors it was possible to separate business units into fields. Within these fields case business units can be chosen in order to explain the reasons for their product innovation position. However, the corrected dataset also makes it possible to investigate profits (with the whole product portfolio) on a deeper level to get information on how it is related to the individual product innovation position.

6.6 PROFITS WITH THE WHOLE PRODUCT PORTFOLIO

The IBFA dataset allowed the calculation of the percentile profit with sold products. In the dataset profit is given for the whole product range. Although this variable represents not only new products it is a good opportunity to investigate the influence of product innovation rate and revenues on profit. In contrast to profits with new products, the view on the whole product range shows whether a business unit has a profitable product portfolio which fits customer demands.

Figure 6.19 and 6.20 show the profits in engineering and E&E engineering achieved with the whole product range in descending order (on the x-axis). From the corrected dataset, data of 48 business units from engineering (84% of the sample size) and 19 business units from E&E engineering (90% of the sample size) were useable. Only two business units in engineering achieved no profit. However, 34% of all business units in engineering and 32% in E&E engineering made profits of more than 10%. 47% in E&E engineering made profits between 0 and 5.0% (engineering 28%) and 21% made profits between 6.0 and 10.0% (engineering 34%). This shows that only a few business units achieved profits over 10%.

Figure 6.21 shows the profits in engineering within the diagram product innovation rate and the percentage of revenues from new products. For each field the number of business units (n), the mean and standard deviation is given. In the sector engineering (mean = 8.5%; standard deviation = 5.4%) most profits are made in Fields 1b with 13.4% and 2b with 8.2%, followed by Fields 2b (8.1%) and 1a (7.0%). Surprisingly the mean for profits is higher in Field 1b (low product innovation rates and a high percentage of revenues from new products) than in Field 2 b with the highest product innovation rates and highest revenues from new products. In the E&E engineering sector (Figure 6.22) a similar picture is shown, but on a higher level (mean = 11.2%; standard deviation = 12.0%) In contrast to engineering the highest profits are achieved in Field 2b with 17.8%. Business units in the Fields 1a and 1b achieve 4.8% and 4.9%. As expected, Field 1a (with the lowest product innovation rates and percentage of revenues from new products) contains the business units with the lowest profits.

Figure 6.19: Profit with the Whole Product Range, Engineering (57 business units – data from one page survey and interviews 1999/2000)

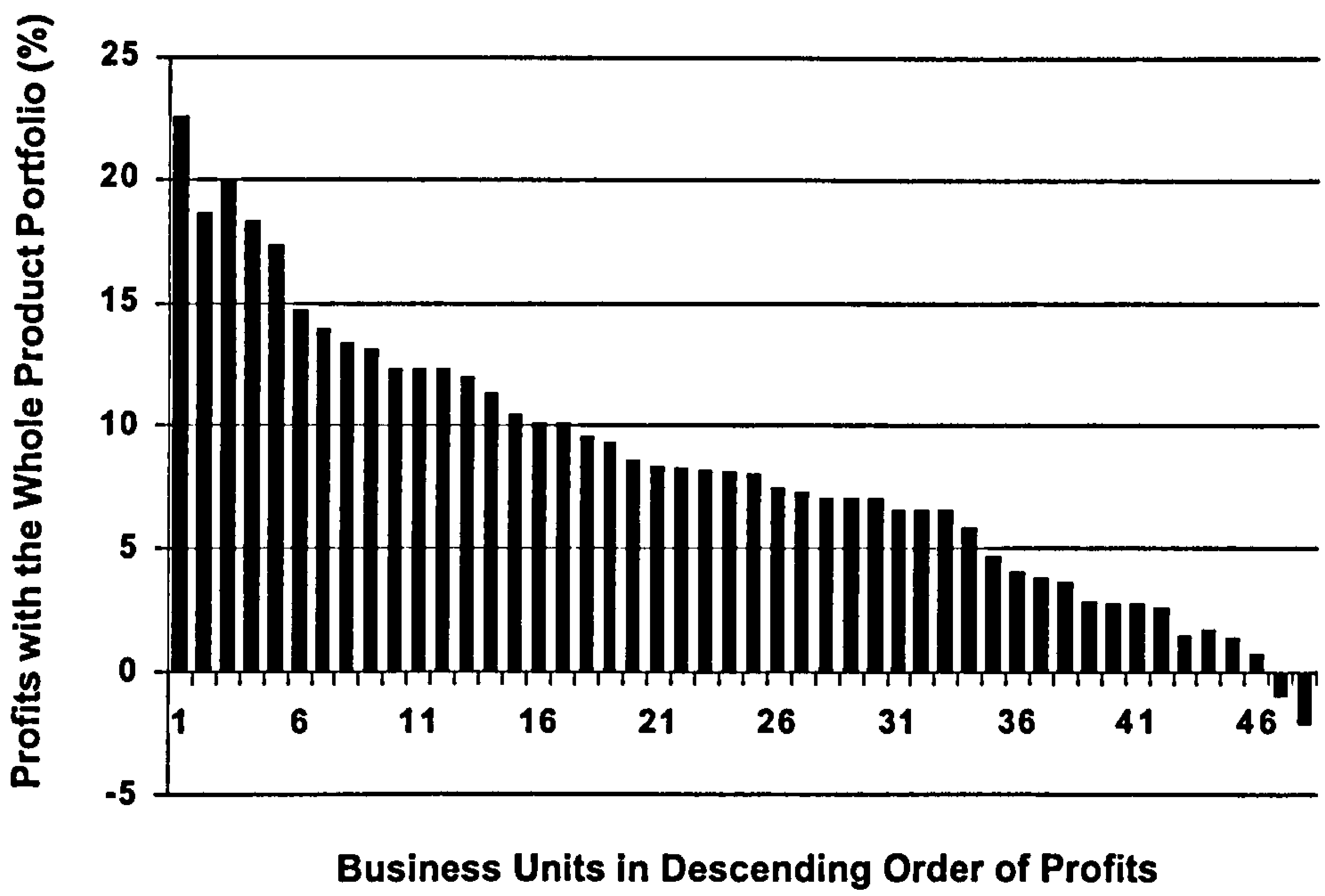


Figure 6.20: Profit with the Whole Product Range, E&E Engineering (21 business units – data from one page survey and interviews 1999/2000)

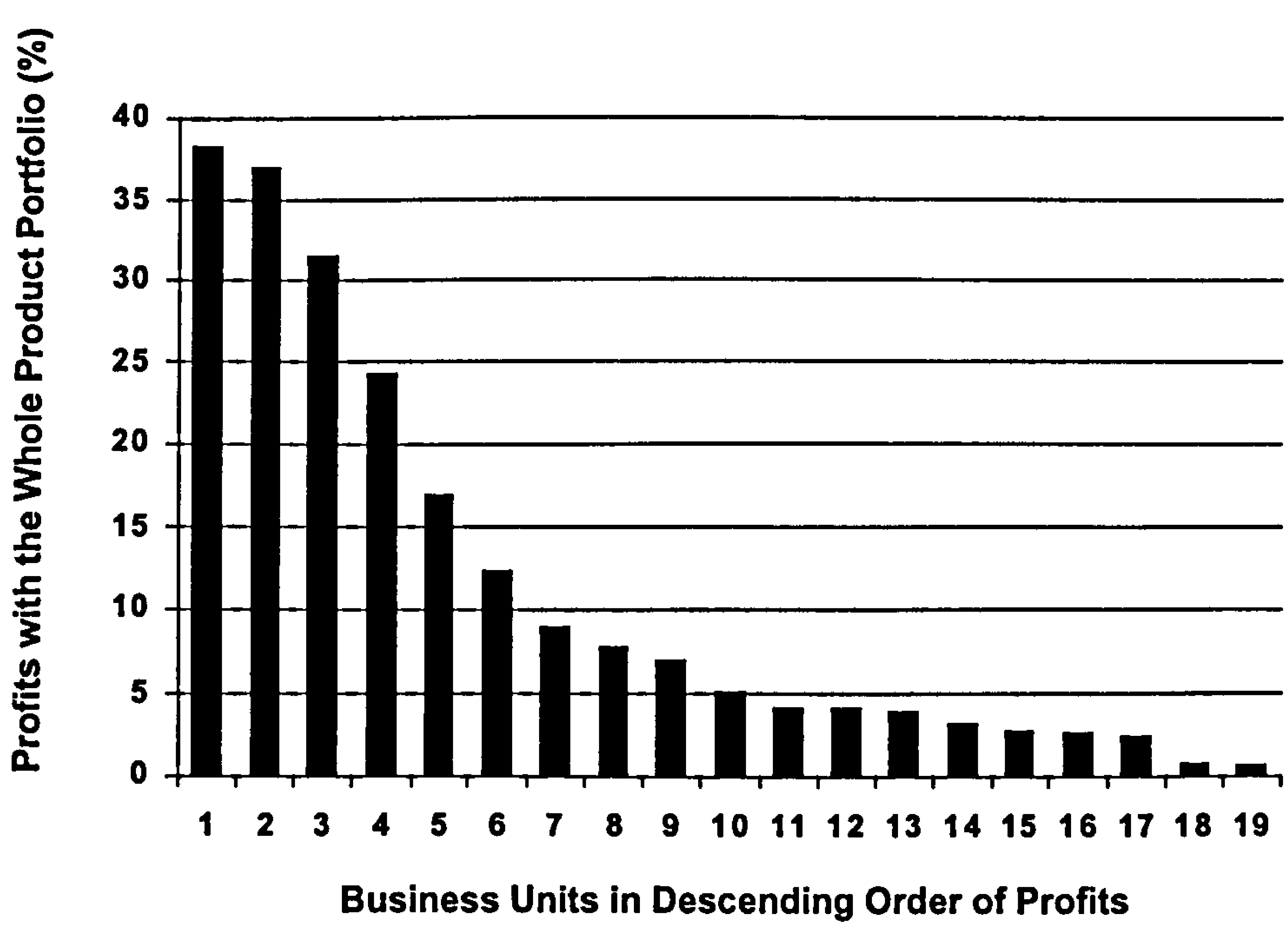


Figure 6.21: Profit with the Whole Product Range within the Fields Product

Innovation Rate (%) / Revenues from New Products (%), Engineering (47 business units – data from 1997, 1998, 1999 IBFA database)

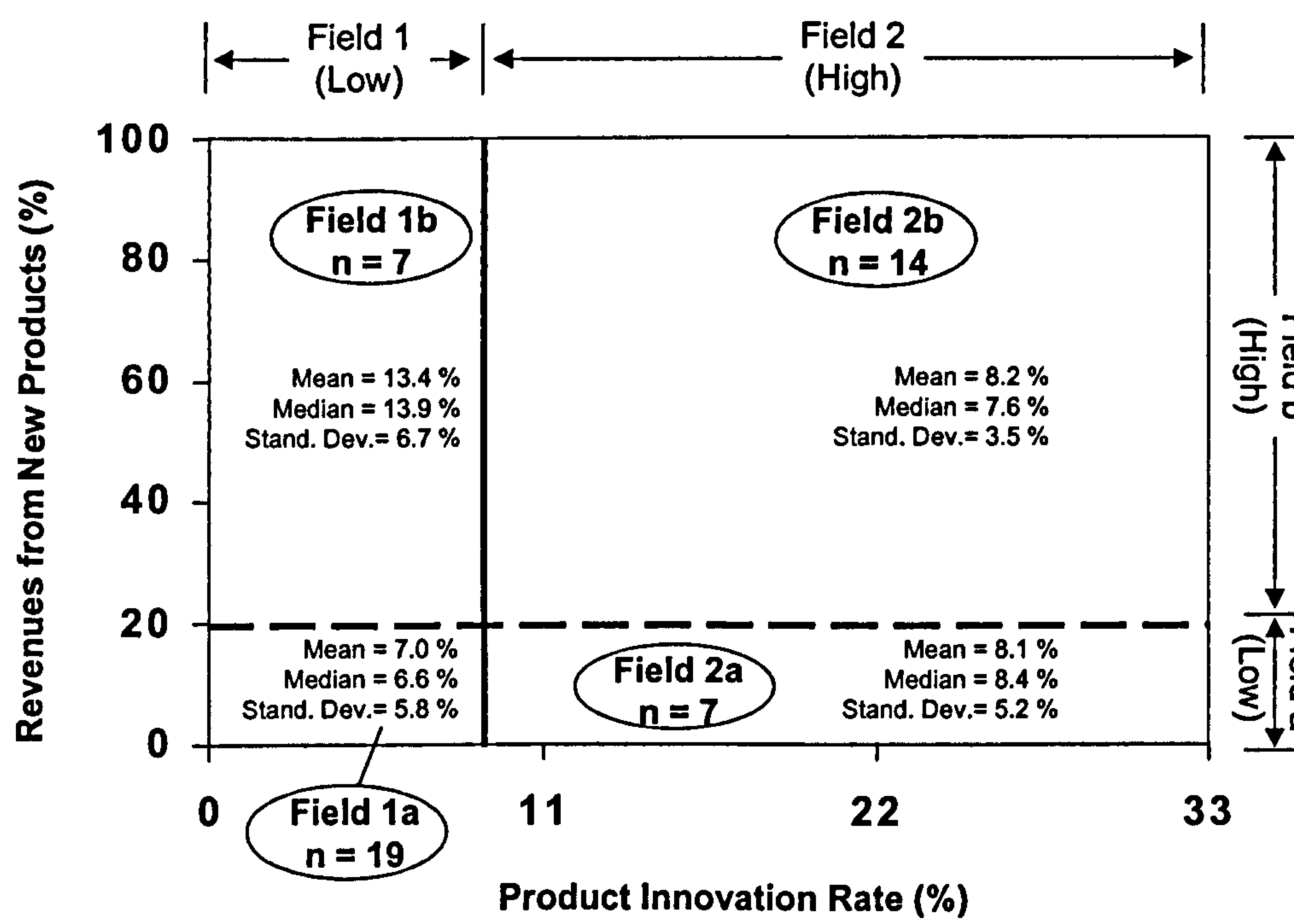
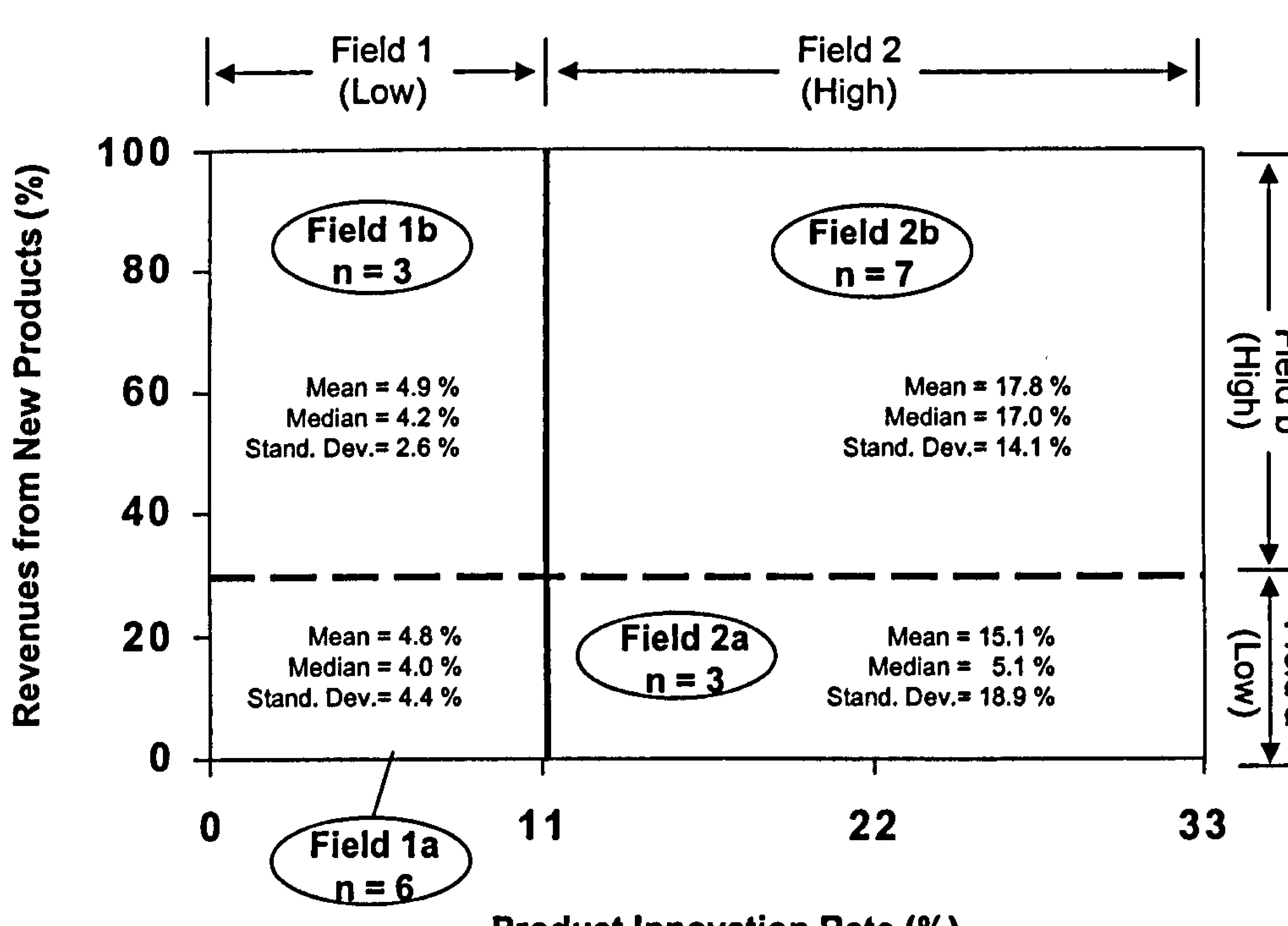


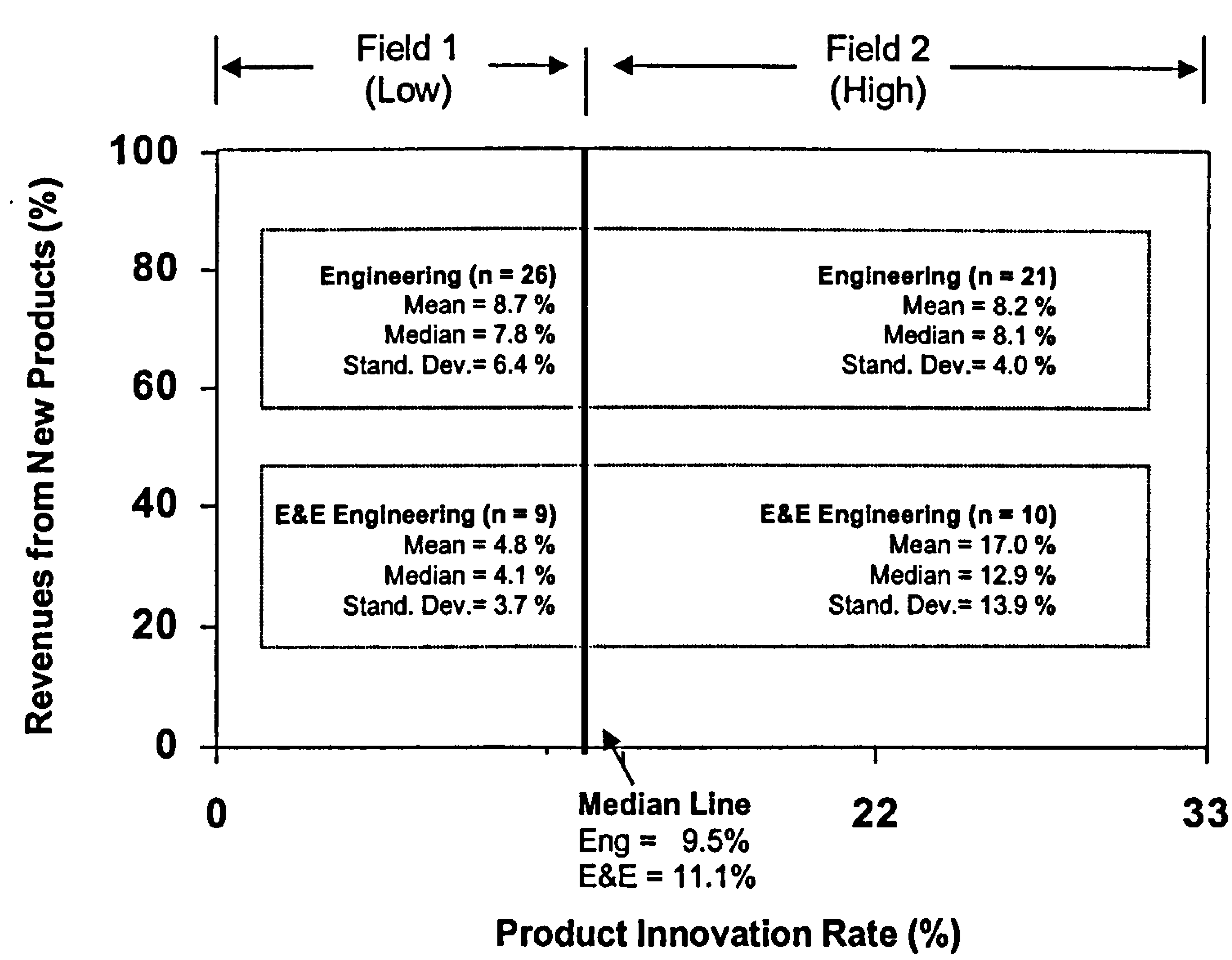
Figure 6.22: Profit with the Whole Product Range within the Diagram Product Innovation Rate (%) / Revenues from New Products (%), E&E Engineering (19 business units – data from 1997, 1998, 1999 IBFA database)



On average in Field 1a with the lowest product innovation rates and revenues the lowest profits are achieved within the two industry sectors. However, for the other fields no tendency can be observed. For the Fields 1b and 2b different results are found. As the standard deviation within the different fields is very high (it varies between 2.6% to 18.9%), the diagrams only show a tendency. However, to show the relationship between product innovation rate and profits a further analysis is carried out.

Figure 6.23 shows the profits sorted into Field 1 (low product innovation rates) and Field 2 (high product innovation rates). Without differentiating into sub-fields "a" and "b" a clear tendency is shown. From the figure the relationship between product innovation rate and profit is obvious for the E&E engineering sector. The interaction of higher product innovation rates and a higher percentage of revenues from new products on average generates higher profits. From this diagram it can be concluded that one reason for business units from E&E engineering to develop more new products is the aim to achieve more profits. However for engineering this is not the case. Business units with high product innovation rate achieve lower profits on average (8.2%) than business units with low product innovation rates (8.7%). In both industry sectors there are also some business units which achieve respectively high profits with low product innovation rates and low percentage of revenues from new products. These business units need deeper investigation to show the reasons for their high profits with a low product innovation rate.

Figure 6.23: Profit with the Whole Product Range within the Fields Product Innovation Rate (%) / Revenues from New Products (%), Engineering and E&E Engineering (66 business units – data from 1997, 1998, 1999 IBFA database)



Although the number of business units within the fields vary, and the sample is not representative for the German industry as a whole, the results can be summarised as follows:

- Business units from E&E engineering positioned in Field 2 (high product innovation rates) in general generate higher profits than business units in Field 1.
- Business units from engineering with low product innovation rates (positioned in Field 1) earn similar profits than business units positioned in Field 2.
- Looking at all diagrams a further tendency is observed. Business units in Field 1a with low product innovation rates and low revenues achieve lower profits than business units in other sub-fields.
- Within the other sub-fields, the tendency is not so clear.

The IBFA dataset allowed further investigations into product innovation variables to be made. In the next section the usefulness of prognosis of product innovation rate by managers is investigated.

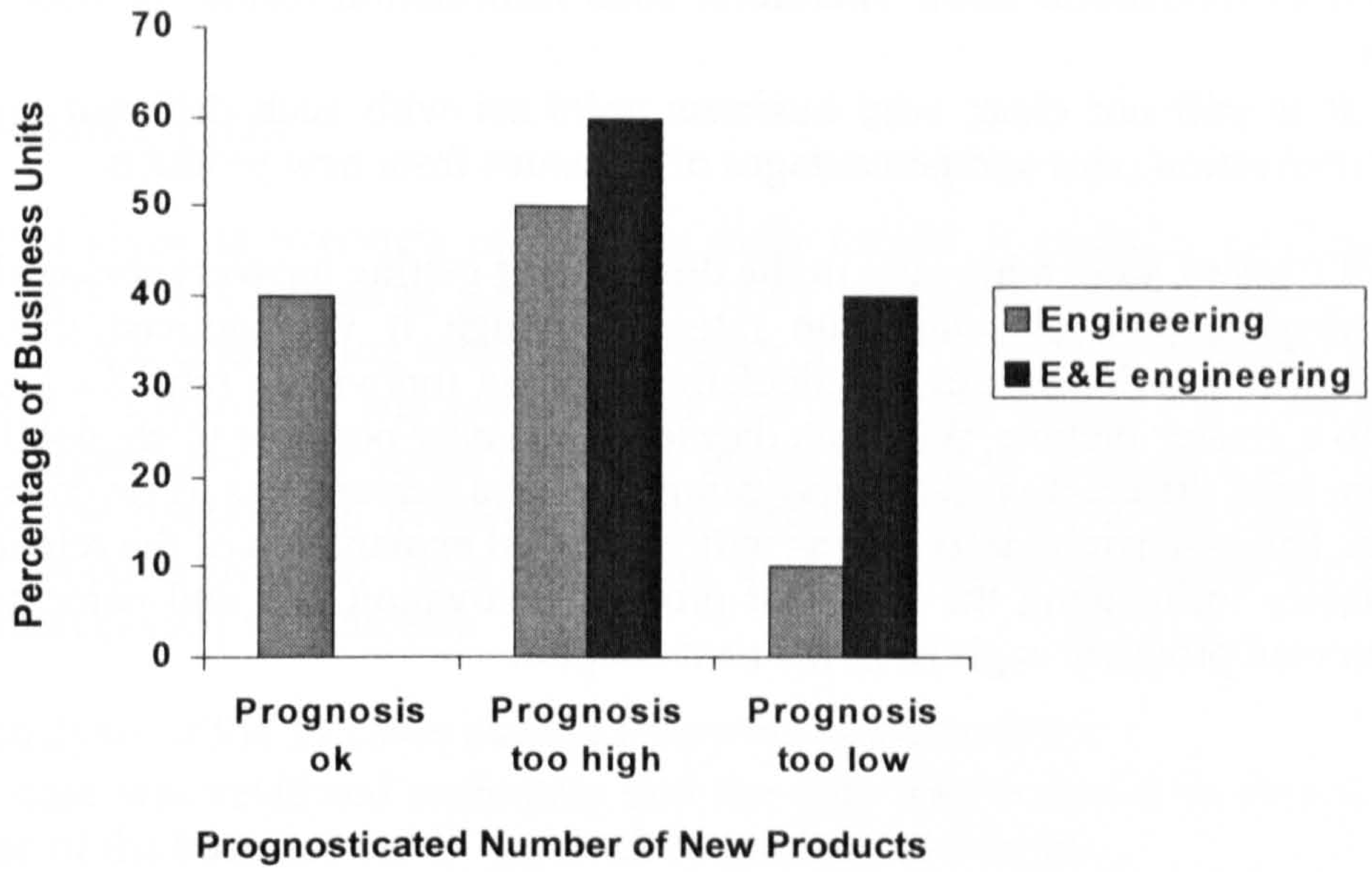
6.7 PROGNOSIS OF PRODUCT INNOVATION RATE

The IBFA dataset gave the opportunity to compare performance measures of business units over a three years period of time. In summary, 12 business units in engineering and five business units in E&E engineering took part at IBFA 1997 and 1999. This allowed some interesting insights into the value of prognosticated data.

How the business units were able to transform their prognosticated NPD projects in 1997 is shown in Figure 6.24. In this diagram the number of new products the business units wanted to develop in the next three years (data from 1997) are compared with the number of products they reported in 1999 for the last three years. The result gives hints on how realistically managers can forecast their product innovation activities. With 40% only the engineering sector contains business units who realised the number of innovations they reported in 1997. All other business units overestimated or underestimated their activities. 50% of business units in engineering (60% E&E engineering) reported a higher number of new products than they had realised. And 10% in engineering (40% in E&E engineering) developed more new products than they prognosticated.

This result shows that measures, based on estimations by managers cannot be used to find answers on research questions. To get a realistic foundation the only possibility is to ask for activities in the past. Most managers overestimated their performance and therefore their data cannot be used. Therefore, no variables were used in the current research project, which are based on prognosticated assumptions.

Figure 6.24: Prognosticated Number of New Products (data from IBFA database), Engineering (n=10) and E&E Engineering (n=5)



6.8 SUMMARY

Phase 2 showed that measurement of product innovation rate needs a detailed understanding of what has to be measured. The telephone interviews showed that some managers had difficulties in reporting realistic product innovation rates. However, most managers had understood the problem and calculated product innovation rate on the basis of comparable variables. The corrected product innovation rates show that for most business units a relationship between product innovation rate and the percentage of revenues from new products exist. With the valid data gained in Phase 2, deeper investigations into the reasons for varying product innovation rates are possible. Main findings in this phase were:

- Wide variations exist in product innovation rate within the engineering and E&E engineering sectors in Germany.
- About 80% of business units in both the engineering and E&E engineering sectors replace more than 5% of their product portfolios per year. However, there are only a few business units with a product innovation rate of more than 20%.
- The relationship between product innovation rates with the percentage of revenues from new products is significant (higher product innovation rates lead to higher revenues). This regularity is shown by the high correlation coefficient of 66% over all business units.
- The diagram product innovation rate and percentage of revenues from new products can be separated into two main fields (business units with high/low product innovation rates) and two sub-fields (business units with high/low percentage of revenues from new products).
- Survey analysis for the case business units showed a relationship between profits and product innovation rate for E&E engineering – in general business units with higher product innovation rates generate higher profits. However, in engineering

such a relationship is not given. On average business units with high product innovation rates earn less than business units with high product innovation rates.

- Managers have difficulties in estimating their future product innovation activities (i.e., product innovation rate). Therefore, such information cannot be used in the research.
- Finally, it is still not clear, why business units act with such different levels of product innovation rates and percentages of revenues from new products.

Results of Phase 2 were a big step in the direction of getting answers concerning the reasons for varying product innovation rates. Although it was noticed that some business units still had difficulties in calculating product innovation rate, the corrected data has led to a clearer picture. With this dataset it was now possible to choose 11 case business units, with different product innovation rates and percentages of revenues from new products. The case study descriptions with a detailed explanation of the relationship between variables influencing the levels of product innovation rate and percentage of revenues from new products is given in the next chapter.

CHAPTER SEVEN

RESULTS OF PHASE 3

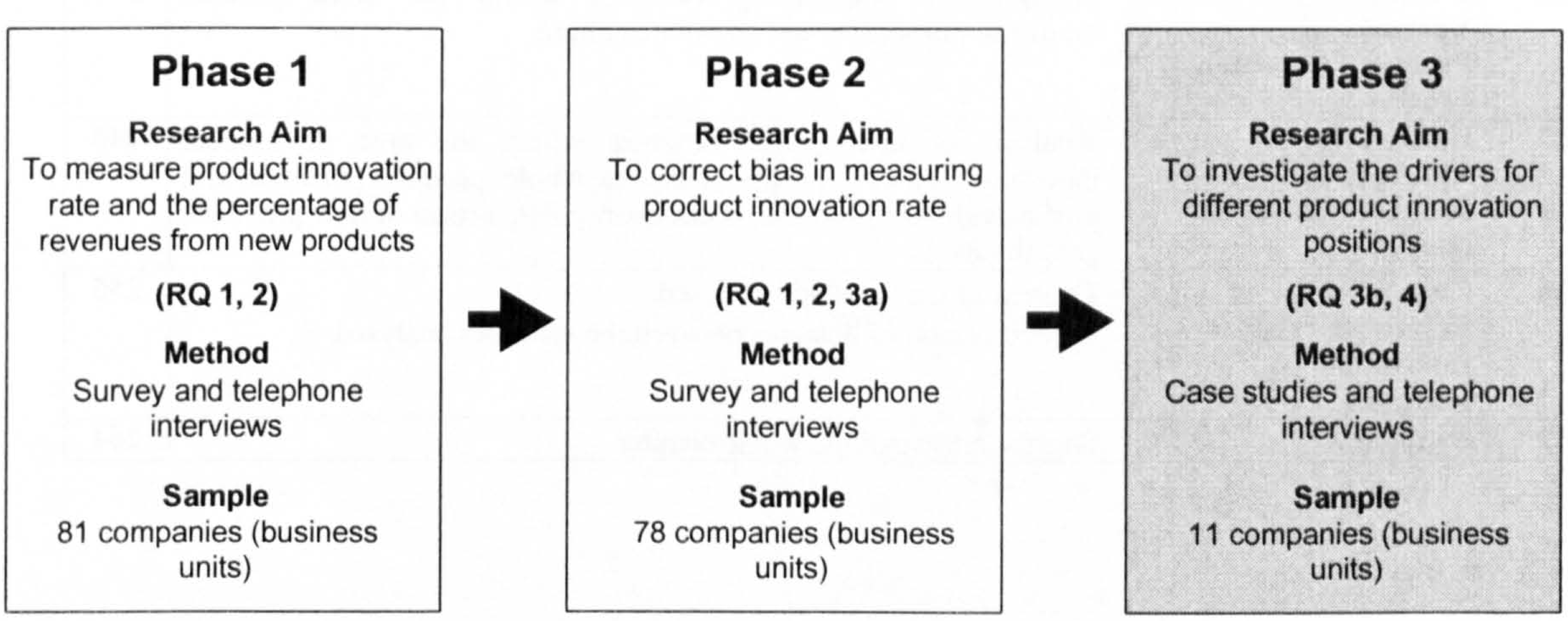
7.0 INTRODUCTION

This chapter gives an overview of the case study results. It explains the findings from the case study visits including six business units in the engineering and five business units in the E&E engineering sector in Germany. Phase 3 built on the findings of Phase 1 and Phase 2 (Figure 7.1) and gave insights into drivers of different product innovation rates and percentages of revenues from new products (RQ 4). Further, it was possible to investigate the relationship between varying product innovation positions and profits with new products (RQ 3b). As a framework for the research the model of Cooper and Kleinschmidt (1993) was chosen.

The analysis of the 11 cases has the following characteristics:

- Each case was reviewed separately and the data was analysed to give a complete picture of the business unit's approach to product innovation.
- Case study descriptions were used as the basis for cross-case comparisons and to determine where similarities and differences existed. To show how the cases were carried out, the case study of Plastics (BU1) is presented in detail.
- 29 product innovation variables were analysed to investigate their relationship with product innovation rate and the percentage of revenues from new products (product innovation position).
- The analysis of the 11 case studies led to the identification of three key drivers for product innovation positions. Additionally two further key drivers for managing product innovation processes were found.

Figure 7.1: Classification of Phase 3 within the whole Research Project



This chapter is divided into nine sections. In order to show how this complex chapter is structured, a detailed overview is given in Table 7.1. In the first section an overview of the business units studied is given. Then, the results from the case study Plastics (BU1) are summarised and detailed insights into the drivers of product innovation at this business unit are given.[55] In order to show how the model of Cooper and Kleinschmidt was used for the cross-case analysis, the method of analysis is presented next. In the next section the complexity of factors influencing product innovation rates and the percentage of revenues from new products is shown. The cross-case analysis identified three key drivers with a relationship to product innovation position. These drivers are operationalised by a set of variables which are analysed in section five. Further underlaying variables with a relationship to product innovation processes (e.g., NPD project management, corporate culture) and product innovation output (e.g., profits, business unit growth) are analysed in sections six and seven. In the eighth section all findings are summarised and the context of drivers on product innovation is presented in detail. A summary of the cross-case analysis is given in the final section.

Table 7.1: Structure of Chapter 7

Section	Heading	Contents	Page
7.1	**Overview of the Sample**	• Overview of the selected case business units within the diagram product innovation rate and percentage of revenues from new products. • General information about the business units studied.	199
7.2	**Case Study Business Unit BU1 "Plastics"**	• Detailed explanation of how the case studies were carried out by using the example BU1 (all other business units are given in Appendix B). Summary of the key drivers of product innovation position and key drivers for managing product innovation processes for all business units studied is given in Appendix A.	201
7.3	**Cross-Case Analysis**	• Systematic of the cross-case analysis. • Definition of product innovation by the managers interviewed (i.e., analysis of the degree of product innovations).	214
7.4	**Explanation of Individual Product Innovation Positions**	• Analysis of the key drivers of product innovation position (i.e., on product innovation rate and on the percentage of revenues from new products).	217
7.5	**Underlaying Variables of Product Innovation Position**	• Analysis of underlaying variables within the areas market, competition and product innovation strategy.	227
7.6	**Underlaying Variables of Product Innovation Process**	• Analysis of underlaying variables within the areas product innovation processes and corporate culture.	241
7.7	**Underlaying Variables of Product Innovation Output**	• Analysis of underlaying variables within the area of product innovation output (profits with the whole product portfolio and profits with new products, break-even-point, stream of new products, growth rates).	248
7.8	**Context of the Drivers of Product Innovation Positions**	• Context of the variables analysed. • Categorisation of linkages between the variables analysed.	255
7.9	**Summary**	• Short summary of the whole chapter	264

[55] An overview of the key drivers for each business unit is offered in Appendix A. Detailed case study descriptions for the other 10 cases are given in Appendix B.

7.1 OVERVIEW OF THE SAMPLE

The case study research investigated a range of manufacturing business units from varying positions within the diagram *product innovation rate versus percentage of revenues from new products*. In summary, 11 cases were selected at random from the corrected database obtained in Phase 2 – six business units from engineering and five business units from E&E engineering. Figure 7.2 (engineering) and Figure 7.3 (E&E engineering) show the position of each business unit. At least one business unit from each industry sector is included in each field within the diagram. However, it has to be noted that not every business unit which was asked to take part in the research project was willing to do so. Especially in Field 1b it was difficult to find business units who were interested in the research topic.

The 11 business units chosen also varied in ownership and size. The smallest business unit visited had 140 employees (including R&D; marketing; and manufacturing) and the largest 3,000. Seven of the 11 business units had less than 500 employees. It is important to note that six manufacturing business units were part of large companies, whereas in five cases the business unit studied constituted the whole company. Six business units were family owned whereas the others are publicly quoted. The youngest business unit was 24 years old and the oldest has been in business for more than 101 years. This shows that no start-up is included in the sample. Table 7.2 gives an overview of the business units studied. The participating business units were promised anonymity and so further details on specific business units will not be given.

Figure 7.2: Overview of Sample, Six Business Units from Engineering (data from Phase 2)

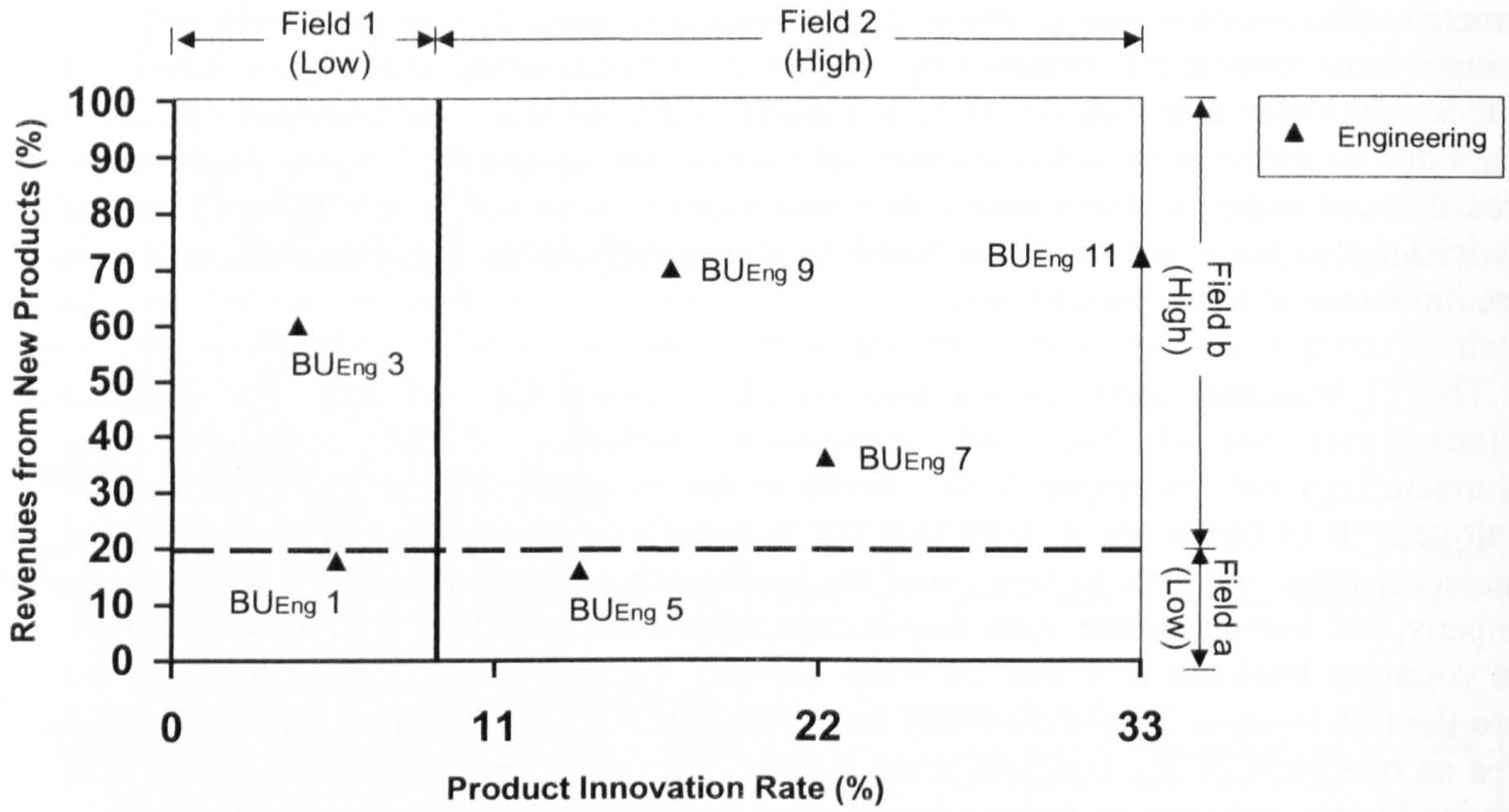
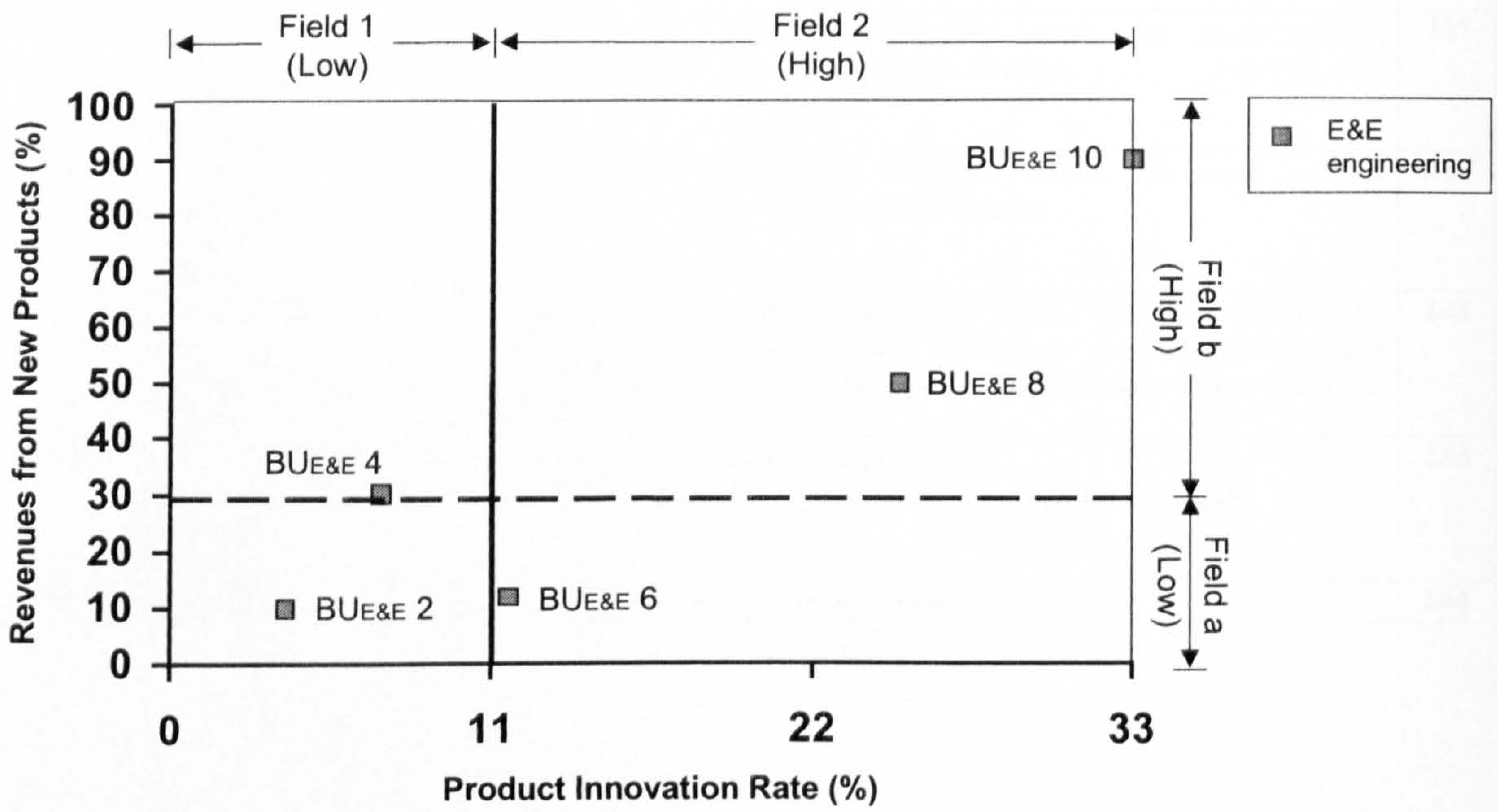


Figure 7.3: Overview of Sample, Five Business Units from E&E Engineering (data from Phase 2)



For all of the business units, exports were a significant part of their business – as a percentage of revenues, exports ranged from 15 to 85% and at five business units exports exceeded 50%. Growth rates over the last three years ranged from 2% reduction to a maximum of 26% growth at one business unit. All 11 business units have R&D, although not in every case is this located at the same site as the production facility (in two business units R&D was centralised in the headquarters).

Table 7.2: The Business Units Studied

Sector	BU	Types of products	Age[1]	Employees per business unit	Part of a large[2] organisation?	Revenues in millions (2000)	Exports (%)
Engineering	1	Plastic packaging systems[3]	50	250	No	Euro 25.5	50
	3	Brake systems	101	3,000	Yes	Euro 306.0	55
	5	Vacuum pumps	38	325	Yes	Euro 54.7	50
	7	Planetary gearboxes	73	160	No	Euro 13.8	15
	9	Exhaust systems	100	600	Yes	Euro 194.0	37
	11	Packaging foils	89	1,150	Yes	Euro 161.0	85
E&E Engineering	2	Electronic time control	73	340	No	Euro 50.0	32
	4	Automotive electronics	24	160	No	Euro 22.4	50
	6	X-ray inspections	55	524	Yes	Euro 153.0	20
	8	Ultrasound-generators	40	140	No	Euro 16.8	30
	10	Vehicle electronics	38	815	Yes	Euro 918.0	78

[1] Age in 2001
[2] Defined as over 1,000 per employees in total.
[3] The case Plastics (BU1) is presented in this chapter. All other case study descriptions are given in Appendix B.

7.2 CASE SUDY BUSINESS UNIT BU 1 "PLASTICS"

7.2.1. Case Study Execution

To show how the studies were carried out, the case study execution is explained in detail for the first case. To gain insights into the reasons for Plastic's product innovation position, the company was visited twice. In the first visit the managing director (who is owner of Plastics and responsible for R&D) and the marketing manager were interviewed on the basis of a predeveloped structured questionnaire. The whole interview was recorded on a tape recorder and key comments were written down in the questionnaire. One part of the questionnaire directly asked for variables such as turnover, profits and break-even-point. To get valid information, this part of the questionnaire (two pages) was sent to the company two weeks before the visit took place. With this procedure the management had time to collect the data within their business unit and it was possible to discuss the variables in the interviews intensively. During the visit, company brochures and other documents were collected for later analysis. In preparation for the visit the internet presentation of Plastics was used as an initial information platform.

In the first part of the visit both managers were interviewed separately. The marketing manager was assisted by his commercial manager to give answers about export rates, revenues with new products and profits. Price lists were also discussed with the marketing manager to get valid information on the product portfolio and especially on the number of new products. At the end of the meeting the managing director and marketing manager were interviewed together to discuss the company's position within the diagram product innovation rate and percentage of revenues from new products.

With the structured questionnaire as a guideline for the interview (see Appendix E), all aspects of the Cooper and Kleinschmidt model were discussed intensively with both managers. However, after the interviews their product innovation strategy was not completely clear. The reason for the confusion was the different approaches of Plastics to the handling of new products. Although they stated that BU1 is a very innovative company, they focused on looking for new markets for their existing products. To clarify this, the researcher attended an in-company workshop eight months after the first visit, where the marketing manager and R&D manager (the position of the R&D manager was installed a few months ago) discussed the product innovation activities of Plastics. After this workshop the marketing manager and R&D manager were interviewed a second time to get more information about the position of Plastics within the diagram product innovation rate / percentage of revenues and their product innovation strategy. Finally, the written case study was sent to the MD and MM to check the case study results. In a follow-up telephone call the paper was discussed and a few outstanding points were qualified.

It has to be noted, that not every case company was visited twice. However, for achieving high-quality case study results the draft of every case business unit was sent to the interview partners and they were asked for their comments. Further, telephone interviews were held for clarifying unclear statements. With the background knowledge of the interviews, the discussion of the case study results within a telephone call and other information sources it was possible to explain the background to the product innovation rate of Plastics (and the other case business units) in detail. Additionally, the position within the diagram product innovation rate and percentage of revenues from new products could be explained. The results of the interview are given in the following section.

7.2.2 Business Unit Overview

Plastics develops, manufactures and supplies plastic packages and plastic packaging systems for industry. They currently employ 250 people in Germany, where they have production, marketing and development. Further plants are in the US, the UK and France – each of which has only production and marketing capabilities. For the purpose of this study, the unit of analysis is a business unit – in this case the business unit constitutes the whole company. The business unit was founded in 1953 and it is family-owned.

In its early years, Plastics manufactured household items made of plastic.. In the search for new production methods, they started to produce blow-moulded plastic packaging parts for engineering and consumer industry. Today their key competence are products produced with the technology blow moulding[56]. The main products are containers, barrels, and packaging tubes. As there is much emphasis on the production method, a key capability of Plastics is the development and production of moulding tools for their production machines. All machines are designed for their specific blow-moulding together with selected suppliers. Plastics had a turnover of Euro 25.56 million in 2000 and growth over the last three years between 10 to 15% per year. The price range for their plastic products ranges from Euro 0.02 to Euro 5.

7.2.3 Case Results

The case results are structured according to the model of Cooper and Kleinschmidt (1993). The seven areas investigated are: market, competition, corporate environment, nature of product innovations / source of ideas, new product process, product innovation strategy and product innovation output. These areas are operationalised by a set of variables.[57] Some of these variables are presented in Table 7.3. In the table information for six areas are given (in the area corporate environment only qualitative variables were asked).

Table 7.3(a): Summary of Quantitative Variables Investigated at Plastics (Source: Plastics, 2001)

Area 1: Market		
Product life cycle[1]		8 years
Market growth per year[2]		12.5 %
Exports		50 %
Markets		World-wide
Area 2: Competition		
Own market share (%)		70%
Market share of the three strongest competitors[2]	1	15%
	2	No information
	3	No information
Area 4: Nature of Projects		
Ideas from external sources		50%
Area 5: New Product Process		
NPD projects running on time		90%
NPD projects cancelled		0%

[56] Blow-moulding is the blowing up of plastic form with pressurised air. With this technology the production of all kinds of hollow bodies is possible.
[57] The variables investigated are selected on basis of a detailed review of the product innovation literature. An overview of the chosen variables is given in Chapter 4 (Section 4.5 'Phase 3')

Table 7.3(b): Continued

Area 6: Product Innovation Strategy			
NPD project horizon	Short	Projects (%)	95%
		Duration	6 months
	Medium	Projects (%)	0%
		Duration	---
	Long	Projects (%)	5%
		Duration	24 months
Investments into R&D			6%
Area 7: Product Innovation Output			
Product innovation rate [(269 / 1600) / 3] x 100			5.6%
Percentage of revenues from new products			18.0%
Average profits from the whole product portfolio			18.0%
Average profits from new products			15.0%
Break-even (months)			Normally it is not measured at Plastics
Business unit growth per year [3]			12.5%

[1] Product life cycle is given as the mean for the whole product portfolio.
[2] Market growth is given as the average growth over the last three years.
[3] Average growth of revenues over the last three years.

Market

The market potential for their products is high, because they are used for applications where customers did not know the benefits of Plastic's products before. One example is packaging systems for the car supply industry. Plastics offer individual packaging solutions for mechanical parts in combination with systems integrated into the production process, e.g., automatic supply systems. One main aim of Plastics is to look for customers who did not know the application possibilities for their products. Because of this strategy their products have a very long life cycle. The MD stated: "About 50% of our products are older than 15 years". However, dependent on the individual product, life cycle is between one year and 15 years (on average eight years). Because of this long product life cycle the number of existing products within their product portfolio is very high. Consequently they have a low product innovation rate and make a low percentage of revenues with their new products.

For their products they are looking for new customers in other countries and, because of this, they have a world-wide export rate of 50%. To the question if Plastics is dependent on any macro economic influences the MD answered: "We are not dependent on one specific branch but on the world-wide economical situation". The market growth for their market segment was estimated with about 12.5% per year (average over the last three years) which is similar to their yearly growth over the last three years. Plastics are in a position to achieve high growth rates with low product innovation rates. As explained later, this is based on their strategy to sell their existing products successfully. However, they also develop many new products.

Competition

The knowledge of Plastics in the technology blow-moulding has led to high market barriers for new competitors. "Know-how in materials, manufacturing and special tools are the key for success" stated the MD. One other factor which makes it difficult for competitors to compete in this market segment is the huge product range they offer. "Plastics has the ability to offer solutions for every packaging problem" (MM). Therefore, they were forced by their customers to build up a large stock of goods to deliver most of their 1600 products in less then 24 hours. As this is combined with high investments, the MM stated "it is very difficult for competitors to compete in this market". However, the MD stated that especially in Asia their products are copied. This he added "is no problem for us because we have a higher quality and are well known as an innovative partner for problem solving".

With 70% market share world-wide, Plastics is market leader in this specific product segment. There is only one main competitor in Germany which has 10% market share. Other competitors are located abroad but each of them have less than 5% market share. From this picture it could be concluded that they are not forced to stay innovative because they have a strong market position. This makes it possible for them to sell their existing product successfully. In other words: Only their ability to develop new products brought them into a position as a market leader.

Corporate environment

All products of Plastics are based on their core competence in blow-moulding. As all of their new products are based on their specific production technology, familiarity is high. To produce their new products they use their own manufacturing resources and to sell their new products they use their own direct sales force. Therefore, it could be concluded that the synergies between the product innovation activities and the firms resource base is high, too. As they concentrate their product innovation activities on products which are based on their core competence they have the ability to offer solutions for a wide range of packaging problems in their market.

Nature of NPD projects / source of ideas

The MD defined Plastics new products as follows: "Something new with a fundamentally reworked design. For our new products, new tools and sometimes new machines have to be developed". This statement was confirmed by the MM who gave following definition: "New products are developed for new customer applications". Such a classification is important to show that the interview is based on a unique understanding of product innovation. As pointed out in the literature review (refer to Chapter 2) the definition of Iansiti and Clark (1994) is used to categorise new products – at Plastics all new products are defined as transformational ones.[58]

Ideas for new products came from employees (50%) as well as from customers (50%). This was supported by the MD who stated that in some cases they had to convince their customers to use a product from Plastics. But there are also many customer specific products where the idea came from the user. To achieve this mixture of "new market ideas" they have installed four different committees. This is shown in Figure 7.4 which was presented by the marketing manager:

- They have installed an employee product innovation circle with about 10 persons. Everybody has the possibility to take part in this circle. Ideas from this circle are discussed in the marketing meetings with the board of management.

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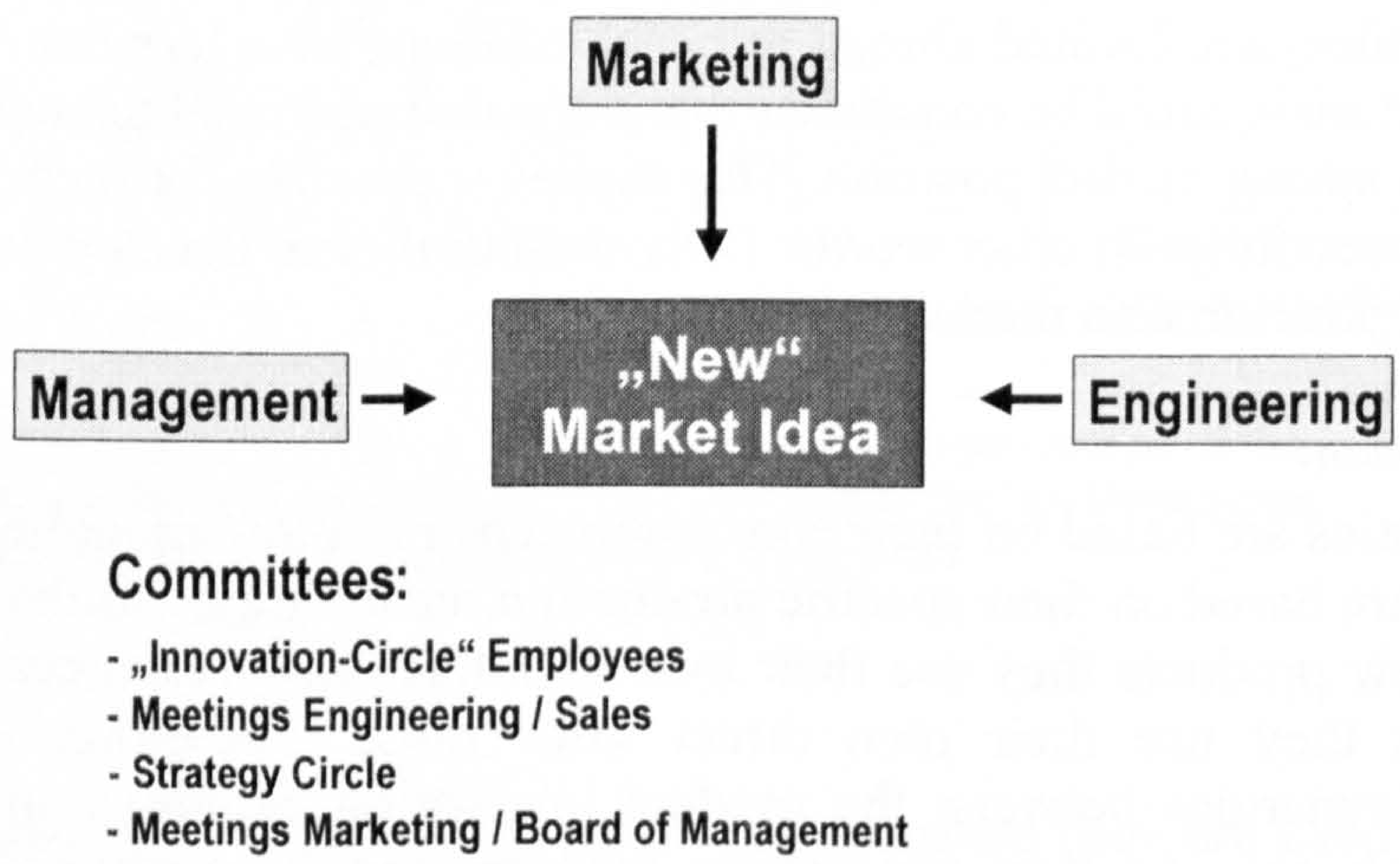
[58] Iansiti and Clark (1994) offered three different degrees of product innovation (incremental, transformational and radical product innovations). In the current research new products are defined as transformational ones (refer to Section 2.1.2 'The Degree of Product Innovation').

- Further, sales and engineering have regular meetings to discuss new product ideas.
- In addition to the employee innovation circle a permanent strategy circle (board of management) discusses new product ideas and decides which products will be developed.
- Twice a year marketing and the board of management discuss and select new product ideas.

Figure 7.4: Committees for Generating New Market Ideas at Plastics
(Source: Plastics, 2001)



Because their products have a very long product life cycle and because they offer many variants Plastics has a huge range of incremental products in their product portfolio. Incremental products contain small changes of standard products to adapt them to specific customer demands, e.g., small changes in size and form. However, as stated earlier, they also create a continuous stream of transformational product innovations for new applications – on the basis of their core competence blow-moulding technology, they develop new products for new branches. One example how the combination of ideas from external and internal led to a new product for the consumer industry is a plastic box for coloured pencils. The first idea for a plastic box for pencils was created by the MD of Plastics and he discussed this idea with the marketing department of a well known manufacturer of pencils. Together with the marketing department of the pencil manufacturer Plastics designed a new pencil box. This new packaging solution offers the pencil manufacturer the opportunity to offer their customers a set of pencils with different colours in a more attractive way.

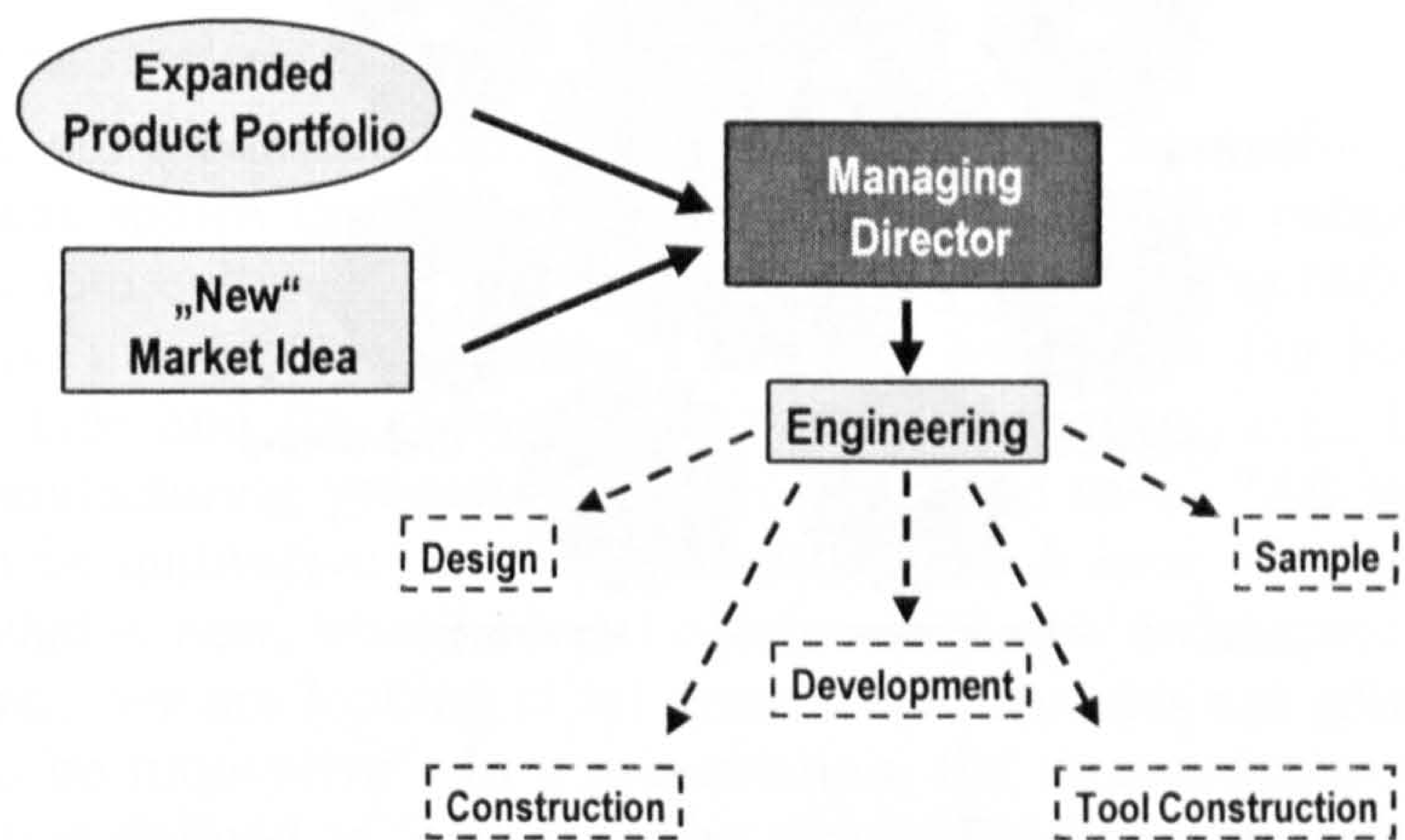
New product process[59]

In the past the NPD process was dominated by the founder and owner. This was shown by the functional R&D organisation managed by the MD. All R&D activities in the past were initiated by the MD who had a strong R&D orientation – his creativity and his ideas were the source for many new products. This strong focus on one person is shown in Figure 7.5 (which was used by the R&D manager to describe their past structure). In

[59] The term new product process is used by Copper and Kleinschmidt (1997). This term is similar to NPD project management.

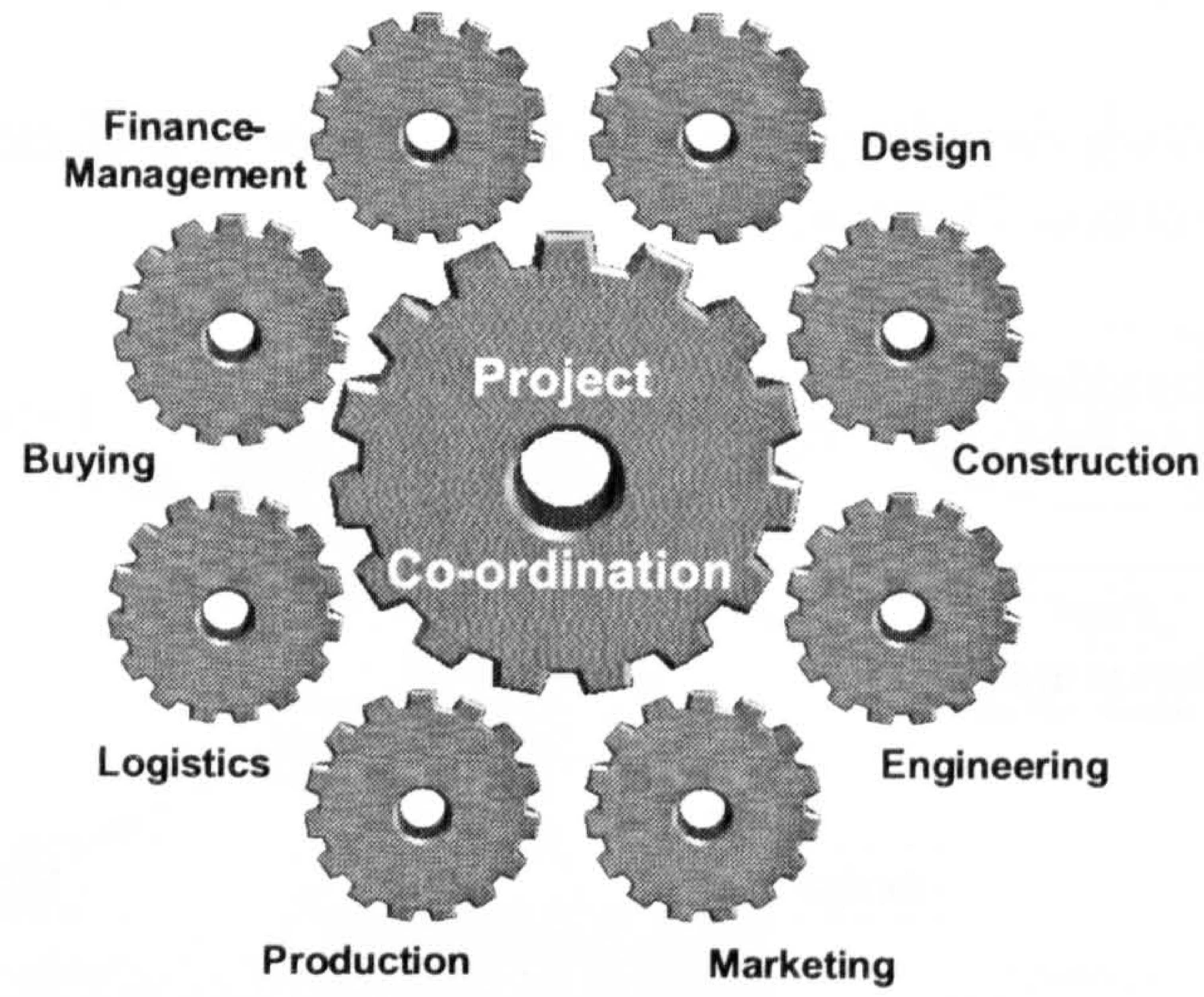
the past the MD was responsible for all ideas and he co-ordinated all R&D activities within the business unit, e.g., design, development and construction.

Figure 7.5: Previous Responsibility for the New Product Development Process at Plastics (Source: Plastics, 2001)



However, in 2000 an R&D department with three employees was installed. This small R&D group is now responsible for co-ordinating the whole of the R&D activities. Figure 7.6 shows the actual product development responsibility of the R&D department. This new structure has an influence on the R&D process and on where projects are developed simultaneously within the different departments. In summary, 30 to 40 NPD projects are running in parallel. Within the NPD process communication between all departments from both MD and MM was seen as the most important point in developing new products successfully. For the MD it is important that everybody is involved in the creation of new products – "not as in the past where only the board of management developed new products and set the aims". Therefore, Plastics installed an R&D online system where information about the latest R&D activities for each NPD project are included. Based on Figure 7.6 the NPD processes were discussed with the R&D manager and it became clear that their philosophy of the "learning company" is directly linked to their product innovation activities. In their company brochure they explain the learning company as a process where all employees are involved. Consequently, everybody within the company has access to this information system.

Figure 7.6: Current Responsibility for the New Product Development Process at Plastics (Source: Plastics, 2001)



The whole NPD process including different stages is documented in their quality handbook (ISO 9000). The stages from idea generation to production are differentiated into 11 steps (Table 7.4). However, as they are a small business unit, the R&D manager stated that "informal communication is more important than formal processes".

Table 7.4: The 11 Stages from Idea Generation to Production at Plastics (Source: Plastics, 2001)

Stage	Process Description
1	Description of the idea
2	Conception of product
3	Market research
4	Calculation of costs
5	Design of product
6	CAD construction
7	Prototype
8	Design and production of tools for producing the developed new products
9	Final control of the product
10	Release of production
11	Start of production

The MD reported that 90% of all projects were running on time and no project had been cancelled in the last three years. This statement was confirmed by the MM, too. The reason for this low cancellation rate is based on their know-how in blow moulding and their experience of what kinds of products can be produced or not. The MD stated that in the whole NPD process they have some problems in the start-phase of new NPD projects, but in general all projects are running without any critical uncertainty.

From this information it can be concluded that their NPD process is good and in consequence this area has no influence on their low product innovation rates. The reason for their position within the diagram product innovation rate and percentage of revenues from new products is mainly influenced by their product innovation strategy as shown in the next section.

Product innovation strategy

In the literature, culture was identified as an important factor for generating new products and it was shown that strategy is directly related to the culture of a business unit – at Plastics both culture and strategy are directly linked. The MD stated that "his business unit is on the way to becoming a learning company". For him innovation is needed in every area and for everybody within his company, e.g., human resource management, manufacturing processes and product innovation. "All areas around our company have to be innovative. Innovation means to look how we can go further. We have to look at what is new, where we can operate with new techniques and where new markets for us are... we are looking at all areas where changes are going on, therefore everybody has to be innovative". In a presentation, the interpretation of Plastics as a learning company is defined as follows: "The aim of Plastic is the commitment to this process [the process of permanent learning] of all employees in all hierarchies. We need to internalise this process in a way where permanent improvement is seen and lived as a continuous and natural process".

The MD stated that the way to a learning company is not easy and he pointed out that especially the ability of employees to organise their work by themselves, to share information and to make own decisions needs time. In a book[60] (published by Plastics) a detailed explanation of their philosophy and their way to a learning company is given. To get further information as to how the ideas for a learning company is converted into the whole company, company further documents were analysed. The fact that Plastics is a company which had consequently transformed this philosophy was documented in the best practice project "Top 100" of the Federal Ministry of Trade and Industry (Warnecke, 2001). In this project the best 100 German companies within different management fields were identified with the aim to transfer their know-how to other companies. In this project Plastics was ranked as a best practice example of a learning company. Because of their ability to generate an innovative culture, where everybody is involved, their living culture and commitment for product innovation was ranked as high.

On the question why Plastics introduces new products into markets the MD answered: "New products were the basis for the growth of the company – in the past a small growth was always achieved. And new products are important as an instrument to always offer customers something new. Another aim is to achieve higher market shares with our product portfolio". Plastics aims to introduce all new product applications

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[60] Together with two Professors from German business universities the owner of Plastics published a book which describes their strategy and their way to a learning company. According to the definition of Senge (1996) all five elements of a learning company are implemented and managed at Plastics. These elements are: continuos learning, involvement of employees into the development of the corporate culture, working in teams, involvement of employees into the development of the future of the company and managing the company in an interdisciplinary way (i.e., managing the company by taking internal and external factors into account).

(100%) with the strategy of being first in the market. Further, the MD stated that "because of the global markets, we want to increase our product innovation activities in the next three years". However, his statement stands in strong contrast to the fact that they are looking for new customers for their existing products. "Plastic's growth in the last years came from new customers (new markets) who did not know the wide field of applications of plastic packaging systems before" (statement MD).

In the discussion with both the MD and MM it became clear that focusing on existing products for new markets is only one part of their product innovation strategy. This was confirmed by discussing their product lists where the MM showed that they have a mixture of standard products and new customer oriented products. Although the main focus is on "existing" products they need to develop new plastic packages for new applications. "Only the ability to offer new packaging solutions makes it possible for us to sell our existing product portfolio successfully" (statement of the MM) further "Plastics want to offer a comprehensive product portfolio to offer a solution for every packaging problem. Therefore, many product innovations are made without looking at the profit." This strategy was checked by interviewing the MD about the vision for product innovation strategy. He said: "We want to continue our successful strategy to introduce a permanent stream of new products. And we want to double our turnover by introducing existing products into new markets". The MM added that they "build up new product segments too with focus on specific customer groups in selected markets".

The categorisation of their strategy was based on an intensive discussion of product innovation with both the MD and MM. Plastics have various aims with their products and following the model of Johnson and Scholes (1999) this means the company has a combination of four different strategies. These are product development, diversification, market development and protection-building. An overview of the strategies and the explanation why they use them is given in Table 7.5.

Table 7.5: Strategies based on Existing Competences at Plastics (analysis based on a framework of Johnson and Scholes, 1999)

Variable	Yes	No	Explanation
Product development	✓		They develop new packaging boxes to replace obsolete products
Diversification	✓		They develop new packaging systems for new applications
Market Development	✓		World-wide they are looking for new customers for their existing new products
Protection-building	✓		Market penetration – with their huge product portfolio of existing products they offer many packaging solutions

As a whole, the product innovation strategy is explained by the MD as follows: "Innovation is the heart of the company – everything grows from it. Innovation means to live daily the development of the company and to involve everybody – not as in the past where only the board of management developed new products and gave the goals" (this statement is reflected in the installation of an R&D department and transfer of product development activities on the whole business unit). The MM summarised

Plastic's strategy as follows: "Back to the roots – growth of the company because product marketing is aggressive and our products are innovative. Additionally, Plastics has a modern human resource management and a strong customer focus". This shows that the MM is convinced that they are an innovative learning company.

The statements of the MD and MM about their ability to develop new products are confirmed in their company brochure: "Innovative products of high quality, customer oriented problem solving and first-class delivery service are the demands of today's markets. Plastics successfully takes up the challenge". Their strong commitment to product innovation can be seen in their internet presentation, too. Here it states: "A continuous stream of innovative products, high product quality and a reliable customer service made us a market-leader." Although they have a clear aim to be innovative, aims are not written down. However, the MD pointed out that in general they have the aim to be active in market-niches and not to go into mass markets.

In summary, Plastics invest 6% of their turnover into R&D. As this figure was reported with 2% in the questionnaire, this was checked on the visit. In the discussion it became clear, that in the reported value no costs for tool construction were included[61]. Together with the investments into tool construction the company achieves investments of 6%. This variable shows, that blow-moulding is a very complicated production method and most of the costs for new products are invested into tool construction. The low personnel cost for R&D is reflected by the low number of R&D employees. Because R&D was strongly focused on the MD, and its own R&D department has been installed now for nearly one year, only 2% of all employees are working in the R&D department.

Plastics product innovation strategy is reflected by the project planning horizon for new products. As it offers packaging solutions for every application, 95% of their NPD projects are planned for a time period of only three to six months. In this short-time planning horizon all new products are included which are based on existing ones. For new product lines planning has a time horizon of two years. In the discussion with the MD it became clear that he does not see any benefits in planning NPD projects for more than two years ahead. This was also stated by the MM who said "our customers need packaging solutions on demand and therefore most of our new products are planned on a short-time horizon."

The MD summarised the reasons for the low product innovation rate and low percentage of revenues from new products in one sentence: "To achieve growth and to be ahead of our competitors we have to be innovative. Therefore, we offer new products to increase our product range. However, our product innovations are more strategic and therefore we do not analyse profits, or other product innovation measures [variables]". This was confirmed by the MM who stated "our strategy is to develop any product a customer wants, and not ask for R&D costs – we develop new products to increase our product range." Therefore, their stream of new products can be described as a continuous flow of product innovations (statement R&D manager).

[61] Different definitions of what is included in the investments into R&D could lead to incomparable data. In the definition used for this research, costs for tool construction are included in the R&D investments. This limitation is given in Section 4.5 'Product Innovation Measurement Variables' (Variable 17).

The analysis of their product innovation strategy shows that Plastics is a very innovative business unit. However, an isolated look at their product innovation position implies other conclusions. The average product life cycles for their products is very long, because they are looking for new markets for their existing products. However, this is only possible in combination with the development of new products. The reason is that their customers need a partner who offers solutions for every packaging problem. This in turn is shown in the mixture of four different strategies (product development, diversification, market development and protection-building). The mixture of these four strategies led to a low product innovation rate and a relatively low percentage of revenues from new products. How their product innovation strategy is related to their product innovation output variables is discussed in the following section.

Product innovation output

With a product innovation rate of 5.6% over the last three years they achieved 18% of revenues from new products. With their whole product portfolio they made 15% profits. Regarding their new products (younger than three years) the MD / MM estimated their profits to be lower but were not able to give an exact figure. In the further discussion with the MM it became clear that they do not measure their product innovation variables regularly and they do not calculate short time profits and break-even point for new products. As stated earlier, the reason why they have no focus on profits of new products is their strategic aim to increase their product portfolio and to offer a wide range of packaging solutions. The MD stated that Plastics "have the ability to develop solutions for every packaging problem. Because we are customer oriented we need a wide range of products to offer solutions for every individual problem". To achieve this, they develop customer specific products which may have low sales. The MM argued that with this strategy they have the reputation of being a "full service provider". On the one hand, this is the reason why "most product innovations are made without looking at the profit". On the other hand, the MD stated that, they "build up existing products (older than three years) for new applications". This fact is reflected by the product portfolio and their low product innovation rate. However, with this product portfolio they generate high profits.

Overall Plastics can be characterised as a highly innovative business unit. However, this is not reflected in their product innovation position which is one of the lowest within the sample size. A summary of the key drivers for their product innovation position is given in the next section.

7.2.4 Key Drivers for the Individual Product Innovation Position

The analysis of the interviews, brochures and internet presentation led to a detailed understanding of Plastics' position within the diagram product innovation rate and percentage of revenues from new products. Although Plastics can be described as a very innovative business unit they have a low product innovation position. There are several key drivers for holding this position:

Market

- Because more than 50% of their products have a life cycle of more than 15 years, they have a huge product portfolio. However, they are also highly innovative.

Product Innovation Strategy

- According to the definition of Johnson and Scholes they have a combination of four different strategies: Product development, diversification, market development and protection-building.
- The mixture of the four different strategies is reflected in their product portfolio including both many existing and new products. With 1600 live products they have a wide product range to offer solutions for every packaging problem. Consequently the number of new products (269) they introduced over the last three years is high, too (refer to Table 7.3). However, because of their huge product range the ratio between new and existing products is very low.
- For developing a high number of new products they invest 6% of their revenues into R&D activities. Most of these investments are necessary for tool construction.
- Most new products are strategic product innovations for specific customer demands (produced in low volumes) – these new products are used as a multiplier to sell their existing products. This is the reason why they are well known as a specialist to offer solutions for every packaging problem.
- In general, they do not look at profits for their new products. Therefore, they do not achieve high revenues with new products.

In addition to the drivers explaining their product innovation position there are further drivers which are important to the innovativeness of Plastics. These drivers are important for Plastics to develop their huge number of new products. The identified key drivers are new product process (NPD project management) and corporate culture:

New Product Process

- They have installed a R&D department and they have standardised NPD processes. New products are developed in interdisciplinary NPD project teams.
- They have installed a structured idea generation process. This is closely related to their corporate culture to generate ideas within employees power.

Corporate Culture

- Their strategy is directly related to the culture within their business unit. They are on the way to becoming a "learning company" where everybody is involved in the creation of new product ideas.
- The managing director has a strong focus on product innovation and his strategy is new product oriented.
- One effect of this culture is the opportunity for all employees to contribute new product ideas through several committees.

This case has shown, that the reasons for a low product innovation position could be based on a specific product innovation strategy (i.e., low product innovation rate is not automatically related to low innovativeness) and long product life cycles (which lead to a high number of existing products within a product portfolio). The basis for Plastic's ability to sell "existing" products successfully is their competence to develop new products for every packaging problem. Only with the combination of existing and new products was it possible for them to build up a strong market position. Overall Plastics innovativeness is not shown by viewing its product innovation position in isolation (Field 1a – Figure 7.2).

The case Plastics (BU1) gave detailed insights into the reasons for varying product innovation positions (the case study descriptions for the other 10 business units are given in Appendix B). The method for the cross-case analysis is presented in the next section.

7.3 CROSS-CASE ANALYSIS

In this section a detailed investigation of the variables identified in the literature is carried out in order to show if they are related to product innovation position. As explained in the following section, this is achieved with a systematic analysis of the case study results (quantitative and qualitative data).

7.3.1 Methodology of the Cross-Case Analysis

The cross-case analysis is performed in three different ways. First, the business units are analysed with regard to their product innovation position (low or high) and key drivers are identified[62]. Second, the cross-case analysis was carried out to identify key drivers for managing product innovation at the NPD project level[63]. Third, the two industry sectors are compared in order to identify whether the areas (and the variables within the areas) are related to one of the two sectors. In order to show how the variables are analysed the investigated areas in the cross-case analysis are given in Figure 7.7.

The areas given in the figure are similar to the areas given in the Cooper and Kleinschmidt model. The dotted lines show that each of the areas could have an influence on the product innovation position by itself. For example, the literature showed that short product life cycles are related to higher product innovation activities (i.e., product innovation rates)[64]. Further, it was shown that business units operating in markets with high growth rates introduce more new products than business units operating in markets with low growth rates. However, in the latest product innovation literature it is shown that the areas are related to each other. This relationship between different areas and their relationship to product innovation activities is often referred to as "context". This context is shown by the normal lines. Consequently, the cross-case analysis is also carried out to identify how the individual areas are related to the context and how this context is related to product innovation position (i.e. the relationship of product innovation rate between the percentage of revenues from new products). In detailed the investigated areas are:

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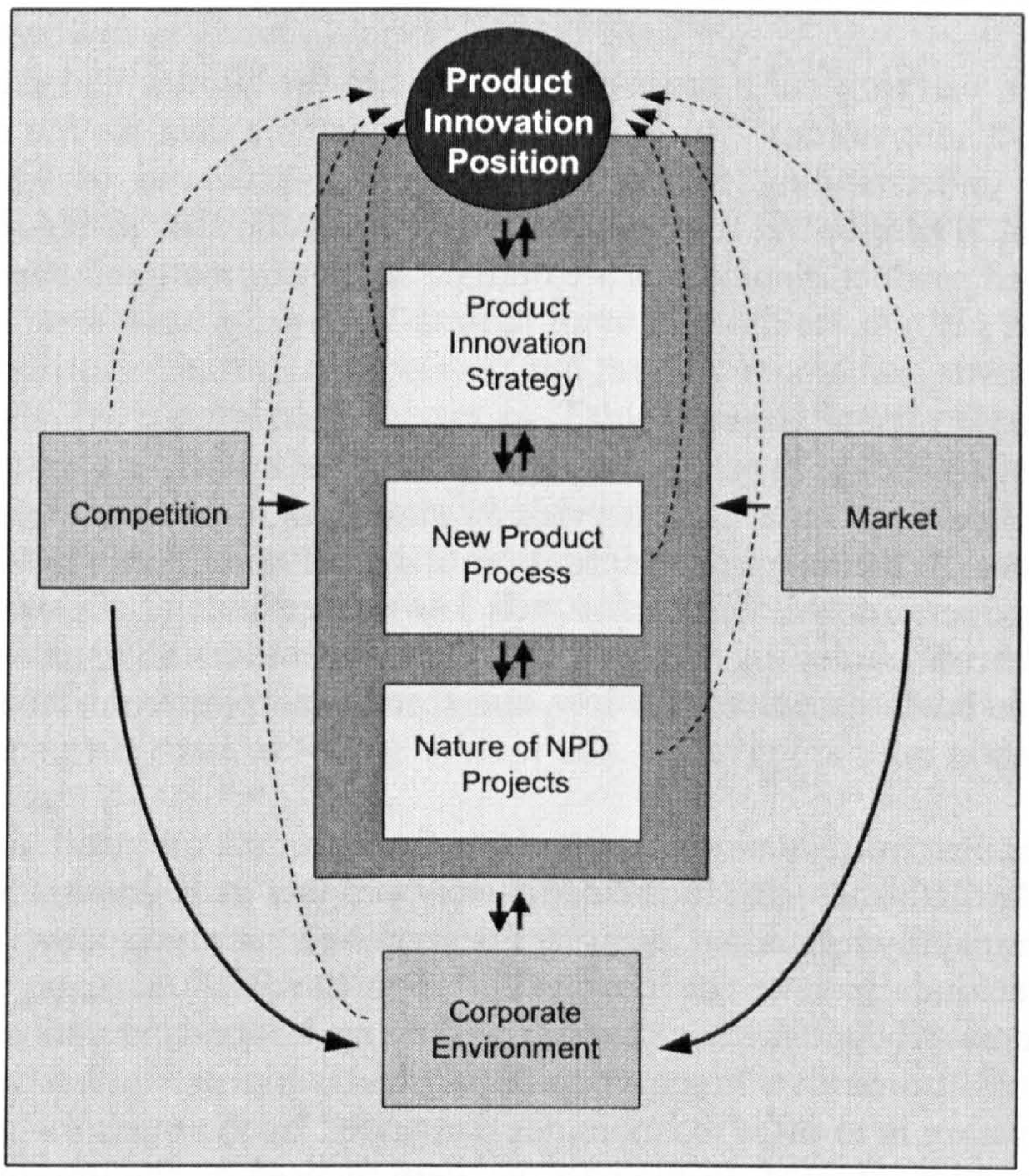
[62] A detailed overview of the key drivers on product innovation position is given in Appendix A (Table 1).

[63] A detailed overview of the key drivers on managing product innovation processes is given in Appendix A (Table 2).

[64] Although the Plastics case discussed in Section 7.2 shows that longer product life cycles are not related to low product innovation activities.

- Market
- Competition
- Corporate environment[65]
- Nature of product innovations[66]
- New product process
- Product innovation strategy
- Product innovation output

Figure 7.7: Drivers of Product Innovation



[65] A detailed analysis of corporate environment is given in Appendix B. In this chapter only the main findings are given. Both familiarity and synergy are high for all case business units. Therefore it is not related to product innovation position.

[66] The nature of product innovations is operationalised with the underlaying variables degree of product innovations and source of ideas. The degree of product innovations is analysed in Section 7.3.2. As it was found that the idea generation process is part of the NPD development process, it is discussed in Section 7.6.1 'New Product Process'.

In the following four sections the cross-case analysis is carried out on two different levels:

- First, the position of the case business units within the diagram product innovation rate and percentage of revenues from new products is investigated. This cross-case analysis is given in Section 7.4.
- Second, underlaying variables[67] within the Cooper and Kleinschmidt areas are analysed individually. As the cross-case analysis found that market, competition and product innovation strategy are key drivers of product innovation position, underlaying variables within these three areas are analysed in Section 7.5.[68] Underlaying variables found as key drivers for managing product innovation processes (e.g., new product process) and underlaying variables of product innovation output are analysed separately in the following sections (Sections 7.6 and 7.7).

One difficulty in carrying out a cross-case analysis is the similar understanding of the degree of product innovations[69]. In order to get comparable data for the cross-case analysis, a similar understanding among all managers interviewed of what a new product is, is crucial. Therefore in the next section, it is shown that in the view of all managers interviewed product innovations are defined as transformational ones.

7.3.2 Degree of Product Innovations[70]

The cross-case analysis found that all interviewed managers defined new products as transformational ones. According to the definition of Iansiti and Clark (1994) it is the creation of new products on the basis of a well known technology. In other words, significant changes are included in new products. To show this similar understanding three examples from business units with low and three examples from business with high product innovation rates are given.

First, the examples from business units with low product innovation rates are presented. The MD of Plastics (BU1) defined a new product as follows: "Something new with a fundamentally reworked design. For our new products new tools and sometimes new machines have to be developed." For the R&D manager of Brake Systems (BU3) a new product is characterised as having a "fundamentally reworked design". The MD of Automotive Electronics (BU4) had a similar understanding. He said: "For me innovation is to offer technologies demanded by the market – not always new but always customer oriented. In the past we were focused on the improvement of functions for our products – today we are developing new products".

The managers from business units with high product innovation rates had the same understanding. The R&D manager from X-ray Inspections (BU6) and Vehicle

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67 The definitions of the underlaying variables for the areas given in the Cooper and Kleinschmidt model are given in Chapter 4 'Research Methodology' (Section 4.5.1).

68 As corporate environment is closely related to product innovation strategy, this area is discussed in Section 7.5 'The Product Innovation Strategy', too.

69 Different definitions of the degree of product innovations led to wrong product innovation rates in Phase 1 of the current research.

70 The degree of product innovations is a variable within the area 'Nature of NPD Projects'. In order to show that all managers define product innovation in the same way, it is discussed in this section.

Electronics (BU10) defined new products as something fundamentally new with a fundamentally reworked design. A similar understanding is given by the MD of Packaging Foils (BU11). He said: "It is a fundamentally new product innovation. It has a noticeably improved new product for existing and new markets." In this context it has to be noted that many managers had a more complex view on product innovation. Although the definition of product innovations was asked for, they stated that innovation in other fields are important, too. Many managers pointed out that they are innovative in creating new production processes, are offering new services or are working on the implementation of new business processes.

As all managers have the same understanding of what new products are, it is possible to start with the cross-case analysis. However, before starting an in-depth analysis of the investigated variables, a first explanation of the individual product innovation positions is given.

7.4 EXPLANATION OF INDIVIDUAL PRODUCT INNOVATION POSITIONS

A systematic cross-case analysis identified three key drivers that are related to product innovation position – market, competition and product innovation strategy. An overview of the key drivers identified is given in Table 7.6. Although the NPD process is important to create a continuous stream of products, it was not identified as a key driver of product innovation position (therefore the ticks are given in brackets)[71]. The reason why the NPD process is not a key driver is the finding that all case business units develop new products and have a well structured NPD management process. Further, they are working with interdisciplinary NPD project teams. In the table, the data for business units from engineering are given in white columns and business units from E&E engineering are marked with grey columns.

Before starting into the in-depth analysis of the key drivers for varying product innovation positions, first insights into the reasons for the business units' position within the diagram product innovation rate and percentage of revenues from new products are given. In the case study visits the diagram was shown to the managers (including the individual position of the business unit visited). Based on the discussion of the business units' position within the diagram a first explanation of product innovation position is possible.

[71] An analysis of key drivers for managing product innovation processes is given in Section 7.6 'Key Drivers of Product Innovation Processes'.

Table 7.6: Key Drivers of Product Innovation[1]

Product Innov. Posit.		BU	Market	Com-petition	Corporate Environ-ment	Nature of New Products	New Product Process	Product Innovation Strategy
Product Innov. Rate	**Revenue from NPs**							
Low	Low (Field 1a)	1	✓	---	---	---	(✓)	✓
		2	✓	✓	---	---	(✓)	✓
	High (Field 1b)	3	✓	✓	---	---	(✓)	✓
		4	---	✓	---	---	(✓)	✓
High	Low (Field 2a)	5	✓	✓	---	---	(✓)	✓
		6	✓	✓	---	---	(✓)	✓
	High (Field 2b)	7	---	✓	---	---	(✓)	✓
		8	✓	✓	---	---	(✓)	✓
		9	✓	✓	---	---	(✓)	✓
		10	✓	✓	---	---	(✓)	✓
		11	✓	✓	---	---	(✓)	✓

Engineering

E&E engineering

[1] The decision rules used to construct the table are explained in detail in Section 7.8.1

In order to show the individual drivers for product innovation positions the business units are compared within the separate fields of the diagram product innovation rate and percentage of revenues from new products (Fields 1 a,b and Fields 2 a,b – refer to Figure 7.2 and 7.3).

7.4.1 Field 1a (Low IR / Low Revenues from NPs)

Two business units of the sample are positioned within the Field 1a (refer to Figures 7.2 and 7.3). The first business unit analysed is Plastics (BU1). Although BU1 is very innovative and develops many new products they have a low product innovation rate. For increasing their product range they offer innovative packaging solutions for any packaging problem and developed 269 new products over the last three years. As they have a product range of 1600 existing products – which is related to their long product life cycles and their strategy to look for new markets for their existing products – the relation of new and existing products is very low. In other words: They have a strong focus on both existing and new products. As they try to sell their existing products into other markets, their product portfolio includes a huge number of existing products. Consequently, their product innovation rate and revenues from their new products are low (which does not show their innovativeness). They develop new products for strategic reasons and do not want to make profits with them. These strategic new products focus on specific customer demands and are sold in low numbers. The aim with these new products is to show competence (i.e., to be innovative) and to position them as an innovative business unit within their market. Further, these new products are used as a multiplier to sell their existing products. In general they do not look at short-time profits for their new products. This was pointed out by the MD who said: "We build up existing products (older than three years) for new applications". Further, the

MM stated: “Plastics want to offer a comprehensive product collection to offer a solution for every packaging problem. Therefore, many product innovations are made without looking at the profit.”

In comparison to BU1, Time Control (BU2) is not so innovative. This is the case because they concentrate on the development of few selected new products. The MD of BU2 stated: “Because we are a small company it is not possible for us to create a lot of new products, because a big flop could be our demise.” The R&D manager of this business unit added that “the support of the board of management to increase our innovation activities is not very high”. However, their focus is more on the development of variants to existing products which ensures that products have long life cycle. Consequently the most successful product is an existing one which generates 16% of their turnover. Because the number of (transformational) new products is low, they achieve a low percentage of revenues from their new products. This was stated by the R&D manager as follows: “Because most products only need to be adapted to customer demands we have a big range of variants”. The MM added: “... in consequence we achieve low revenues with our new products”. As new products are not important in their product portfolio, it could be concluded that they have no structured NPD project management processes. However, their NPD development process is defined over 10 stages and they are working with interdisciplinary NPD project teams. Because they have no continuous stream of NPD projects the R&D manager stated: ‘Because we have problems in working with a permanent stream of strategic innovation projects our R&D employees have to be instructed and motivated for every new innovation project”. This shows that product innovation strategy (and a low commitment of the board of management to product innovation) is the key driver for their low product innovation activities. This in turn is related to difficulties in motivating their R&D employees and a low corporate culture for product innovation.

7.4.2 Field 1b (Low IR / High Revenues from NPs)

With low product innovation rates BU3 and BU4 achieve a respectively high percentage of revenues from new products (refer to Figures 7.2 and 7.3). Although the position of the business units within the diagram product innovation rate and the percentage of revenues from new products is the same, the reasons for their position differ.

Brake Systems (BU3) develop many new products. However, the reasons for their low product innovation rate is *not* a long product life cycle as given at BU1 and BU2. The MD of BU3 explained their position as follows: “We hold the position within this diagram, because we have many products in our portfolio which are necessary. But 80% of our revenues are achieved with less than 1000 products where most of our new products are included.” Taking their huge product portfolio of 6,162 existing main products into account, only 16.2% of their living products are important to generate revenues. Taking this reduced product portfolio, the proportion of new products is approximately higher. With 1000 existing products and 790 new products they would achieve a product innovation rate of 79% over three years (26.33% per year). The reason for this phenomenon is that they have contracts with their customers to supply spares for a 10 year time period. These spares (sold in low numbers) are reported as living products in their product portfolio. This in turn led to a huge product portfolio of existing products and to a low product innovation rate. In contrast to BU1 they have a stronger focus on product innovation and follow a product innovation strategy to sell their new products successfully – existing products are not seen as important for generating revenues. As Brake Systems has a main focus on product innovation, they generate most of their revenues with new products. The MD explained their position as follows: "We hold the position within this diagram, because we have many products in our portfolio which are necessary to have (6,162 products). But 80% of our revenues are achieved with less than 1,000 products where most of our new products are included. In contrast the last 3% of our turnover comes from a huge product range (3,000 products). Therefore, 60% of our turnover is achieved by products of less than three years." This shows that new products are important to have because they are the basis for their revenues.

In comparison to BU3, the strategy of Automotive Electronics (BU4) is to develop a limited number of new key products to generate high revenues. The reason is their limited financial resources and their concentration on few selected NPD projects. Although a similar reason is also given by BU2, their concentration on new products is stronger. The MD explained this as follows: "Because of our size it is not possible to do large and expensive experiments. Our financial resources force us to select our NPD projects carefully." These carefully selected NPD projects have a high priority. With these new products they follow the aim to achieve innovation- and cost-leadership. This in turn is related to a low product innovation rate but to a high percentage of revenues from their few new products. With one new product they made most of their 30.5% revenue from new products in the last year. The MD expected that with one other new product they will achieve even higher revenues in the next years. This was explained by the MD as follows: "Our aim is to develop a limited number of new products. With these few products we try to achieve high revenues. Consequently, with one new product (door protection for children) we will make about 40% turnover in the next year".

7.4.3 Field 2a (High IR / Low Revenues from NPs)

The cases analysed above showed that low product innovation rates are not related to innovativeness (i.e., the number of new products developed). Now it is interesting to show why business units with high product innovation rates achieve low revenues from new products (refer to Figures 7.2 and 7.3). The reason why Vacuum Pumps (BU5) has a high product innovation rate is their aim to become market or technology leader with the development of strategic new products. Further, cost reduction is an important factor when developing new products for their customers. The MD of BU5 stated "A continuous stream of new products is necessary to hold our present customers ...we want to achieve cost and technology leadership". As one main aim of their strategy is to show their competence as an innovative partner, they develop new products for specific customer demands. Therefore, new products are seen as important to sell their existing products to present customers. As they sell more existing products than new ones, the percentage of revenues from new products is low. The MD said: "Sometimes we develop new products for strategic reasons. In this case we do not measure profit and revenue from these products". A further reason is given by the MM who said: "We try to find new customers for our existing products". In summary, their product innovation strategy can be compared with the strategy of BU1. However, as their product life cycle is shorter and the number of existing products within their product portfolio is lower, they act with a higher product innovation rate.

Another business unit in Field 2a is X-Ray Inspections (BU6). For them a high product innovation rate is seen as important for being world-market leader in all product areas for x-ray security. This is explained by the MD with the "aim to achieve world-market leadership in all product areas for x-ray security and to be active in more new business areas". To achieve this he stated it is necessary to develop a continuous stream of new products. Because most of their existing products are replaced by new ones (after a test phase), the number of existing products is limited. Consequently their product innovation rate is high. However, the acceptance of their new products by their customers led to a low percentage of revenues from new products. The reason is that their product innovations need more than three years to be accepted by most of their customers. Therefore, most revenues from new products came later than three years after product introduction. This is explained by the MM as follows: "To get references which are accepted by a wide range of customers we have to run our products for a time-period with a few key customers – this time period is often more than three years". Consequently, the revenues from new products are also generated later (after a three year time period).

7.4.4 Field 2b (High IR / High Revenues from NPs)

Now, the high percentage of revenues of business units with high product innovation rates is analysed (refer to Figures 7.2 and 7.3). All of these business units have a product innovation strategy with the aim to develop many new products and to generate a high percentage of new products within their product portfolio. Although the general strategy is clear, the business units explained their high product innovation rates and high percentages of revenues from new products in different ways. Therefore, statements are given for each business unit.

The reason why Gearbox (BU7) has a high product innovation position is the fact that they are operating in a new market. Although BU7 is an old company, their product portfolio can be compared with a young business unit – they started developing new products 10 years ago. In the past they had no own products and concentrated their activities on the production of products for other companies. The continuous development of new products over the last 10 years led to a high product innovation rate (two thirds of their products within their portfolio are new). This is explained by the MM as follows: "It was our strategy over the last 10 years to increase our turnover with own new products – now we have a position where customers with their problems come to us because other competitors failed". This strategy is directly related to their high percentage of revenues from new products. Today more customers (in comparison to the past) are buying their new products. Consequently, with these new products they achieve high revenues.

For BU8 and BU9 the reason for their high product innovation rates and percentages of revenues from new products is different. They develop new products over a long time with the aim to achieve technological or world market leadership. At Ultrasound (BU8) the board of management is convinced that the only possibility of surviving in the market is to have high product innovation position. The MD explained this as follows: "We want to be the technological leader. Therefore, we introduce more new products than our competitors and these products generate most of our revenues". Exhaust Systems (BU9) has a high product innovation position because their aim is globalisation through product innovation. The MD pointed out: "We have a high innovation rate because our group acts very aggressively in the market. Additionally, competition is very high. Therefore, we have no other choice than to introduce new products with the latest technology." With these new products they achieve most of their revenues. The R&D manager pointed out: "Our focus is on product innovation leadership and first to market. This drives us to introduce a permanent stream of new products. This stream of new products generates a high percentage of our revenues." A further reason for their high product innovation rate is the replacement of most of their existing products by their new ones[72]. That such a replacement is not easy was stated by the MD of BU8. He said: Our customers are pleased with the existing products. By launching a new product, we have to convince them to buy the new one."

For Electronics (BU10) their high product innovation position is related to their short product life cycles and their strategy to offer pacemaker technologies. This, the MD stated, is key for surviving in their highly competitive market. Most of the new products of Vehicle Electronics (BU10) are developed in close relationship to OEMs who are willing to pay for their pacing-technologies. Consequently, the MD stated: "All new products have the same priority. Revenues are generated from all new products and therefore we achieve a high percentage of revenues from new products." However, in the discussion of the product portfolio it was shown that the elimination of existing products does not take place at the same time as the launch of new products. Therefore, some products are still included within their product portfolio, which are older than three years. For Packaging Foils (BU11) the situation is similar to the situation of BU10. Although price pressure is also a driver, they are mainly driven by their short product life cycle. The MD of BU11 stated that "only with the ability to create a permanent stream of new products we are able to stay market leader". As their customers also have a strong demand on product innovation most of their revenues are generated from new products. The MD said: "Our customers normally have a high product innovation rate, too – especially in pharmacy, beauty and hygiene product innovation rate is high. In summary, we achieve most of our revenue with our new products". Because the percentage of existing products is higher than at BU10, the percentage of revenues with new products is lower. For both business units BU10 and BU11 the number of existing products (because of short product life cycles) is low because they replace them regularly by new ones. Therefore their product innovation rates are nearly 33%.

7.4.5 Summary

The cross-case analysis found that an investigation of product innovation position needs a complex view. Further, it was found that the relationship between product innovation rate and the percentage of revenues from new products is no common measure and therefore most managers needed to think about their position within the diagram.

[72] It has to be noted that the average product life cycle of BU9 (3.5 years) is similar to the average product life cycle of BU11 (3 years). Although they are active in the same industry sector their product portfolio is quite different which in turn is related to different product innovation rates. This indicates that live cycle is not the only key driver of product innovation rate.

Overall the discussion of product innovation position was seen as helpful to get a clear understanding of how a business units act in the market. A summary of the findings is given in Table 7.7. Further, Figure 7.8 gives an overview of the individual drivers for varying product innovation rates for each business unit respectively. In Figure 7.9, the key drivers of varying percentages of revenues from new products are summarised.

Table 7.7: Key Drivers of Product Innovation Position[1]

Product Innovation Position		Findings of the Cross-Case Analysis
Low Product Innovation Rate	Low Revenues from NPs (Field 1a)	• One business unit (BU1) has a low product innovation rate because they have a huge product portfolio and are looking for new markets for their existing products. This in turn does not mean that they are not innovative. Quite the reverse, their ability to develop 269 new products over the last three years shows their highly innovative approach. Although many new (strategic) products are developed, they are produced in low quantities. Therefore, the percentage of revenues from new products is low. • BU2 sees new products as an enlargement of their product portfolio. As the focus is not on product innovation they develop few selected new products achieve a low percentage of revenues from new products. Reasons are a long product life cycle and the case that commitment for product innovation of the board of management is low.
	High Revenues from NPs (Field 1b)	• A huge product portfolio (because they were forced by their customers to produce supply spares for a 10 year period and longer) is the reason for low product innovation rate for BU3. They achieve 80% of their revenues with less than 1000 products. From these 1000 products 790 are younger than three years (79%). Consequently, the revenues from new products are high (60%). In contrast the last 5% of their turnover is achieved with 3000 products (older than three years). • BU4 concentrates on the development on some few products. With these few new products they generate a high percentage of revenues. However, in comparison to BU2 commitment for product innovation of the board of management is high.
High Product Innovation Rate	Low Revenues from NPs (Field 2a)	• To achieve technology leadership BU5 has the strategy to develop many new products. They achieve a low percentage of revenues because their market is very conservative. Therefore, they sell their new products in low numbers. Their product innovation strategy can be compared with the strategy of BU1. However, as their product life cycle is shorter than at BU1 (and the number of existing products is lower) they achieve a higher product innovation rate. • For BU6 a high product innovation rate is seen as the most appropriate way for being world-market leader in all product areas for x-ray inspection. However, most of their revenues from new products come later than three years after product launch which is related to a low percentage of revenues from new products. The reason is that their new security products are tested by selected customers.
	High Revenues from NPs (Field 2b)	• For BU7 their high product innovation position is related to their concentration on new markets. They decided to decrease the dependency upon wage-production and to produce own products. As they have a strong focus on new products most of their revenues come from them. • Business units with a high product innovation position have the strategy to achieve technological (innovation) leadership or cost leadership. This they want to achieve with high product innovation rates and high percentages of revenues from new products (this is the case for BU8, BU9, BU10 and BU11). • For BU10 and BU11 their high product innovation rates are directly related to their short product life cycles and their strategy to replace most of their existing products by new ones.

[1] The decision rules used to construct the table are explained in detail in Section 7.8.1

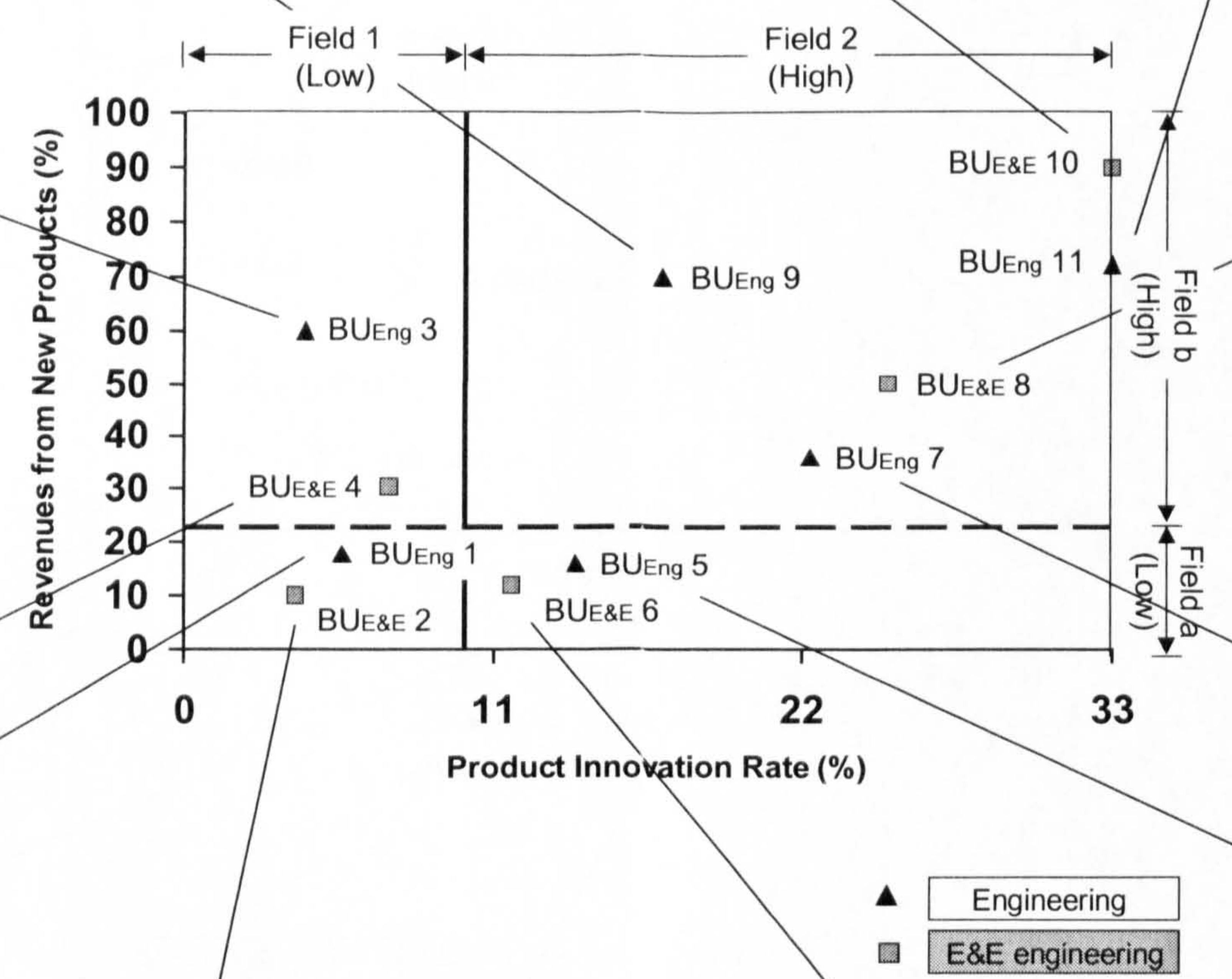
Figure 7.8: Key Drivers of Product Innovation Rate

Driver for the Individual Product Innovation Rate:
They have a strong focus on product innovation. Their aim is globalisation through product innovation.
Exhaust systems are influenced by environmental laws. Therefore they are forced to develop new products with the latest technology for reducing harmful substances.
Comment:
MD: "We have a high innovation rate because our group act very aggressively in the market. Additionally competition is very high. Therefore we have no other chance of introducing new products with the latest technology."

Driver for the Individual Product Innovation Rate:
They are working together with selected customers who see the benefit of transformational and first to market products. For these customers they develop new products for different applications. As they operate in a market with very short product life cycles, they are forced to replace most of their existing products by new ones.
Comments:
MD: "We have the ability to develop radical new products and therefore new markets can be generated".
MM: "To be the only company which offers products first to market and to create market advantages and profits with pacemaker-technologies".

Driver for the Individual Product Innovation Rate:
They are developing a high number of new products to avoid the price pressure as much as possible and to get good margins. Further, the very short product life cycles within their branch forces them to replace most of their existing products by new ones.
Comments:
MD: "New products are necessary to stay competitive - it is in response to high price pressure and the strong competition in the market".
R&D: "...we have to take up the challenge for product innovation – therefore we have planned the development of more new products".

Driver for the Individual Product Innovation Rate:
Because of long term contracts with their customers they have to supply spare parts for a long time period. As every spare part is counted as a living product, they have a high number of existing products in their product portfolio (6,162). However, they are developing a high number of new products (790), too.
Comment:
MD: "We hold the position within this diagram, because we have many products in our portfolio which are necessary to have [because of long term contracts with customers]. ...But 80% of our revenues are achieved with less than 1000 products where most of our new products [790] are included."



Driver for the Individual Product Innovation Rate:
Strong commitment of the board of management on product innovation. They are convinced that the only possibility of surviving in the market is the development of new products. As they replace most of their existing products by new ones, their product innovation rate is high.
Comment:
MD: "We want to be the technological leader. Therefore we introduce more new products than our competitors".

Driver for the Individual Product Innovation Rate:
Because of their financial resources they focused on a few selected NPD projects. Therefore they achieve a low product innovation rate.
Comments:
MD: "Because of our size it is not possible to do large and expensive experiments. Our financial resources force us to select our NPD projects carefully."
MM: "The main focus in the past was on innovation in manufacturing processes".

Driver for the Individual Product Innovation Rate:
2/3 of their products within their portfolio are new. Although they are an old company they started 10 years ago to develop new products. This consequent focus on new products led to a high product innovation rate.
Comments:
MM: "It was our strategy over the last 10 years to increase our turnover with own new products – now we have a position where customers with their problems come to us because other competitors failed"..
MD: "...therefore we want to increase our permanent stream of new products even further".

Driver for the Individual Product Innovation Rate:
More than 50% of their products have a life cycle of more than 15 years. With 2000 living products they have a wide product range to offer solutions for every packaging problem. Therefore the ratio of new to existing products is very low.
Comment:
MD: "We have the ability to develop solutions for every packaging problem. Because we are customer oriented we need a wide range of products to offer solutions for every individual problem".

Driver for the Individual Product Innovation Rate:
Because of limited financial resources they have the strategy to develop some few new products. 80% of their product innovation activities focus on product improvements (variants). As these new products are not counted as main product innovations in the terms of the given definition, their product innovation rate is low.
Comments:
MM: "To fulfil the marketing demands we have to develop existing products further... Therefore we have about 1300 variants... and in consequence we have a low product innovation rate.
R&D: "In summary we have a careful strategy to introduce new products into the market".

Driver for the Individual Product Innovation Rate:
To stay competitive they have to develop a permanent stream of new products. Therefore product innovation rate is high. A high product innovation rate is seen as essential to give world-market leadership in all product areas for x-ray security and to be active in more new business areas.
Comment:
MD: "To gain world-market leadership in all product areas for x-ray security and to be active in more new business areas."

Driver for the Individual Product Innovation Rate:
Because of price pressure they are forced to develop many new products. A further reason is the integration of electronic elements into their products. These factors lead to a high number of new products within their product portfolio.
Comment:
MD: "A continuous stream of new products is necessary to keep our present customers ...we want to achieve cost and technology leadership".

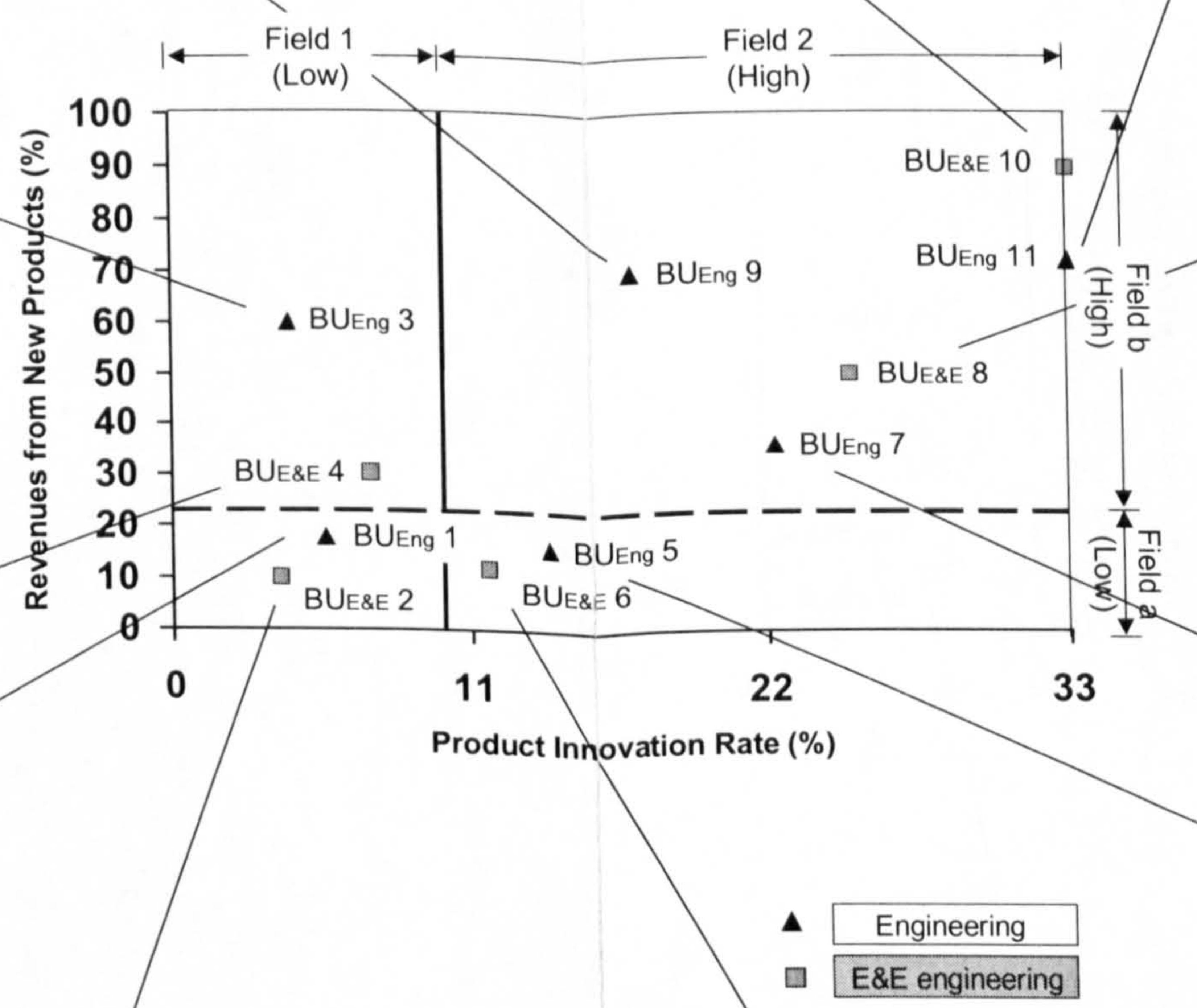
Figure 7.9: Key Drivers of Percentages of Revenues from New Products

Driver for the Individual Percentage of Revenues from New Products:
Their products are directly linked with new car models. For each new car model a new exhaust system has to be developed. With these new products they achieve most of their revenue.
Comment:
R&D: "Our focus is on product innovation leadership and first to market. This drives us to introduce a permanent stream of new products. This stream of new products generates a high percentage of our revenues."

Driver for the Individual Percentage of Revenues from New Products:
Most of their new products are developed in close relationship to OEMs who are willing to pay for their pacemaker-technologies. Further all new products have the same priority and revenues are generated from all new products. Therefore most of their revenues are generated from these new products.
Comment:
MD: "All new products have the same priority. Revenues are generated from all new products and therefore we achieve a high percentage of revenues from new products."

Driver for the Individual Percentage of Revenues from New Products:
Their focus is on multinational customers within a few branches and with high product innovation rates too. As these companies have a strong demand on product innovation most of their revenue is generated from new products.
Comment:
MD: "Our customers normally have a high product innovation rate too – especially in pharmacy, beauty and hygiene product innovation rate is high. In summary we achieve most of our revenue with our new products".

Driver for the Individual Percentage of Revenues from New Products:
As their main focus is on product innovation they generate most of their revenue within the reduced product portfolio with products younger than three years.
Comment:
MD: "We hold the position within this diagram, because we have many products in our portfolio which are necessary to have. But 80% of our revenues are achieved with less than 1000 products where most of our new products are included. In contrast the last 3% of our turnover comes from a huge product range. Therefore 60% of our turnover is achieved by products younger than three years."



Driver for the Individual Percentage of Revenues from New Products:
Their focus is to have product innovation leadership. Therefore they concentrate their marketing activities on their new products. With these products they generate most of their revenue.
Comment:
MD: "We want to be the technological leader. Therefore we introduce more new products than our competitors and these products generate most of our revenue".

Driver for the Individual Percentage of Revenues from New Products:
Their aim is to develop new key products to generate higher revenue. With one new product they made most of their 28% revenue in the last year and with one new product they will achieve 40% revenue.
Comment:
MD: "Our aim is to develop new products. And with few of them we try to achieve high revenues. With 1 new product (door protection for children) we will make about 40% turnover in the next year".

Driver for the Individual Percentage of Revenues from New Products:
Because they are known to be innovative, more customers (in comparison to the past) are buying their new products. With these new products they achieve high revenues.
Comment:
MM: "It was our strategy over the last 10 years to increase our turnover with own new products. And we were lucky that the investments always re-paid us ...because of this situation we achieve a respectable amount of revenues from our new products".

Driver for the Individual Percentage of Revenues from New Products:
Most new products are strategic product innovations for specific customer demands – these new products are used as a multiplier to sell their existing products. In general they do not look at short-term profits for their new products. Therefore they do not achieve high revenues with new products.
Comment:
MD: "We build up existing products (older than three years) for new applications".

Driver for the Individual Percentage of Revenues from New Products:
New products are an enlargement of their portfolio. As their aim is to sell their existing products (variants) revenues from new products are low.
Comments:
R&D: "Because most products only need to be adapted to customer demands we have a big range of variants".
MM: "... in consequence we achieve low revenues with our new products" .

Driver for the Individual Percentage of Revenues from New Products:
Product innovations need more then 3 years to be accepted by most of their customers. Therefore most revenue from new products came later than 3 years after product introduction.
Comment:
MM: "To get references which are accepted by a wide range of customers we have to run our products for a time-period with few key-customers - this time period is often more than three years".

Driver for the Individual Percentage of Revenues from New Products:
They are developing new products without any actual market demand. However, this competence is seen as important to sell their existing products to present customers. Therefore the percentage of revenues from new products is low.
Comments:
MD: "Sometimes we are developing new products for strategic reasons. In this case we do not measure profit and revenue from these products."
MM: "We try to find new customers for our existing products".

7.5 UNDERLAYING VARIABLES OF PRODUCT INNOVATION POSITION

As the complexity of product innovation position is shown in the section above, a detailed analysis of the key drivers is given in this section. The cross-case analysis found that many key drivers are related to other drivers, too. For example shorter product life cycles are not automatically related to a higher number of product innovations. With regard to product innovation rate the number of existing products within the product portfolio plays an important role, too. The management of product portfolios in turn is closely related to product innovation strategy. Because of this context it was found that product life cycle does not have such a strong relationship to product innovation rate as expected. Consequently an isolated view on product life cycle leads to wrong results.

In each area identified as key driver for product innovation position several variables were measured and analysed in detail. The three key drivers discussed are:

- Market
- Competition
- Product innovation strategy

7.5.1 The Market

The underlaying variables analysed in the area market are[73]:

- Product life cycle (years)
- Market growth per year (%)
- Economical influence (i.e. laws)
- Technology

Product life cycle

As explained earlier, the literature points to a relationship between short product life cycles and high product innovation activities. This was found for the two business units with the highest product innovation rates (nearly 33%) where their short product life cycles are the key driver for their high product innovation rates. For Vehicle Electronics (BU10) the average product life cycle is 3.5 years and for Packaging Foils (BU11) it is three years. Because of the short product life cycles most of their products need to be replaced by new ones. Additionally, they have a clear strategy for introducing a permanent stream of new products and are working together with innovative customers. This indicates that product innovation strategy is a key driver, too.

The fact that short product life cycle is not the only driver for product innovation rate is shown by Exhaust Systems (BU9). Although the average life cycle of their products is 3.5 years (similar to BU 10) they achieve a lower product innovation rate (17%). A clearer inspection of the data shows that the product portfolio of existing products is structured in a different way. At Exhaust Systems the percentage of existing products which are replaced by new ones is lower. Therefore more existing products are included in their product portfolio. Consequently product innovation rate is lower than

[73] A detailed overview of the underlaying variables within the area market is given in Appendix B (Section 1 'Overview of the Variables Investigated' – Table 2a).

the rates of BU10 and BU11. This indicates that the (strategic) chosen product portfolio is an important driver for product innovation rate.

Now it could be concluded that the long product life cycles of two business units with low product innovation rates are related to a low number of new product introductions. However, that product life cycle is not related to the innovativeness of business units is shown by Plastics (BU1). Although they have an average life cycle of eight years, they are very innovative (refer to Section 7.2). The reason for their low product innovation rate is their huge product portfolio of existing products. Brake Systems (BU3) is another example. They have a product life cycle of five years and operates with a low product innovation rate. However, they introduced 790 new products over the last three years, too. Their low product innovation rate is a result of their strategy to deliver spare parts for a long time period. Consequently they have a huge product portfolio with living products and therefore their product innovation rate is low.

The fact that product innovation strategy plays an important role is also shown by Time Control (BU2) with an average life cycle of 7.5 years. Because of their long life cycle they have the strategy to improve their existing products – most of their product innovations are incremental ones and therefore they are not counted (they reported to have 670 variants). In comparison to BU1 they have the product innovation strategy to introduce a low number of new products (three new main products). As they do not replace existing products (25 existing main products) by new ones their product portfolio increases even more.

Although it was found that a relationship between product life cycles and product innovation rate is given, the chosen product innovation strategy (i.e., portfolio management) plays an important role, too. The findings indicate that an isolated view on product life cycle leads to wrong conclusions. Especially the conclusion that long product life cycles are automatically related to a low number of new products developed is not given.

Market growth

The data collected during the case study visits allowed the analysis of a further variable – the influence of market growth on product innovation rates. This variable is investigated because previous studies showed that a high market growth may encourage the introduction of new products. An inspection of the data shows that a relationship does not appear to be. Overall, all business units see product innovation as an important driver for staying competitive. Dependent on their strategy they operate with a low or high number of new products within their markets. This is shown by the circumstance that, two business units (BU5 and BU11) with high product innovation rates (and a strong focus on new products) operate within markets with a very low growth rate (2.7% and 2.4%). On the other hand, one business unit with a low product innovation rate but a respectively high number of new products (BU1) acts in a market with a respectively high growth rate of 12.5% per year. Looking at the two industry sectors, growth rates for engineering (average 9.4%) and E&E engineering (average 10.0%) have the same frequency. As a result the analysis found that market growth is not related to product innovation position (i.e., the number of new products developed).

Economical influence
For three business units a relationship was found between economic trends and regulations and product innovation activities. Such a relationship was stated by the MD of X-Ray Inspections (BU6). He pointed out that they have "no great influence by the economical situation but by actual regulations". Their latest boom for new inspection units for airports is based on a new law which forces all airports to install x-ray systems with the latest technology by 2002. This he pointed out has influence on the revenues from new products. Another example is Vehicle Electronics (BU10). As they are operating world-wide, they are influenced by specific laws in other countries. Because of new laws for higher security standards for cars they are forced to develop new products. Similar reasons are given for Exhaust Systems (BU9) who are forced by environmental laws to develop new products. For the other eight business units economical influences are not so important for their product innovation activities.

Technology
A further key driver for product innovation are new technologies. The diffusion of electronics across industries was found as a key driver – especially for business units in the industry sector engineering. To show this, three examples are given. The first one is Brake Systems (BU3) where the MD pointed out that more electronic elements are integrated into their mechanical products. Therefore, he pointed out, they are "moving away from their traditional product structures". However, they still produce brake systems for trucks and the market they operate in is the same for both existing and new products. The same situation is given at Vacuum Pumps (BU5). Here the R&D manager said: "In the past all products worked mechanically. In combination with electronics we can improve our products successfully – mechatronics is the key [to our new products]". Electronics is also a driver for product innovations at Exhaust Systems (BU9) who need to optimise their exhaust systems by electronic steering tools.

Summary
Overall, the data analysis shows that dependent on the product life cycle the number of existing products within the product portfolio could be low or high (which could has influence on product innovation rate). However it is not related to the number of new products developed. Further, it was found that product innovation strategy has strong influence on the product portfolio, too (refer to Section 7.5.3). A relationship with market growth is not given. Further, economical influences and technology forces business units to develop new products which in turn is related to higher product innovation rates. A summary of the findings is given in Table 7.8.

Table 7.8: Summary of the Results in the Area Market[1]

Variable	Findings of the Cross-Case Analysis	Driver of Prod. Inn. Pos. Yes	Driver of Prod. Inn. Pos. No
Product life cycle (1 QT)[2]	• Product life cycles are related to product innovation rate. However, a long product life cycle is not automatically related to a low number of new products introduced into market. For all business units it was found that the individual product innovation strategy plays an important role, too. Dependent on the individual product innovation strategy business units operate with more or less existing products in their markets.	✓	
Market growth per year (2 QT)	• A relationship between market growth and product innovation is not given.		✓
Economical influence (3 QT)	• Economical influences, i.e. laws could be drivers for developing new products (which in turn is related to a higher product innovation rate). Especially for business units which are operating internationally this is an important driver.	✓	
Technology (4 QL)	• New technologies can force business units to develop new products (which in turn is related to a higher product innovation rate). It was found that the technology electronics forces business units from engineering to replace mechanical components by electronic ones.	✓	

[1] The decision rules used to construct the table are explained in detail in Section 7.8.1
[2] QT =quantitative variable, QL = qualitative variable

7.5.2 The Competition

In the literature competition was identified as a main factor with influence on product innovation activities (i.e., higher competitiveness is related to a higher number of product innovations). An important variable for measuring the competitive position of business units is market share. In order to get valid data, the market shares were discussed intensively with the interviewees. Some business units are working together with external market research institutes and stated that they know their market share very well. For example, the MD of BU11 stated that for their specific products the market shares are investigated by research institutes. However, it has to be noted that some business units had difficulties reporting their market shares (e.g., BU2 and BU4).

In summary following variables are analysed[74]:

- Own market share (%)
- Market share of the three strongest competitors (%)
- Market entrance barriers for new competitors
- General competitive situation

[74] A detailed overview of the underlaying variables within the area competition is given in Appendix B (Section 1 'Overview of the Variables Investigated' – Table 2a).

Market share

Before starting the cross-case analysis it has to be noted that an isolated view on market share shows a relationship to product innovation rate. On average business units with low product innovation rates have a respectively higher market share (48.8%) than business units with high product innovation rates (17.4%). However, as explained in the section above, product innovation position is not related to the innovativeness of business units. Consequently a detailed inspection led to the finding that – independent from market share and product innovation position – most business units see product innovation as essential to stay competitive.

To show that market share is not related to product innovation position and innovativeness, four examples are given. The first example is Automotive Electronics (BU4), a business unit with a low market share of only 10%. The MD of this business unit reported that in general they are "one of thousands in the automotive electronic supply industry". Therefore they need to develop new products. However, as explained later they concentrate on the development of some few selected products (which is related to their product innovation strategy). On the other hand business units with similar or higher market shares than their competitors need to develop new products, too. For example this is the case for Exhaust Systems (BU9), Vacuum Pumps (BU5) and X-ray Inspections (BU6).

Many interviewed managers stated that market share is difficult to measure. Nevertheless, they pointed out that their data was based on a detailed analysis of their markets. Another problem is the comparison of product portfolios. Especially business units with high differences in market shares of specific products have difficulty in giving an average value. For example, Packaging Foils (BU11) is a world market leader with one specific packaging foil (market share >40%). However, on average they achieve a low market share of 5%. This business unit had difficulties in giving the average market share over all products. A further difficulty is the comparison with competitors where only a part of their product portfolio overlaps. For example, the MD of Vacuum Pumps (BU5) reported that most of their competitors are operating with a higher market share. However, the MD pointed out that the product portfolio is not the same. Most of their competitors produce vacuum pumps for both consumer and industrial applications. As Vacuum Pumps only produces pumps for industry it was difficult for them to give their actual market share. As it has to be ensured that only similar product portfolios have been compared, the market share for this business unit has to be interpreted carefully. Although for some business units the validity of their market shares is not high, the implication is clear – market share is no driver for developing less or more new products.

Market entrance barriers

All business units reported having high market entrance barriers. In general the main reasons for high market barriers are know-how in manufacturing processes and product design. Therefore no relationship to product innovation position is given. Further factors are high investments into plants, customer loyalty and competences of the sales force. Although the reasons for high market entrance barriers are explained by the interviewed managers in detail, some managers were not sure if these barriers are really impossible to surmount. For example, the MD from Packaging Foils (BU11) said: "Market barriers for new entrants are very high, because of customer loyalty – we are a conservative branch". Further, he pointed out that their products have to be proved over years with very expensive stability tests. "To produce our products", he stated, "high investment costs of Euro 25 to 50 million for one production line are necessary". Although he described the market entrance barriers as very high he added: "...competitors in a niche could have a chance, but only with a limited number of products".

General competitive situation

In comparison to market share and market entrance barriers competitiveness in general was identified as a key driver for developing new products. Dependent on their individual competitive situation business units develop more or fewer new products. Main drivers are globalisation, increased competitiveness and lower profit margins. For example the R&D manager of Exhaust Systems (BU9) said: "...the market and our competitors force us to improve our products". At Brake Systems (BU3) the MM stated: "...we are forced by our customers – we have to increase their added value". Further, the R&D manager pointed out: "...globalisation and expanded markets force us to develop new products". For Ultrasound (BU8) the reason for product innovation is good margins. There the R&D manager said that they want "...not to be forced by market prices – we want to achieve good margins in the market. In other words we want to make more profits. But this is only possible with innovations". A similar reason was given by the R&D manager of Vacuum Pumps (BU5) who said: "...further the price pressure from the market forces us to produce innovative products which are difficult to produce more cheaply by our competitors – this is a very important success factor."

An overview of these drivers including comments of the interviewees is given in Figure 7.11 (which is given at the end of Section 7.5). In the figure business units from E&E engineering are marked grey. Overall it was found that dependent on the individual competitive situation, business units choose the most appropriate product innovation strategy to operate in their market. This in turn is reflected in their individual product innovation position.

Summary

Overall, the analysis showed that market share and market entrance barriers are no driver for product innovation. However, it was found that most business units see new products as an important driver for staying competitive. Dependent on their competitive situation and their strategic aim they decide to operate with more or fewer new products in their market (which is directly related to their product innovation position). The findings are summarised in Table 7.9.

Table 7.9: Summary of the Results in the Area Competition[1]

Variable	Findings of the Cross-Case Analysis	Driver of Prod. Inn. Pos.	
		Yes	No
Market share (5 QT, 6 QT)[2]	• In the sample size one business unit with a respectively low market share has a low number of new products and a low product innovation rate. In contrast all other business units (independent from product innovation position) see product innovation as an important driver for staying competitive. Consequently market share is not related to product innovation position.		✓
Market entrance barriers (7 QL)	• Overall, market entrance barriers are high in all business units. Therefore a relationship to product innovation position (product innovation rate) is not given.		✓
General competitive situation (8 QL)	• Dependent on their competitive situation and product innovation strategy business units operate with different product innovation positions.	✓	

[1] The decision rules used to construct the table are explained in detail in Section 7.8.1
[2] QT =quantitative variable, QL = qualitative variable

7.5.3 The Product Innovation Strategy

As pointed out in the sections above, some of the variables analysed in the areas market and competition are related to strategic aspects. Variables which are analysed in this section are[75]:

- NPD project planning horizon (months)
- Investments into R&D (%)
- Product launch strategies
- Product innovation strategy according to the model of Johnson and Scholes
- Corporate environment[76]

NPD project planning horizon

The first variable investigated is the planning horizon for NPD projects. The managers were asked to divide their NPD projects over the last three years into three categories – NPD projects realised in a short, medium or long time horizon. As this time period is closely related to time-to-market of new products this term was not used in the discussion with the respondents. This was the case, because the aim was to investigate how NPD projects are related to strategy. Further, the running time in months for each kind of NPD project was asked for. Because it can be assumed that this variable may be related to the branches the business units operate in, the relationship to branches was investigated, too.

The analysis of the NPD project horizon shows that this variable is independent from the number of new products developed. However, it is closely related to the size of business units. It was found that big business units with financial resources have a

[75] A detailed overview of the underlaying variables within the area product innovation strategy is given in Appendix B (Section 1 'Overview of the Variables Investigated' – Table 2e).
[76] A detailed overview of the underlaying variables within the area corporate environment is given in Appendix B (Section 1 'Overview of the Variables Investigated' – Table 2b).

longer NPD project horizon than small business units. For example Plastics (BU1), a highly innovative medium sized business unit from engineering operates with a high percentage of short term projects (95%). On average these projects run for six months. In comparison Packaging Foils (BU11) a big business unit in the same industry sector operates with a high percentage of long term projects (60%). These long term projects normally run for 48 months. A similar picture is also given for the industry sector E&E engineering.

The reason is that big business units have the possibilities and resources to develop new technologies and to develop more complex products than business units with limited financial resources. One indicator for this is the organisation of R&D within the business units. In business units that belong to a greater organisation normally R&D is centralised. These research centres are able to experiment and to do pure research. This in turn is reflected in a higher cancellation rate of NPD projects which is discussed later.

Comparing the two industry sectors the percentage of NPD projects categorised as short and medium is higher for engineering. In comparison the percentage of NPD projects categorised as long term NPD projects is higher in E&E engineering. Further it was found that for most business units in E&E engineering the NPD project horizon is longer than in engineering. This indicates that NPD projects in E&E engineering are more complex than in engineering. Further, it has to be noted that within the industry sectors the NPD project horizon is independent from branches. For example, Automotive Electronics (BU4) and Vehicle Electronics (BU10) operate in the same branch. However, as BU10 is bigger than BU4 they have the resources to develop more complex products. Therefore for all kind of NPD projects the NPD project horizon is higher for BU10 than for BU4.

Investments into R&D

A further variable with an expected relationship to product innovation position is the percentage of revenues which is invested into R&D activities. An isolated view on this variable shows that for E&E engineering the percentage of R&D investments for business units with high product innovation rates is higher than in business units with low product innovation rates. However, as product innovation rate is not related to the number of products developed such a relationship is not given. Overall each business unit sees their R&D investments as a suitable amount for financing the development of new products. This in turn is related to their individual product innovation strategy.

Further, the data analysis found that investments in E&E engineering are higher than in engineering. All business units from E&E engineering (excepted BU2) invest more than business units from engineering. This indicates that in E&E engineering the development of new products is more complex than in engineering. This is in line with the findings above where it was found that on average the NPD project horizon is longer in E&E engineering (which needs higher financial resources) than in engineering.

With regard to the size of business units a relationship with R&D investments is given. Because of higher financial resources big business units are able to invest more into R&D activities. In big business units this is reflected in a longer NPD project planning horizon (as explained above) and to a higher cancellation rate of NPD projects because of experimentation (refer to Section 7.6.1).

Product launch strategies

The strategy literature offered a further variable which could have an influence on product innovation position – the market launch strategy with new products. Therefore, the percentage of new products introduced with the strategy first to market was directly asked for in the case study visits. Overall, the percentage of new products launched with the strategy first to market ranges between 20% and 100%. However, it was found that this variable is closely related to market and competition. Dependent on the competitive situation and their strategy with new products business units choose the most appropriate launch strategy.

In this context two other launch strategies were identified – technological leadership and cost leadership. In the visits the aims with product innovations were asked for to find out the strategies with new products. Such an open question was chosen to avoid influencing the interview partners with predefined questions. As the respondents had difficulties reporting the number of new products following these two strategies, no percentages are given. The data analysis showed that the strategy technological leadership is more important than the strategy cost leadership. 10 business units reported introducing new products with the aim of technological leadership. In comparison to technological leadership only three business units follow the strategy cost leadership with new products. All strategies are not used independently but are combined. An overview of the launch strategies and comments of the interviewees is given in Figure 7.11 (presented at the end of this section).

To show how the launch strategies are related to market and competition, four examples are given – two for business units with low product innovation rates and two with high product innovation rates. The first example presented is Time Control (BU2). Although they have a low percentage of products with first to market (20%) and do not have the aim to gain technological leadership, product innovation is seen as important. The R&D manager said: "With our new products we are following two aims. We are developing new products for new markets and we are improving our existing products to maintain our market share. With these product innovations we try to secure our customers." However, this is not the case for Brake Systems (BU3). To understand their launch strategy it is necessary to know their aims with new products. On the question why they are introducing new products into market the MD answered: "First we develop new products for OEMs [original equipment manufacturers]. Second, we develop our own new products because we identified the market requirements. Third, the new technology mechatronic is the future. Fourth, [new brake] systems are demanded by the market – we offer such systems." To achieve this the MD stated: "We want to increase our market share with our products and we want to achieve innovation- and cost-leadership." As their focus is on product innovation leadership, the R&D manager pointed out, that 100% of their new products are first into the market.

Second, two examples for business units with high product innovation rates are given. The first example is Exhaust Systems (BU9). On the question why they are developing new products the R&D manager said: "..the market and our competitors force us to improve our products." This is also reflected in their vision stated the MD: "We as a producer of exhaust systems want to become market leader world-wide in our branch." To achieve this they launch 100% of their new products first to market. The MD said: "One of our slogans is to always be among the leaders in our sector of activities... For each family of strategic purchases, at least two suppliers are among the world leaders in their market, and contribute with Exhaust Systems to the development of new technology." The next example is Ultrasound (BU8). The R&D manager said that they are developing new products because of the following reasons: "...Not to be forced by market prices – we want to achieve good margins in the market. In other words we want to make more profits. But this is only possible with innovations". This, he added, is only possible by launching 100% of our products first to market and by technology leadership.

Product innovation strategy according to the model of Johnson and Scholes

As shown above product planning horizon, investments into R&D and market launch strategy are not related to product innovation position. However, a systematic analysis of product innovation strategies according to the model of Johnson and Scholes (1999) found such a relationship. The four strategies they offer are product development, diversification, market development and protection-building. A summary of the different strategies used by the business units is given Figure 7.10. (in the figure business units from E&E engineering are marked grey). Further, comments from the interviewees are given to show how they explain their product innovation strategy.

The figure shows that one business unit with low product innovation rates concentrates its activities only on product development (BU3). This is reflected in their high number of new products developed and their high percentage of revenues from new products. One other concentrates on product development and diversification (BU4) which is shown in their strategy to develop some few selected products to achieve a high percentage of revenues with them. BU2 another business unit with low product innovation rate is focusing on a mixture of three strategies (product development, protection building and diversification). Further, BU1 mix all four different strategies. A comparison of the fields in the diagram product innovation rate and percentage of revenues from new products shows that only the two business units with the lowest product innovation rate and the lowest percentage of revenues from new products (Field 1a) use protection-building as one strategy. All other business units did not see this as an appropriate strategy for their products. Overall, three business units (one with low and two with high product innovation rates) develop new products, based on both existing and new competences (BU3, BU5, BU9). All these business units are from the industry sector engineering. The reason why they develop new products is based on the increase of electronic steering tools in their mechanical products[77]. All other business units concentrate their product innovation activities on existing competences.

[77] The fact that electronic steering modules replace mechanical functions is discussed in Section 7.5.1 'Technology'.

With regard to the product innovation position a relationship can be derived. Business units with high product innovation rates and/or high percentages of revenues from new products do not mix the strategy product development with the strategy protection building. This strategy may be the reason why these business units have a low product innovation position. Further, it was found that market development is only used by three small business units (BU1, BU5 and BU8). As all bigger companies have international activities there is no need for them to follow this strategy.

It has to be noted that dependent on market and competition business units choose the most appropriate product innovation strategy (which is closely related to the individual product innovation position) to stay competitive (refer to Sections 7.5.1 and 7.5.2). The individual product innovation position (strategy) is also reflected in the product innovation process (refer to Section 7.6) and in the profits made with new and existing products (refer to Section 7.7).

Corporate environment

A further area which needs to be discussed is corporate environment. Although this area was given by Cooper and Kleinschmidt as a separate one, the case analysis showed that it is closely related to product innovation strategy. The corporate environment of business units shows how existing competences and resources are used to develop and market new products. It was measured with the two variables familiarity and synergy. Both variables are characterised with a set of sub-variables[78]. An overview of the sub-variables is given in Appendix B. It was found that familiarity which compares product type, markets and technologies of existing and new products is high for every business units. Further, synergies of product innovations with existing skills and resources (e.g., production technology, marketing) are high, too. Independent from product innovation rate and industry sectors the synergies are high at all business units. Although some business units implement new technologies into their products (e.g., electronics) it was found that every business unit concentrates its activities on their core competences.

Summary

The analysis of the area product innovation strategy showed that the time horizon for short and medium NPD projects is not related to product innovation position. However, it was found that NPD project horizon is related to business unit size. Further, the analysis identified that NPD projects in E&E engineering are more complex than in engineering. An investigation of R&D investments showed that for E&E engineering the percentage of R&D investments is higher than for business units from engineering – a relationship to product innovation position was not found. The analysis of launch strategies and corporate culture showed no relationship to product innovation position but to market and competition. Dependent on market, competition and business unit size the most appropriate strategies and product innovation positions are chosen. Corporate environment (given as an extra area in the Cooper and Kleinschmidt model) is not related to low or high product innovation activities. An overview of the findings is given in Table 7.10.

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[78] Familiarity and synergy were measured with a set of sub-variables used by Cooper and Kleinschmidt (1997). They measured the sub-variables via ranking scales of low familiarity/synergy (1) to high familiarity/synergy (10). Such a measurement was considered but rejected. In the case study visits it was asked whether familiarity and synergy is low or high. An detailed analysis of corporate environment is given in Appendix B (Section 1.1 'The Corporate Environment').

Table 7.10: Summary of the Results in the Area Product Innovation Strategy[1]

Variable	Findings of the Cross-Case Analysis	Driver of Prod. Inn. Pos. Yes	No
NPD project planning horizon (16 QT)[2]	• NPD projects in E&E engineering are more complex than in engineering. In E&E engineering the percentage of NPD projects with a medium and long time NPD project horizon is similar or higher for 4 business units (except for one) than for business units in engineering. It has to be noted that a relationship to branches[79] was not found. • NPD project horizon is not related to product innovation position but on business unit size.		✓
Investments into R&D (17 QT)	• R&D investments (measured as the percentage of revenues invested into R&D) in the industry sector E&E engineering are higher than in engineering. It has to be noted that a relationship to branches was not found. • R&D investments are not related to product innovation position.		✓
Product launch strategies (18 QT), (19 QL)	• The strategies first to market, technological leadership and cost leadership are not related to product innovation position. Further, most business units mixed these strategies • It was found that the strategy technological leadership is more important than the strategy cost leadership. 10 business units stated the introduction of new products with the aim of technological leadership. • Product launch strategies are not related to product innovation position but to market and competition.		✓
Product innovation strategy according to the model of Johnson and Scholes (21 QL)	• Business units with high product innovation rates or high percentages of revenues from new products have a stronger focus on product development – they do not use protection-building as a strategy. • The strategy market development is only used by three small business units. • Dependent on market and competition business units choose the most appropriate product innovation strategy (which is closely related to the individual product innovation position)	✓	
Corporate environment (9, 10 QL)	• Corporate environment is not related to product innovation position. Familiarity and synergy is high for every business unit. However, it is closely related to product innovation strategy.		✓

[1] The decision rules used to construct the table are explained in detail in Section 7.8.1
[2] QT =quantitative variable, QL = qualitative variable

[79] The definition of branches is given in Chapter 3 (Section 3.0 'Product Innovation in German Industry').

Figure 7.10: Product Innovation Positions and Strategies (according to the model of Johnson and Scholes, 1999)

Product Innovation Strategy:
- Product Development: On existing / new competences

Comments:
- MD: "...always be among the leaders in our sector of activities".
- Company brochure: "...an innovative range of products for the automotive industry... the group deploys state-of-the-art technologies, testing and research resources all over the world... positions the group as a provider of innovative solutions compatible with environmental preservation."

Product Innovation Strategy:
Mixture of two strategies:
- Product Development: On existing competences
- Diversification: On existing competences

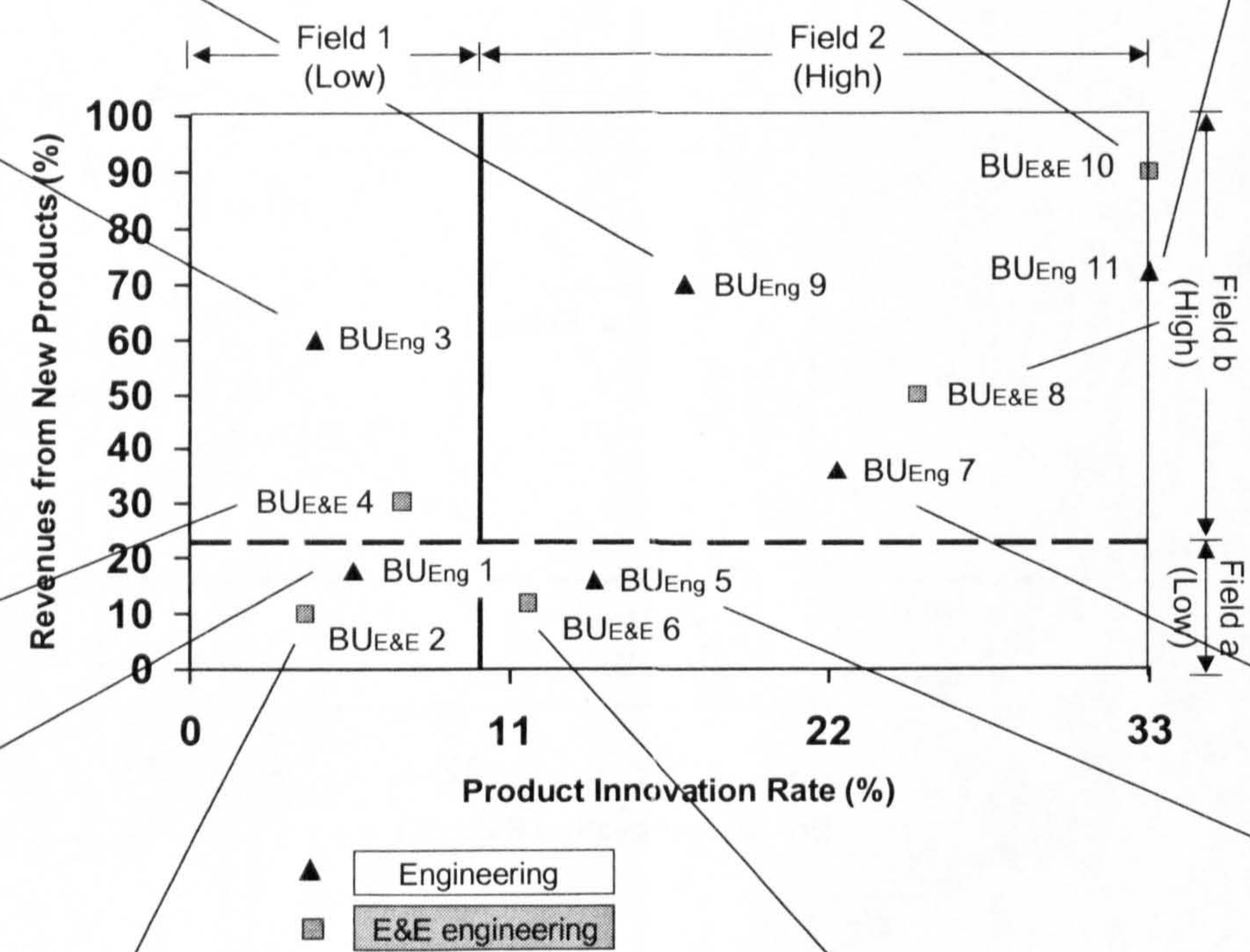
Comments:
- MM: "...to be the only company which offers products first to market and to create market advantages and profits with pacemaking-technologies".
- MD: "We develop customer specific products and hold on to the product innovation leadership"
- R&D: "Innovation is new technologies and new products for new markets, with a better price/performance relationship"

Product Innovation Strategy:
Mixture of two strategies:
- Product Development: On existing competences
- Diversification: On existing competences

Comments:
- MD: "We are innovative in holding up our innovation leadership and to hold on to our market share ...to be market leader in some sectors ...our main aim is to develop new products for new markets.
- R&D: "We are innovative in offering our customers new possibilities. With our new products we differentiate against the products of our competitors."

Product Innovation Strategy:
- Product Development: On existing / new competences

Comment:
- MD: "In summary electronic features increase and therefore our products move away from mechanical to electronic steering apparatus. Our aim is to integrate new technologies into our products. ...Further we are looking for niches and other [business] fields."



Product Innovation Strategy:
Mixture of three strategies:
- Product Development: On existing competences
- Diversification: On existing competences
- Market Development: New territories

Comments:
- R&D: "...it is not only to hold up our technology leadership. It is the summary of our strong focus on customer demands".
- MD: "In the past we had a strong dependency from the automotive sector. To reduce this, we have looked for new products and markets to decrease this dependency ...Nevertheless, we do not want to go into markets (branches) we do not know."

Product Innovation Strategy:
Mixture of two strategies
- Product Development: On existing competences
- Diversification: On existing competences

Comments:
- MD: "...to achieve a stronger market position and to extend our activities into further countries (side by side) with our new products".
- MD: "To extend our know-how in the field of our core competencies and to generate new product fields.

Product Innovation Strategy:
Mixture of two strategies:
- Product Development: On existing competences
- Diversification: On existing competences

Comments:
- MD: "We started 10 years ago to develop own products because we wanted to become independent from wage-manufacturing.
- MM: "We always want to offer new products for new markets".

Product Innovation Strategy:
Mixture of four strategies:
- Product Development: On existing competences
- Diversification: On existing competences
- Protection building: Market penetration
- Market Development: New territories

Comments:
- MD: "We want to continue our successful strategy to introduce a permanent stream of new products. And we want to double our turnover by introducing existing products into new markets".
- MM: "...build up new product segments too with focus on specific customer groups in selected markets".

Product Innovation Strategy:
Mixture of three strategies:
- Product Development: On existing competences
- Protection building: Market penetration
- Diversification: On existing competences

Comments:
- MD: "We are developing new products for new markets and we are improving our existing products to hold up our market share".
- R&D: "With product innovations we secure our market potential and we have the ability to extend our market ...20% of product innovations are focusing on new customers and new markets".

Product Innovation Strategy:
Mixture of two strategies:
- Product Development: On existing competences
- Diversification: On existing competences

Comments:
- MM: "...with new products including a new design we want to produce our products more efficiently."
- MD: "Our aim is to get world-market leadership in all product areas for x-ray security. ...Therefore we have to be active in more new business areas"

Product Innovation Strategy:
Mixture of two strategies:
- Product Development: On existing / new competences
- Market Development: New markets

Comments:
- MD: "Our present customers are more important to us than new customers. We try to catch new customers but our present customers are staying with us."
- R&D: "In the past all products worked mechanically. In combination with electronics we can improve our products successfully - mechatronic is the key".
- MD: "We try to find new customers for our old products, too."

Figure 7.11: Drivers of the Need for Product Innovation and Launch Strategies

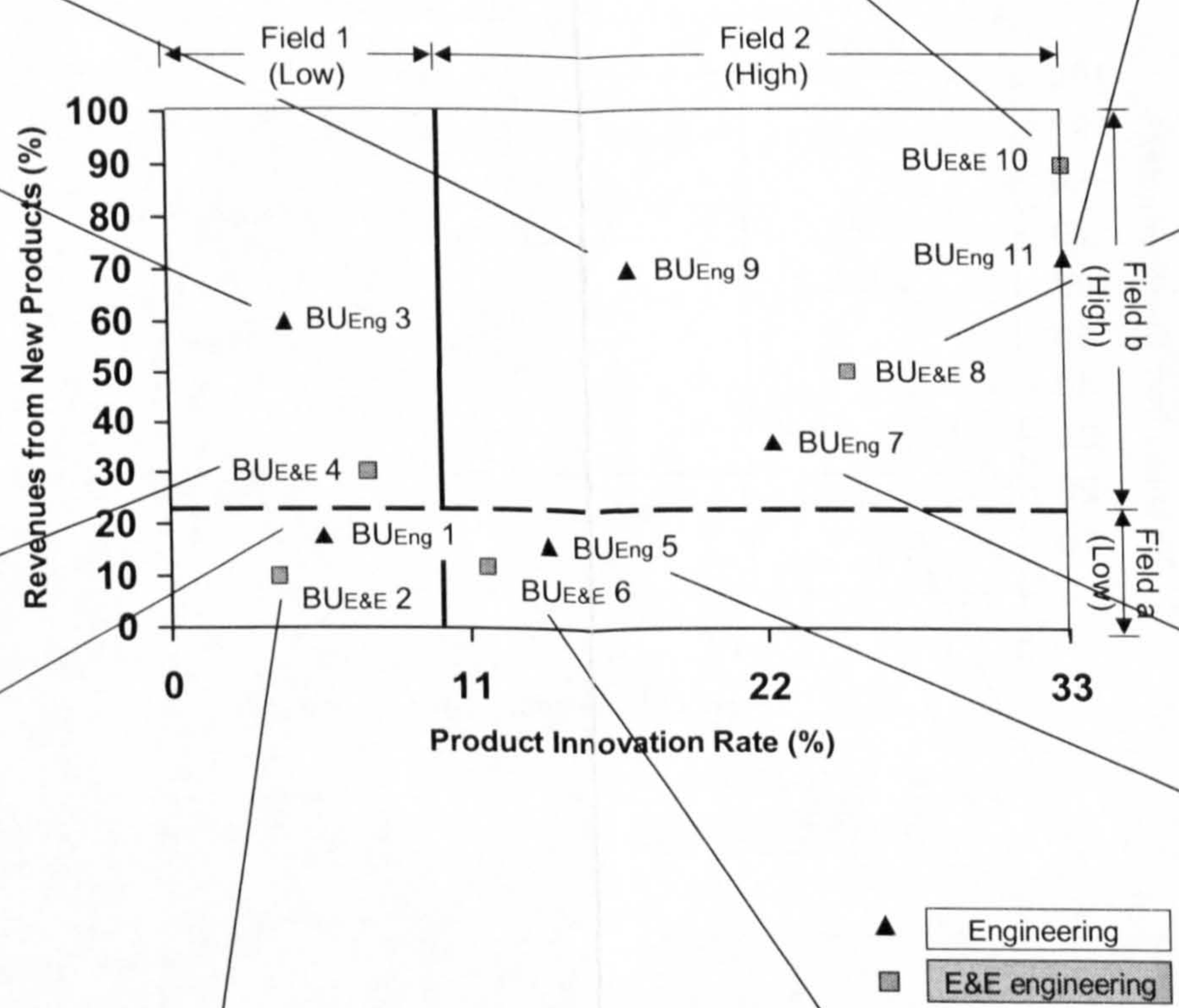
Driver for Product Innovation:
R&D: "...the market and our competitors forces us to improve our products." This aim is also reflected in their visions stated the MD: "We as a producer of exhaust systems want to become market leaders world-wide in our branch."
Launch Strategy:
MD: "One of our slogans is to be always among the leaders in our sector of activities [which is related to their strategy to introduce 100% of their products first to market] ... For each family of strategic purchases, at least two suppliers are among the world leaders in their market, and contribute with Exhaust Systems to the development of new technology."

Driver for Product Innovation:
MD: "...Further, new products are necessary to stay competitive - it is in response to high price pressure and the strong competition in the market. ...innovations are only possible with strategic customers. Therefore a partnership with customers who stand behind the innovative (first to market) products from Vehicle Electronics are important. Only such partners are willing to pay more for innovative high-tech products:"
Launch Strategy:
MM: "To be the only company which offers products first to market [100%] and to create market advantages and profits with pacemaking-technologies".

Driver for Product Innovation:
MD: "Products get cheaper and therefore more features can be offered for the same price. Other reasons are to make customers more satisfied and to make more profits with new products. ...our customers have the demand to go with their innovative products".
Launch Strategy:
MD: "We are innovative to hold up our innovation leadership and to hold up our market share [54% of their products are first to market]".

Driver for Product Innovation:
R&D: "...globalisation and expanded markets forces us to develop new products".
MM: "We are forced by our customers – we have to increase their added value".
Launch Strategy:
MD: "We want to be the innovation leader and we want to be [with 100% of our new products] first on the market".

Driver for Product Innovation:
R&D: "...not to be forced by market prices – we want to achieve good margins in the market. In other words we want to make more profits. But this is only possible with innovations".
Launch Strategy:
MD: "We want to be the technological leader in our segment [which is related to introduce 100% of their products with the strategy first to market]".
R&D: "...is not only in holding up our technology leadership. It is the summary of our strong focus on customer demands, to employ the best persons and to have contented employees".



Driver for Product Innovation:
MD: "... we develop our own new products because we identified the market requirements ... the new technology mechatronic is the future. ..Mid-term we want to show that we are able to act as an independent company - this is our entrepreneurial aim."
Launch Strategy:
MD: "We want to increase our market share with our products and we want to achieve innovation- and cost-leadership [they achieve this with 100% of their products first to market]".

Driver for Product Innovation:
MD: "We transferred our customer demands into our own development activities. However, we started 10 years ago to develop own products because we wanted to become independent from wage-manufacturing.
Launch Strategy:
MD: "We will first achieve product innovation leadership or technology leadership. We are on the way to achieving this, because 50% of our new products are introduced with the strategy first to market."

Driver for Product Innovation:
MD: "Because of the global markets, we want to increase our product innovation activities in the next three years".
MM: "Only the ability to offer new packaging solutions made it possible for us to sell our existing product portfolio successfully".
Launch Strategy:
MM: "Plastics want to offer a comprehensive product collection to offer solution for every packaging problem" [as they develop customer oriented packaging solution, 100% of their new products are launched with the strategy first to market]".

Driver for Product Innovation:
R&D: "With our new products we are following two aims. We are developing new products for new markets and we are improving our existing products to hold up our market share. With these product innovations we try to secure our customers to us."
Launch Strategy:
R&D: "Because most of our products only needed to be adopted to customer demands we have a big range of variants [consequently only 20% of their new products are first to market]".

Driver for Product Innovation:
MM: "First we want to make profits with new products. And with new products including a new design we want to produce our products more efficiently. Additionally the market and our competitors forces us to introduce new products."
Launch Strategy:
R&D: "We want to be the leader in technology and quality. Because in the past our focus was on these two points, with the most products we were not first to market [40% first to market]".

Driver for Product Innovation:
R&D: "...further the price pressure from the market forces us to produce innovative products which are difficult to produce more cheaply by our competitors – this is a very important success factor."
Launch Strategy:
MD: "...cost and technology leadership [and 100% of their products are launched with the strategy first to market]".

7.6 UNDERLAYING VARIABLES OF PRODUCT INNOVATION PROCESS

As shown in the previous section, a low product innovation position is not automatically related to a low innovativeness (i.e., a low number of new products developed). Product innovation position is mainly influenced by market, competition and product innovation strategy. Independent from product innovation position, all business units reported that new products are important for staying competitive. Therefore in a next step the data collected in the case study visits are analysed to identify key drivers for managing product innovation. From this analysis the two key drivers given in Table 7.11 are new product process and corporate culture. Together with product innovation strategy (also found as a key driver for product innovation position) they are the key drivers for managing the development of new products. As for the management of NPD projects market and competition are not important, these two areas are given in brackets. In the table, the data for business units from engineering are given in white columns and business units from E&E engineering are marked with grey columns.

Table 7.11: Key Drivers for Managing Product Innovation Processes[6]

Product Innov. Position		**BU**	**Market[1]**	**Compe-tition[1]**	**Corp. Environ-ment[2]**	**Nature of New Products[2]**	**New Product Process[3]**	**Product Innovation Strategy[4]**	**Corporate Culture[5]**
Product Innov. Rate	**Revenue from NPs**								
Low	**Low (Field 1a)**	**1**	(✓)	---	---	---	✓	✓	✓
		2	(✓)	(✓)	---	---	✓	✓	✓
	High (Field 1b)	**3**	(✓)	(✓)	---	---	✓	✓	✓
		4	---	(✓)	---	---	✓	✓	✓
High	**Low (Field 2a)**	**5**	(✓)	(✓)	---	---	✓	✓	✓
		6	(✓)	(✓)	---	---	✓	✓	✓
	High (Field 2b)	**7**	---	(✓)	---	---	✓	✓	✓
		8	(✓)	(✓)	---	---	✓	✓	✓
		9	(✓)	(✓)	---	---	✓	✓	✓
		10	(✓)	(✓)	---	---	✓	✓	✓
		11	(✓)	(✓)	---	---	✓	✓	✓

Engineering

E&E engineering

[1] Market and competition were identified as key drivers for varying positions of business units within the diagram product innovation rate and the percentage of revenues from new products. However, for the management of product innovation processes within a business unit they are no important drivers. Therefore the ticks are given in brackets.

[2] Corporate environment and nature of new products were not identified as key drivers.

[3] New product process was identified as key drivers for the management of product innovation processes.

[4] Product innovation strategy was identified as a key driver for both product innovation position and managing product innovation processes. It is closely related to corporate culture.

[5] Additionally to the areas given in the Cooper and Kleinschmidt model corporate culture was identified as a key driver for managing product innovation.

[6] The decision rules used to construct the table are explained in detail in Section 7.8.1

7.6.1 The New Product Process

The first area discussed is the new product process. This terminology used by Cooper and Kleinschmidt is similar to the term "NPD management process". It can be assumed that the influence of NPD management techniques and the effectiveness of NPD processes on the number of new products developed is high. The variables discussed in this area are[80]:

- NPD projects running on time (%)
- NPD projects cancelled (%)
- NPD project management
- Ideas from external sources (%)[81]

Percentage of NPD projects on time

The first variable analysed is the percentage of projects running on time. This variable is defined as the deviation of the market launch from the time which was determined at the start of the NPD project. This variable was investigated because it can be assumed that a higher number of product innovations is related to a low number of NPD projects without any time delay. Although this measure is rough, it shows whether NPD processes are planned to be finished in a realistic time period. Therefore, only significant delays (longer than one month) were analysed.

To get deeper insights into the reasons for different percentages of projects running on time, an in-depth analysis of the cases was carried out. The analysis found that especially for one business unit this may be an indicator for their low level of product innovation. At Time Control (BU2) hardly any project is running on time. The low percentage of projects running on time (2%) is explained by the R&D manager as follows: "We are on the way to improving our product innovation management system. Because we have problems in working with a permanent stream of strategic innovation projects our R&D employees have to be instructed and motivated for every new innovation project." These difficulties are closely related to the low commitment of the board of management to product innovation and the strategy to develop more variants than new products stated the R&D manager. Because of the strategy to develop some few products personal resources for NPD projects are strongly limited and employees have difficulties to carry out NPD projects.

Overall, all other business units have some problems in carrying out their NPD projects, but this is not related to their ability to create a continuous stream of new products. For example Plastics (BU1) and Automoitive Electronics (BU4) reported having some problems in their NPD project management and therefore a few NPD projects (10%) are not on time. The R&D manager of Brake Systems (BU3) stated that they have some problems with their R&D capacity and resources. Therefore, 50% of their NPD projects are not on time. At Gearbox (BU7) the delay of 34% of their NPD projects is based on "time and personnel capacity". The MD of this business unit sees this as the biggest problem in their development process. A similar explanation is given

[80] A detailed overview of the underlaying variables within the area new product process is given in Appendix B (Section 1 'Overview of the Variables Investigated' – Table 2d).

[81] The source of ideas is a variable within the Cooper and Kleinschmidt area nature of new products A detailed overview of this variable is given in Appendix B (Section 1 'Overview of the Variables Investigated' – Table 2c).

by the R&D manager of Ultrasound (BU 8). The most important problem with the delay of NPD projects is the fact that "most new products are developed apart from the daily work". At X-ray Inspections (BU6) more complex systems and their limited man power are the reasons for 20% of the delay of NPD projects. The R&D manager of Vacuum Pumps (BU5) stated that the main reason was a too short calculated development time. Therefore, only 30% of their NPD projects are on time. The MD of Packaging Foils (BU 11) reported a further problem in their product innovation process: "There is a conflict of aims – researchers often want to transfer their ideas into reality very quickly, but often the organisation unit has other priorities". Overall, the analysis shows that the reasons for delays in NPD project management vary across the whole sample size (e.g., personnel capacity, changing customer demands).

It was found that the main reasons are personal resources and the management of NPD projects apart from the daily work. Other reasons are complex products, changing customer demands, problems in transferring laboratory concepts into production, other priorities of the business unit (i.e., for business units within a large company). Some of these reasons were found as delays because of innovative NPD approaches. As shown next, innovative NPD approaches are identified as a criteria for cancelled NPD projects.

Percentage of NPD projects cancelled

A further variable with an expected influence on the number of products developed is the percentage of NPD projects cancelled over the last three years. It was found that cancellation rates are related to the size of business units (i.e., financial resources) and to product innovation strategy – but not to product innovation position.

In Table 7.12 it is shown that the percentage of cancelled NPD projects is lower for small business units than for large ones. Small business units (1-500 employees) have an average cancellation rate of 2%. In contrast, big business units (more than 500 employees) cancel 18.6% of their NPD projects. A detailed inspection of the case data shows that almost no NPD project was cancelled by small business units in the last three years (the cancellation rate varies between 0% and 3.3%). For large business units the cancellation rate is higher. For large business units with high product innovation rate an average percentage of 19.5% of cancelled NPD projects is given. As this relationship was not expected, a detailed analysis of the case interviews is carried out.

Table 7.12: Average Percentage of Cancelled NPD Projects

Variable	Low IR (n = 4)		High IR (n = 7)		Small BU[1] (n = 6)	Large BU[2] (n = 5)
	Small BU[1] (n=3)	Large BU[2] (n=1)	Small BU[1] (n=3)	Large BU[2] (n=4)	----	----
NPD projects cancelled %	~ 0	15	3.3	19.5		
	5.0		12.6		~ 2.0	18.6

[1] Small business unit: 1 – 500 employees
[2] Large business unit: More than 500 employees

First, the business units with a low percentage of NPD failure rates are analysed. Automotive Electronics (BU4) only stopped one NPD project in the last three years. This was explained by the R&D manager who said that the circumstances for a small business unit to cancel a NPD project are not easy. He said: "Because NPD projects need high investments, we have to plan them very carefully". A similar explanation is given by Time Control (BU2). The fact that they have not cancelled an NPD project is directly linked with the risk when a new product fails. The MD stated that a big flop could be their demise. Additionally, at Gearbox (BU7) the reason for their low cancellation rate is based on a careful selection of NPD projects – this is closely related to their small size.

A higher failure rate is given by Vacuum Pumps (BU5) and Gearbox (BU8). These business units have a 5% failure rate. As they want to achieve technology leadership, some of their NPD projects are planned to be cancelled. However, because of their size and limited financial resources, their failure rates are much lower than the failure rates of large business units with high product innovation rates. Now, it can be concluded that the size and a careful selection of some few NPD projects is the reason for the 0% failure rate for Plastics (BU1). However, their low failure rate is closely related to their product innovation strategy to develop everything their customers want. They do not cancel any NPD project because they use strategic product innovations to show their innovativeness. As their new products are mainly based on their know-how in production it possible for them (as a small business unit) to realise every NPD project.

Secondly, business units with high percentages of failure rates are analysed. The first example is Brake Systems (BU3) with a respectively high cancellation rate of 15%. The R&D manager of this business unit pointed out that they are developing fundamental new technologies which is part of their product innovation strategy. "This is the reason why we calculate a percentage of projects which have to be cancelled". The MD of Vehicle Electronics (BU10) explained the high failure rate of 30% with the fact that they have planned for cancelling a percentage of projects. "This is the price we pay for being the most innovative producer of electronics parts for the automotive industry" stated the MD. The high failure rate of 33% at Packaging Foils (BU11) is based on similar reasons. The R&D manager stated that "...there is a lot of work in transferring the laboratory processes into the real production process – at the beginning of this transfer phase it becomes clear that a product innovation is realisable". From these statements it can be concluded, that financial resources are the driver for cancelling a defined percentage of "experimental" NPD projects. This is shown by the high number of failure rates due to technological problems.

NPD management process

A further variable which could have an influence on the number of new products developed is the way in which NPD processes are defined and how they are carried out. Before beginning the analysis, background information and some comments about the organisational structure of the sample size is given. All business units are organised in a functional way (except BU10 who have a matrix organisation). In every business unit interdisciplinary NPD project teams are installed. In these teams members from the R&D department, production and marketing work together within an NPD project. Further, the phases in the NPD processes are fixed in every business unit. In most cases NPD processes are documented with ISO 9000 or VDA6 certification.

Although all business units structured their NPD processes very well, some have difficulties transferring the planning into practice. The R&D manager of Ultrasound (BU8) pointed out that "personal contacts are more important for co-ordinating all product innovation activities than formal controlling". The statement of the MD of Gearbox (BU7) goes in the same direction "...nobody controls whether or not ISO 9000 is implemented". Further, he stated: "because of the small size of the company, communication between all persons who are involved in a research project is the most important aspect for success". However, because of their corporate culture where product innovation is seen as important for staying competitive, the NPD processes are working. As a result it has to be noted that informal information transfer is more important in small business units than in bigger ones. Difficulties in the NPD project management process of small business units are compensated by informal information transfer. However, such an information transfer is closely related to corporate culture. Only when all employees are willing to share information and have a common understanding of product innovation, do NPD project management processes work without any major difficulties.

Source of ideas

The literature review showed that both ideas from external sources (e.g., customers, suppliers) and internal sources (e.g., employees) are important for generating new products. Therefore, the source of ideas was discussed intensively with the interviewees. It was found that all business units use ideas from external and internal sources.

Summary

The data analysis identified no relationship between the delays of NPD projects and cancellation rates with product innovation. However, for cancellation rates a relationship to business unit size and product innovation strategy was found. The case study analysis showed that NPD project management processes are well organised in all business units. Further, it was found that most of the business units are dealing with problems in managing NPD projects. Especially small business units (in comparison to bigger ones) use informal personal contacts more intensively to compensate difficulties in the NPD project management process. Further it is shown that the source of ideas is not related to product innovation position. A summary of the findings is given in Table 7.13.

Table 7.13: Summary of the Results in the Area New Product Process[1]

Variable	Findings of the Cross-Case Analysis	Driver for Prod. Inn. Process	
		Yes	No
Organisation (QL)[2]	• All business units except one (with a matrix organisation) used a functional organisation form for managing R&D activities. • In all business units interdisciplinary NPD project teams are installed. In these teams members from different departments (e.g., R&D, production and marketing) work together within NPD projects.		✓
NPD projects on time (13 QT)	• Delays in NPD projects (e.g., because of limited resources and complexity) are given in all business units. It is not related to the ability to create a continuous stream of new products.		✓
NPD projects cancelled (14 QT)	• The failure rate of NPD projects is not related to the number of new products developed. • A relationship between cancellation rate and business unit size is identified. Because of high costs for small business units it is almost impossible to cancel an NPD project. Further, it was found that big business units have the financial resources to experiment on a higher level. The reason is, that bigger business units planned to cancel a predefined percentage of NPD projects because of experimentation (which is closely related to the product innovation strategy).		✓
NPD processes (15 QL)	• The phases in the NPD processes are fixed in every business unit. In most cases NPD processes are documented with ISO 9000 or VDA6 certification. However, small business units (in comparison to bigger ones) use personal contacts more intensively than structured and formalised NPD process stages.	✓	
Source of new ideas[3] (11 QT)	• All business units use ideas from outside (e.g., customers) and inside (e.g., employees) the business unit to develop new products. It is not related to innovativeness.		✓

[1] The decision rules used to construct the table are explained in detail in Section 7.8.1
[2] QT =quantitative variable, QL = qualitative variable
[3] Variable within the area nature of new products

7.6.2 The Corporate Culture

The next area investigated is living culture and the commitment of the board of management to product innovation.[82] Although this area is not given as a separate one in the Cooper and Kleinschmidt model it was identified as an important driver for managing product innovation processes. It has to be noted that this area is closely linked to human resource management which was discussed in the case study visits, too.

[82] Corporate culture is discussed within the area product innovation strategy. A detailed overview is given in Appendix B (Section 1 'Overview of the Variables Investigated' – Table 2e).

A first indicator of how important product innovation is seen within a business unit, is the way in which product innovation aims are written down. The data analysis shows that four business units have no written aims (BU1, BU2, BU5 and BU7). Although the sample size includes some business units without any written innovation strategies, the commitment and living culture is high in 10 of 11 business units. Only the R&D manager of Time Control (BU2) stated that "the support of the board of management to increase our innovation activities is not very high". To show that the commitment to product innovation is high in most business units four examples are given.

The first two examples are from engineering. The MD of Plastics (BU1) explained their product innovation activities as follows: "Innovation is the heart of the company – everything grows from it. Innovation means to live daily with the learning development of the company and to involve everybody". This strong focus on product innovation is given, although Plastics has not written down their product innovation aims. The reason is that the MD of this business unit is the owner who has a strong focus on product innovation – most of all new products were developed by himself. Although his ideas are the main source for product innovations he transfers his innovative thinking into the whole business unit. To achieve this, he installed different committees (i.e., an employee product innovation circle and a strategy circle) which discuss new product ideas. Now, it can be assumed that for BU1 this is the case, because it is medium sized (250 employees) and family owned. Therefore, the influence of the MD's view is very strong. However, the same strong focus on product innovation was observed for Brake Systems (BU3) – a big business unit – who aimed to hold on to innovation leadership. Their strong focus was confirmed by the R&D manager who stated that "process orders in NPD project management are active". In the discussion with him it became clear, that all members of project teams are improving their NPD project development processes continually.

The next business unit with a high commitment to product innovation discussed is Ultrasound (BU8). This business unit from E&E engineering has 140 employees and is similar to Plastics (BU1). Although the founder of this family owned business unit is not on the board of management anymore, his strong focus on product innovation is still alive. The R&D manager pointed out that their aim with innovation "is not only to hold on to our technology leadership. It is the summary of our strong focus on customer demands, to employ the best people and to have contented employees". This view was also taken by the MD who pointed out that their aim is to hold on to technology leadership and to involve their employees in R&D activities. In comparison to BU8, the MD of Vehicle Electronics (BU10) – which is a big business unit – has a strong focus on product innovation, too. He transfers his visions to the whole business unit. He stated that this strong commitment is dependent upon a set of different factors: "...open leading style, strong concentration on self-sufficient business fields, creativity, and financial background". Additionally, he pointed out that they are the "only company which offers products first to market and to create market advantages and profits with pacemaking-technologies".

In all business units employees play a central role in creating new products. Further, it was found that in most business units (except for BU2) corporate culture is characterised by an experimental environment and an open leading style. For example the MD of Exhaust Systems (BU9) stated: "I try to motivate our employees, use kaizen and other management techniques to achieve higher quality and stable processes." A further example is Vacuum Pumps (BU5). The MD of this business unit pointed out that product innovation is a living culture within their business unit. He said: "Employees are involved very strongly in product innovation – it is a living culture within our company".

Summary

Corporate culture and the commitment of the board of management to product innovation are closely related to product innovation strategy. Especially the importance of new products within the product portfolio is reflected in the way employees are involved into the NPD management process. Further, it was found that especially small business units compensate difficulties in the formalised NPD project management process by informal communication. A summary of the findings is given in Table 7.14.

Table 7.14: Summary of the Results in the Area Corporate Culture[1]

Variable	Findings of the Cross-Case Analysis	Driver for Prod. Inn. Process	
		Yes	No
Culture and commitment of the board of management (20 QL)[2]	• Corporate culture has no influence on the number of products developed but on the way new products are generated. • Corporate culture and the commitment of the board of management to product innovation is important for being innovative (i.e., developing new products). Such a culture is given in all business units except one where the commitment of the board of management to product innovation is low (BU2). It has to be noted that for this business unit this low commitment is related to their difficulties to handle their (strategic) NPD projects.	✓	

[1] The decision rules used to construct the table are explained in detail in Section 7.8.1
[2] QT =quantitative variable, QL = qualitative variable

7.7 UNDERLAYING VARIABLES OF PRODUCT INNOVATION OUTPUT

In addition to product innovation position (as one product innovation output measure) further variables were investigated in the case study visits. The most interesting variable is profit. In the current research profits for the whole product portfolio (including existing and new products) and for new products are investigated. In this context also the break-even-point and the stream for new products was analysed. In summary the following variables are analysed[83]:

- Average profits with the whole product portfolio
- Average profits with new products
- Break-even point
- Stream of new products
- Business unit growth

[83] A detailed overview of the underlaying variables within the area product innovation output is given in Appendix B (Section 1 'Overview of the Variables Investigated' – Table 2f).

7.7.1 The Profits with the Whole Product Portfolio

The first variable analysed is the profit with the whole business unit. A detailed inspection of the data shows that the business unit with the highest product innovation rate and percentage of revenues from new products –Vehicle Electronics (BU10) – achieves the lowest profits (2.4%). In comparison Brake Systems (BU3), a business unit with a low rate and a high percentage of revenues from new products achieves relatively high profits (18.6%). This contradiction can be explained with regard to the profit margin within the industry sectors the business units operate in. The MD of BU10 pointed out, that because of the high competitive situation within their market, the margins are lower than in other industry sectors. The high profits of the business units BU1, BU2, BU3 can be explained with their strong market position. Further, the profits of BU6 and BU8 are related to their operation within specific niches. Within these branches the margins are higher than in other markets. Further, it has to be noted that in the engineering sector the profits are higher (13,5%) than in the E&E engineering sector (11,5%). However, this is not representative and may be related to the limited sample size investigated in Phase 3. For example two business units within E&E engineering operate in a competitive environment (BU4 and BU10) with very low profit margins.

This finding implies that profits with the whole sample size are mainly dependent on environmental factors such as market and competition. However, a more meaningful analysis is the comparison of profits with the whole product portfolio to the profits with new products. As shown next, the differences between these two variables is closely related to product innovation position.

7.7.2 The Profits with New Products

The next variable analysed is profit with new products. Before beginning the analysis of this variable it has to be noted that seven business units had difficulties giving information about their profits from new products. These business units do not measure their profits from new products regularly and therefore no actual data was available. However, based on available data sources (information from the marketing and accounting departments), the interviewees stated that the profits reported are realistic. Further, one business unit was not able to give any information. In summary, only three business units were able to give detailed information about their actual profits from new products.

One surprising result arises by comparing the profits from the whole product portfolio (all products) with the profits from new products. An overview of these findings is given in Table 7.15. The analysis shows that only two business units earn more from new products than from the whole product portfolio. Further, six business units earn the same profits with both new products and the whole product portfolio. Surprisingly two business units (one business unit from engineering and one from E&E engineering) earn less with their new products. This indicates that profits are closely related to the individual product innovation position and the strategy with new products.

Table 7.15: Comparison of Profits from the Whole Product Portfolio and from New Products (frequency across business units)

Variable	Low IR (n = 4)	High IR (n = 6[1])	Eng. (n = 5[1])	E&E (n = 5)	Overall (n = 10[1])
Higher profits from new products	BU2	BU10	---	BU2 BU10	2
Same profits with both new products and whole product portfolio	BU3 BU4	BU5 BU8 BU9 BU11	BU3 BU5 BU9 BU11	BU4 BU8	6
Lower profits from new products	BU1	BU6	BU1	BU6	2

[1] BU7 (Gearbox) was not able to give any information about profits from new products.

One business unit with higher profits with their new products is Time Control (BU2). As new products do not play an important role they are able sell these new products on a higher price level. Although the profit margins of their new products are higher, the percentage of revenues from new products is low. The reason is that they have a stronger focus on existing products. From this finding it can be concluded that the higher prices for their new products are more strategic – they do not sell their products to competitive prices. Another reason is given for Vehicle Electronics (BU10). Most of their products within their product portfolio are new ones and they have the aim to develop pacemaking technologies for selected innovative customers. These customers are willing to pay more for their new products than for their existing ones. Consequently the profit margins are higher.

As Table 7.15 shows, six business units earn the same profits with both new products and the whole product portfolio. One reason for similar profits could be the price pressure within industries. This is the case for Brake Systems (BU3), Vacuum Pumps (BU5), Exhaust Systems (BU9) and Packaging Foils (BU11). They are forced to develop products with good value and sell them on a similar price level as existing products. The MDs of BU3 and BU9 reported that especially in the automotive industry the calculation for new products must be revealed and the margins are set by the OEMs. This is the reason why higher profits are not possible to achieve.

Because at Ultrasound (BU8) the profits are as high for both new and existing products (30%), this was discussed with the MD in detail. He explained this phenomenon as follows: "For new products the prices are higher than for existing ones. However, the profits for existing and new ones are almost the same. The reason is, that the production of new products is more expensive. Manufacturing lead time is longer and often difficulties which were not recognised with the production of the prototypes arise. In comparison, the manufacturing process for existing products is running without any difficulties. Production employees are trained very well and need less time than for the manufacturing of new products. A further reason is, that in the transitional phase of replacing existing products with the new ones, the produced number of items for existing products is very high. Overall, the reason for the same profits is the cost reduction in manufacturing for existing products. The margin for existing products is the same as for new products, although existing products are sold at a lower price level." In other words: Standardised manufacturing processes, low manufacturing costs and higher production series reduce the costs for existing products. This cost reduction is passed on to their customers. Going further, the cost reduction can offset the margins for existing products which are sold at a cheaper price level than new ones.

Lower profits with new products are given by Plastic (BU1) and X-Ray Inspections (BU6). The MD of Plastic (BU1) explained this as follows: Plastics "...offer solutions for every individual problem". He continued: "To achieve this we develop customer specific products with low selling numbers ...this is the reason why most product innovations are made without looking at the profit". From this finding it can be concluded that new products are not important at Plastics. However, the MD pointed out: "...new products are important as an instrument to always offer customers something new". Further, the MM stated: "Only the ability to offer new packaging solutions made it possible for us to sell our existing product portfolio successfully."

The example above shows that product innovation can be seen as a strategy for selling existing products. Consequently, more profits are generated with existing products. However, for X-Ray Inspections (BU6) there is another reason for their lower profits with new products. The MM stated that most of their revenues for their x-ray systems comes later than three years after product introduction. Their customers are very critical of how a new product works and therefore they ask for references. He said: "To get references which are accepted by a wide range of customers we have to run our products for a time-period with a few key-customers – this time period is often more than three years". For these pilot machines they were not able to achieve such high margins (prices) as for the "tested" new products. As their tested machines normally are older than three years the revenues and profits are those for existing products.

The analysis of profits shows that dependent on the chosen product innovation position the profits with new products are high or low. This depends on the individual product innovation strategy and the way new products are seen within the product portfolio. As explained next, this is closely related to the break-even-point.

7.7.3 The Break-Even-Point

In a further step it is interesting to investigate the break-even-point[84]. The break-even-point shows the time period from product introduction to the point when a product generates profits. Further, it has to be noted that the average break even (over all products) is closely related to the profits with new products and product innovation strategy. For business units which see product innovations as important for selling their existing ones the break-even is long. In comparison business units with many new products within their product portfolio need a short break-even-point. Overall it range between six and 36 months and no tendency can be observed.

It has to be noted that only two business units were able to give correct data. Seven business units estimated the break-even and two were not able to give any information.

[84] The break-even-point is explained in Section 2.3.5 'Research Studies of Product Innovation Strategy' (Figure 2.10, Return Map).

7.7.4 The Stream of New Products

Finally, the stream of new products is investigated. The frequency across business units is given in Table 7.16. It is shown that most business units have a permanent stream of product innovations. However, two business units reported having slight waves and two reported to have waves. The analysis shows that the way in which new products are introduced into market is related to product innovation strategy and economical influences. To give insights into the different ways for product introductions, six examples are given.

Table 7.16: Stream of New Products (frequency across business units)

Variable	Low IR (n = 4)	High IR (n = 7)	Eng. (n = 6)	E&E (n = 5)	Overall (n = 11)
Permanent stream	BU1 BU4	BU6 BU7 BU9 BU10 BU11	BU1 BU7 BU9 BU11	BU4 BU6 BU10	7
Slight waves	BU3	BU5	BU3 BU5	----	2
Waves	BU2	BU8	----	BU2 BU8	2

First, two examples for waves are given. For Time Control (BU2) the innovation activities are correlated to their sales. The MD stated that the reason for developing new products was the recession in the construction industry. Therefore, they decided to develop new products for new markets. This statement shows that they are driven by external factors (i.e., tendencies of the economical situation within their market). In contrast new product introductions of Ultrasound (BU8) are based on their philosophy of securing their technological leadership. Therefore, they replace their existing products in two to five year waves. The MD pointed out that in most cases they are not forced to develop new products. He stated: "Our customers are pleased with the existing products. By launching a new product, we have to convince them to buy the new one." Although, their products are introduced in waves the R&D manager stated that the aim is to have a permanent stream of new products on a high level.

Other business units introduce new products in slight waves. Brake Systems (BU3) described their stream of new products as a slightly increasing wave. "We develop our products in small waves. But we try to keep it as permanent as possible" stated the R&D manager. The reason for the waves is their dependency upon new models in the truck market. Because they have many different customers, new truck models overlap and waves are toned down. The same reason was given by the MM of Vacuum Pumps (BU5). He pointed out: "Nowadays we are working together with OEMs, therefore small waves can be observed." These waves arise, because new products are dependent upon the introduction of car models. Because product innovations of their customers (from different industries) overlap, their waves are very slight.

Finally, two examples for business units with a permanent stream of product innovations are given. The MM of Plastics (BU1) stated "our strategy is to develop any product a customer wants". As this is an ongoing permanent process they have a permanent stream of new products. The other example is Vehicle Electronics (BU10). Although they are dependent upon three to five years life cycle time of car models, they have a permanent stream of new products. The reason is that they have a lot of different customers and therefore these individual car model waves overlapped, stated the MM.

The findings show, that the way in which new products are developed is not related to the number of new products within the product portfolio. Overall waves are compensated over a the three years time period for measuring product innovation rate.

7.7.5 The Business Unit Growth

The next variable investigated is the growth rate where no relationship to product innovation position for most business units is given. All Business units who see product innovation as an important factor for staying competitive achieved growth rates. Overall growth rates vary between 2.4 and 26.6 %. Only for Time Control (BU2) – a reduction of 2% is given. As explained earlier, the commitment of the board of management to product innovation is low and they have difficulties in developing a continuous stream of new products. However in this case the reduction of their market was 2%, too.

An indicator that growth rates are not related to product innovation position is the fact, that only four managers saw a clear relationship between product innovation activities and growth. The MD of Plastics (BU1) pointed out that new products are introduced to achieve growth: "To achieve growth and to be ahead of our competitors we have to be innovative... New products were the base for the growth of the company – in the past a small growth was always achieved". A similar statement was given from the MM of Brake Systems (BU3). He said that product innovation is important to "produce growth through our new products and to concentrate on core products and processes". The MD of Vehicle Electronics (BU10) saw a further growth of product innovation activities because markets increase further. This in turn guarantees a business unit growth. Further, the MD of Exhaust Systems (BU9) stated "...to grow internationally one important part is to have innovative products ...".

7.7.6 Summary

The analysis of product innovation output variables found a relationship between profits from the whole product portfolio and new products with product innovation position. Dependent on the individual product innovation position profits from new products are higher or lower than profits with the whole product portfolio. Further it was found that profit margins are mainly influenced by market and competition. Especially three business units which are active in specific branches with a limited number of competitors achieve high profits. As a relationship between profits from new products is given a relationship with the break-even is given, too. An investigation of the stream of new products found no influence on product innovation position. In all cases waves are compensated over a three year time period. Further, no relationship to product innovation position was given for growth rates. Table 7.17 gives an overview of the findings.

Table 7.17: Summary of the Results in the Area Product Innovation Output[1]

Variable	Findings of the Cross-Case Analysis	Driver of Prod. Inn. Pos.	
		Yes	**No**
Average profits with the whole product portfolio (25 QT)[2]	• Profits (in comparison to profits with new products) are related to product innovation position and product innovation strategy. • Overall, profit margins are not related to product innovation position but to market and competition.	✓	
Profits with new products (26 QT)	• Profits from new products are related to product innovation position. • The case analysis showed that product innovation can be seen as a strategy for selling existing products. For business units following this strategy, profits from new products are low. • A further reason for low profits from new products can be the circumstance that revenues come later than three years after product introduction. • Because of price pressure the margins for new products are similar to those for the whole product portfolio. • It was found that cost reduction can offset the margins for existing products which are sold at a cheaper price level than new ones. In this case the profits for both products within the whole product portfolio and new products are the same. • Higher profits (given for only two business units) can be related to high strategic prices (with the aim to show innovativeness) or on higher margins because customers are willing to pay more for new products. • Seven business units were not able to give detailed information (because they do not measure profits with new products) and one business unit was not able to give any information about their profits from new products.	✓	
Break-even-point (27 QT)	• Break-even-point is related to profits with new products, i.e., dependent on product innovation strategy.	✓	
Stream of new products (28 QL)	• The stream in which new products are launched into market (waves, slight waves or permanent stream) is not related to product innovation position. With the measurement over a three year time period waves are compensated. • A relationship was found with product innovation strategy and market.		✓
Business unit growth (29 QT)	• A relationship between growth rate to both product innovation position and product innovation was not found. • Overall, the average growth rates in both industry sectors are similar.		✓

[1] The decision rules used to construct the table are explained in detail in Section 7.8.1
[2] QT =quantitative variable, QL = qualitative variable

7.8 DRIVERS OF PRODUCT INNOVATION POSITIONS

Before beginning a detailed description of the key drivers of product innovation position and their interrelationship to other areas, the decision rules used to identify the key drivers for the product innovation position are presented.

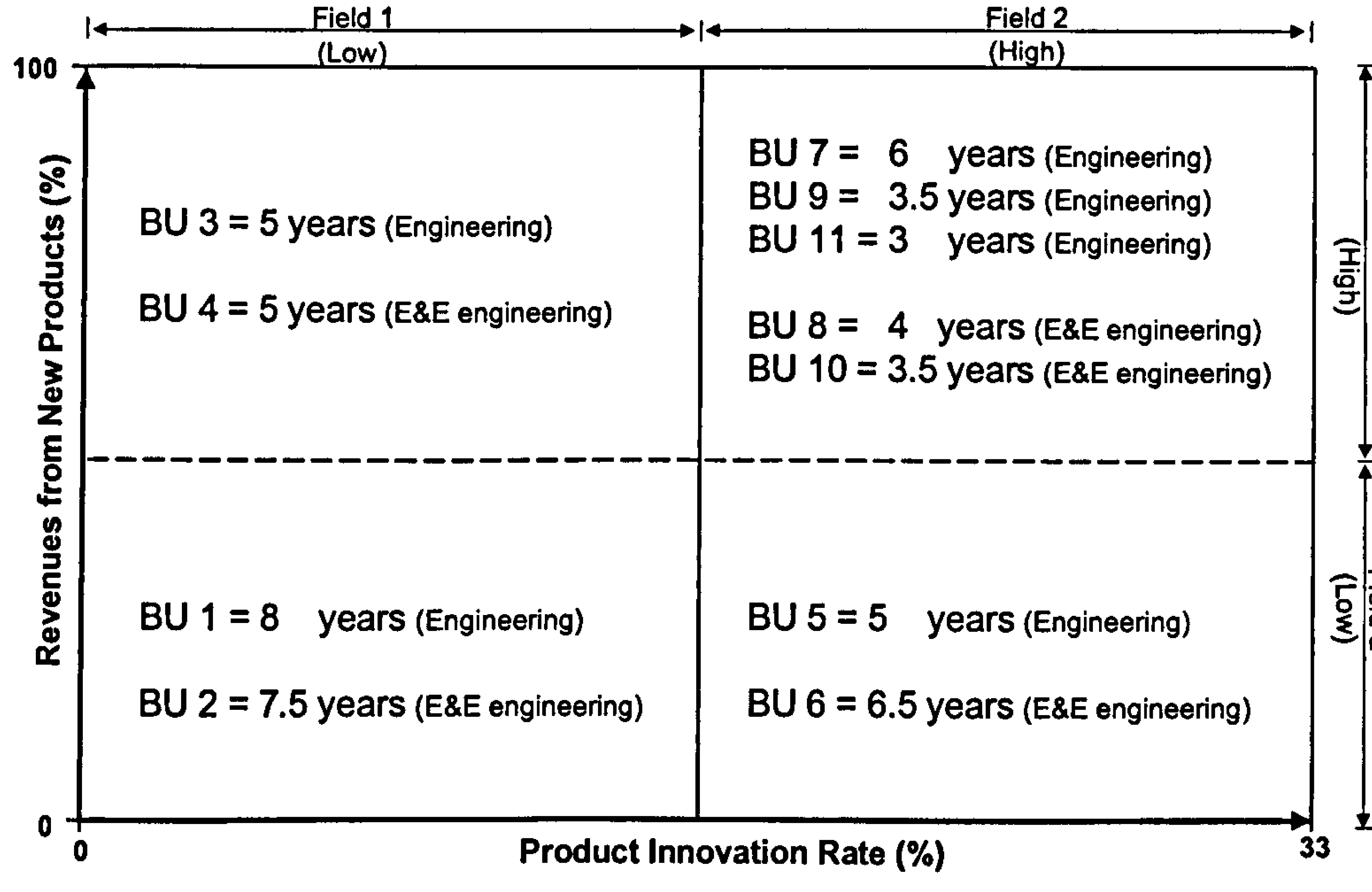
7.8.1 Identification of the Key Drivers of Product Innovation Position

The relationships of the underlaying variables of product innovation position, product innovation process and product innovation output were identified in a systematic way. As a basis for the identification of the relationship of variables to product innovation position and the interrelationships to other variables, the following methods are used:

- Analysing the relationship of product innovation position (quantitative data) with qualitative information (refer to Figures 7.8,7.9, 7.10, 7.11).
- Categorisation of the key drivers of product innovation position within the Fields 1b,b and 2a,b (refer to Figures 7.2 and 7.3). This categorisation is given in Appendix A.
- Overview of the quantitative variables measured by sorting them into the Fields 1a,b and 2a,b (refer to Appendix B, Table 2).
- The relationship of variables with business unit size is analysed by separating the cases into small (1-500 employees) and large (more than 500 employees) business units (refer to Section 7.6.1, Table 7.12).
- In-depth analysis of the case study visits.

In order to show how the analysis is carried out, the example product life cycle is presented in detail (Figure 7.12). It is shown that the business units with the shortest product life cycles (BU8, BU9, BU10, BU11) are positioned in Field 2b. In comparison the business units with the longest product life cycles (BU1, BU2) are positioned in Filed 1a. However, as this relationship is not given for every business unit, product innovation strategy is identified as a driver for product life cycles, too. This is given for all business units. Independent from the average product life cycle given in Figure 7.12 some products have a longer or shorter product life cycle. For example this is the case for BU6. Although the average product life cycle is long, their product innovation rate is high. The reason is, that they have the strategy to show their innovativeness by developing new products for selected customers. However, as most of their customers are conservative, they are not able to replace all their existing products with new ones. This leads to a mixture of existing products with both a long and short product life cycle. Consequently the percentage of revenues from new products is low.

Figure 7.12: Analysis of the Key Driver Product Life Cycle



As shown by the example above the analysis of the variables is very complex. Therefore, the decision rules for showing the relationship with product innovation rate and interrelationship with variables are slightly different for each variable – the decision rules for each variable are summarised in Table 7.18. The table shows the areas of the Cooper and Kleinschmidt model and the variables selected from the literature to operationalise each area (e.g., four variables were used to characterise market; five for product innovation strategy). For each of the variables the decision rules are explained in detail.

Table 7.18 (a): Decision Rules for the Identification of the Key Drivers of Product Innovation Position

Area	#	Variable	Decision Rule
Market	1 (QT)[2]	Product life cycle	*Relationship with product innovation position: **Yes*** Four business units (BU8, BU9, BU10, BU11) with extremely short product life cycles operate with high product innovation position. Two business units with extremely long product life cycles (BU1, BU2) operate with low product innovation positions. *Relationship between product life cycle and product innovation strategy: **Yes*** However, product life cycles are also dependent on the individual product innovation strategy. This relationship is given for all case business units.
	2 (QT)	Market growth per year	*Relationship with product innovation position: **No*** Market growth differs for all business units. Therefore no relationship to product innovation position is given.
	3 (QL)[3]	Economical influence	*Relationship with product innovation position: **Yes*** For three business units (BU6, BU9, BU10) the economic trends and regulations are related to product innovation position *Relationship between economical influence and product innovation strategy: **Yes*** For the three business units national regulations are closely related to their product innovation strategy.
	4 (QL)	Technology	*Relationship with product innovation position: **Yes*** For three business units in the engineering sector (BU3, BU5, BU9) new technologies (i.e. electronics) are related to product innovation position. *Relationship between technology and product innovation strategy: **Yes*** For the three business units technology is closely related to their product innovation strategy.
Com-petition	5 (QT)	Own market share	*Relationship with product innovation position: **No*** Market share differs for all business units. Therefore no relationship to product innovation position is given.
	6 (QT)	Market share of the three biggest competitors	*Relationship with product innovation position: **No*** Market share of the three biggest competitors differs for all business units. Therefore no relationship to product innovation position is given.
	7 (QL)	High market barriers for new competitors	*Relationship with product innovation position: **No*** Market growth differs for all business units. Therefore no relationship to product innovation position is given.
	8 (QL)	General competitive situation	*Relationship with product innovation position: **Yes*** For all business units the general competitive position is related to product innovation position. *Relationship between the general competitive position and product innovation strategy: **Yes*** Dependent on the general competitive position each business units operates with the most appropriate product innovation strategy.

Table 7.18 (b): Continued

Area	#	Variable	Decision Rule
Corporate Environment	9 (QL)	Familiarity	*Relationship with product innovation position: **No*** Familiarity is high for every business unit. Therefore no relationship to product innovation position is given. *Relationship between familiarity and product innovation strategy: **Yes*** For all business units familiarity is related to product innovation strategy.
	10 (QL)	Synergy	*Relationship with product innovation position: **No*** Synergy is high for every business unit. Therefore no relationship to product innovation position is given. *Relationship between synergy and product innovation strategy: **Yes*** For all business units synergy is related to product innovation strategy.
Nature of NPs	11 (QT)	Source of new ideas	*Relationship with product innovation position: **No*** All business units use both internal company (e.g., from employees) and external ideas (e.g., from customers) for developing new products. Therefore no relationship to product innovation position is given.
	12 (QL)	Degree of product innovations	*Relationship with product innovation position: **No*** All business units develop transformational new products. Therefore no relationship to product innovation position is given. *Relationship between the degree of product innovations and product innovation strategy / business unit size: **Yes*** Dependent on the individual product innovation strategy and the size of business units, the complexity of new products is low (given for six business units) or high (given for five business units).
NPD Process	13 (QT)	Percentage of NPD projects running on time	*Relationship with product innovation position: **No*** The percentage of NPD projects running on time differs for all business units. Therefore no relationship to product innovation position is given. *Relationship between the percentage of NPD projects running on time and product innovation strategy / corporate culture: **Yes*** At one business unit (BU2) almost no project is running on time. This is related to a low product innovation strategy and a low commitment of the board of management to product innovation.
	14 (QT)	Percentage of NPD projects cancelled	*Relationship with product innovation position: **No*** The percentage of NPD projects cancelled differs for all business units. Therefore no relationship to product innovation position is given. *Relationship between the percentage of NPD projects cancelled with product innovation strategy / business unit size: **Yes*** Dependent on the individual product innovation strategy and size of business units the percentage of NPD projects cancelled is low (given for six business units – BU1, BU2, BU4, BU5, BU7, BU8) or high (given for five business units – BU3, BU6, BU9, BU10, BU11).

Table 7.18 (c): Continued

Area	#	Variable	Decision Rule
NPD Process	15 (QL)	NPD project management	*Relationship with product innovation position:* ***No*** All business units have a well defined NPD project management. Therefore no relationship to product innovation position is given. *Relationship between NPD project management and corporate culture / business unit size:* ***Yes*** Two small business units (BU7, BU8) have a corporate culture in which informal information processes are more important than planned NPD processes.
Product Inno-vation Strategy	16 (QT)	NPD project planning horizon	*Relationship with product innovation position:* ***No*** The NPD project planning horizon differs for all business units. Therefore no relationship to product innovation position is given. *Relationship between NPD project planning horizon and business unit size:* ***Yes*** Because of limited financial resources for the six small business units (BU1, BU2, BU4, BU5, BU7, BU8) the average planning horizon is shorter than for the five big business units (BU3, BU6, BU9, BU10, BU11).
	17 (QT)	Investments into R&D (%)	*Relationship with product innovation position:* ***No*** The percentage of investments (in relationship to revenues) differs for all business units. Therefore no relationship to product innovation position is given. *Relationship between NPD project planning horizon and business unit size:* ***Yes*** The amount of investments is higher for the five big business units (BU3, BU6, BU9, BU10, BU11) than for the six small business units (BU1, BU2, BU4, BU5, BU7, BU8).
	18 (QT) 19 (QL)	Product launch strategies, e.g first to market, technological leadership or cost leadership	*Relationship with product innovation position:* ***No*** Product launch strategies differs for all business units. Therefore no relationship to product innovation position is given. *Relationship between product launch strategies and market / competition:* ***Yes*** Dependent on market and competition each business unit chooses a product launch strategy which is seen as the most appropriate one.
	20 (QL)	Corporate culture for product innovation	*Relationship with product innovation position:* ***No*** For all other business units corporate culture (i.e., the commitment of the board of management to product innovation) is high. This is reflected in a strategy where new products are seen as essential to stay competitive. *Relationship between corporate culture and product innovation strategy:* ***Yes*** For one business unit (BU2) corporate culture (i.e., the commitment of the board of management to product innovation) is low. This is directly related to a careful introduction of new products (product innovation strategy) and their low product innovation position.

Table 7.18 (d): Continued

Area	#	Variable	Decision Rule
Product Inno-vation Strategy	21 (QL)	Product innovation strategy (model Johnson and Scholes, 1999)	*Relationship with product innovation position: **Yes*** For all business units the individual product innovation strategy is a key driver for their product innovation position. *Relationship between product innovation strategy and market / competition / corporate culture / size of business units: **Yes*** Dependent on market, competition, corporate culture and the size of business units product innovation strategy differs.
Product Inno-vation Output	25 (QT)	Average profits with the whole product portfolio	*Relationship with product innovation position: **Yes*** For all business units the relationship between profits with the whole product portfolio and profits with new products is closely related to product innovation position *Relationship between the average profits with the whole product portfolio and market and competition: **Yes*** For all business units the absolute average profits with new products are related to market and competition. *Relationship between the average profit with the whole product portfolio and product innovation strategy: **Yes*** For all business units the relationship between the average profits with the whole product portfolio (in relationship to the average profits with new products) and product innovation strategy is given.
	26 (QT)	Average profits with new products	*Relationship with product innovation position: **Yes*** For all business units the relationship between profits with the whole product portfolio and profits with new products is closely related to product innovation position *Relationship between the average profits and new products and product innovation strategy: **Yes*** For all business units the relationship between the average profits with new products (in relationship to the average profits with the whole product portfolio) and product innovation strategy is given.
	27 (QT)	Break-even-point	*Relationship with product innovation position: **Yes*** For all business units the relationship between break-even-point and product innovation position is given. *Relationship between break-even-point and product innovation strategy: **Yes*** For all business units the relationship between break-even-point and product innovation strategy is given.
	28 (QL)	Stream of new products	*Relationship with product innovation position: **No*** The stream of new products differs for all business units. Therefore no relationship to product innovation position is given. *Relationship between the stream of new products and market / product innovation strategy: **Yes*** For all business units the stream of new products is related to market and product innovation strategy.
	29 (QT)	Business unit growth	*Relationship with product innovation position: **No*** Growth rates differ for all business units. Therefore no relationship to product innovation position is given.

7.8.2 Context of the Drivers of Product Innovation Position

The case studies gave much contextual data. Table 7.19 is similar to Table 7.18 and shows the areas of the Cooper and Kleinschmidt model and the variables selected from the literature to operationalise each area. In addition, the table shows inter-relationships. First, for each variable it is shown if it is a key driver of product innovation or not. Second, the relationship between each variable to other variables is given. It was found that most variables are related to product innovation strategy. However, other variables appear to be related to market, competition, corporate culture and the size of business units. This shows that research into product innovation needs to take a broader view to give an understanding of the linkages.

In the area market the variables product life cycle, economical influence and technology are related to product innovation position (i.e., to product innovation rate). All three variables are not independent and are also related to product innovation strategy. For example product life cycle is given by the market. However, dependent on how products are eliminated (or not), product life cycle within a business unit's product portfolio can be influenced by product innovation strategy, too. As shown in Table 7.18 economical influences and technology are also related to product innovation strategy.

In the area competition only the general competitive situation is related to product innovation position which in turn is closely related to product innovation strategy. Dependent on the competitive situation business units choose a product portfolio which is seen as the most appropriate for staying competitive. Market share and high barriers for competitors are not identified as main drivers.

Synergy and familiarity which are variables in the area corporate environment are not related to product innovation position – for each business unit it was found that synergy and familiarity are high. It has to be noted that both variables are closely related to product innovation strategy. Dependent on the chosen strategy business units develop products based on their own competencies or on new ones as the Johnson and Scholes model shows.

The variables source of ideas and degree of product innovations which are investigated in the area nature of products are not related to product innovation. However, the degree of new products is closely related to product innovation strategy and the size of business units. It was found that especially big business units with financial resources are able to develop more complex products than smaller ones.

Although the NPD process is not related to product innovation position it is related to the ability to develop new products. This variable in turn is related to corporate culture and business unit size. It was found that difficulties in the NPD process in small business units are compensated with informal processes. Further, the product development process and the involvement of different departments in the NPD process requires a culture of openness. Further, the commitment of the board of management must be given to develop new products successfully. Additionally, it was found that the delay of NPD projects has no influence on the number of new products developed. However, it is related closely to the product innovation strategy and the corporate culture. A similar finding was made for the cancellation rate. This variable is related to product innovation strategy (the aim to develop pacemaker technologies or doing pure research) and business unit size. In the sample size only big business units with financial resources were able to cancel a planned percentage of NPD projects.

It was found that product innovation strategy and product innovation position are closely related. Also a relationship of product innovation strategy to market, competition, corporate culture and the size of business units is given. Corporate culture is not related to product innovation position but to the ability to develop new products, i.e., to be innovative. In the cross-case analysis it was found that culture is an important driver for generating new products. Further, it was found that it is closely related to NPD management. However, due to its importance, it should be positioned as a separate area in a reworked Cooper and Kleinschmidt model. The variables NPD project planning horizon, investments into R&D and product launch strategies (e.g. first to market, technological leadership or cost leadership) are not related to product innovation position. However, it was found the NPD project planning horizon is related to business unit size. As stated earlier, big business have the resources to run NPD projects for a long time period. However, this is only possible because they have the financial resources. Additionally product launch strategies are related to market and competition.

In the area product innovation output, profits from both the whole product portfolio and new products are related to product innovation position. This is also the case for the break-even-point which is closely related to profits with new products. All three variables are related to the chosen product innovation strategy, too. For example a strategy focusing on existing products leads to low profits with new products. On the other hand a strong orientation of revenues on new products is normally related to high profits with new products. Further, it was found that profit margins with the whole product portfolio are related to market and competition. The stream of new products and growth rates were identified as variables not related to product innovation position but to product innovation strategy and market. For business unit growth, no relationship to product innovation position was found.

Table 7.19: Context of the Drivers of Product Innovation Position[1]

Areas	#	Variable	Key driver for product innovation position? Yes	Key driver for product innovation position? No	Relationship to other areas: Market	Compet.	Prod. Inn. Strategy	Corporate culture	Size of bus. unit
Market	1 (QT)[3]	Product life cycle	✓		---	---	✓	---	---
	2 (QT)	Market growth per year		✓	---	---	---	---	---
	3 (QL)[4]	Economical influence	✓		---	---	✓	---	---
	4 (QL)	Technology	✓		---	---	✓	---	---
Com-petition	5 (QT)	Own market share		✓	---	---	---	---	---
	6 (QT)	Market share of the three biggest competitors		✓	---	---	---	---	---
	7 (QL)	High market barriers for new competitors		✓	---	---	---	---	---
	8 (QL)	General competitive situation	✓		---	---	✓	---	---
Corporate Environmt.	9 (QL)	Familiarity		✓	---	---	✓	---	---
	10 (QL)	Synergy		✓	---	---	✓	---	---
Nature of NPs	11 (QT)	Source of new ideas		✓	---	---	---	---	---
	12 (QL)	Degree of product innovations		✓	---	---	✓	---	✓
NPD Process	13 (QT)	Percentage of NPD projects running on time		✓	---	---	✓	✓	---
	14 (QT)	Percentage of NPD projects cancelled		✓	---	---	✓	---	✓
	15 (QL)	NPD project management	(✓)[2]		---	---	---	✓	✓
Product Innovation Strategy	16 (QT)	NPD project planning horizon		✓	---	---	---	---	✓
	17 (QT)	Investments into R&D (%)		✓	---	---	---	---	✓
	18 (QT) 19 (QL)	Product launch strategies, e.g first to market, technological leadership or cost leadership		✓	✓	✓	---	---	---
	20 (QL)	Corporate culture for product innovation	(✓)[2]		---	---	✓	---	---
	21 (QL)	Product innovation strategy (model Johnson and Scholes, 1999)	✓		✓	✓	---	✓	✓
Product Innovation Output	25 (QT)	Average profits with the whole product portfolio	✓		✓	✓	✓	---	---
	26 (QT)	Average profits with new products	✓		---	---	✓	---	---
	27 (QT)	Break-even-point	✓		---	---	✓	---	---
	28 (QL)	Stream of new products		✓	✓	---	✓	---	---
	29 (QT)	Business unit growth		✓	---	---	---	---	---

[1] Based on rules presented in Table 7.18

[2] NPD project management and corporate culture were not identified as key drivers of product innovation position but on the management of product innovation processes. Therefore they are given in brackets.

[3] QT =quantitative variable [4] QL = qualitative variable

7.9 SUMMARY

This chapter investigated the reasons for varying product innovation positions in a systematic way. The basis for an in-depth analysis were the case study results of 11 business units from the German industry sectors engineering and E&E engineering. In summary, the cross-case analysis in Phase 3 showed:

- Product innovation is complex. For explaining product innovation positions a detailed understanding of all areas with an influence on product innovation was necessary. On the basis of the model of Cooper and Kleinschmidt it was possible to carry out such an analysis in a structured way.
- It was shown that only some few areas are related to product innovation position (i.e., the position within the diagram product innovation rate and the percentage of revenues from new products). The identified key drivers for the different product innovation positions are: market, competition and product innovation strategy.
- In addition to the key drivers for product innovation position, two key drivers on the management of product innovation processes were found. The drivers are NPD project management and corporate culture. These two drivers in turn are closely related to product innovation strategy.
- It was found that product innovation position does not show how innovative a business unit is. In other words, business units with low product innovation rates (positions) could have a strong focus on new products. In the sample size this is the case for three business units (of four) with low product innovation rates.
- Product life cycle is related to the number of existing products within the product portfolio. It is not related to the number of new products developed.
- Product innovation output variables such as profits with the whole product portfolio and profits with new products are closely related to product innovation position.
- No significant differences among the reasons for varying product innovation positions between business units in the industry sectors engineering and E&E engineering were found.

The 11 cases gave detailed insights into the key drivers for product innovation positions and led to a detailed explanation of these key drivers. However, this result was mainly based on a systematic selection process of business units and the chosen case study approach. Consequently the survey results made in Phase 2 are qualified. A discussion of the results of Phase 2 and Phase 3 is discussed next. Further it is shown how the findings are in line with the findings from earlier studies.

CHAPTER EIGHT

DISCUSSION OF THE RESULTS

8.0 INTRODUCTION

This chapter discusses the results of the current research and compares the findings with the results from previous research studies. It is shown that some findings are in line with earlier research studies. However, some findings are new and have led to new conclusions for analysing product innovation position on a business unit level.

This chapter is classified by the following characteristics:

- The results of Phase 2 and Phase 3 were discussed and compared with the findings in the product innovation literature.
- Previous studies used product innovation rate or the percentage of revenues from new products to show how innovative a business unit is. However, the current research study found that such a relationship is not given. Therefore the discussion is carried out in order to show the limitations of previous studies.
- Product innovation rate has no common variable for measuring product innovation activities. A more common measure is the percentage of revenues from new products. The discussion shows the limitation of both variables as product innovation measures.
- As product innovation position is related to the context, the findings of previous studies were analysed in order to show the investigation in this context.

Each variable investigated in the case study research is compared with findings from previous research studies. This comparison is carried out in Section 8.2. As the findings are many sided, a summary is given in Section 8.3. In this section the results are given in a table and the results are marked if they are in line with earlier findings or not. Finally, a summary of the main findings is given in Section 8.4.

8.1 DRIVERS OF PRODUCT INNOVATION

The systematic analysis of variables with an expected relationship to product innovation found that fewer variables are related to product innovation position than expected from the literature. In order to operationalise product innovation position at business unit level 29 variables are analysed. 26 of these variables (excluding the variables for measuring product innovation position) are given in Table 8.1. As shown in the chapter above, eight of these variables were identified to be a key driver of product innovation position. Further NPD process and corporate culture were found to be key drivers for managing product innovation processes (as they are not related to product innovation position they are given in brackets). In the first column of the table the areas according to the Cooper and Kleinschmidt model are shown. In the second column the number of the variables are given as investigated in the chapter above and presented in the research design (Chapter 4). In the following columns the variables are marked with a tick in order to show if they are related to product innovation position and if an exertion of influence by management is given.

The form of presentation was chosen to identify variables which are related to product innovation position and variables which can be influenced by managers. From the eight variables related to product innovation position four can be managed by business units. These are variables from the areas of product innovation strategy and product innovation output (average profits with the whole product portfolio, average profits with new products, break-even-point). Further the two variables NPD project management and corporate culture as important drivers for product innovation processes are manageable. The four variables which can not be managed are the market (product life cycle, economical influence, technology) and competition (general competitive situation).

A further main finding in Phase 3 was that many of the variables related to product innovation position are related to other variables, too. As for this context of variables and their influence on product innovation position no detailed explanation in the literature was found, this is discussed in the following sections in detail.

Table 8.1: Variables Related to Product Innovation Position

Areas	#	Variable	Related to prod. innov. position?		Exertion of influence by management?	
			Yes	No	Yes	No
Market	1 (QT)[9]	Product life cycle	✓[1]			✓
	2 (QT)	Market growth per year		✓		✓
	3 (QL)[9]	Economical influence	✓			✓
	4 (QL)	Technology	✓			✓
Com-petition	5 (QT)	Own market share		✓	✓	
	6 (QT)	Market share of the three biggest competitors		✓		✓
	7 (QL)	High market barriers for new competitors		✓	✓	
	8 (QL)	General competitive situation	✓			✓
Corporate Environmt.	9 (QL)	Familiarity		✓[2]	✓	
	10 (QL)	Synergy		✓[2]	✓	
Nature of NP	11 (QT)	Source of new ideas		✓	✓	
	12 (QL)	Degree of product innovations		✓	✓	
NPD Process	13 (QT)	Percentage of NPD projects running on time		✓[4]	✓	
	14 (QT)	Percentage of NPD projects cancelled		✓[3]	✓	
	15 (QL)	NPD project management	(✓)[4]		✓	
Product Innovation Strategy	16 (QT)	NPD project planning horizon		✓[5]	✓	
	17 (QT)	Investments into R&D		✓	✓	
	18 (QT) 19 (QL)	Product launch strategies, e.g first to market, technological leadership or cost leadership		✓	✓	
	20 (QL)	Corporate culture for product innovation	(✓)[6]		✓	
	21 (QL)	Product innovation strategy (model Johnson and Scholes, 1999)	✓[7]		✓	
Product Innovation Output	25 (QT)	Average profits with the whole product portfolio	✓[8]		✓	
	26 (QT)	Average profits with new products	✓[8]		✓	
	27 (QT)	Break-even-point	✓[8]		✓	
	28 (QL)	Stream of new products		✓	✓	
	29 (QT)	Business unit growth		✓	✓	

[1] A relationship is given to the number of existing products within the product portfolio which in turn is related to a low product innovation rate. However it is not related to the number of new products developed.

[2] For each case business unit familiarity and synergy is high.

[3] Low or high cancellation rates are related to the product innovation strategy and to the size (financial resources) of business units.

[4] All business units in Phase 3 reported to have a well structured NPD process. However, significant problems in NPD project management could be related to low product innovation rate.

[5] NPD project horizon is related to the size (financial resources) of business units.

[6] Low commitment of the board of management on product innovation may be related to difficulties in the NPD management process. Further, it was found that corporate culture is closely related to product innovation strategy.

[7] Dependent on the product innovation strategy product innovation rate (level) could be low or high. Further market, competition and corporate culture are related to product innovation strategy.

[8] The relationship between the percentage of profits with the whole product portfolio and new products is related to product innovation strategy and the chosen product innovation position. The absolute profits are related to the profit margins of branches. It has to be noted that in Phase 2 a relationship between higher product innovation rates and higher profits in the industry sector E&E engineering was found.

[9] QT = quantitative variable, QL = qualitative variable

8.2 DISCUSSION OF THE RESULTS

According to the variables investigated in Phase 2 and 3 of the current research project (given in Chapters 6 and 7) a systematic discussion of the results was carried out. The following areas are discussed in order to show whether the findings are in line with the findings of earlier studies or not:

- Drivers of product innovation position
- Market
- Competition
- Corporate environment
- Nature of product innovations
- New product process and organisation
- Product innovation strategy
- Product innovation output

8.2.1 Drivers of Product Innovation Position

In the product innovation literature no study was found which investigated product innovation position (i.e., the relationship between product innovation rate and the percentage of revenues from new products) in depth. One reason for this may be the fact that product innovation is complex and both variables at a business unit level and project level need to be investigated. For example previous research studies found that activities at project level are related to other management areas (e.g., to product innovation strategy). For example, Zirger and Hartley (1994), Tabrizi and Walleigh (1997), Balachandra and Friar (1997), found that NPD processes are embedded into the whole context of a company. Griffin (1997a) pointed out that both management areas on a company level and project level are closely related. This was also found by other researchers, Brown (1991), Hughes and Chafin (1996) Liversay et al (1996) and Schoonhoven and Jelinek (1997). Although the relationship of product innovation to the context was found by several researches, only a few of them investigated this "context" on a deeper level.

Cooper and Kleinschmidt (1993, 1995) carried out research studies which were going in this direction. Although they investigated product innovation by taking the whole business unit into account, their main aim was to investigate specific NPD projects within companies. Consequently Cooper and Kleinschmidt (1995) identified a high-quality NPD process as number one driver for company performance (e.g., profitability), followed by a well-communicated new product strategy and entrepreneurial climate for product innovation. Similar findings were made by Loch et al (1996) who identified development productivity as a very important driver for business unit performance (e.g., higher revenues from new products, higher degree of product innovations). However, Phase 3 in the current research project identified well organised NPD processes for all business units. Consequently NPD project management was not identified as a key driver for business unit performance.

One further step in the investigation of product innovation at a business unit level was made by Terwiesch et al (1998) who investigated the relationship of business units internally (NPD project management) and external factors (market, competition) to profitability. As discussed later (refer to Section 8.2.7, Product Innovation Output) they used product innovation rate as a performance measure on project level However, the current research study found that product innovation rate is not related to NPD management. Therefore their results should be proved through further investigations by not using the variable product innovation rate as a performance measure. It has to be noted that their results are limited to showing relationships of different product innovation variables. This is the case, because they only analysed survey data. However, to gain insights into the reasons why business units operate with different product innovation rates, case studies need to be carried out. As such a research project is very complex and not common, the results of the current research project are particularly new.

Although Terwiesch et al used product innovation rate in their study no detailed information about this variable is offered in their study. As Table 8.2 shows no detailed information was available from the product innovation literature. Therefore, only data from the current research project is given in the table. Further, it was noticed that product innovation rate is defined in different ways. For example, Brennecke et al, 2001 used this terminology for the variable percentage of revenues from new products. A further definition was used by Loch et al (1996).

Table 8.2: Comparison of Findings – Average Values for Selected Variables

Variable	Griffin (1997a)[1]	Brennecke et al (2001)[2]	Legler et al (2001)[3]	Phase 2, current research project	Phase 3, current research project
Product innovation rate	----	----	----	11.4%	16.1%
Revenues from new products	34.0%	32.4%	45%	30.7%	42.2%

[1] Average values for manufacturing products commercialised in the last 5 years.
[2] Average value for three German industry sectors in 2000: Engineering, E&E engineering and software (n=342).
[3] Average value for German manufacturing companies in 1999.

With regard to the product portfolio Brockhoff (1993) and Kenny and Quelch (1994) found that the balance between existing and new products is important to stay competitive. Further, Tellis and Golder (1996) and Clement et al (1998) found that introducing a new product often results in the elimination of existing products. That the elimination of existing products by new ones is not always the case was shown in Phase 3 of the current research project. Two business units (one with low and one with high product innovation rate) are developing new products to show their innovative competences. These products are not developed to replace existing products but as a multiplier to sell their existing products, too.

In comparison to product innovation rate the percentage of revenues from new products is more common in product innovation research. Table 8.2 shows three selected studies which used this measure as a main variable in their research. The table shows that new products generate a significant amount of revenues. In the studies given in the table the percentage of revenues ranges between 30% and 45%. This was also found by other studies which identified similar percentages of revenues from new products (e.g., Brenner, 1994; De Meyer and Pycke, 1996, Firth and Narayanan, 1996;

Goffin et al, 2000). The findings in Phase 2 of the current research project are in line with these findings. For the whole sample size the average percentage of revenues from new products is 30.7%. Griffin (1997a) took a further approach and differentiated between best practice firms and "average" firms in her research. She found that 64.7% of the best practice firms set revenue growth targets, with average goals of these firms being 45% of sales to come from products commercialised in the last three years. In comparison only 46.5% of the rest of the firms set these targets with the average goal being to derive 25% of sales from new products. However, Phase 3 of the current research project found that the percentage of revenues from new products is no indicator for innovativeness. Dependent on product innovation rate and the chosen product innovation strategy with new products, the revenues from new products could be low or high.

Although Phase 3 showed that the relationship between high product innovation rates and high percentages of revenues from new products is not automatically given, Phase 2 found such a relationship. There it was found that business units with high product innovation rates, generate on average significantly more revenues from new products than the rest of the other business units. This in turn depends on the structure of the sample size. For the case study research (Phase 3) outliers in the Fields 1b and 2a were selected. However, the number of business units within these fields is much lower than in the Fields 1a and 2b[85]. This in turn shows the limitations of surveys. Although they can show tendencies a clear explanation of a business unit's product innovation position is not possible.

8.2.1 Market

The area market is operationalised with four variables in order to show whether they are related to product innovation position. These variables are product life cycle, market growth, economical influence and technology.

The first variable discussed is product life cycle. Previous studies identified different life cycles across industries and found that product life cycles decreased in later years. For example, Jantz et al (2001) found that life cycles in the E&E engineering sector decreased from six years in 1992 to five years in 1999. In the automotive industry product life cycle decreased from eight years in 1992 to seven years in 1999. Similar life cycles were identified by Griffin (1997a) and in Phase 3 of the current research project. As found by Anonymous (1996b) it can be assumed that differences in product life cycle are directly related to product innovation activities. Further it can be assumed that because of high product life cycles and a low number of product innovations, product innovation rate is low. However, a main finding in Phase 3 was that product innovation rates do not show how innovative a business unit is (i.e. how many new products they develop). Business units with both long and short product life cycles see product innovation as an important driver to stay competitive. The reason for low product innovation rates of business units operating in markets with long product life cycles is the high number of existing products within their product portfolio. Consequently the approach of Terwiesch et al (1998) for using product life cycle as a variable for

[85] The distribution of business units within the diagram product innovation rate and percentage of revenues from new products is given in Chapter 6 (Section 6.5.2 'Distribution of Business Units').

measuring market environment and product innovation rate for measuring NPD performance is questionable. First, it was found that product innovation activities are independent from product life cycle. Second, product innovation rate is no variable for measuring NPD Performance on project level as Terwiesch et al did. As the relationship between product life cycles and product innovation position (product innovation rate versus the percentage of revenues from new products) was not investigated in previous studies this finding is particularly new.

Market growth is a further variable which is expected to be related to product innovation. Zarah (1993b) and Gupta and Wilemon (1990) found that high industry growth may encourage the clear introduction of new products. However, the case study analysis in Phase 3 showed that independent from market growth business units develop new products. Further, it was found that dependent on the product innovation strategy business units chose to develop more or less products. Although market growth is not related to product innovation activities, a relationship between product innovation and economical influences was found. According to OECD (1996b) laws can be an important driver for developing new products. This driver is also given for three business units investigated in Phase 3 – they see laws as an important driver for developing new products. Further, it was found that the diffusion of the technology electronics into the whole industry encourage the development of new products. Similar findings are given in other studies (e.g. Archibugi and Iammarino, 1999; Isoard und Soria, 1999; Sharp, 1999).

8.2.2 Competition

That competitiveness is related to product innovation activities was shown by researchers as Porter (1990), Gupta and Wilemon (1990) and Zarah (1993b). They identified the association between vigorous international rivalry in an industry as an important enforcement for innovation. A similar finding was made by Loch et al (1996). Further, they found a relationship between higher competition and development process performance. However, such a relationship was not found in the case study research in Phase 3. Independent from market share business units see new products as an important driver to stay competitive. One reason for this finding is the circumstance that in today's global markets high market shares are not seen as a factor to think oneself safe (as stated by several managers from business units with high market shares). Their strategy to be ahead of product innovation followers is the strategy to develop a continuous stream of new products. Consequently it can be concluded that the general competitive situation is the key driver for product innovation which is in line with the driver "intensified competition" given by Shethh and Ram (1987).

The next variable investigated in this area are market entrance barriers. In more than 100 interviews with managers Simon (1996) found that most of the companies in his sample size estimated having high market entrance barriers. This is partly in line with the findings of Goffin and Pfeiffer (1999), too. They investigated German and British manufacturing companies and identified that market entrance barriers were estimated by the interviewees as being high – this they found, is independent from product innovation rate. These findings are also confirmed in the current research project. All investigated case business units reported to have high market entrance barriers. Overall, market entrance barriers are not related to product innovation position. This is also in line with the findings of Cooper and Kleinschmidt (1993) who found that market entrance barriers are not significant for product innovation success (i.e., profitability, technological success).

8.2.3 Corporate Environment

Synergy and familiarity are often given as key factors for developing new products (e.g., Maidique and Zirger, 1990; Simon, 1996). In contrast Cooper and Kleinschmidt (1993) found no significant impact of familiarity on new product success in most areas. They stated: "The impact of synergy and familiarity on new product success was less than might have been expected, however, perhaps as a result of the high levels of synergy and familiarity generally achieved". Although their results are based on an investigation in the chemical industry their findings are in line with the findings in the current research project.

Taking their definition into account, all business units build on existing and in-house management skills (high familiarity) and do not produce new product categories which are not familiar to the business unit (high synergy). As the sample size was limited to 11 business units, this needs to be investigated in further research projects. Further, it was found that corporate environment is closely related to product innovation strategy, i.e. to the strategies offered by Johnson and Scholes (1999). However, it has to be noted that this does not automatically mean that corporate environment (i.e., familiarity and synergy) is not important. Especially business units dealing with unfamiliar new products need to be aware of the risk of developing such products. This is shown by the risk cube offered by Bowman and Faulkner (1997)[86].

8.2.4 Nature of Product Innovations

According to the definition of Booz and Hamilton (1982) new products were defined as transformational ones, i.e., significant changes based on well known technologies. Overall, it became clear that valid data for product innovation rates was only possible by an intensive discussion of the product portfolio. As many product innovation studies are based on surveys, a unique understanding of product innovation by all respondents is questionable. Further, it has to be noted that most interviewed managers had a broader view of innovation which was also found by Goffin and Pfeiffer (1999).

A further variable investigated in the case study visits was the source of ideas. Several researchers found that both views of customers and companies should be taken into account for the generation of product innovations (e.g., Spreng and Olshavsky, 1996; Simon, 1996; Leonard and Rayport, 1997; Pawlak, 1996; Herstatt und Hippel, 1997). The findings of other studies are in line with the findings of the current research. It was found that for each business unit both external and internal ideas are important for generating new products. This is independent from the ability to create a continuous stream of product innovations. It has to be noted that the idea of a generating process is part of the NPD project management process which is discussed next.

[86] The model of Jonson and Scholes (1999) and the risk cube of Bowman and Faulkner (1997) are given in Chapter 2 (Section 2.3.4 'General Aspects of Product Innovation Strategy').

8.2.5 New Product Process

Before starting the discussion of variables related to the management of NPD processes, the results with regard to the organisation of R&D at a business unit level are discussed. In 1988, Gobeli found that matrix organisations are perceived as more desirable than functional ones. In contrast Read (1996), Anonymous (1996), Griffin (1997a) and Gassmann (1997) found that functional organisation forms (independent of the degree of product innovations) are more common for managing R&D activities at a business unit level. Their findings are in line with the current research project. Overall, 10 of the 11 case business units have a functional organisation – only one big business unit used a matrix organisation. The finding of Brennecke et al (2001) that business units with more innovative NPD projects use a functional organisation is not confirmed.

NPD project management

Going further it is interesting how NPD projects are organised at a project level. Griffin (1997a) found that 53% of the firms used more than one structure for organising innovative NPD projects (e.g., functional, venture group, NPD staff department). Further, she found that multi-functional teams have now been broadly instituted for developing new products. This was also found in the current research project. All case business units have installed cross-functional teams. Dependent on the business unit organisation they are working in different structures. The finding of Kluge et al (1996) that German electronics companies had problems with the integration of cross-functional teams was not found – for the case business units in the E&E engineering sector this was not a problem anymore. Overall, Griffin (1997a) found that NPD reporting structures for best practice firms do not differ statistically from reporting structures for the rest of the firm". However, her research showed that more than one-third of all firms use no formal process for managing NPD. Her findings are also confirmed in the current research project. Although all business units had well defined NPD processes (e.g., ISO 9000), the way in which these systems are used is different. Especially small business units tended to use more informal information sources than structured reporting structures to manage their NPD projects (four of 11 cases).

In many cases product development performance is related to a person who starts the initiative. Such a person (defined as promotor) could be an important driver. This was found by several researchers such as Hauschildt and Kirchmann (1997), Gemünden and Walter (1995), Wildemann (1993), Mabert et al (1992) and Hammel (2000). They found that promotors for product innovations have a key influence on the success of NPD projects. This was also found in the case study results where the commitment of the board of management to product innovation was identified as a driver to develop new products. It was found that especially in one business unit without such a commitment significant difficulties in the NPD project management process are given. The finding of Simon (1996) that in several firms a single, solitary, outstanding figure responsible for R&D was found in two case business units. There the owners were identified as being such outstanding persons. However, both business units recognised that their R&D activities had to be co-ordinated more systematically. To achieve this, they noticed that the necessity was to spread their innovative thinking into the business units as a whole. Therefore, they have built up R&D departments over the last few years.[87]

[87] As discussed in Section 8.2.6 the new product process is closely related to corporate culture.

Percentage of NPD projects cancelled

The next variable discussed are cancellation rates. Page (1993) found that most of the projects are eliminated in an early phase of the NPD process, where less time and money has been spent on any particularly idea (i.e., in the phase of idea screening and business analysis). However, in the current research project it was asked for cancellation rates of running NPD projects. With regard to running NPD projects Griffin (1997a) found that "today's portfolios of NPD projects are wasting less money on unsuccessful projects". As found in the current research, small business units especially tend not to cancel NPD projects. The reason is that bigger business units have the financial resources for experimentation. In comparison to smaller business units they plan to cancel a percentage of experimental NPD projects. On average, small business units (1-500 employees) cancelled 2% of their NPD projects while big business units (more than 500 employees) cancelled 18.6% of their NPD projects. As this relationship was not found in the previous product innovation literature, this finding needs to be investigated in future research studies.

Percentage of NPD projects on time

An analysis of the delays of NPD projects identified no relationship with either the development of a continuous stream of new products or industry sectors. The data analysis showed that most business units have some problems in the NPD management process. Further, it was found that the main reasons for delays in NPD project management is based on personnel capacity. The fact that resources are important for planning NPD projects running efficiently was also shown by other researchers (e.g., Kulicke et al, 1997; Goffin and Pfeiffer, 1999; Cooper, 1999).[88]

8.2.6 Product Innovation Strategy

As stated above variables from the project level are related to product innovation strategy which gives the framework for all product innovation activities. The variables discussed in this area are NPD project planning horizon, investments into R&D, market launch strategies, corporate culture for product innovation and product innovation strategy.

NPD project planning horizon

It has to be noted that NPD project horizon is not the same as the variable time to market which was intensively investigated by Griffin (1993, 1997b) and Griffin and Page (1993). In comparison to their definition of time to market (which is related to a specific NPD project), NPD project horizon is related to the type of projects. Such a definition was used by Griffin (1997a). In her research she differentiated between major revisions (average 19 months), new-to-the-firm (average 30.5 months) and new-to-the-world projects (average 44 months). In order to avoid influencing the of interviewees, such predefined definitions were not used in the current research project. Therefore, the NPD project horizon was asked for short projects (14.2 months), medium (27.6 months) and long term projects (51.2 months). A comparison of the findings is given in Table 8.3. It is shown that in both studies the time horizon is very similar. Additionally to the

[88] Delays are not related to product innovation position.

findings of Griffin it was found that the percentage of NPD projects with a short time horizon is higher for engineering than for E&E engineering which indicates that NPD projects in engineering are less complex. Further, it was found that the NPD project horizon is longer in big business units than in smaller ones.

Table 8.3: NPD Project Horizon by Project Type

Variable			Griffin (1997a) (Survey)	Current research (case studies)
	Sample Size		n = 292	n = 11
NPD project horizon	Short (Major revision)[1]	months	12.8	14.2
	Medium (New-to-the-firm)[1]	months	30.5	27.6
	Long (New-to-the-world)[1]	months	44.0	51.2

[1] Definition used by Griffin (1997a)

Investments into R&D

The next strategy variable discussed is the percentage of revenues invested into R&D. Simon (1996) found that on average 6.3% of sales are invested by German companies. In the current research project the average R&D investments for the sample size in Phase 3 are particularly higher (9.8%). An investigation of the relationship between R&D investments and profits by Cooper and Kleinschmidt (1995) found differences between companies. They found that most successful companies (i.e., highest sales and profitability) – named 'solid performers'[89] – invest on average 6.67%. This is more than the dogs and low-impact performers do (5.82% but low profits and low percentage of sales from new products), but less than the high-impact technical winners who invest 9.49% with the highest percentage of revenues from new products, but lower profits than solid performers. Such a relationship was also found by Morbey (1988). He found that R&D expense levels (which is related to a higher percentage of new products) predict growth, but not profitability. With regard to profits these findings are confirmed in the way that higher R&D investments are not related to higher profitability. Overall the findings of Cooper and Kleinschmidt that variables at project level are related to variables at company level are in line with the findings in the current research project. The finding of Wakasugi and Koyata (1997) that in bigger companies the R&D expenditures are higher than in smaller ones was also found in the current research projects (refer to the section above and to Section 8.2.5 'Percentage of projects cancelled').

Market launch strategies

The next variables discussed are first to market, technological leadership and cost leadership. Berger (1995) and Stalk (1988) pointed out that with a first-to-market strategy price differentiation is possible and therefore high profits can be achieved. This was also seen as an important point by seven case business units. Independent from product innovation position and industry sectors these business units reported

[89] In the definition of Simon et al (1996) such companies are 'hidden champions'.

introducing 100% of their product innovations with the strategy first to market. However, only one business unit reported using this strategy as the only one - all others mixed it with other market launch strategies.

With regard to cost leadership Cooper and Kleinschmidt (1993) found that a low price strategy does not work as a new product strategy in the chemical industry. Their findings from the chemical industry are partly confirmed in the current research project. Overall, only three business units reported using cost leadership as a strategy. In comparison 10 business units follow the strategy technological leadership with their new products.

Corporate culture for product innovation

The next variable discussed is culture and the commitment of the board of management to product innovation. For example, Griffin (1997a) pointed out "that producing successful NPD is the need for tangible and visible top management support of NPD, especially in terms of providing adequate funding and resources and explicit, consistent strategies". Similar findings were made by Cimento and Knister (1994), Cooper and Kleinschmidt (1995), Reiple and Vyakarnam (1996) and Kim and Mauborgne (1997). Further, product innovation is related to a culture of the tolerance of mistakes (e.g., Clark and Wheelwright, 1992; Senge, 1990, O'Reilly and Tushman, 1997). It has to be noted that this is independent from product innovation position and the number of new products introduced into market. Dependent on the product innovation strategy and financial resources business units concentrate more or less on the development of new products. This is shown by the circumstance that in most business units (except one) a high commitment to product innovation is given. This in turn is related to the ability to create a continuous stream of new products. It has to be noted that corporate culture (and a positive climate for innovation) is closely related to product innovation strategy and senior management commitment. This finding was also made by Cooper and Kleinschmidt (1995) who identified these drivers as important factors within the NPD project management process and the ability to develop new products.

Product innovation strategy

Now, the findings with regard to the product innovation strategies are discussed. For example, Page (1993) reported that only 56.4% of his sample had a specific NPD strategy in 1990. A study in the consumer packaging goods area found that only 60% of the management reported having such a clear point of view (Anonymous, 1995b). Further, Griffin (1997a) found that 62.7% of the responses in her research "have a specific strategy for their NPD activities which directs and integrates the entire new product program". Although in the current research project every manager was able to explain their aims and strategy with new products, only seven have reported having their product innovation strategy written down (63%), which is in line with the findings of Griffin. The analysis of product innovation strategies according to the model of Johnson and Scholes (1999) found that two business units used one strategy (product development) as the only one. All other business units mixed this strategy with other strategies as diversification, protection building and market development. This finding is in line with the findings of Simon (1996) who found that most business units of his sample size use a mixture of different strategies. Based on the individual product innovation strategy business units choose the most appropriate product innovation position to act in their market[90].

8.2.7 Product Innovation Output

An overview of the actual findings of profits compared to the findings from previous research studies is given in Table 8.4. In the table profits overall of the whole business unit (including the product portfolio as a whole) and profits with new products are given. As shown in the table, Griffin found a higher percentage of profits from new products (32.4%) than the current research (13.7%). Further it is shown that for the business units investigated in Phase 3, the average profits from the whole product portfolio and the profits from new products are almost the same. The reasons for this phenomenon are discussed next.

Table 8.4: Comparison of Findings – Average Values for Selected Variables

Variable	Griffin (1997a)[1]	Berth (1997)[2]	Phase 2, current research project	Phase 3, current research project
Profits of the whole business unit	----	----	9.4%	12.6%
Profits with new products	32.4%	9.0%	----	13.7%

[1] Average values for manufacturing products commercialised in the last five years.
[2] Average value for both manufacturing products and services products commercialised in the last nine years.

Profits with the whole product portfolio

As revenues from new products play an important role it is now interesting to discuss how profits are related to both product innovation rate and the percentage of revenues from new products. The results found in Phase 2 and 3 are given in Table 8.5 in detail. The table shows the profits with the whole product portfolio for business units with low and high product innovation rates. Further, a differentiation between the two industry sectors engineering and E&E engineering is given and the average profits for the whole sample size are presented in the last column. Comparing the average profits from Phase 2 and 3 contradicting results are given. In Phase 2 business units from E&E engineering with high product innovation rates (average profits 4.8%) achieve higher profits than business units with low rates (average profits 17.0%). Further it was found that the average profits in the Fields 2a and 2b are higher than in Fields 1a and 1b (refer to Chapter 6, Section 6.6). For the industry sector engineering no difference of profits between business units with low and high product innovation rate was found. In comparison to Phase 2 another finding is given in Phase 3. The average profits are higher for business units with low product innovation rates (13.2%) than for business units with high rates (12.3%). The reason for the different results is based on the limited sample size in Phase 3, where three business units with low product innovation rate have a strong market position. Therefore, the margins are higher than for business units with high product innovation rates (where both business units with high and low market shares are included).

[90] A detailed discussion of product innovation position is given in Section 8.2.1 'Drivers of Product Innovation Position'.

Table 8.5: Profits of the whole Portfolio, Comparison of the Results of Phases 2 and 3

Phase		Low IR		High IR		Eng.	E&E	Overall
		Eng.	E&E	Eng.	E&E			
Phase 2	n	26	9	21	10	47	19	66
	Profits of the whole Portfolio	8.7	4.8	8.2	17.0	8.5	11.2	9.4
		8.1		10.6				
Phase 3	n	2	2	4	3	6	5	11
	Profits of the whole Portfolio	18.3	8.2	11.1	14.0	13.5	11.5	12.6
		13.2		12.3				

An investigation of the individual cases found that each business unit saw their chosen product innovation position as the most appropriate way to operate within their branches. Because of this reason a categorisation as used in Table 8.5 need to be interpreted with caution. However, it shows that the explanation of the relationship between product innovation rate and profits need a complex view of factors influencing product innovation activities.

The finding that profits are dependent on the profit margins within the industry sectors and the competitive situation (as shown by the high profits of business units with low product innovation rates but high market shares) is in line with the findings of other researchers. Terwiesch et al (1998) found that industry membership (i.e., membership to a specific product group within the electronics industry, e.g., computer, automotive) accounts for 23% of the variance of profits. Further, they found that NPD performance (e.g., technical performance, proportion of sales from new products and development intensity) explains 30% of the profitability variance among the high-market-share business units, but none of the variance of low-market-share business units. However, the relationship of NPD performance of high-market-share business units with profits was not found in the current research.

A further finding of Terwiesch et al (1998) is that development performance matters more in markets with slow growth and long life cycles, where their model explains up to 70% of the variance to profitability. However, as explained earlier, this finding is not confirmed in the current research study because the chosen categorisation of the variables of Terwiesch et al is questionable. In their research higher product innovation rate and higher percentages of revenues from new products are related to higher development performance. Again, the current research found that business units with low product innovation rates could have a high development performance, too (i.e., develop many new products).

Another study with regard to profits was carried out by Cooper and Kleinschmidt (1995). They found that firms which achieved positive performance in terms of highest percentage of revenues from new products and technical success rating (defined as high-technical winners) have a lower profitability relative to competitors. In comparison a large group of companies achieved higher profits relative to competitors with lower revenues from new products and a lower success rate (defined as solid performers). Cooper and Kleinschmidt concluded that these companies "featured a somewhat focused and synergistic new product strategy". An answer of how a synergistic product innovation strategy works was found in the case studies of Phase 3. Especially business units with low product innovation rates and/or low revenues from new products use such a synergistic strategy. Therefore the research of Cooper and Kleinschmidt should be repeated with a detailed investigation of product innovation positions. A further limitation of the study by Cooper and Kleinschmidt (1995) is the estimation of profit margins against competitors. For example, all case business units in Phase 3 reported that their percentage of revenues from new products and their profits are higher or similar than the profits of their direct competitors (independent from the percentage of revenues from new products and technical success rating).

Profits from new products

Profits from new products were investigated in Phase 3 of the current research project. It was found that only two business units earn more from new products than from the whole product portfolio. Further, six business units earn the same profits with both new products and the whole product portfolio and two business units earn less with new products. The reason is that some business units develop new products to sell their existing ones more successfully, while others aim to make more revenues and profits with their new products.

Overall, the findings showed that both, business units with low and high product innovation positions use new products to achieve higher profits. For example a low product innovation rate and a low percentage of revenues from new products can be related to the development of new products as a multiplication to sell existing products more successfully. Consequently the percentage of revenues and profits from new products are low. This finding implies that the percentage of revenues and profits with new products are chosen according to the most appropriate strategy for competitiveness. Taking this conclusion into account the statements of many researchers that product innovation is one of the most important sources of profits needs to be qualified in this way (e.g., Nevens et al, 1990; Cimento et al 1993; Wieandt, 1995; Pleschak and Sabisch, 1996; Blachandra and Friar 1997).

It has to be noted that most business units estimated their profits from new products because they were not able to give detailed information. This is in line with previous research projects (e.g., Booz et al, 1982; Page, 1990; Griffin. 1997a). For example, Griffin found that not all firms measure NPD performance. In her 1995 sample of firms, 75.6% develop formal financial objectives against which actual performance will be evaluated (best practice firms 83.9%). Further, she found that, even though objectives were set, only 50% of the respondents went back and evaluated actual performance. However, such a high percentage of business units with formal financial objectives was not found in the current research. Three of the 11 case business units (27.3%) were able to give detailed information for their profits with new products. For these business units the profits from new products are used as an internal controlling measure. All other business units do not measure profits from new products regularly.

Break-even-point

The next variable discussed is the break-even-point. For the German industry Berth (1994) found that on average German innovation needs 60 months to achieve the break-even. However, such a long time period for the break-even is not confirmed in the current research where the break-even figure ranges from six to 36 months. The finding of Patterson (1998) at Hewlett Packard (operating in a branch with very short product life cycles) that an early break-even is important for generating revenues to finance future R&D was not found. Especially in branches with a long product life cycle R&D investments are financed with profits from existing products – an early break-even is not given in such branches. Overall, Phase 3 showed that the break-even-point is related to a company's individual product innovation strategy, too. Dependent on the aims with new products the break-even can be early or late.

Stream of new products

It was assumed that product innovation rate is related to the stream of how products are introduced. Several researchers demanded to have permanent streams of new products (e.g., Utterback, 1994; Anonymous, 1995a; Patterson, 1998). As most case business units tried to have a permanent stream, a relationship to product innovation rate was not found. It was found that over a three years time window (definition of product innovation rate) given waves are compensated.

Business unit growth

The fact that growth rates are related to revenues from new products was found by several researchers. For example, Rommel (1991) and Roper et al (1996) found that companies with new products generate higher revenues and achieve higher growth. Geroski and Machin (1992) found that innovative firms are both more profitable and grow faster than non-innovators. Further, Hax and Majluf (1991) and Brenner (1994) found that companies that follow an internal growth strategy have the possibility of growing with new products. This is in line with the current study where 10 of 11 business units achieved growth rates. However, it has to be noted that in many business units new products are the driver to achieve growth rates with the whole product portfolio. Consequently the findings made by Kulicke et al (1997) that nearly 50% of companies, which earn more than 25% of their revenues from new products also experience growth, need to be proved in future research studies.

This section has shown that an investigation of profits with new products needs a detailed insight into reasons for varying product innovation positions. This in turn is only possible by taking a case study approach. To prove the findings of the current research more case studies in this direction are demanded. Additionally to product innovation outcome variables the research offered the possibility to analyse how the age and size of business units are related to product innovation position.

8.2.8 General Variables

The first variable discussed is the age of business units. It is shown that the average age for business units is 62 years (it ranges between 38 and 101 years). As all business units develop new products, the age of business units is not related to product innovation. This was also shown by Dougherty and Hardy (1996) who investigated 96 year old companies. They found that some business units have organisational problems in the organisation of innovation. However, for the most successful companies they found, that product innovations were the driver to reinforce existing practices and structures of the whole organisation. This is in line with the findings of (Liversay et al, 1996) who found that product innovation for old business units is as important as for young business units to stay competitive.

The next variable which is discussed is business unit size. The size of the case business units vary between 140 and 3,000 employees. Overall, no relationship of business unit size with either product innovation position or industry sector was found. However, in the product innovation literature contradicting findings are given. Several researchers found that small companies are more innovative, i.e., develop more new products (e.g., Acs, 1994; Geroski, 1994; Cohen and Klepper 1996a, 1996b). In contrast other researchers found that big businesses are more innovative (e.g., Bertscheck and Entorf, 1996; Wakasugi and Koyata, 1997; Kulicke, 1998). However, the findings of the current research project are in line with the findings of Audretsch and Vivarelli (1996) who found no differences in product innovation activities between small and large companies.

This section discussed the relationship of different variables to product innovation rates and the percentage of revenues from new products individually. It was shown that most of them are related to the context. Further, it was shown that investigations into the drivers of varying product innovation positions is helpful to get deeper and more detailed insights into product innovation activities of business units.

8.3 OVERVIEW OF THE RESULTS

Because of the complexity of the research and the broad set of variables discussed an overview of the findings is given. In Table 8.6 for each variable the main findings are given. Further, the findings from other researchers on this variable is presented. In the last column (heading given with "In line...") it is marked with a tick as to whether the results are in line with the findings from other researchers or not.

Table 8.6(a): Comparison of Findings in the Current Research Project with Findings from Previous Research Studies

#	Variable	Findings of the Current Research Project	Findings of other Researchers	In line ... Yes	No
PRODUCT INNOVATION OUTPUT					
24 (QT)	Product innovation position	Key drivers identified for varying product innovation positions are market, competition and product innovation strategy. Product innovation rate is not related to innovativeness. Key drivers related for product innovation are NPD project management and corporate culture.	Product innovation position was not investigated in depth in earlier studies.		New
		Phase 2 (survey) showed a relationship between higher product innovation rates and higher percentages of revenue from new products.	The relationship of product innovation rate and the percentage of revenues from new products was not investigated in depth in earlier studies. However, the case studies (Phase 3) found that such a relationship is not given automatically.		New
22 (QT)	Product innovation rate	The cancellation of existing products by introducing a new one is not automatically given. This is shown by two business units who develop new products for selling their existing products more successfully.	With regard to the product portfolio Tellis and Golder (1996) and Clement et al (1998) found that introducing a new product often results in the elimination of existing products.		✓
		A low product innovation rate is not automatically related to low product innovativeness. Two business units with a low rate are very innovative and introduce a high number of new products into the market. Consequently, product innovation rate is no indicator for innovativeness.	Terwiesch et al (1998) used product innovation rate as a variable to explain product innovation performance on project level. This is questionable because the key drivers it identifies are market, competition and product innovation strategy.		✓
23 (QT)	Percentage of revenues from new products	A significant amount of revenue was earned with new products.	That new products generate a significant amount of revenues was also found by other researchers as: Brenner (1994), De Meyer and Pycke (1996), Firth and Narayanan (1996), Goffin et al (2000).	✓	
		Phase 3 (case study) found that lower revenues from new products could be related to the strategy to use new products as a multiplier to sell existing products more successfully.	Higher revenues are related to a higher innovativeness. Therefore Brennecke et al (2001) and Griffin (1997a) used this variable as a performance measure.		✓

Table 8.6(b): Continued

#	Variable	Findings of the Current Research Project	Findings of other Researchers	In line ... Yes	No
MARKET					
1 (QT)	Product life cycle	Product life cycle is a driver for a high number of existing products within the product portfolio. Therefore product innovation rate (position) could be low. It is not related to a low innovativeness (i.e., to a low number of new products developed)	Loch et al (1996) and Terwiesch et al (1998) found that product life cycle is related to product innovation performance.		✓
2 (QT)	Market growth per year	A relationship between market growth with the number of new products developed is given.	Zarah (1993b) and Gupta and Wilemon (1990) found that high industry growth may encourage the clear introduction of new products.		✓
3 (QL)	Economical Influence	Laws can be a driver for developing new products – especially for business units which are operating internationally.	According to OECD (1996b) laws can be a driver for developing new products.	✓	
4 (QL)	Technology	Electronics was identified as a technology which forces business units from engineering to replace their mechanical components (products) by electronic ones.	Archibugi and Immarino (1999), Isoard and Soria (1999) and Sharp (1999) identified the diffusion of new technologies as a driver to develop new products.	✓	
COMPETITION					
5 (QT) **6 (QT)**	Market share	A relationship between market share with product innovation was not found.	Gupta and Wilemon (1990), Porter (1990), Zarah (1993b), and Loch et al (1996), identified a low market share as an important enforcement for innovation.		✓
			Cooper and Kleinschmidt (1993) found that new product success seems not to be dependent so much on the competitive situation.	✓	
7 (QL)	Market entrance barriers	Market entrance barriers were reported to be high at every business unit. Overall, market entrance barriers are not related to product innovation.	Cooper and Kleinschmidt (1993) found that market entrance barriers are not significant to product innovation activities.	✓	
8 (QL)	General Com-petitive situation	Because of global markets, business units with high market shares need to develop new products, too. Overall increased competitiveness forces business units to develop new products.	Because of intensified competition and globalisation new products are important to stay competitive. This was shown by Gupta and Wilemon (1990), Porter (1990), Zarah (1993b), and Loch et al (1996).	✓	

Table 8.6(c): Continued

#	Variable	Findings of the Current Research Project	Findings of other Researchers	In line ... Yes	In line ... No
		CORPORATE ENVIRONMENT			
9 (QL) 10 (QL)	Corporate environment	All business units had high levels of both familiarity and synergy. This is not related to the ability to create new products.	Cooper and Kleinschmidt (1993) found high levels of familiarity and synergy in their sample which is not significant to product innovation outcome.	✓	
		NATURE OF NPD PROJECTS			
11 (QT)	Source of ideas	All business units investigated used both ideas from outside (customers) and inside (from employees) the business units to generate new products.	Several researchers found that both views of customers and companies should be taken into account for the generation of product innovations (e.g., Spreng and Olshavsky, 1996; Simon, 1996; Leonard and Rayport, 1997; Pawlak, 1996; Herstatt und Hippel, 1997).	✓	
12 (QL)	Nature (degree) of product innovations	A research over two phases (Phase 1 and 2) was necessary to identify a valid dataset which is based on a similar understanding of the degree of product innovations (defined as transformational new products). To get such a dataset an intensive discussion of the product portfolio with managers via telephone interviews was necessary.	Many studies on product innovation are based on surveys. With the surveys the degree of new products were not proved, the results of these studies need to be proved in future research studies (e.g. Loch et al, 1996, Terwiesch et al, 1998).		✓
		NEW PRODUCT PROCESS			
13 (QT)	NPD projects on time	Delays in NPD projects because of limited resources are given for both, business units with low and high product innovation rate.	The fact that personnel resources are often the case for delays in NPD projects was found by Kulicke et al (1997), Goffin and Pfeiffer (1999), Cooper (1999).	✓	
14 (QT)	NPD projects cancelled	The data analysis identified a relationship between high cancellation rates of NPD projects and business unit size.	This relationship was not found in the previous product innovation literature.		New
—	R&D Organisation	All business units except one (with a matrix organisation) used a functional organisation form for managing R&D activities. This is not related to product innovation.	Read (1996), Anonymous (1996), Griffin (1997a), Gassmann (1997) found that functional organisational forms are more common for managing R&D activities at a business unit level	✓	
			The finding of Brennecke et al (2001) that more business units with innovative NPD projects are using a functional organisation is not confirmed.		✓

Table 8.6(d): Continued

#	Variable	Findings of the Current Research Project	Findings of other Researchers	In line ...	
				Yes	**No**
		NEW PRODUCT PROCESS			
15 (QL)	NPD process (NPD project management)	No differences in NPD project management between business units within the sample size were found	Griffin (1997a) identified no big differences in NPD project management between the best and rest of the firms.	✓	
		In every business unit investigated in Phase 3, interdisciplinary NPD project teams are installed. In these teams members from different departments (e.g., R&D, production and marketing) work together within NPD projects.	Griffin (1997a), found that most companies (independent from product innovation performance) are using multifunctional teams.	✓	
		A high quality NPD process is given for all business units. It is not related to business unit's profits and the number of new products developed.	Cooper and Kleinschmidt (1995) and Loch et al (1996) identified a high quality process as an important driver for business unit performance (e.g. profitability, number of new products developed).		✓
		PRODUCT INNOVATION STRATEGY			
16 (QT)	NPD project planning horizon	NPD project planning horizon is not related to product innovation	Griffin (1997a) found no differences in cycle time of highly-innovative projects between the best and the rest.	✓	
		NPD planning horizon is related to business unit size.	No information about NPD planning horizon and business unit size was found in the product innovation literature.		New
17 (QT)	Investments into R&D	A relationship of product innovation activities (i.e., the number of products developed) and investments into R&D was not found.	Cooper and Kleinschmidt (1995) found that high-impact technical winners invest more into the development of new products.		✓
		R&D investments are related to the size of business units.	Wakasugi and Koyata (1997) found that in big companies the R&D expenditures are higher.	✓	
		Higher R&D investments are not related to higher profitability.	Cooper and Kleinschmidt (1995) found that higher investment into R&D is not related to higher profits.	✓	
18 (QT) 19 (QL)	Product launch strategies	The strategies first to market, technological leadership and cost leadership are not related to product innovation and profits with new products. Further, most business units mixed these strategies. It was shown that the strategy of technological leadership is more important than the strategy of cost leadership.	Berger (1995) and Stalk (1988) found that with a first-to-market strategy price differentiation is possible. Further, Cooper and Kleinschmidt (1993) found that price differentiation is not seen as an appropriate strategy for his sample size.	✓	

Table 8.6(e): Continued

#	Variable	Findings of the Current Research Project	Findings of other Researchers	In line ... Yes	In line ... No
PRODUCT INNOVATION STRATEGY					
20 (QL)	Corporate culture for product innovation	A culture supporting innovation and a high commitment of the board of management to product innovation is important for being innovative. However, this is not related to product innovation rate and percentage of revenues from new products.	Cimento and Knister (1994), Reiple and Vyakarnam (1996), Kim and Mauborgne (1997) and Griffin (1997a) found that culture and the commitment of the board of management is important for staying innovative.	✓	
21 (QL)	Product innovation strategy (model of Johnson and Scholes, 1999).	Most business units (except two) mixed different product innovation strategies. Business units with high product innovation rates or high percentages of revenues from new products have a stronger focus on product development – they do not use protection-building as a strategy.	Simon (1996) found that most companies in his sample combined different strategies.	✓	
		63% of the business units investigated in Phase 3 had a written product innovation strategy	Griffin (1997a) found that 62.7% of the responses in her research have a specific NPD strategy.	✓	
PRODUCT INNOVATION OUTPUT					
25 (QT)	Average profits with the whole product portfolio	Profits are not related to product innovation rate but to market share. Therefore, businesses units with high market shares make more profits than business units with low market shares.	Terwiesch et al (1998) found that profits are dependent upon the profit margins within the industry sectors and the competitive situation (i.e., market share).	✓	
		Market growth and product life cycle are not related to profits (it has to be noted that they are not related to product innovation position, either).	Terwiesch et al (1998) found that development performance matters more in markets with slow growth and long life cycles, where their model explains 70% of the variance to profitability.		✓
26 (QT)	Average profits with new products	Higher profits from new products are not related to product innovation position. Profits are dependent upon the individual product innovation strategy with new products. This can be explained in detail with an in-depth analysis of the chosen product portfolio (product innovation rate).	Cooper and Kleinschmidt (1995) found a large group of companies who achieved higher profits relative to competitors with lower revenues from new products and a lower success rate (defined as solid performers) than business units with a high success rate (e.g., technological leadership). However, a detailed explanation of this phenomenon was not given in their study.	✓	

Table 8.6(f): Continued

#	Variable	Findings of the Current Research Project	Findings of other Researchers	In line ... Yes	No
PRODUCT INNOVATION OUTPUT					
27 (QT)	Break-even-point	The break-even-point is related to product innovation strategy. (i.e. the aim with new products).	The example of Hewlett Packard showed that the break even point is important for generating revenues to finance future R&D activities (Patterson, 1998). This in turn is related to the product innovation strategy of Hewlett Packard.	✓	
28 (QL)	Stream of new products	Most business units (independent from product innovation rate) reported having the aim to create a permanent stream of new products.	Utterback (1994), Anonymous (1995a) and Patterson (1998) demanded the creation of a permanent stream of new products to stay competitive.	✓	
29 (QT)	Business unit growth	Growth rates for business units vary between –2% and 12.5% (E&E engineering 2.4% to 26.6%). All business units are product innovators and achieved growth rates (excepted one).	Hax and Majluf (1991), Geroski and Machin (1992), Brenner (1994), Roper et al (1996), and Kulicke et al (1997) found that with new products growth can be achieved.	✓	
—	Financial objectives	Most business units estimated their profits from new products because they were not able to give detailed information.	Booz et al (1982, Page (1990) and Griffin (1997a) found that not all firms measure NPD performance. However, Anonymous (1994) and Griffin (1997a) found that the percentage of best practice firms with formal financial objectives is higher.	✓	
GENERAL VARIABLES					
—	Age of business units	The average age for business units is 62.0 years. All business units see product innovation as a driver to stay competitive.	Dougherty and Hardy (1996) and Liversay et al (1996) found that product innovation for old business units is as important as for young business units to stay competitive.	✓	
—	Size of business units	Overall, no relationship of business unit size with either product innovation rate or industry sector was found.	Although several studies found differences in product innovation activities (e.g., Koyata, 1997; Kulicke, 1998), Audretsch and Vivarelli (1996) found no differences in product innovation activities between small and large companies.	✓	

8.4 SUMMARY

This chapter has shown that an investigation of product innovation activities on business units level is not common in product innovation research. Further, it was shown that product innovation position was not investigated with in depth studies in the past. Based on a survey of 78 business units in Phase 2 and 11 case studies carried out in Phase 3, a systematic comparison of the actual findings with the results from previous research studies was made. The main findings are as follows:

- In line with other studies the research found that product innovation position is related to the context. Activities from the whole business unit have to be taken into account for managing product innovation positions systematically. It has to be noted that other studies did not investigate this context with in-depth studies.
- Previous research studies used product innovation rate as a variable for operationalising the area of the NPD process. However, the current research project found that product innovation rate is mainly driven from market competition and product innovation strategy.
- Earlier studies mainly used surveys for the investigation of revenues from new products and found that a significant amount of revenue was earned with new products. However, in the case studies of Phase 3 it was found that lower revenues from new products could be related to the strategy of using new products as a multiplier to sell existing products more successfully.
- The finding of other researchers that product innovation is one of the most important sources of profits has to be qualified as follows: Dependent on the individual product innovation position (less or more new products within the product portfolio and less and more revenues from new products), profits are supported directly or indirectly by new products.

The comparison of the results of the current research project with the findings from previous research studies led to some new findings. Therefore, the demand for future research projects in this direction is given to prove these findings. Further, it has to be noted that the research itself was very complex. To get meaningful results it was necessary to investigate the company and project level. Based on a systematic investigation of these areas the conclusions and recommendations are presented in the following chapter.

CHAPTER NINE

CONCLUSIONS AND RECOMMENDATIONS

9.0 INTRODUCTION

This chapter presents the overall conclusions and recommendations from the research. It was shown that an explanation of the individual product innovation positions (e.g., varying product innovation rates and varying percentages of revenues from new products) needs a complex view of different areas on a business unit level.

This chapter covers:

- The model of Cooper and Kleinschmidt is reworked in order to show how the areas analysed are related to product innovation position.
- The overall conclusions and recommendations from the research are presented. Based on the detailed explanation of the individual product innovation positions recommendations for both managers and researchers are presented.
- A new approach is offered as to how product innovation positions can be managed systematically.
- The conclusions from the research are given.
- The counter-intuitive conclusions drawn from the study are presented.
- The limitations of the research are summarised.

This chapter is separated into seven sections. Based on the findings in the current research project a modified version of the model of Cooper and Kleinschmidt is presented in Section 9.1. In Section 9.2 the recommendations for researchers are given. The recommendations for managers and a guideline for managing the product innovation position systematically is given in Section 9.3. In the following section (Section 9.4) the overall conclusions from the research are given. Further, an alternative view of the research conclusions are presented in Section 9.5. The limitations identified in the research are summarised in Section 9.6. Finally, a summary is given.

9.1 THE MODIFIED COOPER AND KLEINSCHMIDT MODEL

Based on the actual findings the model from Cooper and Kleinschmidt was modified. This was seen to be necessary, because their model was built to investigate individual NPD projects within companies. However, as the current research project is focusing on product innovation on business unit level, their model has to be optimised. The modified model is given in Figure 9.2. Additionally, the original model is presented in Figure 9.1.

The reworked model contains the three key drivers of product innovation position (market, competition and innovation strategy). As NPD project management and corporate culture[91] were found as key drivers for managing product innovation

[91] As corporate culture is not given in the original model, this is given as a new one.

processes, these areas are also included in the modified model. Further, it was found that a corporate environment and the nature of project (degree of a product innovations) is closely related to product innovation strategy. Consequently, in the modified model these two areas are not given separately but are included in the area product innovation strategy. In the original model of Cooper and Kleinschmidt the linkage between business environment (market and competition) with management areas at a business unit level is given by the area source of ideas. However, it was found that the process of ideas generated is part of NPD project management. Therefore it is not given in the reworked model as an extra area. As the current research mainly investigated product innovation position, this terminology replaces project outcome and success / failure which is given in the original model. In comparison to the original model of Cooper and Kleinschmidt the arrows between the areas at a company level are directed in two directions.

The modified model itself can be explained as follows: A business unit is operating as a whole in the business environment (market and competition). In order to operate in the most competitive way they have chosen a product innovation strategy which forms the framework as to how products are launched into the market (e.g., first to market, technological or cost leadership). The product innovation strategy gives the framework of how many products are developed and how their position within the product portfolio is defined (i.e., new products to strengthen existing ones or new products to replace existing ones). The strategy in turn is reflected in the commitment for product innovation by the board of management and the corporate culture for product innovation. Such a culture can be characterised by an open and informal information transfer and the involvement of all employees into the generation process of new products. Based on both, the corporate culture and product innovation strategy, new products are developed. This is characterised with the NPD management process, including NPD project management, composition of teams (i.e. multifunctional teams) and formalised information transfer between teams and departments. The relationship of all areas is reflected in a product innovation position which is seen as the most appropriate to stay competitive. In other cases, where a product innovation strategy is not given and the commitment of the board of management for product innovation is low, often a culture for product innovation is not given. This in turn can be related to difficulties in NPD project management processes and to a low number of new products developed. All in all this leads to an unmanaged (low) product innovation position.

It has to be noted that it is important for managers to understand the context in which a business unit operates. Such a broad view is necessary because many (underlaying) variables relate to each other. For example market share is not related to product innovation rate but to profits. On the one hand, well defined NPD processes are not related automatically to product innovation rate. On the other hand, bad NPD processes could have an influence on product innovation rate (i.e., they are related to lower rates). Further, the size is related to the percentage of cancelled NPD projects but not on the number of new products developed. This implies that strategic decisions about the product innovation strategy are more meaningful as more background knowledge of markets and processes is available. Overall, the interaction of all areas results in the product innovation position. The relationship between product innovation rate and the percentage of revenues from new products reflects the way a business unit operates within the market.

Although most managers were roughly aware of their current product innovation strategy, they had difficulties in explaining their product innovation positions spontaneously. This implies the need for a framework which will help them to manage their product innovation position systematically. This approach was taken up and the model of Cooper and Kleinschmidt was modified.

Figure 9.1: The Cooper and Kleinschmidt Model (1993)

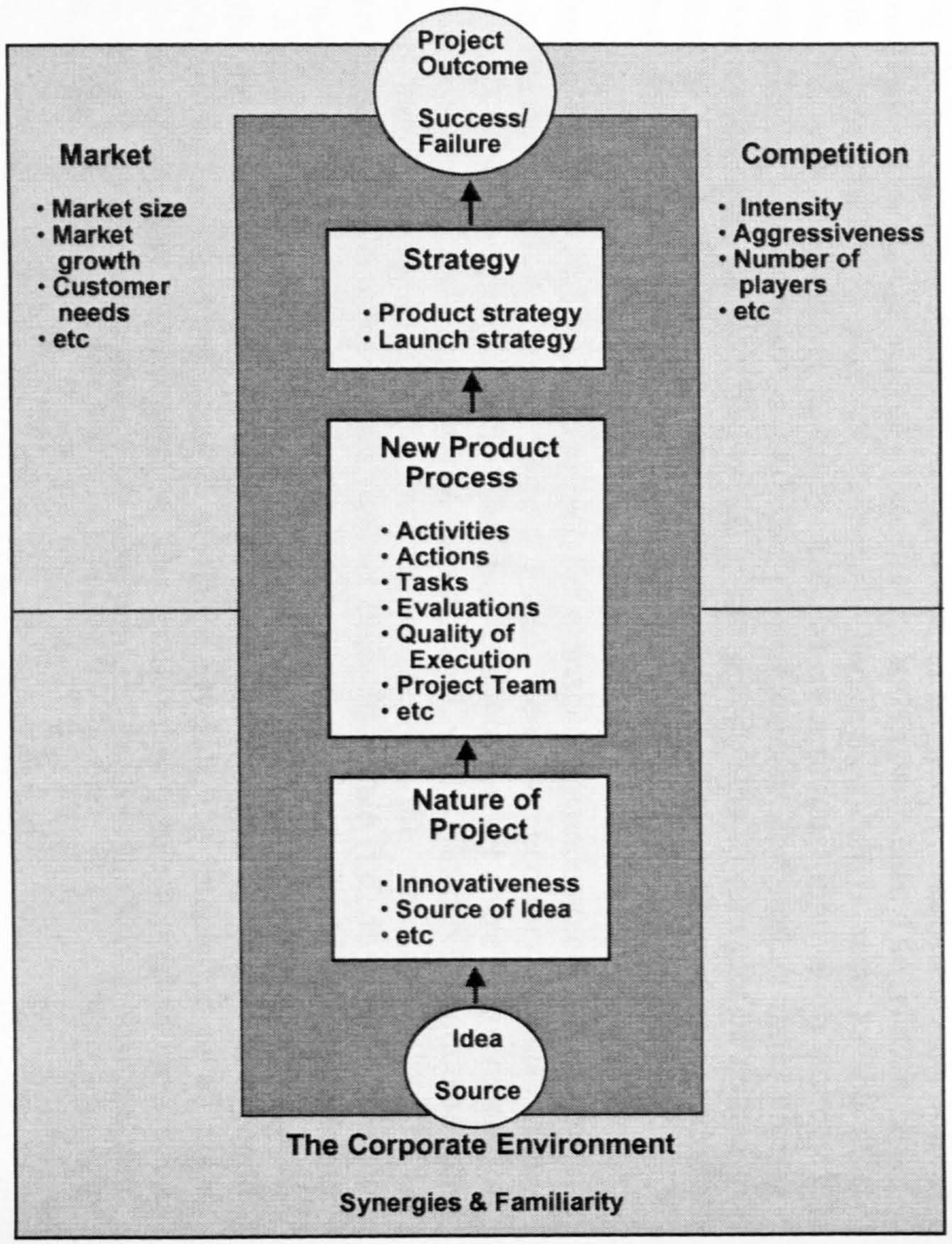
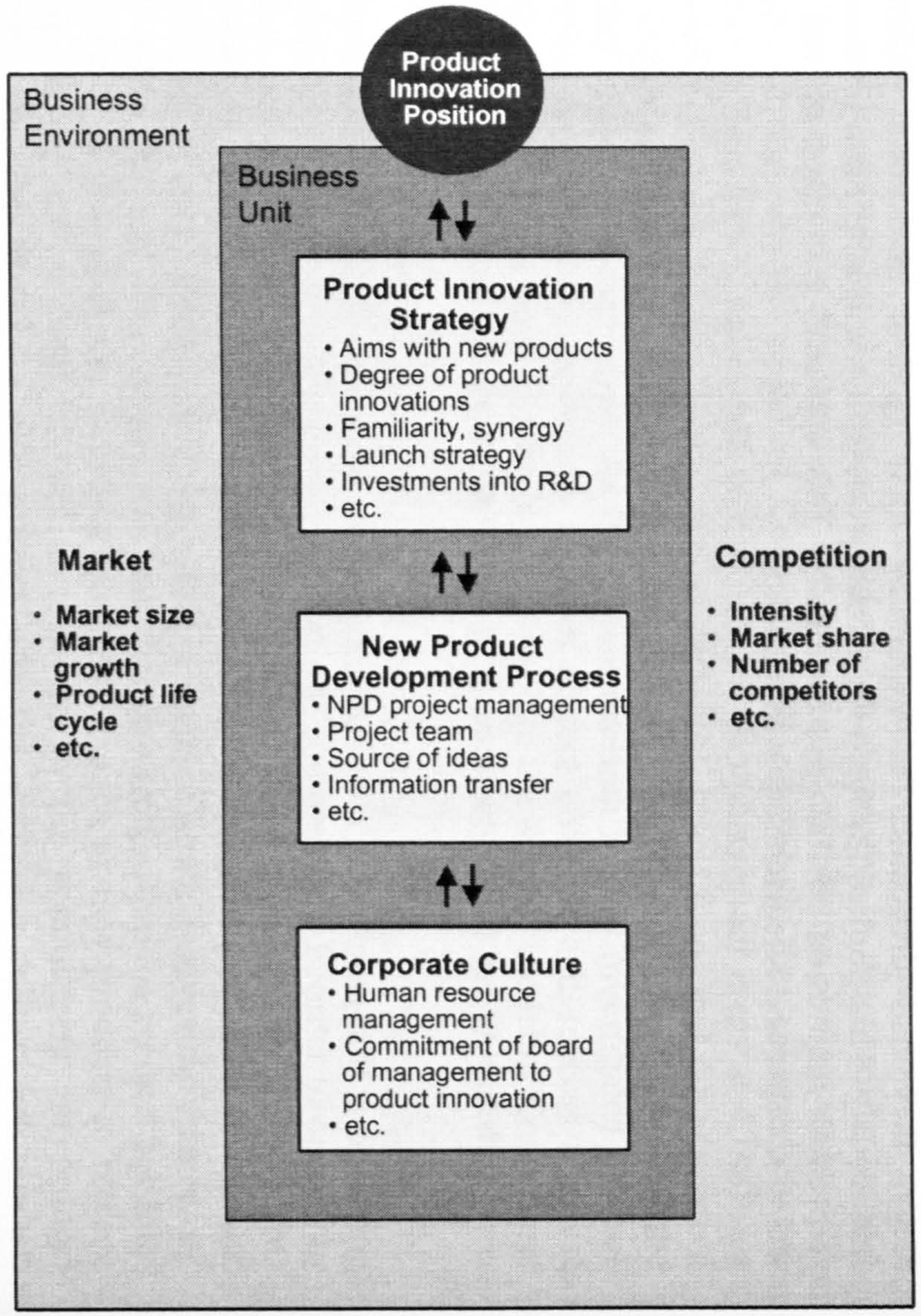


Figure 9.2: The Modified Cooper and Kleinschmidt Model



The modified model shows that business environmental factors and factors at a business unit level (company level) and project level are closely related. In the research it was shown that the complexity makes it necessary to have detailed background information about all of the given areas. This in turn is only possible with a research method which combines quantitative and qualitative information. Based on the actual findings recommendations for researchers are derived which are presented next.

9.2 RECOMMENDATIONS FOR RESEARCHERS

Although the research investigated 78 German business units with a survey and 11 business units from two industry sectors (which may not be representative of German industry as a whole), the research attempts to generalise. Overall, it shows the importance of investigations of product innovation rate and the percentage of revenues from new products at a business unit level. However, this is only possible by using a case study approach. Therefore, further research is essential at business unit level with a broader dataset.

The key points for researchers are:

- Product innovation rate is difficult to measure. To get comparable data for product innovation rate, the product portfolio (i.e., the relationship between existing and new products) has to be discussed with the board of management. As this is difficult to do with mail surveys, case studies have to be carried out. This limitation has to be taken into account by carrying out surveys which deal with product innovation on business unit level.
- Product innovation rate is mainly influenced by the key drivers market, competition and product innovation strategy. In previous studies it was used as a performance measure on project level. (i.e., higher product innovation rates are related to a higher number of product innovations). However, low product innovation rates do not automatically imply that a business unit is not innovative (i.e., is developing no new products). Low rates can be dependent on a specific product innovation strategy (i.e., the focus on specific new products). In this case, low product innovation rates have to be ranked as high performances, too. Therefore, researchers need a detailed understanding of the reasons why business units are operating with their specific product innovation rate. This in turn has influence on using the variable product innovation rate as a benchmarking (best practice) variable. Consequently the methodology of studies using product innovation rate as a performance measure should be reworked.
- Previous research studies show that higher percentages of revenues from new products increase competitiveness. Further, it was assumed that higher revenues from new products are related to higher product innovation performance, too (i.e., higher product innovation rates are related to a higher percentage of revenues from new products). However, the current research showed that low percentages of revenues may be related to a strategy which focuses on selling existing products more successfully. In this case this is not related to a low product innovation performance. The implication is the same as for product innovation rate. This variable can only be used in benchmarking studies with detailed background knowledge about the reasons for low or high percentages of revenues from new products.

- One main finding of the research was that the product innovation position and other product innovation output variables are related to the context. In summary three key drivers of product innovation position and two key drivers on managing product innovation processes were found. Therefore, more case studies should be carried out in order to identify more reasons for varying innovation positions. Furthermore, investigations in this direction are helpful to be able to generalise the findings of the current research project.
- Based on the variables of the product innovation rate and the percentage of revenues from new products a selection method of case business units was developed. The separation of the diagram of the product innovation rate and the percentage of revenues from new products into four fields was seen as an appropriate way to choose case business units in a random but systematic way. As such selection methods are not common, further research projects should improve the suggested method further.
- In previous research studies it was not common to use the product innovation position as a variable for selecting case companies. However, to get better insights into the management of product portfolios, this would be necessary for using this variable more often.
- The current research project showed the difficulty of capturing the complexity of drivers of product innovation positions on business unit levels. Going further, a business unit could be a part of a greater organisation which in turn makes the research more complex. Therefore, more investigations of product innovation positions on a company or holding company level are demanded.
- Although the reworked model of Cooper and Kleinschmidt was based on the systematic investigation of 11 business units, it should be tested through further investigations. This seems to be necessary to ensure that the model is a valid representation of the complexity of product innovation on business unit level.
- Future expectations of product innovation rate are not valid. Phase 2 of the current research project showed that managers are not able to prognosticate product innovation rate. Therefore such information should not be used in future research projects.
- One possibility for further studies would involve the comparison of "direct competitors" – unfortunately, the German dataset does not contain such a sample. Consequently, the reasons for different product innovation positions across business units within the same industry sector can only be found by investigating business units with different product portfolios.

9.3 RECOMMENDATIONS FOR MANAGERS

The case study visits showed that managers were not really aware of their actual product innovation position. Overall, the managers of three of the 11 business units were not able to explain their product innovation position spontaneously. However, the in-depth discussion of their position within the diagram of product innovation rate and percentage of revenues from new products helped them to get a clearer picture about their position within the diagram. Some MDs were surprised about their position, while others were able to give a detailed explanation. It was further shown that most managers had no detailed data about profits from new products. However, an inspection of the data showed that more profits are achieved with the whole product portfolio than with new products. This indicates that managers need more information about the relationship of product innovation position and profits with new products.

From the findings that practitioners need support for managing product innovation positions in a systematic way, the following recommendations can be made:

- It was found that three of 11 business units were not able to explain their position within the diagram product innovation rate and percentage of revenues from new products spontaneously. However, a systematic discussion of their individual position within the diagram helped them to understand more clearly, how they are operating with their product portfolio. Consequently, the diagram product innovation rate and the percentage of revenues from new products can be used as a basis for investigating product innovation on a business unit level systematically. Overall, it was identified as a very good tool for starting an in-depth discussion about product innovation with managers.
- The Cooper and Kleinschmidt model was modified in order to show the complexity of product innovation positions. Together with the diagram product innovation rate and the percentage of revenues from new products it can be used by managers to identify their key drivers on their product innovation position.
- A main finding in the product innovation literature was, that new products are developed to generate revenues. However, the current research found, that new products can be developed to show a business unit's product innovation performance (i.e., to strengthen their brand). The aim with such new products in not making high revenues but to sell existing products more successfully.
- It was found that the whole product portfolio (including both existing and new products) is a key for making profits. Therefore managers need a detailed understanding of their product portfolio. This in turn is closely related to the individual product innovation strategy (e.g., new products to sell existing products more successfully or a strong focus on new products).
- Product innovation rate and the percentage of new products is not related to NPD project management. The current research project showed that it is related to the context. Therefore, the whole business unit with all functions needs to be optimised in such a way so it can act with the most appropriate product innovation position. The advice for managers is to move away from optimising only NPD processes. The innovativeness of business units needs a complex view on product innovation strategy, NPD project management and corporate culture.
- As product innovation position is influenced by many drivers, managers need to be aware of such variables which are related to it. A systematic analysis of a set of 29 variables identified eight with a relationship to product innovation position (and two for managing product innovation processes). For managers it is important to know that most of these variables can be influenced by managerial actions. Or in other words: Product innovation positions are not mainly influenced by environmental effects. They are dependent on managerial decisions and actions.
- The positions within the diagram of product innovation rate and percentage of revenues from new products offers several strategies on how to operate within a competitive environment. Overall, 11 examples from business units with different product innovation positions are analysed in this study (see Appendix A).
- Business units should use a systematic guideline to investigate their current product innovation positions. Such a systematic investigation is seen to be necessary to be

able to understand the individual position within the diagram product innovation rate and percentage of revenues from new products. Only with detailed insights into the reasons for the actual product innovation position will managers be able to strengthen their product portfolio and their competitive position.

- Managers need to learn how to manage their product innovation positions and how different areas (i.e., from the modified Cooper and Kleinschmidt model) are related. Only if they are willing to learn from the past and to learn how their business innovation position has to be managed, are they able to increase their competitiveness.
- Most managers estimated their profits from new products. However, to be able to manage profits it will be necessary to have valid information. Therefore the demand for managers is to measure their profits from new products regularly.

Overall, the need for managers to investigate their product innovation position more systematically was made. Further, it was shown that the product innovation position is related to the context. To help managers check their product innovation position in a systematic way a guideline for managing product innovation position is presented in the following section.

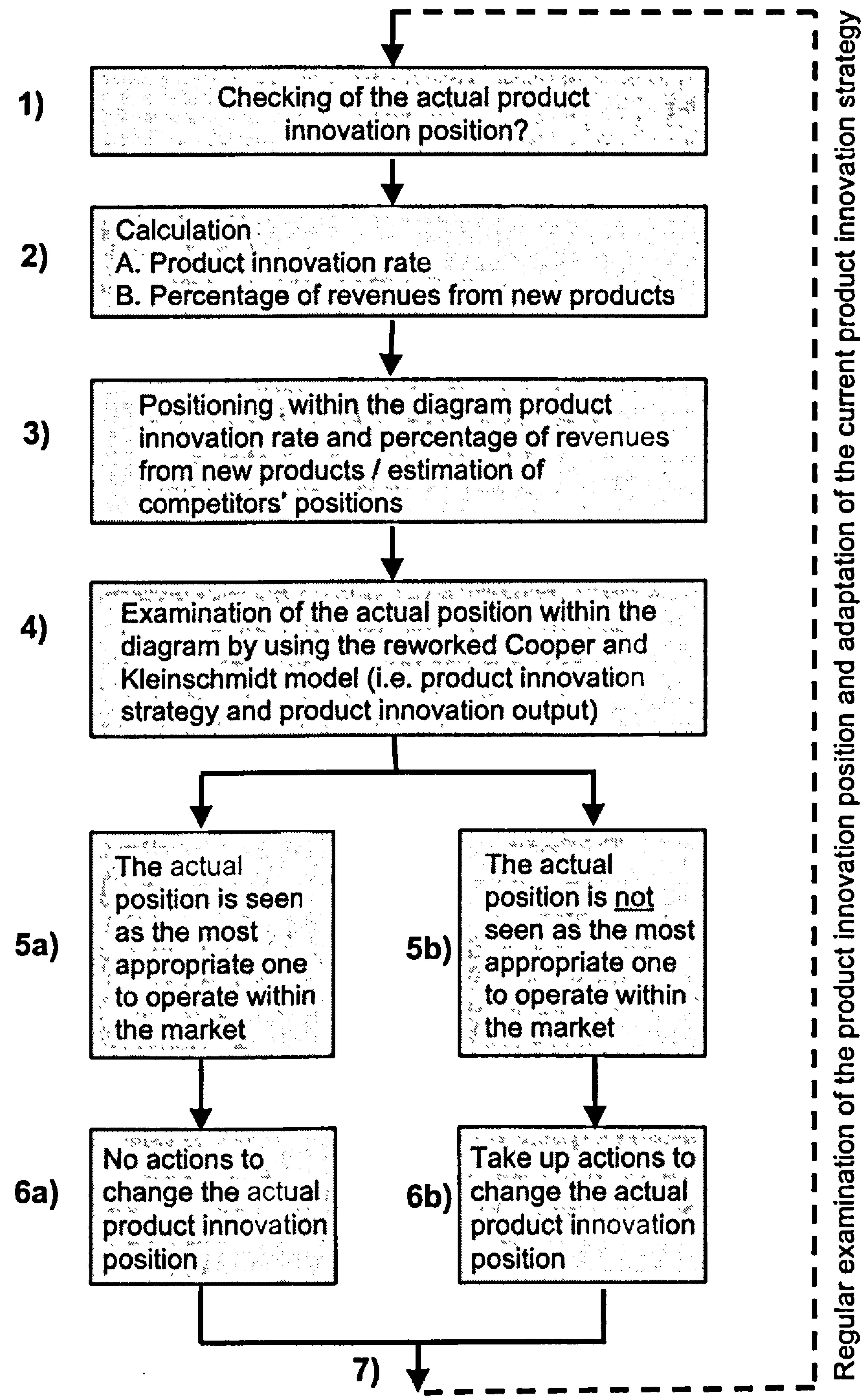
9.3.1 Managing Product Innovation on the Business Unit Level

Business units cannot allow their product innovation strategies to stagnate because their competitors do not. If they do not put into place a mentality of adopting product innovation positions, they could, slowly but increasingly, be left behind competitively. To do so, a guideline on how product innovation position can be managed systematically is offered in this section. Further, a product innovation audit was developed[92]. The structure of the audit is similar to the modified model of Cooper and Kleinschmidt.

To implement an ongoing process for managing product innovation position, a systematic process was developed. This guideline is based on the modified Cooper and Kleinschmidt model given in the section above and is presented in Figure 9.3. It includes 7 stages for a continually improving and adopting improvement of the actual product innovation position. The seven stages are related to one another and each of them need management resources.

[92] Such innovation audits were also demanded by Feige and Cooper (1998).

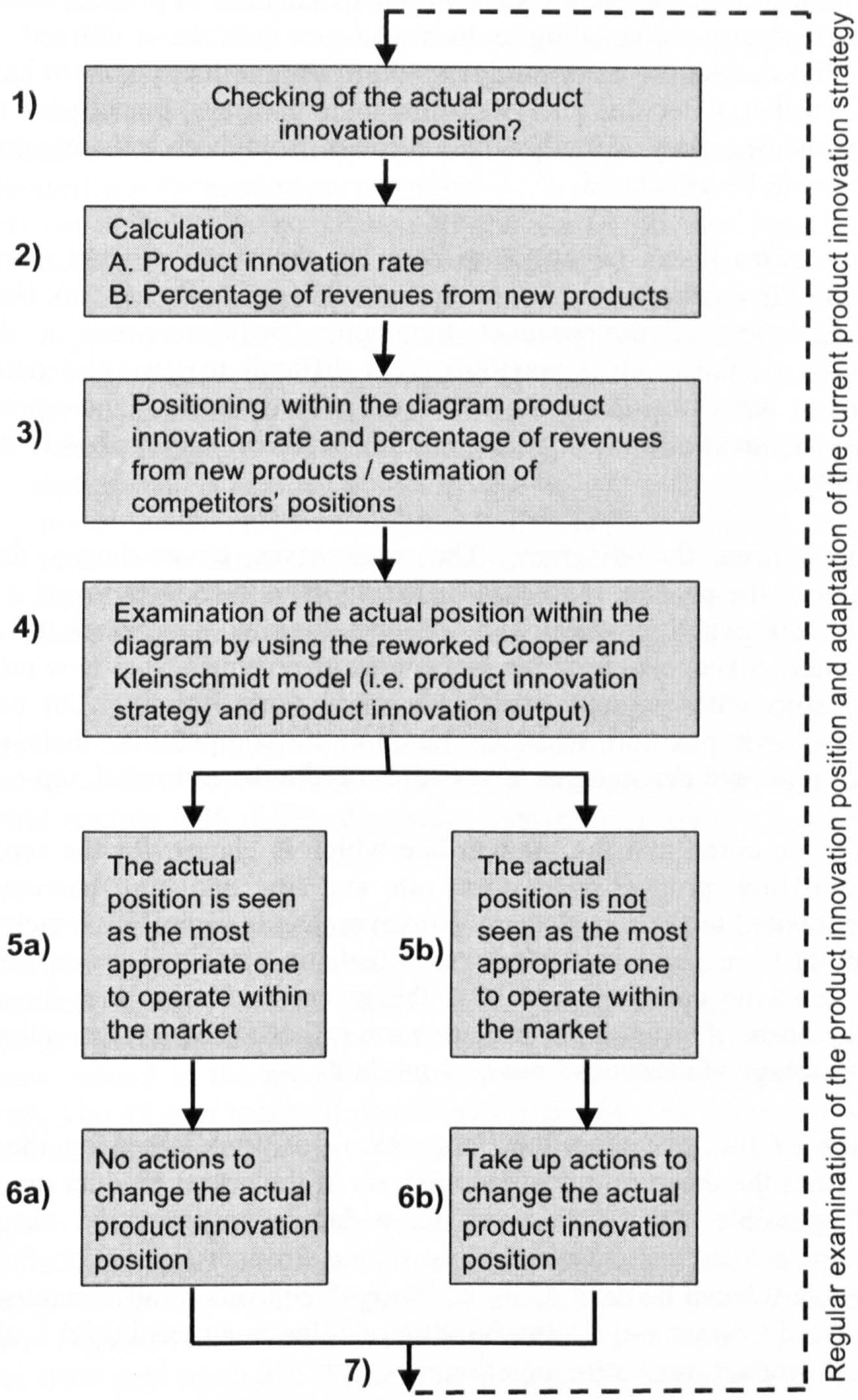
Figure 9.3: Guideline for Managing Product Innovation Position Systematically



The seven stages (steps) given in the figure are explained in detail:

Step 1: Checking the actual product innovation position: It was shown that business units are often unaware of how and why they have a particular product innovation position. Basis for doing this is the conviction that an investigation of both product innovation rate and the percentage of revenues from new products will help to increase competitiveness.

Figure 9.3: Guideline for Managing Product Innovation Position Systematically



The seven stages (steps) given in the figure are explained in detail:

Step 1: Checking the actual product innovation position: It was shown that business units are often unaware of how and why they have a particular product innovation position. Basis for doing this is the conviction that an investigation of both product innovation rate and the percentage of revenues from new products will help to increase competitiveness.

Step 2: Calculation of the variables of product innovation rate and percentage of revenues from new products: Basis for the analysis is the calculation of the two variables. The current research has shown the calculation of product innovation rates needs a clear understanding as to how a new product is defined. To get valid data, the number of main products within the product portfolio has to be identified. Further, a detailed analysis of the main products, launched in the last three years is necessary. Finally, the revenues from both existing and new products have to be calculated.

In some cases it can be useful to compare their own product innovation position with the positions of other business units (e.g., competitors). However, as the calculation of the product innovation position needs a detailed understanding of the product portfolio, it is difficult to get valid data from competitors or other business units within an industry sector. Therefore, it has to be noted that data of benchmarking studies based on surveys has to be used very carefully.

Step 3: Positioning within the diagram: The case visits have shown that the visualisation of the product innovation position helps managers to get a clearer picture of their actual position and it gives them a benchmark to test it. Although many managers know the percentage of revenues from new products, the relationship with product innovation rate is not common. In order to compare the own position with the position of competitors, their product innovations rates and percentages of revenues need to be estimated, too.

It has to be noted that the median line which is chosen for the separation into low and high product innovation rate and low and high percentage of revenues is related to the sample size. However, as the sample size includes 78 business units from two industry sectors a realistic picture is given. For other industries, e.g., the consumer industry, the given separation lines have to be fixed on the basis of an in-depth investigation of both product innovation rates and the percentage of revenues from new products.

Step 4: Examination of the actual product innovation position: Based on the actual position within the diagram a detailed analysis of the actual product innovation position is possible. As a framework for a detailed examination the "Audit Questions for a Systematic Investigation of the Product Innovation Position" given in Table 9.1 can be used. Only an in-depth analysis of all variables given in the reworked Cooper and Kleinschmidt model led to a meaningful evaluation of the actual product innovation position.

Step 5: Based on the identified reasons for the actual product innovation position, two main conclusions are possible:

5a) No change of the actual product innovation position: The actual product innovation position is seen as the most appropriate one to operate in the market. The analysis of the reworked Cooper and Kleinschmidt model led to the result, that all organisation and NPD processes are well organised and are well managed. Further, the identified product innovation position is in line with the actual product innovation strategy.

5b) Change of the actual product innovation position: The actual product innovation position is not seen as the most appropriate one to operate in the market. The analysis of the reworked Cooper and Kleinschmidt model led to the result, that organisation and NPD processes need to be optimised. Further, the identified product innovation position is not in line with the actual product innovation strategy.

Step 6: Based on the conclusions and the actual product innovation strategy two possibilities for actions are possible:

6a) No actions: As no change of the actual product innovation position is necessary, no actions are necessary either.

6b) Actions to change the actual product innovation position: Actions are dependent on the findings in the in-depth analysis. Maybe the organisation structure has to be reorganised or the human resource management needs to be managed in another way. When problems in the NPD process are a reason for too low product innovation rates, the NPD processes need to be optimised. A further action could be the increase or decrease of R&D investments. This in turn can lead to higher or lower product innovation rates in the future. Another conclusion could be that existing products have to be eliminated earlier (higher product innovation rates) or the product life time has to be increased (lower product innovation rates).

These examples given above show that possible actions are diverse. As pointed out earlier, the actions are dependent on an individual business unit's product innovation strategy. Case study examples for the reasons why business units operate with different product innovation positions is given in Appendix A.

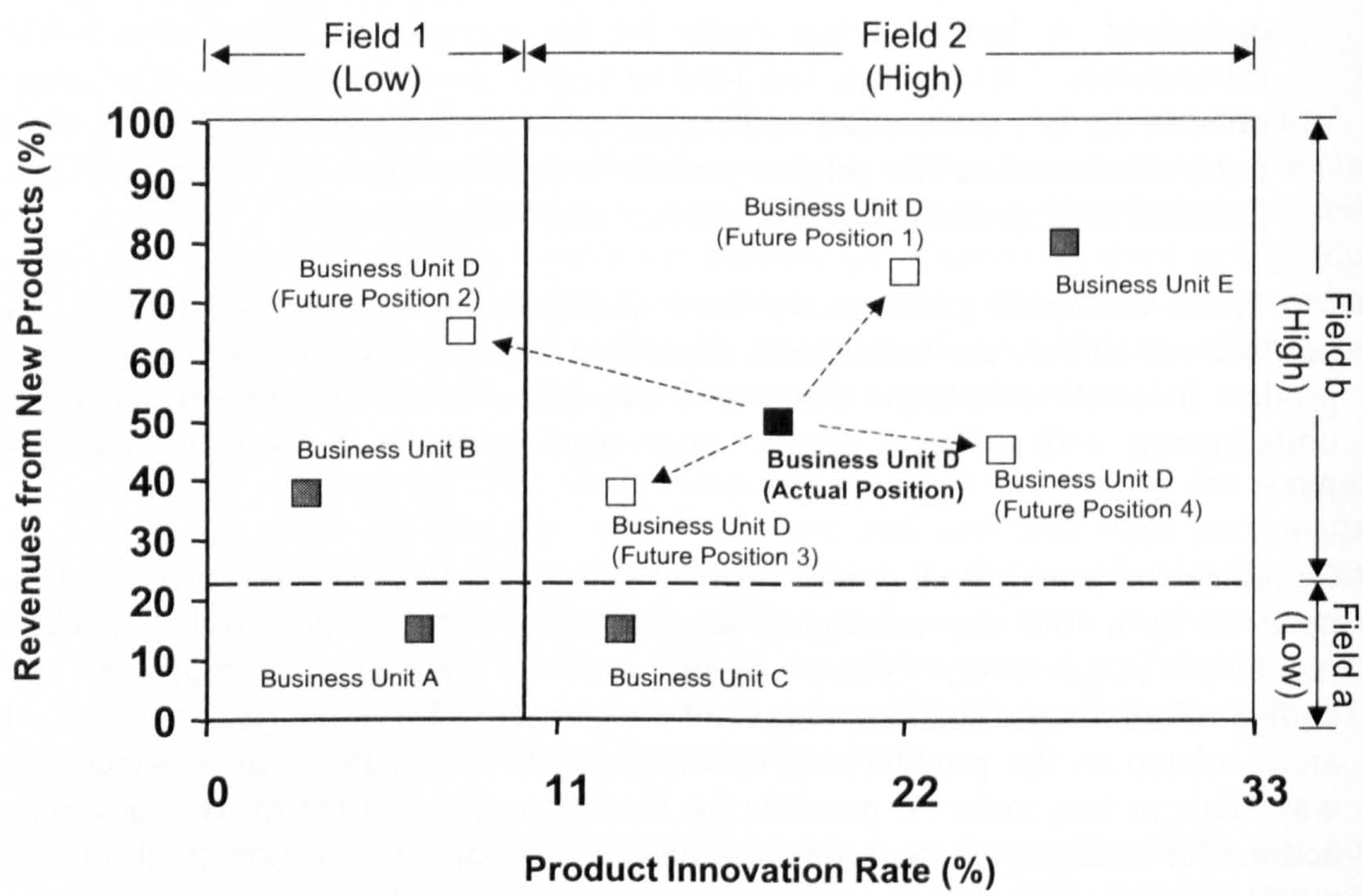
Step 7: Checking the actual product innovation position: To use the product innovation position as a tool for managing product innovation, it has to be checked regularly (e.g., every year). With such a regular investigation the competitiveness of a business unit can be increased. This is the case, because all areas related to the product innovation position are analysed in a systematic way. This in turn makes it possible for managers to select the most appropriate actions for changing or strengthening the actual product innovation position.

The given guideline shows the possibility of managing the product innovation position in a systematic way. As the guideline presented above is very abstract, an example is given on how it can be used for managing the product innovation position strategically. Figure 9.4 shows the diagram product innovation rate and the percentage of revenues from new products. Within this diagram five business units are positioned. The business unit for which several options are given, is Business Unit D.

9.3.2 Strategic Options for Managing Product Innovation Position

As pointed out earlier, the investigation of the actual product innovation position can lead to different conclusions and different actions. In summary, five possibilities are given in the diagram. The first possibility is to hold up the actual product innovation position. Further, both the product innovation rate and the revenues from new products can be increased or decreased. This in turn leads to four different product innovation positions – given as white boxes marked with "future position A, B, C, D". The possibilities are given in Figure 9.4.

Figure 9.4: The Diagram of Product Innovation Rate and Percentage of Revenues from New Products – a Tool for Strategic Planning



Business Unit D (marked with a black box) has a high product innovation rate and achieves a high percentage of revenues from new products (position in Field 2b). In detail the given possibilities for the future product innovation position are:

No change of the position:

An in-depth analysis of variables related to product innovation position led to the actual position within the diagram of product innovation rate and percentage of revenues from new products. This position is seen as the most appropriate way to act in the market. Therefore, no change of the position is necessary.

Position 1: To achieve this position both product innovation rate and the percentage of revenues from new products have to be increased. This can be achieved by the elimination of existing products or by the market introduction of more new products.

Position 2: This position with lower product innovation rates but a higher percentage of revenues from new products can be achieved by focusing on selected new products. With these few new products most of the revenues can be achieved.

Position 3: Lower product innovation rate and a lower percentage of revenues from new products is another option. Reasons could be that the focus is more on strategic new products, i.e., the strengthening of the market position of existing products.

Position 4: To achieve a higher product innovation rate but lower revenues from new products is a further option. At first viewing such a strategy seems to be unrealistic. However, this strategy can be useful for business units that are developing strategic new products which are sold to selected customers. Although the revenues with new products decreases, the high product innovation rate shows their competence to be innovative at a high level.

It is shown that a complex view of all areas related to the product innovation position is necessary to be able to draw conclusions for taking up actions. One main point is the in-depth examination of the product innovation position (Step 4 of the guideline for managing product innovation positions strategically). For supporting an investigation of product innovation position, a set of audit questions is presented next.

9.3.3 Audit Questions

The questions within the audit are asked in two different ways. First there are questions which could be answered with yes and no. In most of the cases a yes answer implicates that the process asked for is running well. If managers have difficulties in finding an answer for the predefined questions or if a question is answered with "no", the process (or variable) asked for could be related to a low product innovation position (e.g., no defined NPD project management processes could not be related to low product innovation rates). Further, open questions are given. These questions ask to think about specific aspects which are related to product innovation position. The current research project has shown, that only a complex view of all areas (given in the modified Cooper and Kleinschmidt model) makes it possible to use the product innovation position as a management tool for managing product innovation activities strategically.

The audit questions for a systematic investigation of the product innovation position are given in Table 9.1. Questions are asked about the product innovation position and the product innovation output variables. Further, questions were asked of the three key drivers for product innovation position and the two key drivers for managing product innovation processes. First, initial questions on the product innovation strategy are asked. Then, audit questions for investigating the new product development process and corporate culture are presented. Finally questions for the area market and competition are asked.

Although the findings are based on a suitable dataset of 78 business units (Phase 2) and the analysis of 11 case studies (Phase 3), it was shown that research activities into product innovation positions is a very complex undertaking. Consequently, the research has some limitations which are given in the following section.

Table 9.1: Audit Questions for a Systematic Investigation of Product Innovation Position

Product Innovation Position and Output

- What is the actual product innovation rate?
- What is the actual percentage of revenues from new products?
- How much profit is gained from existing and new products? Are the profits from existing and new products in line with the actual product innovation strategy?
- What is the actual business unit growth? Is a relationship with the product innovation position given?

Business Unit

Product Innovation Strategy

- What is your product innovation strategy or combination of product innovation strategies (i.e., product development, diversification, market penetration or protection building)? Is it in line with your general strategy?
- Is it clear why new products are developed (e.g. for strengthening existing products or for replacing existing ones)?
- Is both familiarity (i.e., familiarity with product type, markets and technologies of existing and new products) and synergies (i.e., synergy of product innovations with existing production technology, marketing skills and resources) given for your new products?
- How are the investments into R&D? Is the relationship of investments and the number of developed new products balanced?
- Overall: Is the actual product innovation strategy reflected in the actual product innovation position? Is it necessary to change the actual product innovation position?

New Product Development Process

- Are NPD processes defined (or laid down) and is the given framework converted into action?
- Are interdisciplinary NPD project teams installed?
- Are different departments, customers or suppliers involved into NPD projects?
- Is the percentage of NPD projects with delays justifiable? Are enough resources given to carry out NPD projects on time?
- Are the reasons for the percentage of cancelled NPD projects based on strategic reflections or on difficulties in the NPD process?

Corporate Culture

- How is the information transfered between the departments organised? Is it guaranteed that information (i.e., ideas) for new products is used? Is there a mixture of ideas for new products from inside and outside the business unit?
- Is there a common understanding (definition) of what a new product is?
- Are product innovation aims known by all employees?
- Are all employees involved in the generation process for developing new products? Are there innovation circles installed?
- Is there a living culture for product innovation? Is it allowed to make mistakes and is there an experimental environment?
- Is the commitment to product innovation given by the board of management?

Market, Competition

- What is the product life cycle in your industry? Does it have an influence on your product innovation rate?
- What is the market share of the three biggest competitors?
- What is the market growth per year? Do you have a faster growth than the average in the industry sector?
- How is product innovation seen by your competitors? Do you know their product innovation rates and percentages of revenues from new products?
- Are there any economical factors with influence on your product innovation rate (e.g. laws)?
- Are the market entrance barriers for new competitors really high?
- How is the stream of new products? Does it have an influence on product innovation rate?

9.4 RESEARCH CONCLUSIONS

Research of the product innovation position on business unit level is not common. Consequently, no study in the product innovation literature was identified investigating this topic with in-depth studies. Additionally no published data about the relationship of product innovation rate and the percentage of revenues from new products were found. Therefore, this study helps to increase the knowledge about key drivers for varying product innovation positions.

Based on the recommendation for researchers (Section 9.2) and recommendations for managers (Section 9.3) this section presents the research conclusions in a more general way, starting with the contributions of the research

9.4.1 Contributions of the Research

Overall, the research made following main contributions which have already been discussed in the chapters above. These are:

- It showed that the conclusions, based on the analysis of quantitative data do not show all facets of product innovation position. Both researchers and managers need to be aware of the limitations based on decisions of surveys (e.g., product innovation position is not related to the performance – profits – of business units).
- It made a first qualitative analysis of how business units manage their product portfolio of existing and new products and their percentage of revenues from new products.
- It investigated the key drivers for product innovation position and showed that a lot of interrelationships between different areas exist. This will help managers to understand how decisions in one management area are related to other areas, too.
- Starting from a simple diagram (the diagram product innovation rate and the percentage of revenues from new products), a more comprehensive way in which product innovation could be evaluated at a business company level was tested. As a result the Cooper and Kleinschmidt model was modified. The management of several case companies visited will use this approach for monitoring their product innovation activities (i.e., their product portfolio) systematically.
- It showed that the research design can be used for investigating product innovation positions in different industry sectors. The test in two industry sectors showed no difficulties in using the chosen framework in the engineering and E&E engineering sectors. Consequently a transfer into other industry sectors would be possible.
- It offered a framework of how product innovation position could be evaluated in a systematic way. The basis of this framework is an in-depth analysis of the key drivers identified for managing product innovation position. The analysis of these key drivers could form a basis for further investigations into the drivers of the product innovation position.

Based on the contributions identified, the implications of the research are given next.

9.4.2 Implications of the Research

As stated earlier, the literature review showed that product innovation position was not investigated in depth in earlier studies. As no experience of the research into this topic was given, a research design, running over three phases was developed and carried out. Phase 1 and 2 used a survey approach and in Phase 3 case studies were carried out. Consequently for each of the research methods implications are given. It has to be noted that some of the given implications are given in the sections above but are not discussed in detail.

Implications of the surveys

The key result of the survey was that product innovation rates are difficult to measure via mail surveys, because managers have different views of how new products are defined. Surprisingly, this is the case although the degree of product innovations is described in detail and an example is given in the questionnaire[93]. Consequently, data about innovation rates collected via mail surveys are not valid and can not be used in research projects. The research found that telephone interviews or case studies need to be carried out to get valid data.

Further, it was found that product innovation rate is no common variable for monitoring product innovation activities. Some managers interviewed in the telephone interviews mentioned that they had never measured this variable. Additionally some were confused about the definition of product innovation rate. The managers pointed out that often the product innovation rate is defined as the percentage of revenues from new products which was seen as a common variable. Therefore the definition used for measuring product innovation rate needs to be clearly communicated.

As stated earlier, one further key result was that the statistical analysis of the relationship between product innovation rate and the percentage of revenues from new products do not lead to results which can be used by managers. Although a correlation of more than 50% is given between the two variables, no recommendations for managers are possible. The reason is that many companies do not follow this regularity and operate with low or high product innovation rates but high and low percentages of revenues from new products. These business units operate with their individual product innovation position over a long time. As these business units seemed to operate in a competitive way in their markets, the conclusion that higher product innovation rates are related to higher percentages of revenues is not given.

Implications of the interviews

The case study visits showed that the diagram product innovation rate and percentage of revenues from new products is a good instrument for starting an in-depth discussion of product innovation strategy. In the discussion of the variables product innovation rate and percentage of revenues from new products it was found that some managers had problems with the definition of what a new product is. Although the definition itself was clear, they had difficulty in transferring the definition on their own products. Consequently, in some cases the product lists were discussed in detail to check if the

[93] The reworked survey questionnaire is given in Appendix D

variable product innovation rate is valid. This finding shows that the product innovation rate needs to be discussed intensively with managers to get a valid dataset.

As research into the reasons for varying product innovation positions is very complex all areas of the Cooper and Kleinschmidt were discussed with the managers. In the structured questionnaire (refer to Appendix E) the areas of their model were operationalised into qualitative and quantitative questions. Because of the complexity of the data the two page questionnaire with quantitative data was sent one week in advance of the interview to the business units. This procedure was identified as being useful, because in the interviews more time could be spent on discussing the variables intensively. Because some managers had set a limited time window for the interview, the time spent together was used more effectively.

One further finding in the interviews was that different respondents within one business unit have different viewpoints on their product innovation activities. In one business unit the MD stated that they are very innovative and new products are a key to staying competitive. In contrast the R&D manager of this business unit was more critical and gave detailed insights into the problems in their product innovation strategy from his viewpoint. In other cases the R&D managers and MMs qualified the statements of the MDs more precisely. Although this finding was made in earlier research studies, too[94], it is seen as an important implication that it is necessary to interview managers from different departments.

One difficulty in the interviews about different aspects of product innovation strategy was to keep the interviewees on track. Although questions were asked on the basis of a structured questionnaire some managers digressed. Especially MDs tended to explain their product innovation activities in all facets. Consequently, the researcher was forced to guide the interview in a very structured way. However, as in the interviews the managers did not wanted to be snubbed, this was no easy undertaking. It has to be noted that after the half of the interviews the researcher developed a routine to guide the interviewees.

The implications of the research are closely related to the conclusions on the research design which are discussed next.

9.4.3 Conclusions on the Research Design

The research combined the two methods of survey and case study to investigate the key drivers for varying product innovation positions. The framework of the research was the dataset International Best Factory Awards Germany[95]. Most of these business units were willing to take part in the current research activities and were very interested in the results. Consequently, they were regularly informed about publications or presentations at conferences.

[94] The necessity for interviewing different informants is recommended in Table 4.12 (Validity in the Strategy Field).

[95] The international Best Factory Awards German are presented in Chapter 4 in detail (Section 4.3.3 'Sample').

The systematic analysis of case business units from the dataset International Best Factory Awards allowed detailed answers to be given on the research questions. The research questions were identified in a structured way from the analysis of the product innovation literature (refer to Chapter 2). After carrying out the research project, this is still seen as a good method for identifying the gap of knowledge. Further, the variables investigated are selected in a structured way. As the product innovation literature offers a lot of different variables, only the most common are selected. It has to be noted that this selection method has limitations because measures which are not used very often could be useful ones, too.

In Phase 2 of the research a method was developed as to how to select cases in a structured way from the diagram product innovation rate and percentage of new products. Although the offered method by separating the diagram with the median lines into four fields seems not to be a challenge, it needed plenty of time to identify this systematic method. As this framework can be used in further research projects, the categorisation of case business units would be easier. As this framework has implications on the analysis of data, too, a more efficient data analysis will be possible in future research studies. Especially the combination of quantitative and qualitative data by using the diagram product innovation rate percentage of revenues from new products was helpful for identifying the key drivers of the product innovation position (refer to Figures 7.8, 7.9, 7.10, 7.11).

One important finding in the current research project was the identification of interrelationships between variables from different areas. These interrelationships are important to be understood by managers, because decisions in one area (e.g., product innovation strategy) have implications on other areas (e.g., corporate culture). The method as to how the relationship between different variables are identified was presented in detail. Looking back, the given framework is seen as a good method to present the interrelationships between variables. It is expected that the way on how the interrelationships are presented will help managers to mange their business units in a more effective way (refer to Table 7.19 an 8.1).

As the current research project was the first one which investigated the product innovation position some steps in the research design were necessary which would not be repeated in a further study. At the beginning of the research it was not clear what the key drivers for product innovation are. As no tested model was identified in the product innovation literature with a focus on product innovation position, all areas given in the Cooper and Kleinschmidt were investigated. This complexity led to a huge number of qualitative and quantitative data which was not easy to analyse. First, two to three case descriptions for each business unit were written (refer to Appendix B). In addition to the case description an overview of the quantitative variables is created (refer to Appendix B, Table 2). Finally, the key drivers identified are summarised in tables divided into the four fields of the diagram product innovation rate and percentage of revenues from new products (refer to Appendix A). A helpful tool for analysing the data without losing the overview was the summary of the key answers of the case interviews in a plan (1.50m x 2m). Because of this complexity the number of case business units should be reduced in further research studies.

Overall it is felt, that the research design of combining surveys and case studies functioned well. However, as one main finding was that product innovation position needs to be checked via telephone interviews or case studies, Phase 1 would not be repeated in a further research study. Further, Phase 2 would be reduced on the collection of a valid number of product innovation rates and percentages of revenues from new products for the selection of case companies. A statistical analysis of the survey data would not be carried out because no managerial conclusions can be created from such an analysis. Additionally, in Phase 3 the reworked model of Cooper and Kleinschmidt (with less areas in comparison to their original model) would be used for investigating the product innovation position. In other words: a reworked research design would be more focused and concentrated on the three key drivers identified.

The main conclusions of the research are based on a systematic analysis of the findings. However, the case study visits showed that the key drivers identified need to be embedded into a broader context which is discussed next.

9.5 RESEARCH CONCLUSIONS – AN ALTERNATIVE VIEW

This analysis has, up until now, followed a strictly scientific approach. Therefore, research questions and a suitable model for investigation into product innovation position were identified from the product innovation literature. Then, variables were selected in a systematic way from the product innovation literature. However, the interviews with managers from the business units provided a lot of ideas about the broader context of the research.

In order to show the broader contributions of the research, hypotheses have been developed. In evaluating research, Dane (1990) pointed out that "inductive inferences cannot be proved as true, but we need to use them to construct theories until we have evidence to the contrary". Consequently, an inductive view is necessary to recognise the full contribution of the research. Therefore in this section the implications into other management areas are discussed, starting with the broader contributions of the research.

9.5.1 Broader Contributions of the Research

The interviews within the case business units showed that the variable product innovation position has no common measure. Especially product innovation rate (defined as the percentage of new products in the product portfolio which are less than three years old) is not widely be used by managers. Further, it was found that the three key drivers for varying product innovation position identified have many interrelationships. As there are many interrelationships between these areas it could be assumed that there are other interrelationships, too.

Based on the results of the current study, theories for following areas were identified:

- Management: One business unit used a high product innovation position for building up an own product line. With these new products they became independent from wage production. Based on this, finding new products can be seen as a possibility for building up an own market position and to act as an independent company.

- Supplier Management: As there is a tendency to integrate suppliers into the NPD process, it will be important for companies to chose the "right" partner. In order to do so, product innovation position can be used as an criteria for selecting suppliers systematically.
- Marketing: The relationship of existing and new products and their contribution to the success of companies (i.e., profit) is still not widely understood by managers. Consequently, a systematic analysis of the product portfolio will help them to increase their competitive position further.
- Sales: As the relationship of existing and new products is not clear for management, the sales force could have problems, too. Therefore the sales force need clear instructions on how to market the product portfolio to customers. From this finding it can be assumed that the importance of new products as a driver for staying competitive is overestimated in the product innovation literature.
- Price: As existing and new products are important to stay competitive, the price structure for the whole product portfolio need to be balanced, too. Dependent on the aims with new products prices need to be fixed individually.
- Diffusion: Existing products are necessary in conservative branches. In these branches "present" customers do not want to buy new products, because they are pleased with existing products. In other cases customers could be very innovative and a high number of existing products within the product portfolio are seen as an indicator for being uninnovative. For both customers groups a business unit's individual marketing of existing and new products is essential.

The conclusions given above show that a product portfolio with both existing and new products is important which leads to the broader implications of the research.

9.5.2 Broader Implications of the Research

The analysis of the results followed the framework given by the model of Cooper and Kleinschmidt. Therefore, only the implication identified for the given areas are discussed in detail. However, the broader conclusions presented above show that the results need to be interpreted in a broader view. Consequently the results have implications to other areas, too.

The first area for which the results have real implications is marketing in general. Dependent on the aims with existing and new products marketing activities could differ (as explained above, marketing activities could have more focus on existing products or on new products). Some business units have the aim to develop new products for strengthening their brand. As their aim with these new products is to sell their existing products more successfully this has implications to marketing activities. In such a case the sales force need a detailed understanding as to why product innovation is important and what the strategy with new products is.

In the case that new products are used as a multiplier for selling existing products more successfully, a subtly differentiated marketing strategy needs to be used. Although it is communicated that such a business unit is new product oriented, the existing product portfolio needs to be marketed, too. As both existing and new products are important to generate profits, the sales force must be clearly instructed which product should be offered to customers. For example, the sales force need to be trained for both existing and new products. Further, such a strategy has implications as to how NPD projects are carried out. If the strategy is to develop everything a customer wants, marketing studies for such products are not necessary and R&D costs are secondary. With regard to NPD project management the NPD project leader could be from marketing, because this person has the closest relationship to customers. Taking this finding into account, a close interrelationship of marketing with product innovation strategy is given.

In contrast to the example above, business units who aimed to sell highly innovative products need another marketing strategy. The current research study found that one business unit with high new products is looking for customers who are willing to pay more for innovative products and are willing to take into account minor mistakes in the first series. To identify such customer groups it will be necessary to communicate that the products developed are unique. Consequently, all marketing activities (e.g., advertisement, price structure) need to be brought into line with the product innovation strategy. It has to be noted that independent of product innovation position, the sales force need to be trained very well in terms of product features (e.g. technology) and product innovation strategy.

The second area for which the results have implications is supplier management in general. The selection of suppliers gets more important, because it is more common to develop new products together with (specialised) suppliers. The current research study found that for one business unit it is essential to work together with world leader suppliers. This is seen as important because they are convinced that only with such suppliers competitive new products could be developed. Further, this philosophy is clearly communicated into the market in order to emphasise their innovative approach (which is closely related to marketing, too). This implies that dependent on the actual product innovation strategy supplier management will differ. Overall, the research showed that suppliers are more often integrated into research activities of their customers. Therefore, they will need the competence to develop products, too. This in turn has implications for the purchase department. Not only the price and quality but innovation performance of suppliers play a important role, too. Consequently it will be necessary to know the product innovation position of suppliers in order to find the right partner for operating in the market.

In addition to the broader implications of the research the practical value of the research is presented next.

9.5.3 Practical Value of the Research

The results enable a number of practical recommendations to be made for managing the product innovation position on business unit level. These are:

- Monitor the product innovation position systematically in order to clarify the strategic aims with the actual product portfolio (refer to Table 9.1).
- When managing product innovation position, consider the interrelationship of different areas. Taking into account the interrelationships of marketing and supplier management which are not investigated in-depth in the current research study.

- Be aware that new products can be used as a multiplier for selling existing products more successfully.
- Measure product innovation variables (e.g., the profits with new products) in order to be able to manage product innovation strategy. Use the data to compare the actual product innovation strategy with the strategy planned (refer to Table 4.3).
- Compare the actual product innovation position with the estimated position of direct competitors in order to identify the own unique selling preposition (USP).
- Promote the right mix of existing and new products to gain a competitive advantage.

As stated earlier, the results have broad implications for normal (non-high-technology) business units. The empirical data demonstrate that the balance between existing and new products is a key for success. Surprisingly it was found that most business units do not manage their product portfolio systematically. One further finding was that the percentage of revenues with new products is no indicator for competitiveness. This is a particularly valuable result, because most of the product innovation literature with focus on the industry sectors engineering and E&E engineering demand the importance of high revenues with new products.

As the research is very complex some limitations need to be taken into account, which are given in the following section.

9.6 LIMITATIONS OF THE RESEARCH

The research is based on a survey of a large number of 78 business units and made 11 in-depth studies to give detailed insights into the reasons for high and low product innovation positions. Although the reliability of the dataset is high, the current results should be interpreted with caution because the investigated companies (business units) may not be representative of German industry as a whole.

Overall, the limitations identified in the current research project can be summarised as follows:

- The case study sample is restricted to the 11 business units within the engineering and E&E engineering sectors. However, the differences and similarities within these industry sectors warrant caution with regard to further investigations across industry sectors in general.
- Information about product innovation positions were gauged through one-day visits. It should be taken into account that the investigation of product innovation rates and the percentage of revenues from new products on a business unit level through interviewing the management team in one-day visits is limited. Therefore, longitudinal studies are demanded to get better insights into the reasons for varying levels of product innovation rates and percentages of revenues from new products.
- The current research project focuses on German manufacturing industry. Because management practices, cultures and norms differ around the world, these findings may be less interesting for business units in other countries.
- The current research examined product innovation rates and the percentage of revenues from new products on business unit level. To do so, different areas (according to the Cooper and Kleinschmidt model) were investigated. However, as

each of the areas is very complex (as this research project is itself) an in-depth analysis of each area was impossible. Therefore, the conclusions have to be interpreted with caution.

- For several variables it was not possible to get statistical data. For example, market share is difficult to measure. Therefore, this variable was estimated (based on own market research activities) by the business units investigated. This in turn can lead to an invalid dataset.
- The separation lines used in the diagram product innovation rate and percentage of revenues from new products are limited to the sample size. For other samples and industries, the separation lines need to be fixed through further investigations.

The limitations given above show that the results have to be interpreted with caution. However, the chosen methodology in the current study contributed significantly to the reliability and validity of the results. Therefore, the results are interesting for both researchers and managers. The summary of this chapter is given in the next section.

9.7 SUMMARY

It was shown that the whole product portfolio (including both existing and new products) is the key for making profits. Product innovation strategy was espacially identified as a (manageable) main driver for varying product innovation positions. Overall, the main findings in this chapter were:

- Product innovation position was not investigated in earlier studies: To do so the model of Cooper and Kleinschmidt was modified.
- It was found that three of 11 business units were not able to explain their position within the diagram product innovation rate and percentage of revenues from new products spontaneously. Therefore the need for managing the product innovation position systematically is given.
- The diagram product innovation rate and the percentage of revenues from new products was identified as a very good tool for starting in an in-depth discussion about product innovation with managers. Therefore a guideline for a systematic investigation of this variable was developed.
- The variables of product innovation rate and percentage of revenues from new products (product innovation position) can not be used as performance measures. Dependent on the three key drivers identified it can be low or high.
- Although existing products are the profit makers within some business units the conclusion that product innovations are not important for these business units is not given. All business units saw the mix of both existing and new products as a key for being successful in their markets.
- Additionally to the implications based on the systematic analysis of the results, broader implications were identified. The management of the product innovation position is related to the areas marketing and supplier management.
- It was shown that an investigation of product innovation position needs a case study approach. For identifying such cases, the research offered a possibility to select case business units in a structured way. The basis is the diagram product innovation rate and the percentage of revenues from new products which is divided into four fields with the median lines.

Although some limitations were identified, the research contributed significantly to reliability and validity. It is hoped that the conclusions of this research will find practical applications and lead to improvements in the management of the product innovation position. In order to give an overview on the whole research, a summary of the main findings is given in Chapter 10.

CHAPTER TEN

RESEARCH SUMMARY

10.0 INTRODUCTION

This chapter summarises the results of the current research project which investigated product innovation positions in German manufacturing business units in the two industry sectors engineering and E&E engineering. It ran over three phases. Phase 1 of the research showed an error in measuring product innovation rate. This error was corrected in Phase 2 of the research. Based on the corrected dataset 11 case business units with both low/high product innovation rates and low/high percentages of revenues from new products were selected. These 11 case business units were investigated in order to show the reasons for their individual product innovation positions.

The main characteristics of the current research project were:

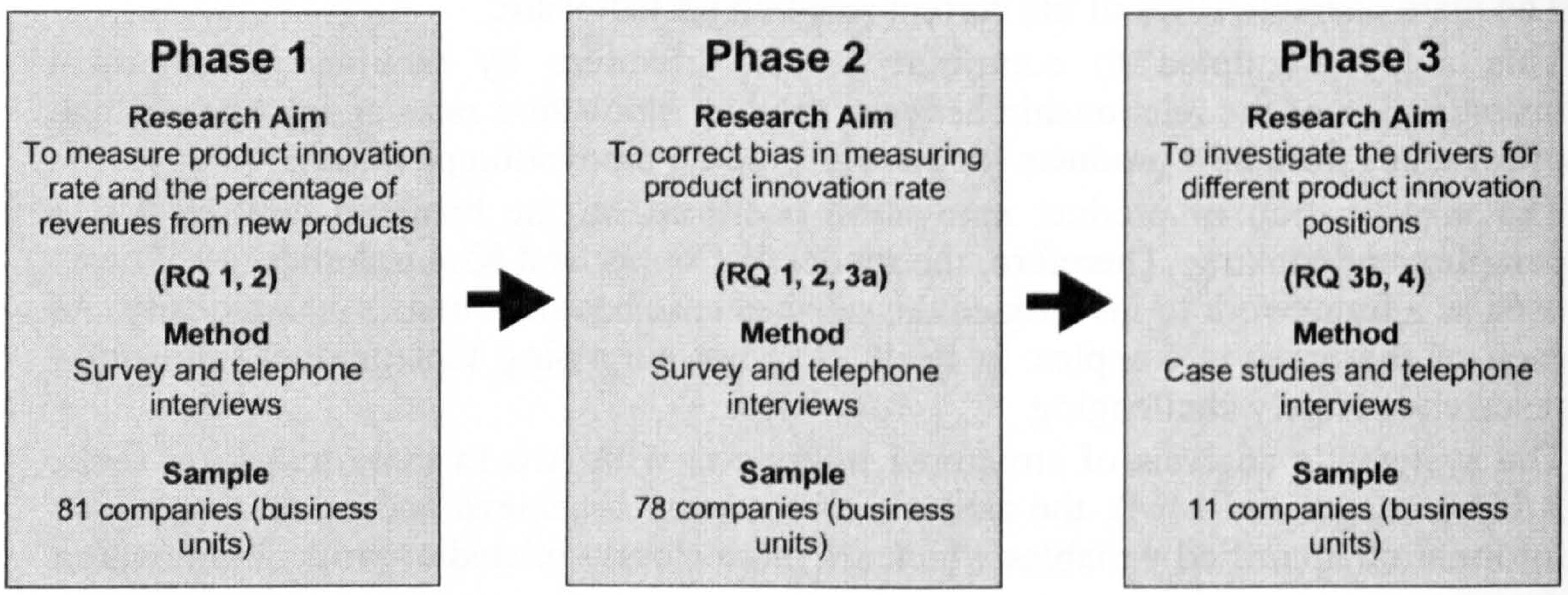
- This study attempted to contribute to the literature by making an empirical investigation of the relationship between product innovation rates and the percentage of revenues from new products (defined as product innovation position).
- The investigation of product innovation positions on the business unit level is a complex undertaking. Therefore, the model of Cooper and Kleinschmidt (1993) was used as a framework to investigate the selected case business units systematically. As each of the areas is complex in itself, it is not surprising that product innovation research is hugely challenging
- The systematic analysis of structured interviews with two to three managers (MD, R&D manager and MM), the analysis of company brochures and other sources for information identified variables which are more closely related to product innovation position.
- Validity issues were taken into account systematically – these are validity in the strategy area, constructive validity, internal validity, external validity and reliability. Therefore, the findings contribute significantly to theory and methodology.
- Based on the findings of three key drivers for product innovation position (market, competition, product innovation strategy) and two key drivers for managing product innovation processes (NPD project management, corporate culture) a framework was developed for managing the product innovation position systematically.

This chapter is separated into seven sections. First, a summary of the structure of the project is given. Then, an overview over the main findings is presented. In the third section the contribution to knowledge is summarised. Implications of the research to theory and methodology and implications for practising managers are given in sections four and five. In the sixth section new areas of research are presented. The last chapter ends with a final word.

10.1 SUMMARY OF THE PROJECT

The research investigated the reasons for varying product innovation positions (defined as the relationship between product innovation rate and the percentage of revenues from new products). This was carried out by an investigation of German manufacturing companies in the two industry sectors engineering and E&E engineering. Because of the complexity of product innovation at a company level, the research focused on a more comprehensible level – the business unit level. The whole dataset was based on the database International Best Factory Awards Germany. Overall, the research ran over three phases (Figure 10.1). Phase 1 and 2 (given in Chapter 5 and 6) and were necessary to get a valid dataset of product innovation rates for a suitable set of business units. Based on this dataset it was possible to select case business units in a systematic way and to carry out case studies in Phase 3 (given in Chapter 7).

Figure 10.1: Overview of the Three Phases of the Research



To address the complexity, the study combined two approaches – survey and case study research. It was shown that such an approach was necessary to get valid data for the variable product innovation rate and to get insights into the reasons for varying product innovation positions. Further, it was shown that to understand the reasons for different product innovation positions, a detailed understanding of how business units operate in their market and what their strategy with new products is needed.

It was shown that product innovation position is influenced by the interaction of areas from business environment (market and competition) and management (product innovation strategy). Further, the NPD process and corporate culture were found as key drivers for the development of new products. It has to be noted that because of the complexity, no in-depth analysis of each of these areas was possible. Therefore, one aim of the current research project was to show the linkages between product innovation position and its relationship to profits, break-even-point, stream of new products and business unit growth. This approach itself is hugely challenging and led to results which are particularly new.

10.2 SUMMARY OF THE FINDINGS

As stated above the research was divided into three phases. Each phase had a different research aim and therefore the methods of survey and case study were used in order to find answers to the research questions. A summary of the answers to the research questions are given in Table 10.1. As the main aim of the current research project was the explanation of varying product innovation positions (RQ4), the results on this question are presented in detail in Figure 10.2. In the figure the reasons for varying product innovation positions are presented for the four fields (Field 1 a,b and Field 2 a,b) within the diagram product innovation rate and percentage of revenues from new products.

Before beginning the presentation of the results on the research questions, the summary of more general findings is presented. The research showed that product innovation positions are related to a broader context. The main findings going in this direction are:

- As three of eleven case business units had difficulties in explaining their product innovation position spontaneously, the need for a systematic monitoring is given. (a guideline for managing product innovation position systematically is given in Section 9.3.1).
- The product innovation position needs to be investigated with case studies. The first reason is that managers have difficulties in defining the degree of product innovation and therefore surveys lead to wrong results. The second reason is that the analysis of (valid) survey data does not show the complexity of drivers for varying product innovation positions.
- The (simple) diagram product innovation rate versus the percentage of revenues from new products was identified as an effective instrument of starting an in-depth discussion of the (complex) topic product innovation strategy with managers.
- New products can be developed for showing innovativeness and strengthening of the brand. Companies who follow this strategy have a stronger focus on selling existing products than new ones.
- The research investigated the key drivers for the product innovation position and showed that a lot of interrelationships between different areas exist.
- Additionally to the interrelationships of the areas given in the reworked model of Cooper and Kleinschmidt the results have implications on marketing (e.g., marketing of existing and new products) and supplier management (e.g., the selection of suppliers and integration into R&D activities) in general.

Table 10.1: Overview of the Findings

Research Question	Findings	Notes
RQ 1 What are the typical product innovation rates of business units in the German engineering and electrical & electronics engineering (E&E engineering) sectors?	• In summary, valid data for 78 business units (57 from engineering and 21 from E&E engineering) were collected (sample size Phase 2). • On average business units have a product innovation rate of 11.4% (engineering 10.6% and E&E engineering 13.5%).	Valid data can only be gained with a combination of survey and telephone interviews.
RQ 2 How are product innovation rates and the percentage of revenues from new products related (defined as product innovation position)?	• On average business units achieve 30.7% revenues from new products (engineering 28.3% and E&E engineering 37.2%) • For the whole sample size (Phase 2) the correlation coefficient between product innovation rate and the percentage of revenues from new products is given with 66%. For engineering it is 59% and for E&E engineering it is 76%. However, there are business units which do not follow this relationship. On the one hand, there are business units with low product innovation rate but respectively high revenues from new products. On the other hand, some business units with high product innovation rate earn a low percentage of revenues from new products.	Although surveys show a relationship it was found that a case study approach is necessary to explain the relationship of both variables.
RQ 3a, b How are product innovation positions and profits (profits from the whole product portfolio and profits from new products) related?	• Phase 2 found that on average higher profits (from the whole product portfolio) are related to higher product innovation rates for business units from E&E engineering (the highest profits are given in Field 2b). For engineering no regularity was found. • Phase 3 of the current research project showed that (independent from product innovation position) two business units earn more from new products than from the whole product portfolio. All other business units earn less or similar profits with existing products. This implies that profits from new products are related to the individual product innovation strategy.	Profits from new products were not measured by most of the business units investigated.
RQ 4 Why do different manufacturing business units in the industry sectors engineering and E&E engineering act with different product innovation rates and why do they achieve different percentages of revenues from new products (i.e., why they act with different product innovation positions)?	• Three key drivers related to product innovation position were found. These are market, competition and product innovation strategy. Additionally two key drivers for managing product innovation processes – NPD management process and corporate culture – were found. • The five key drivers were operationalised with 26 variables. From these variables eight are related to product innovation position and two to the management of product innovation processes. Overall the case study visits showed that product innovation position is closely related to the context (i.e., the key drivers are related to each other). • Dependent on the individual product innovation strategy business units choose the most appropriate product innovation position (low or high) to operate in their markets. This finding implies that a low product innovation position is not automatically related to a low innovativeness (i.e., a low number of new products developed).	To get answers for varying product innovation positions a case study approach is necessary. Surveys are not suitable for giving answers to this question.

Figure 10.2: Drivers of Product Innovation Position

Revenues from New Products (%)	Field 1 (Low)	Field 2 (High)	
100	• Low product innovation rate but high revenues from new products can be based on how a living product is defined. One business unit counted all spare parts which they have to produce for their customers because of long term contracts. Therefore, they have a high number of existing products within their product portfolio. This in turn led to a low product innovation rate. However, 80% of their turnover is made with about 16% products from their whole product portfolio. From this reduced product portfolio 79% of the products are less than three years old. This is the reason why they achieve high revenues with new products on basis of a low product innovation rate. • A high percentage of revenues can be achieved with some few new products. The strategy of one business unit – because of limited financial resources – is the focus on some few products. With these few new products they aim to generate a high percentage of revenues.	• For business units with both high product innovation rates and a high percentage of revenues from new products their product innovation position is directly linked to their product innovation strategy (e.g., technological leadership). The managers of these business units are convinced that with a high product innovation rate higher profits (in comparison to their direct competitors) can be achieved. • For one business unit their high product innovation rate and high percentage of revenues from new products is is related to their concentration on new markets. 10 years ago, they decided to decrease the dependency upon wage-production and to produce own new products. • Because of very short product life cycles two business units have the strategy to replace most of their existing products by new ones. Consequently the number of existing products within their product portfolio is low and most of their revenues are generated by new products.	Field b (High)
0	• One reason for both low product innovation rates and low percentages of revenues from new products could be a low commitment of the board of management to product innovation and a strong concentration on existing products (because of long product life cycles). For one business unit the development of variants is more important than the development of new products. • A low product innovation position is not automatically related to a low number of new products developed. Because of very long product life cycles one business unit has a big product range but a high number of new products, too (which is related to a low product innovation rate). Their main aim is to sell their existing products more successfully. However, they are convinced that the only possibility to do this is to develop many new products, too. These new products are produced in a low quantity to show innovation competence to their customers. Therefore, the percentage of revenues from new products is low.	• High product innovation rates but a low percentage of revenues can be based on the development of strategic new products. Although one business unit has the strategy to become cost and world-market leader, new products are sold in low numbers. The reason is that their market is very conservative. Consequently, the revenues from existing products are higher than the revenues from new products. • A further reason for high product innovation rate and low revenues from new products is the three years time window used for the calculation of product innovation rate. For one business unit their revenues from new products regularly come later than three years after product launch. The reason is that their new security products are tested by selected customers for a longer time period. Consequently, their percentage of revenues from new products is low.	Field a (Low)
	0	Product Innovation Rate (%)	33

10.3 CONTRIBUTION TO KNOWLEDGE

The current research project is a systematic investigation of product innovation positions at the business unit level. Because of the complexity, research in this area is not common. As pointed out earlier, research activities in this direction were strongly recommended by several researchers such as Liversay et al (1996), Schoonhoven and Jelinek (1997), Griffin (1997a), and Terwiesch et al (1998). The literature review has shown that previous researchers mainly focused their research activities on the number of product innovations without taking the whole product portfolio into account (e.g., Zarah, 1993b; Wakasugi and Koyata, 1997; European Commission, 2001b; OECD, 2000). This gap was closed by the examination of the reasons for different product innovation rates (i.e., the relationship of new products and existing products) with an in-depth analysis of case studies. Further, the reasons for varying levels of percentages of revenues from new products was investigated systematically. Although revenues from new products is a common variable in product innovation studies (e.g., Firth and Narayanan, 1996; Brennecke, 2001), the reasons why business units achieve different percentages of revenues from new products has not previously been investigated with in-depth studies, either.

The findings of the research are interesting for both researchers and managers. For researchers it is important to know the key drivers for product innovation position and how the variable product innovation position can be measured and used in further research projects. For example it was shown that product innovation rate does not show how innovative a business unit is. Additionally it was revealed that an investigation of product innovation positions is helpful for investigating the context of different variables. For managers an explanation of different innovation positions is given. It was explained, that independent from industry sectors, product innovation position can be used as a variable for managing the product portfolio systematically. Further, it was found that an efficient NPD process and a corporate culture for product innovation is necessary for developing new products but does not help to optimise the product portfolio (i.e., the relationship between existing and new products). Therefore, knowledge about the way variables are related to product innovation position makes it easier for managers to find their "optimal" product innovation concept to stay competitive.

10.4 IMPLICATIONS TO THEORY AND METHODOLOGY

Based on the actual findings, this section presents the implications to theory and methodology.

The implications for theory are:

- The variables product innovation rate and percentage of revenues from new products are mainly related to market, competition and product innovation strategy. Therefore they can not be used to measure product innovation performance on project level.
- The research showed that individual product innovation variables are related to the context. Therefore an isolated view on product innovation variables (e.g., product life cycle) could lead to wrong results. A framework of how product innovation variables are related to each other is offered in the current research.

- The research showed the complexity of product innovation within manufacturing business units. A framework (i.e., the reworked Kleinschmidt and Coooper model) was offered to handle this complexity.
- The research helps to understand product innovation positions in the German manufacturing industry. Although only two industry sectors were investigated, the results are transferable to other industry sectors.

The implications for methodology are:

- The research used a combination of survey and case studies. This combination is unusual and demonstrates the tyre of contribution to innovation research that combined techniques can make.
- Product innovation rate is difficult to measure because managers have no common definition of what a new product is. For example, the mixture of main products and variants can lead to invalid data. To get valid data, the whole product portfolio and the degree products have to be discussed with managers. Therefore, researchers have to qualify such data by carrying out case studies.
- The research developed a method of selecting business units for innovation case studies in a systematic way. This approach contrasts strongly with the opportunistic or reputation-based selection of cases prerelevant in innovation research.
- A significant dataset from the survey (78 business units in Phase 2) and rich case study data (11 case studies in Phase 3) were used to answer the research questions. Such a dataset seems to be useful to generalise the findings.
- Product innovation rate and the percentage of revenues from new products (product innovation position) is not related to the innovativeness of a business unit. It is shown that both variables are related to market, competition and product innovation strategy. Therefore product innovation rate and the percentage of revenues from new products have to be used carefully in benchmarking studies.

Several limitations to this research should be kept in mind when applying the results, to either what a business unit might want to change within their product innovation position or to future research projects. Although the reliability of the dataset is high, the current results should be interpreted with caution because the investigated business units may not be representative of German industry as a whole. Further, it should be taken into account that the investigation of product innovation rates and the percentage of revenues from new products on business unit level through interviewing the management team is limited. Nevertheless, the chosen methodology in the current study contributed significantly to the reliability and validity of the results.

Although the current research project identified a need for managing the product innovation position, this was not seen as general. The implications for managers are given in the following section.

10.5 IMPLICATIONS FOR PRACTISING MANAGERS

The management of product innovation is complex. However, with a detailed understanding of all areas related to the actual product innovation position, competitiveness can be increased. Overall, the implications for practising managers are:

- Managers need a detailed understanding of their actual product innovation position and how it relates to their strategy. As the factors with influence on the product innovation position are diverse they need a broader view.
- Managers must move away from concentrating their product innovation activities on specific management areas as NPD project management. The current research project showed that all areas given in the modified Cooper and Kleinschmidt model need to be managed in order to achieve the most appropriate product innovation position.
- As it is possible to manage only such variables which are measured regularly, managers need to be aware of such variables.

As pointed out above, the evaluation of the product innovation position needs a detailed understanding of the relationship of many variables. To make it easier for managers to handle the complexity of product innovation a framework for managing the product innovation position was developed. Further, an innovation audit was offered where key questions are given.

10.6 NEW AREAS FOR RESEARCH

Although the research concentrated on specific research questions the complexity was difficult to handle and presents a challenge in further investigations. Therefore, the following areas for further examinations are recommended:

- In further research projects the focus should be on the company or holding level. The challenge in this case is capturing of the complexity of different products from different business units which are operating in different industries. This in turn increases the complexity even more. However, such an investigation is helpful to show if the suggested framework for managing the product innovation position is applicable in other sectors.
- Research into product innovation has to move from the investigation of highly innovative and "famous name" companies to the investigation of more "normal" ones – these business units are the basis of national economies all over the world. Therefore, it is important to offer them possibilities of improving their innovativeness too. To do so, it is important to show them how they can manage their product innovation positions. Therefore, more case studies in this direction are demanded.
- Service innovations will become more important in the future. Therefore, manufacturing companies are forced to combine both new services and new products. This was recommended by several managers in the current research who demanded a broader view of innovation. Taking these statements into account, the framework of the current study should be transferred to service innovation too. It would be interesting to investigate how the mixture of both product and service innovation rates are related to innovation output variables (e.g., profits and company growth).
- The relationship between product innovation rate and the percentage of revenues from new products (defined as product innovation position) seems to be a very good variable which can be used in a balanced scorecard (Kaplan and Norton, 2001). This should be proved by both managers in their practical work and by researchers in further research studies.

New areas for future research projects are diverse. However, as pointed out earlier, the main challenge of research into product innovation positions is its complexity.

10.7 A FINAL WORD

The main findings of the research for companies (business units) is that product innovation rate and the percentage of revenues from new products is dependent upon three key drivers. Market, competition and product innovation strategy have a strong influence on the mixture of existing and new products within the product portfolio and the percentage of revenues earned with these products. The findings that two further drivers need to be taken into account for investigating product innovation position (NPD project management and corporate culture) shows the context of these areas. Overall, business units perceived their product innovation position as their best way for staying competitive. This implies the following actions:

- Managers should have an integrated view of their product innovation activities. The current research project offered a method to take such an integrated view.
- Product innovation research has to move from the investigation of specific self-contained areas (e.g., NPD project management) to more research on the relationships between such areas.
- Because of the complexity of product innovation at a company level, only a case study approach leads to a detailed understanding of the reasons for varying product innovation rates and percentages of revenues from new products. As research of product innovation at a company level is not common, more case studies are needed.

Although product innovation has been investigated by many researchers, this topic is still challenging. Especially research activities at a company level have to be intensified. As for business units services get more important, the relationship of both product and service innovations should be investigated in future studies. The current research project offered a method as to how such investigations could be carried out systematically.

ACRONYMS

ACRONYMS USED IN THIS THESIS

BU	business unit
CAD	computer-aided design
DIW	Deutsches Institut für Wirtschaftsforschung
E&E	electrical and electronic
EU	European Union
HRM	human resource management
IBFA	International Best Factory Awards
Ifo	Institut für Wirtschaftsforschng e.V.
IR	Innovation Rate
ISO	International Standard Organisation
M	million
MD	managing director
MM	marketing manager
n	number
NP	new product
NPD	new product development
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
QFD	Quality Function Deployment
R&D	research and development
RQ	research question
SME	small and medium enterprises
USP	unique selling preposition
ZEW	Zentrum für Europäische Wirtschaftsforschung

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APPENDIX A

KEY DRIVERS OF PRODUCT INNOVATION

As the case data (Phase 3) are very complex for each business unit, the key drivers for both product innovation position and product innovation processes are given in Table 1 and 2. In the tables the data for business units from engineering are given with white columns and business units from E&E engineering are marked with grey columns.

Based on these findings a systematic cross-case analysis is carried out which is presented in Chapter 7. The detailed case study descriptions are given in Appendix B.

Table 1(a): Key Drivers of Product Innovation Position

Product Innov. Position		Bus. Unit	Key Drivers of Product Innovation Position
Low Product Innovation Rate	Low Percentage of Revenues from New Products	BU1	*Market* • Because more than 50% of their products have a life cycle of more than 15 years, they have a huge product portfolio. However, they are also highly innovative. *Product Innovation Strategy* • According to the definition of Johnson and Scholes they have a combination of four different strategies: Product development, diversification, market development and protection-building. • The mixture of the four different strategies is reflected in their product portfolio including both many existing and new products. With 1600 living products they have a wide product range to offer solutions for every packaging problem. As they offer solutions for every packaging problem, the number of new products (269) they introduced over the last three years is high, too. However, because of their huge product range the ratio between new and existing products is very low. • For developing a high number of new products they invest 6% of their revenues into R&D activities. Most of these investments are necessary for tool construction. • Most new products are strategic product innovations for specific customer demands (produced in low volumes) – these new products are used as a multiplier to sell their existing products. This is the reason why they are well known as a specialist to offer solutions for every packaging problem. • In general, they do not look at profits for their new products. Therefore, they do not achieve high revenues with new products.
		BU2	*Market* • Because the life cycle of their products is between five and 10 years, they have a huge product portfolio with many variants. *Competition* • They are market leader (and are well known) in Europe. This in turn allowed them to sell their existing products successfully. *Product Innovation Strategy* • According to the definition of Johnson and Scholes they have a combination of three different strategies: Product development, diversification and protection-building. The fact that they do not have strong concentration on the development of new products is shown in their product portfolio. 80% of their product innovation activities focus on product improvements. As these new products are not counted as main product innovations in the terms of the given definition, their product innovation rate is low. • Their investment into R&D activities are expected to be 2% to 3% lower than investments of their direct competitors. • Because of their small size, they concentrate on the development of some few products. Additionally the board of management do not see the necessity of developing too many new products. • New products are an enlargement of their portfolio. With these few new products they do not achieve high revenues. The most successful product within their product portfolio is an existing one which generates 16% of their turnover. • The fact that new products are not seen as so important is shown by their well defined development process for variants.
	High Percentage of Revenues from New Products	BU3	*Market* • Because of latest technological developments, more electronic elements are integrated into their mechanical products. Therefore they need to replace their mechanical products by new ones. *Competition* • Although their main competitor is smaller, they are convinced they can only hold up their market leader position with a high permanent stream of product innovations. Therefore their strategy is to be first to market and to achieve product innovation leadership. *Product Innovation Strategy* • According to the definition of Johnson and Scholes they concentrate their activities on product development. However, this can not be seen in the variable product innovation rate. The reason is, that they are forced by their customers to supply products for a long time period (in general for 10 years). Therefore, they have a huge product portfolio where the number of their new products is low. • For developing a high number of new products they invest 7% of their revenues into R&D activities which are expected to be slightly lower than the investments of their direct competitors. • They make 80% of their turnover with only 16% of their whole product portfolio (6,162 products). With this background information the proportion of new products within this reduced product portfolio is higher. Taking the reduced product portfolio (1000 products) and their new products (790 products) they achieve a product innovation rate of 79% over three years (= 26.33% per year). • As their main focus is on product innovation they generate most of their revenue within the reduced product portfolio with products younger than three years.
		BU4	*Competition* • To develop some few new products for specific applications is seen as the most appropriate way to survive in their highly competitive market. *Product Innovation Strategy* • According to the definition of Johnson and Scholes they concentrate their activities on the two strategies product development and diversification. However, because of their financial resources they focused on a few selected NPD projects. Therefore, they achieved a low product innovation rate. • For developing new products they invest 10% of their revenues into R&D activities which are expected to be higher than investments in their branch. • Their aim is to develop new key products and to generate high revenues with these key products – with one new product they make most of their 30.5% revenue.
High Product Innovation Rate	Low Percentage of Revenues from New Products	BU5	*Market* • Because of latest technological developments, more electronic elements are integrated into their mechanical products. Therefore they need to replace their mechanical products by new ones. *Competition* • Because they are operating in a highly competitive market environment price pressure is very high. This is the reason why they are forced to develop new products which offers their customers a price advantage. *Product Innovation Strategy* • According to the definition of Johnson and Scholes they concentrate their activities on the two strategies product development and market development. They have a mix of customer oriented incremental products (for existing customers) and transformational new products including new technologies for both existing and new customers. As the number of new (transformational) products is high, they achieve a high product innovation rate. • For developing a high number of new products they invest 15% to 20% of their revenues into R&D activities which are expected to be higher than investments of their direct competitors. • Their aim is to achieve technological leadership. Therefore, they are developing new products without any actual market demand. Consequently their product innovation rate is high. However, this competence is seen as important to sell their existing products, too. This in turn is also a reason for the low percentage of revenues from new products. • A further reason for their low percentage of revenues from new products is their concentration on present customers. Therefore, market potential is limited and this in turn had influence on the turnover with new products which is not high.
		BU6	*Market* • Product innovations need more than three years to be accepted by most of their customers. As a result most of their revenues from new products come later than three years after product introduction. Therefore their revenues from new products (as defined in the current research project) are low. *Competition* • To hold up their market leadership (together with one other main competitor) they are forced to develop a permanent stream of new products. Therefore, product innovation rate is high. *Product Innovation Strategy* • According to the definition of Johnson and Scholes they concentrate their activities on the two strategies product development and diversification. Therefore a high product innovation rate is seen as essential to give world-market leadership in all product areas for x-ray security and to be active in more new business areas. • For developing a high number of new products they invest 15% of their revenues into R&D activities which are expected to be similar to the investments of their direct competitors. • Both product innovation and quality are the main aims of X-Ray Inspections. To achieve a high quality it is not possible to be innovation leader with all products. Therefore, only 40% of their products are first to market.

Table 1(b): Continued

Product Innov. Position		Bus. Unit	Key Drivers of Product Innovation Position
High Product Innovation Rate	High Percentage of Revenues from New Products	BU7	*Competition* • Although they concentrate their activities on a specific niche they have recognised that this niche gets more attractive for new competitors, too. Therefore they are forced to be innovative to hold up their actual market position. *Product Innovation Strategy* • According to the definition of Johnson and Scholes they concentrate their activities on the two strategies product development and diversification. Their strategy is to increase their turnover with own new products. As they have a strong focus on product innovation two third of their products within their portfolio are new. Although they are an old company they started 10 years ago to develop own new products (and experienced that the investments are re-paid). This consequent focus on new products led to a high product innovation rate. • For developing a high number of new products they invest 5% of their revenues into R&D activities which are expected to be similar to the investments of their direct competitors. • Because they are known to be innovative, more customers (in comparison to the past) are buying their new products. With these new products they achieve high revenues. However, many of these customers buy their existing products, too.
		BU8	*Market* • Because of latest technological developments, more electronic elements are integrated into their mechanical products. Therefore they need to replace their mechanical products by new ones. *Competition* • Although they have a strong market position in Europe and in the US, they are convinced that the only possibility to survive in the market is to have a high product innovation rate and a high percentage of revenues from new products. *Product innovation Strategy* • According to the definition of Johnson an Scholes they concentrate their activities on the three strategies product development, diversification and market development. Because they follow all three strategies with new products, the number of existing ones in their product portfolio is low. • For developing a high number of new products they invest 15% of their revenues into R&D activities which are expected to be higher than investments of their direct competitors. • Their focus is to have product innovation leadership. Therefore, they concentrate their marketing activities on their new products. With these products they generate most of their revenue.
		BU9	*Market* • Exhaust systems are influenced by environmental laws. Therefore, they are forced to develop new products with the latest technology for reducing harmful substances. • Because of latest technological developments, more electronic elements are integrated into their mechanical products. Therefore they need to replace their mechanical products by new ones. *Competition* • Their aim is globalisation through product innovation. As they have three main competitors with similar market shares, they need to be innovative to become market leader world-wide. *Product Innovation Strategy* • According to the definition of Johnson and Scholes they concentrate their activities only on the strategy product development. Because of this strong orientation on new products, they achieve a high product innovation rate and a high percentage of revenues from new products. • For developing a high number of new products they invest 6% of their revenues into R&D activities which are expected to be similar to the investments of their direct competitors. • Because they have to supply spare parts too, they still have some products in their product portfolio which are older than three years.
		BU10	*Market* • Product life cycle for most products is very short (average 3.5 years). Because of their short product life cycles most of their existing products are eliminated after the introduction of new products. As most of their products within the product portfolio are new ones, they achieve a high product innovation rate. *Competition* • Because they operate in a highly competitive market, price pressure is very high. However, with new products they are able to achieve satisfied margins. *Product Innovation Strategy* • According to the definition of Johnson and Scholes they concentrate their activities on the strategies product development and diversification. As they have the strategy to diversificate with new products, they achieve a high product innovation rate. • For developing a high number of new products they invest 17 to 18% of their revenues into R&D activities which are expected to be higher than investments of their direct competitors. • They are working together with selected customers who see the benefit of transformational and first to market products. Most of their new products are developed in close relationship to OEMs who are willing to pay for their pacemaking technologies. • All new products have the same priority and therefore the percentage of revenues from new products is high.
		BU11	*Market* • With three years, their average product life cycle is very short. Consequently their product innovation rate and revenues from new products is high. However, as some products have a life cycle of 10 years they achieve some revenues with existing products, too. • Their focus is on multinational customers within a few branches operating with high product innovation rates. This in turn forces them to develop new products, too. *Competition* • They are developing a high number of new products to avoid price pressure and to achieve good margins. Only with the ability to differentiate against the products of their competitors they have the ability to remain market leaders. *Product Innovation Strategy* • According to the definition of Johnson and Scholes they concentrate their activities on the strategies product development and diversification. As they have the strategy to diversificate with new products, they achieve a high product innovation rate. • For developing a high number of new products they invest 6% of their revenues into R&D activities which are expected to be higher than investments of their direct competitors. • They want to improve their profits with product innovations. This strong demand on product innovation is reflected in the high percentage of revenues from new products.

Table 2: Key Drivers of Product Innovation Process

Product Innov. Position		Bus. Unit	Key Drivers on Product Innovation Processes
Low Product Innovation Rate	Low Percentage of Revenues from NPs	BU1	*New Product Process* • They have installed a R&D department and they have standardised NPD processes. New products are developed in interdisciplinary NPD project teams. • They have installed a structured idea generation process. This is closely related to their corporate culture to generate ideas within employees power. *Corporate Culture* • Their strategy is directly related to the culture within their business unit. They are on the way to becoming a "learning company" where everybody is involved in the creation of new product ideas. • The managing director has a strong focus on product innovation and his strategy is new product oriented. • One effect of this culture is the opportunity for all employees to contribute new product ideas through several committees.
		BU2	*New Product Process* • They have a detailed product innovation management process running over 10 stages and are working with interdisciplinary teams. However, the R&D manager stated that they have to improve their product innovation management processes even more. • Because of limited personal resources (which is based on the low support of the NPD management activities by the board of management) only 2% of their NPD project are running on time. *Corporate Culture* • The commitment of the board of management to product innovation is low (as stated by the R&D manager). This in turn is reflected in the way how NPD projects are carried out – personal resources for NPD projects are strongly limited. • Ideas are mainly created within the business unit – only 20% of ideas for new products come from customers. This indicates that innovative impulses from outside the business unit are not seen as important.
	High Percentage of Revenues from NPs	BU3	*New Product Process* • Although they have a high cancellation rate of NPD projects (15%), their NPD process well defined. The analysis showed that their high cancellation rate is related to their product innovation strategy and corporate culture – they have planned for cancelling a percentage of NPD projects. • All new products are developed in NPD project teams with members from different departments (e.g. R&D, marketing, production) *Corporate Culture* • The aim to achieve innovation leadership is reflected in their corporate culture. This is shown by the statement of the R&D manager who pointed out that their process orders in NPD project management are living. The strong commitment of the board of management on product innovation is also shown in their five years strategy plan for positioning them as a partner for excellent OEMs.
		BU4	*New Product Process* • Their R&D processes are well structured and their NPD project teams are working in an interdisciplinary way. The stages of their NPD processes were developed together with the departments marketing, production and R&D. • As they have a strong customer focus the project leader of their NPD projects is always a member of the marketing department. *Corporate Culture* • The business unit is driven by the visions of the owner who has a strong commitment to product innovation. • The board of management have a strong focus on product innovation because they see new products as a basis to act as an independent company for a long time. This is also seen by their (fixed down) aim to introduce at least one new product per year.
High Product Innovation Rate	Low Percentage of Revenues from NPs	BU5	*New Product Process* • Although only 30% of their NPD projects (because of limited personnel resources and very short development times) are running on time, their whole NPD processes are structured in a systematic way into seven phases. Further, new products are developed in teams with members from different departments. *Corporate Culture* • In the interview a strong commitment of the board of management for product innovation was recognised. This is reflected in their strategy to be number one world-wide in three to five years. • There is a living culture to involve every employees into product innovation processes. This is shown by their well trained sales force to sell their products successfully.
		BU6	*New Product Process* • R&D processes are structured systematically and interdisciplinary NPD project teams are working within NPD projects world-wide. • However, because of more complex products and their limited R&D capacities, their product innovation rate decreased slightly over the last years. *Corporate Culture* • Their aim is to be world-market leader. To achieve this they have a strong commitment to developing new products. This is shown by their close collaboration with universities and on-going training programmes on the latest technologies.
	High Percentage of Revenues from New Products	BU7	*New Product Process* • A few years ago they have installed an own R&D department and are on the way to improve their NPD management system even more. All new products are developed with interdisciplinary NPD project teams. • Although they have some problems in the NPD process, these problems have no influence on their product innovation activities. The reason is the good information transfer between all persons who are involved into a research project. *Corporate Culture* • The strong commitment of the board of management (owners) to product innovation is seen in their decision 10 years ago to develop new products. Although the risk was high that the investments will be not repaid, they took this risk into account. • Especially the involvement of all employees into the creation process of new products is one of their strengths.
		BU8	*New Product Process* • The whole NPD process is structured and all new products are developed with interdisciplinary NPD project teams. • Although their R&D processes are not running optimally, they are highly innovative. The reason why these problems have no influence on product innovation processes are the short communication ways within the business unit. *Corporate Culture* • The strong commitment of the board of management to product innovation is reflected in their view that the only possibility of surviving is a position in Field 2b of the diagram product innovation rate and percentage of revenues from new products. • They have a strong employee orientation. This is shown by their philosophy to have well educated employees who guarantee the product innovation leadership. • Their technology is not well known. In some cases they have to convince new customers to buy their products. However, this is only possible with a well trained sales force.
		BU9	*New Product Process* • The whole NPD process is structured in a systematic way into nine steps and new products are developed in interdisciplinary NPD project teams. • They had a centralised R&D with well defined NPD processes and research centres are located all over the world. *Corporate Culture* • Their strong commitment to product innovation is seen in the selection process of their suppliers – they are selected on the basis of their product innovation abilities. • To develop new products they have a culture of working with international and interdisciplinary teams.
		BU10	*New Product Process* • They have well defined NPD process differentiated in six defined phases from acquisition to production with interdisciplinary NPD project teams. • They have the financial background to develop many new parallel products and to take the risk to cancel 30% of their NPD projects. This in turn is closely related to their strategy and corporate culture of developing pacemaker technologies. *Corporate Culture* • The board of management has a strong commitment to product innovation. The MD is convinced that freedom of employees is necessary to develop new products. • Their product innovation driven culture is also shown in their philosophy that minor mistakes in the first series are acceptable. This in turn is shown by their culture of experimentation.
		BU11	*New Product Process* • NPD processes are divided into seven steps and they are working with interdisciplinary NPD project teams. It has to be noted that their high cancellation rate of NPD projects (32.5%) is related to their strategy and corporate culture for experimentation and not on difficulties in their NPD processes. *Corporate Culture* • The commitment of the board of management to product innovation is high. This is shown by their highly (planned) percentage of cancelled NPD projects which is a indication for a culture of experimentation and openness for new things. • They have a strong focus on customer demands which is shown by their high percentage of ideas based on this information source (95%).

APPENDIX B

CASE STUDY DESCRIPTIONS PHASE 3

0. INTRODUCTION

Appendix B gives an overview of the case study results including six business units in the engineering and five business units in the E&E engineering sector in Germany. The results from the case study visits are summarised and detailed insights into the reasons for varying levels of product innovation rate and percentage of revenues from new products (product innovation positions) are given. Overall, 11 case study descriptions are presented in Appendix B. The case of Plastics (BU 1) is presented in Chapter 7 "Results of Phase 3".

Table 1 gives an overview of the whole number of business units which were visited in 2000 and 2001. For each business unit the industry sector, number and types of products is given. Further, the age, employees per business unit, part of a large organisation and revenues are presented.

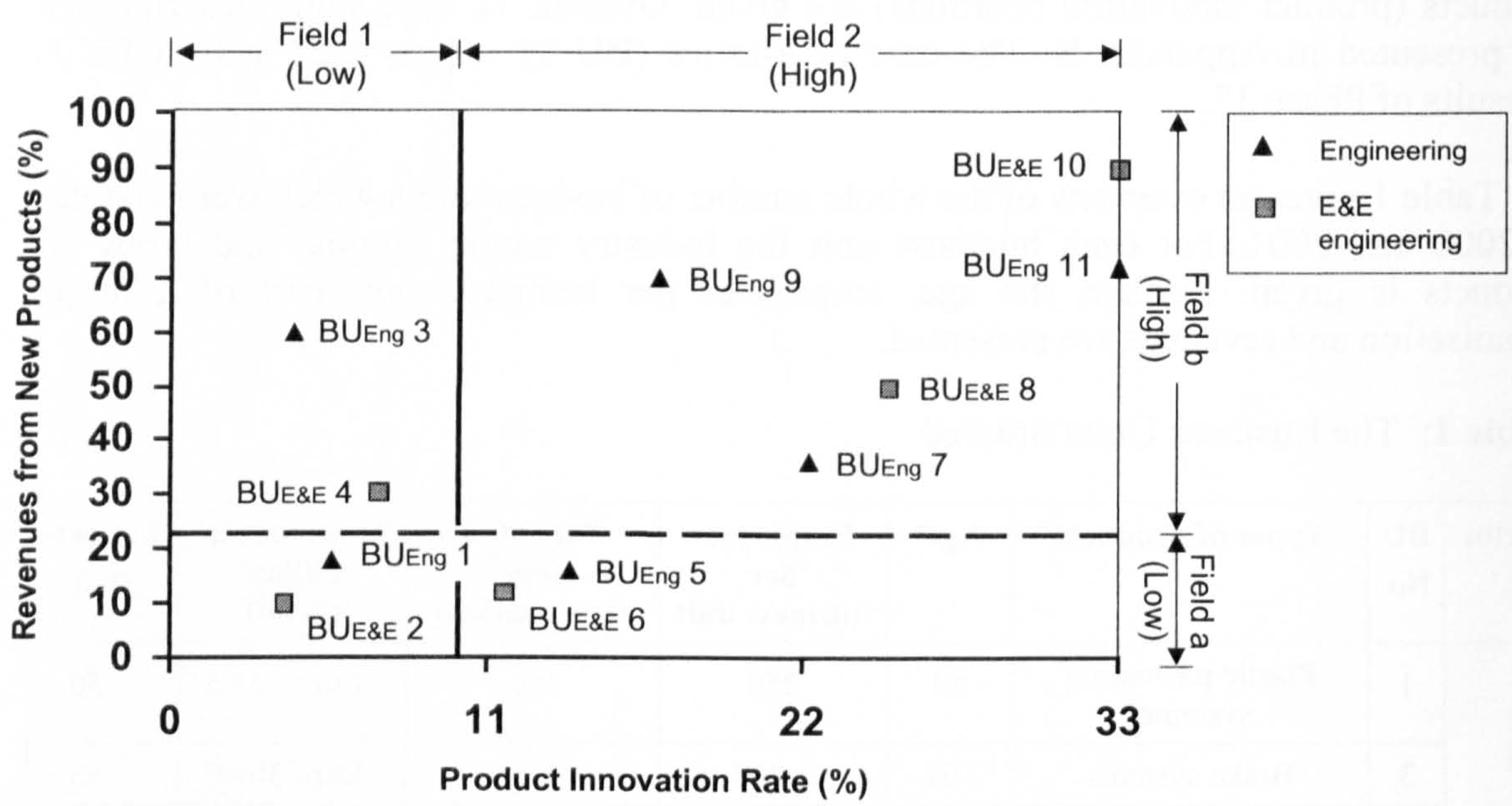
Table 1: The Business Units Studied

Sector	BU No	Types of products	Age[1]	Employees per business unit	Part of a large[2] organisation?	Revenues in millions (2000)	Exports (%)
Engineering	1	Plastic packaging systems[3]	50	250	No	Euro 25.5	50
	3	Brake systems	101	3,000	Yes	Euro 306.0	55
	5	Vacuum pumps	38	325	Yes	Euro 54.7	50
	7	Planetary gearboxes	73	160	No	Euro 13.8	15
	9	Exhaust systems	100	600	Yes	Euro 194.0	37
	11	Packaging foils	89	1,150	Yes	Euro 161.0	85
E&E Engineering	2	Electronic time control	73	340	No	Euro 50.0	32
	4	Automotive electronics	24	160	No	Euro 22.4	50
	6	X-ray inspections	55	524	Yes	Euro 153.0	20
	8	Ultrasound-generators	40	140	No	Euro 16.8	30
	10	Vehicle electronics[4]	38	815	Yes	Euro 918.0	78

[1] Age in 2001
[2] Defined as over 1,000 per employees in total.
[3] The case Plastics (BU1) is presented in Chapter 7. All other case study descriptions are given in Appendix B.
[4] Vehicle Electronics (BU10) is presented in a more detailed way to give insights of how the cases in the industry sector E&E engineering are analysed.

In order to be able to analyse all cases in a systematic way, each case study description has a similar structure. First a business unit overview is given. Then, the case study results are presented according to the model of Cooper and Kleinschmidt. Finally, a summary of the reasons for the individual product innovation position is given. It has to be noted that for the industry sector E&E engineering the case Vehicle Electronics (BU10) is given in a more detailed way than the other case study descriptions. For the industry sector engineering, a detailed case study description is given in Chapter 7 (case BU1, Plastics).

Figure 1: Overview of Sample, Six Business Units from Engineering and Five Business Units from E&E Engineering Sector (data from Phase 2)



1. OVERVIEW OF THE VARIABLES INVESTIGATED

As the case data are very complex a first overview of the results is given in Table 2. In the table a categorisation of the main findings and the variables asked in the case studies is given. Because of the complex dataset the table is split into six pages. The variables are sorted according to the areas given by Cooper and Kleinschmidt (market, competition, corporate environment, nature of projects, new product process, product innovation strategy and product innovation output). Further a differentiation into low / high product innovation rate and low / high percentages of revenues from new products is included. This differentiation is similar to the categorisation identified in Phase 2 of the research. In the table, the data for business units from engineering are given with white columns and business units from E&E engineering are marked with grey columns.

The cross-case analysis of the data found that corporate environment is high in every business unit. Consequently it was not identified as a key driver and it was not presented in detail in the main thesis. However, to give the reader an overview about this area, a detailed presentation of the results is given in this Appendix (in addition to the tables given next).

Table 2(a): Overview of the Results of the 11 Cases in Phase 3

Engineering / E&E engineering		Low Product Innovation Rate				High Product Innovation Rate						
		Low Revenue		High Revenue		Low Revenue		High Revenue				
Business Unit		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
MARKET												
Product life cycle (years)[1]		8	7.5	5	5	5	6.5	6	4	3.5	3.5	3
Market growth per year (%)[2]		12.5	> -2	7	< 5	2.7	17	< 15	< 10	17	< 20	< 2.4
Exports (%)[3]		50	55	50	15	37	85	32	50	20	30	78
Markets[4]		WW	EU	WW	EU	WW	WW	EU	WW	EU	WW	WW
COMPETITION												
Own market share (%)		70	65[5]	50	10[5]	10	35	15	15	19	8	20
Market share of the three strongest competitors[6]	1	15	20	45	> 10	10	38	30	> 15	16	16	< 20
	2	---	10	< 45	---	< 10	< 35	20	---	15	16	---
	3	---	---	---	---	---	---	10	---	15	---	---
Market entrance barriers for new competitors?[7]		High	High	High	High	High	High	High	High	High	High	High
Markets[8]		WW	EU	WW	EU	WW	WW	EU	WW	EU	WW	WW

[1] Product life cycle is given as the mean for the whole product portfolio.
[2] Market growth is given as the average growth over the last three years. All variables were given by the board of management on basis of the latest branch report
[3] Export rates are only given to show the importance of foreign markets for the case companies. A cross-case analysis is not carried out.
[4] Location of customers: World-wide = WW; Europe = EU; Germany = D.
[5] Own market shares were estimated by the interview partners. Therefore, the data has to be interpreted with caution.
[6] Market shares of the strongest competitors based on the estimation of the board of management.
[7] The categorisation of market entrance barriers were estimated by the interviewed managers.
[8] Location of customers: World-wide = WW; Europe = EU; Germany = D

Table 2(b): Continued

	Engineering / E&E engineering	Low Product Innovation Rate				High Product Innovation Rate						
		Low Revenue		High Revenue		Low Revenue		High Revenue				
	Business Unit	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
	CORPORATE ENVIRONMENT											
Familiarity	Technology	✓	✓	✗	✓	✗	✓	✓	✗	✗	✓	✓
	Product type[1]	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Against competitors[2]	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Distribution channel	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Customer needs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Production process	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Synergy	R&D/NPD skills[3]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Salesforce skills[3]	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Technical support skills[3]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Distribution skills[3]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Management skills[3]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Market research skills[3]	✗	✗	✓	✓	✗	✓	✗	✗	✓	✓	✗
	Manufacturing skills[3]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓

[1] Existing category in business unit
[2] Against competitors familiar to company
[3] Skills and resources
✓ High familiarity/synergy
✗ Low familiarity/synergy

Table 2(c): Continued

Engineering / E&E engineering	Low Product Innovation Rate				High Product Innovation Rate						
	Low Revenue		High Revenue		Low Revenue		High Revenue				
Business Unit	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
NATURE OF NPD PROJECTS											
Understanding of the degree of product innovations (transformational) according to the definition of Iansiti and Clark (1994)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ideas from external sources[4] (%)	50	20	60	80	70	50	50	30	30	70	95
Degree of product innovation (relationship between incremental and transformational products within the product portfolio)	More incre-mental new pro-ducts[2]	More incre-mental new pro-ducts[2]	More transfor mational new pro-ducts[1]	Mix[3]	Mix [3]	More transfor-mational new pro-ducts[1]	Mix[3]	More transfor-mational new pro-ducts[1]	More transfor-mational new pro-ducts[1]	More transfor-mational new pro-ducts[1]	Mix[3]

[1] These business units have more transformational (>50%) than incremental (<50%) new products in their product portfolio.
[2] These business units have more incremental (>50%) than transformational (<50%) new products in their product portfolio.
[3] These business units have a balanced mixture of both incremental (~50%) and transformational (~50%) new products in their product portfolio.
[4] Ideas from external sources can be based on ideas from customers, suppliers or research institutes.

Table 2(e): Continued

Engineering / E&E engineering			Low Product Innovation Rate				High Product Innovation Rate						
			Low Revenue		High Revenue		Low Revenue		High Revenue				
Business Unit			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
PRODUCT INNOVATION STRATEGY													
NPD project horizon[1]	Short	Projects (%)	95	50	30	40	50	30	50	30	50	70	10
		months	6	6	24	12	6	6	12	24	24	24	12
	Medium	Projects (%)	---	40	60	50	30	60	20	---	30	20	30
		months	---	18	36	30	24	12	36	---	36	36	24
	Long	Projects (%)	5	10	10	10	20	10	30	70	20	10	60
		months	24	30	>36	>30	60	36	120	60	60	60	48
Investments into R&D (%)			6	5	7.2	10	17.5	15	5	15	6	17.5	4
Launch strategies	First to market (%)		100	20	100	100	100	40	50	100	100	100	54
	Technological leadership[2]		Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Cost leadership[3]		No	No	No	Yes	Yes	No	No	No	No	No	Yes
Product innovation strategy written down?[4]			No	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes

[1] Although terms may vary per market, it shows how NPD projects are categorised.
[2] Strategy of technological leadership with new products.
[3] Strategy of cost leadership with new products.
[4] Product innovation aims written down, e.g., in a business unit's philosophy, quality handbook or company brochures. This was investigated in order to show how important product innovation is seen within a business unit.

Table 2(f): Continued

Engineering / E&E engineering	Low Product Innovation Rate				High Product Innovation Rate						
	Low Revenue		High Revenue		Low Revenue		High Revenue				
Business Unit	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
	PRODUCT INNOVATION OUTPUT										
Product innovation rate (%)	5.6	4.0	4.3	7.3	13.9	11.9	22.2	25	17	32	32.5
Number of main products	*1600*	*25*[7]	*6162*	*32*	*12*	*40*	*3*	*4*	*700*	*5*[5]	*890*
Number of new main products	*269*	*3*[7]	*790*	*7*	*5*	*14*	*2*	*3*	*360*	*5*	*870*
Revenues new products (%)	18.0	10.0	60.0	30.5	16.0	12.0	36.0	50.0	70.0	90.0	72.0
Average profits from the whole product portfolio (%)	18.0	12.0	18.6	4.3	12.0	8.5	15.0	31.0	10.0	2.4	7.2
Average profits from new products (%)	15.0[1]	25.0[1]	18-19[1]	4-5.0[1]	12.0[1]	6.0[1]	No inf.	31.0	10.0	5.0	7-8.0[1]
Break-even (months)	No inf.	24[2]	36[2]	36[2]	24[2]	18[2]	No inf.	6	12-24[2]	18-24[2]	30
Permanent stream of new products?[3]	Stream	Waves	Waves[4]	Stream	Waves[4]	Stream	Stream	Waves	Stream	Stream	Stream
Business unit growth per year (%)[6]	12.5	-2	7	5	7.6	26.6	15	10	17	20	2.4

[1] As no detailed data was available the percentage of average profits with new products were estimated by the MD or MM. For business units which gave a minimum and maximum value, the average profits are used for calculating the mean.
[2] As no detailed data was available the break even for new products was estimated by the MD or MM.
[3] Categorisation of the way product innovations are introduced into the market over time.
[4] These business units introduce their new products in ripples.
[5] They still have variants in their product portfolio which are based on existing products. Therefore, product innovation rate is not 33%.
[6] Average growth of revenues over the last three years.
[7] The 25 product lines include 670 variants and the three new product lines include 61 variants.

1.1 Findings in the Area Corporate Environment

As stated earlier, corporate environment is presented in detail in this Appendix. The corporate environment of business units shows how existing competences and resources are used to develop and market new products. It was measured with the two variables familiarity and synergy. Both variables are characterised with a set of sub-variables[96]. An overview of the sub-variables is given in Table 2b. Each of them was discussed in the case study visits to show whether familiarity and synergy is high (marked with a tick) or low (marked with a cross).

Familiarity

The first variable which will be analysed is familiarity which compares product type, markets and technologies of existing and new products. Although the type of products and technologies were not familiar in some cases, familiarity was characterised as being high for all cases. Therefore, a relationship to product innovation rate is not given. The reasons why new products from all business units are characterised as familiar with existing ones is explained with four examples (three examples from engineering and one example from E&E engineering).

The first example is Brake Systems (BU3). The MD of this business unit pointed out that more electronic elements are integrated into their mechanical products. Therefore, the MD pointed out, they are "moving away from their traditional product structures". However, they still produce brake systems for trucks and the market they operate in is the same for both existing and new products. Because of these facts the familiarity of new products with existing ones is categorised as high. The same situation is given at Vacuum Pumps (BU5). Here the R&D manager said: "In the past all products worked mechanically. In combination with electronics we can improve our products successfully – mechatronic is the key [to our new products]". Although they are using new technologies, the product types and markets are not changing. The next example from engineering is Plastics (BU1). They produce products for new markets and they are developing new types of products for new customer groups. In these new markets they compete with competitors they did not know before. Based on these findings it can be concluded that the familiarity between existing and new products is not very high. However, they are looking for new markets for their existing products, too. Further, the technology in their new products is closely related to the tool design – this technology is similar for all products. Taking all these arguments into account their new products can be categorised as familiar with existing products. The last example for familiarity is Ultrasound (BU8) from E&E engineering. Their products are technology driven, and their new products are quite different in design, steering and electronic components. However, the basic technology (i.e., the ultrasound generator) is the same in both existing and new products. This generator was developed by the founder and is produced in different variants. Because of this correspondence of existing and new products familiarity is high.

[96] Familiarity and synergy were measured with a set of sub-variables used by Cooper and Kleinschmidt (1997). They measured the sub-variables via ranking scales of low familiarity/synergy (1) to high familiarity/synergy (10). Such a measurement was considered but rejected. In the case study visits it was asked whether familiarity and synergy is low or high.

Synergy

A further criterion for describing corporate environment is the synergy of product innovations with existing skills and resources (e.g., production technology, marketing). Independent from product innovation rate and industry sectors the synergies are high at all business units. Three examples (representative for the whole sample size) show these high synergies.

The first example is Vehicle Electronics (BU10) from E&E engineering. Although the production technology for their new products varies, existing distribution channels are used in marketing new products. The main basis of selling new products successfully are "existing customer relationships" stated the MD. Additionally, they are using their own resources and the resources from their headquarter to develop new products. Because of these reasons, the synergy is high. The second example is Gearbox (BU7) from engineering. They needed 10 years to convince their customers that they are able to develop high tech gear-boxes successfully. The production methods were improved over the last 10 years and they are working together with four external commercials over a long time. This focus on core competences and existing distribution channels is seen as the main important factor in selling their new products successfully. The same factors are given at Automotive Electronics (BU4). Technology, marketing skills and resources are similar for both new and existing products. Therefore, the synergy between existing products and product innovations is high at both business units.

Summary

Overall, corporate environment (i.e., familiarity and synergy) is not related to product innovation rate at all. A summary of the findings is given in Table 3.

Table 3: Findings of Corporate Environment Influence on Product Innovation Rate

Variable	Findings of the Cross-Case Analysis
Familiarity (9 QL)	• All business units had high levels of familiarity. This is not related to product innovation.
Synergy (10 QL)	• All business units had high levels of synergy. This is not related to product innovation.

In the following sections the case study results for each business unit are presented in detail.

2. CASE BUSINESS UNIT BU 1 "PLASTICS"

This case is given in Chapter 7.

3. CASE BUSINESS UNIT BU 2 "TIME CONTROL"

3.1 Business Unit Overview

This business unit constitutes the whole company which develops, manufactures and supplies digital time control and temperature control systems for electric installations. Their products have a wide field of applications, e.g., house hold industry and facility industry. R&D for the whole company is centralised in the headquarters in Germany where 340 employees are located. A further plant for production and marketing is situated in Great Britain. Additionally, three further marketing dependencies are located in France and Italy. The company is family owned but it is important to state that the owner family has no active role in the management.

In 1921 they started with the production of time control apparatus and since 1965 they have concentrated their business on electronic time control systems embedded in plastic cases. Time control had a turnover of Euro 51 million in 2000 and they have had a 5% reduction of their business over the last two years within a stagnated market (about 2% reduction over the last three years). The price range for their plastic products ranges from Euro 5.6 to Euro 204.

3.2 Case Results

Market

The market of time control systems is described by the MM as a constant one, because their products are standard applications used by the E&E industry. Digital time control and temperature control systems have a normal life time of more than 10 years. Independent from the life time, the life cycle time of the products is between five and 10 years (mean 7.5 years). To supply most of their products they are working with external trade missions. However for key customers from industry they have started direct delivery activities with key account managers.

Time Controls marketing is concentrated in European countries where 55% of their products are exported. However, as one of their main markets is applications in buildings, e.g., automatic time control systems for lights, venetian blinds, heating and water processing, they have a strong dependency on construction industry. As the German construction industry has been in a recession over the last five years, there has been a reduction of their turnover. The market growth for their market segment was estimated with a reduction of more than 2% per year (average over the last three years) which is similar to their yearly reduction of revenues over the last three years.

Competition

Time Control's key technology in the manufacturing processes and their huge product range has led to high market barriers for new competitors. "New competitors will have difficulties in offering as many variants as we do and therefore it is difficult for them to compete with us. This fact is shown in our product portfolio. In summary, we have 25 main products but about 1300 variants." stated the R&D manager.

They have a strong market position in Germany and with 65% market share they are market leaders. However, only in Europe are they well known and world-wide they are one of many players in this market (less than 10% market share). Time Controls main competitor in Germany has 20% market share, followed by a second one with a 10% market share.

Corporate environment

All new products of Time Control are developed to offer better solutions for time or temperature control applications for their customers. Most of their products need small changes to fit with new customer demands, therefore most new products are familiar to the existing product range.

Synergies between resources and NPD projects are very high at Time Control. For developing and producing their new products they use their own manufacturing and development resources. Further, they use their present marketing structure to sell their products.

Nature of product innovations / Source of ideas

The MD defined product innovation as "something new with a fundamentally reworked design". The same definition was used by the MM. The R&D manager pointed out that "80% of their product innovation activities are concentrated on the improvement of existing products and 20% of product innovations are focused on new customers and new markets". Therefore, most of their products are incremental product innovations.

Within their company they make a clear difference between strategic product innovations and customer adoptions. New ideas for 80% of their new products came from internal sources and 20% from external sources, i.e., customers. The R&D manager pointed out that the basis for external sources are "simply customer inquiries".

New Product Process

They have a well defined NPD process over 10 stages for both the development of new products and variants and are working with interdisciplinary NPD project teams. Although they have clearly defined phases for their NPD process (ISO 9000) and no project was cancelled in previous years, only 2% of all NPD projects are running on time. The fact that most of their NPD projects are delayed was supported by a statement of the R&D manager who said: "We are on the way to improving our product innovation management system. Because we have problems in working with a permanent stream of strategic innovation projects our R&D employees have to be instructed and motivated for every new innovation project." The reason for their low cancel rate was explained by the R&D manager with their small size and their limited financial resources. He said: "Because we do not have so much money for R&D activities it is dangerous to cancel NPD projects".

For transferring strategic product innovations Time Control installed interdisciplinary core teams with members from all departments. However, in general the new product process for transformational new products is not running optimally as the R&D manager pointed out: "We have to improve our ability to create more strategic product innovations because it is not systematic enough." However, as shown later, this is not related to difficulties to their NPD processes but on the low commitment of the board of management for product innovation.

Deficits within the new product process are a reflection of their aims with new products and their careful product innovation strategy which are described in the next section

Product innovation strategy

Time Controls strategy is to offer time control solutions for every case. Therefore, they have to offer a huge range of different products to their customers as the MD pointed out: "Because most of our products only needed to be adopted to customer demands we have a big range of variants".

On the question why they are introducing new products into the market the MD manager pointed out: "With our new products we are following two aims. We are developing new products for new markets and we are improving our existing products to hold up our market share. With these product innovations we try to secure our customers to tie our customers to us." A further reasons is the demand for systems. The R&D manager pointed out that in many products bus technology has to be integrated and especially in this technology they are known to be very innovative." However, only 20% of their product innovations are seen as first to market introductions.

Their general strategic aims are written down in several company brochures. In the company philosophy (1st paragraph) it is stated: "Time Control is an independent world-wide innovative manufacturer and problem solver in the area of time control systems...". However, the discussion showed that the statement "world-wide" is not a reality – their main market is Europe. A statement in the ISO 9000 handbook confirms their aim to be innovative: "On changed market demands, laws, norms... we react early with permanent innovation in design, technique and process". However, although they are aiming to increase their innovation activities, clear aims for their product innovation activities are not written down.

Although they see product innovation as an important factor for staying innovative their product innovation strategy can be described as a very careful one. The MD explained this strategy as follows: "Because we are a small company it is not possible for us to create a lot of new products, because a big flop could be our demise." This careful product innovation strategy can be seen by the moderate support of the board of management. The R&D manager pointed out that "the support of the board of management to increase our innovation activities is not very high". He also recommended that "further more we have to increase our product range with new products. The aim over the next years is to introduce one new product every year".

As a whole the product innovation strategy of Time Control is explained as follows by the R&D manager: "We want to offer solutions for our customers – our strength is to offer products with high quality and correct functionality. With product innovations we secure our market potential and we have the ability to extend our market. However, in summary we have a careful strategy to introduce new products into the market." This is shown by the categorisation of their strategies according to the model of Johnson and Scholes (1999). Table 4 shows that product development is mixed with three strategies – product development, diversification and protection-building.

Table 4: Strategies on Existing Competences at Time Control (analysis based on a framework of Johnson and Scholes, 1999)

Variable	Yes	No	Explanation
Product development	✓		They develop new time control systems to replace existing products.
Diversification	✓		They develop new time control systems for new applications.
Market Development		✓	They concentrate their activities on their present markets.
Protection-building	✓		As the product life cycles are long, market penetration is seen as an appropriate strategy.

Time Control invested 5% of their revenues which is expected to be 2% to 3% lower than their competitors. In summary, 12% of their employees are working in R&D projects. Their aim is to offer product adaptations for customer specific applications and is reflected in the project planning horizon for their new products. 25% of their NPD projects are planned for three months and 40% have a time horizon of six months to 18 months. These short-planned projects are focused on incremental product innovations. For transformational product innovations they have planned 10% of their NPD projects for a time horizon between 24-30 months.

Product innovation output

With a low product innovation rate and low revenues from new products Time Control is positioned in Field 1a within the diagram product innovation rate and percentage of revenues from new products. Over the last three years they achieved a product innovation rate of 4% and with these new products they generated 10% in revenues. In comparison to the revenues with new products they achieve 16% turnover with their most important existing product.

With the revenues from their whole product range they made 12% profit. Looking at the profits with their new products they achieve respectively more (20% to 25%). As they are measuring all product innovation variables regularly they were able to give valid data to the break-even point for new products which is given with a two year time period.

On the question how they can explain their position within the diagram product innovation rate and percentage of revenues from new products the R&D manager stated: "Because most products only need to be adapted to customer demands we have a big range of variants. And in summary we have a careful strategy, too." The MM stated that a further reason is "to fulfil the marketing demands. That means to develop existing products further... Therefore, we have about 1300 variants... and in consequence we have a low product innovation rate and achieve low revenues with our new products."

Looking at the way they introduce new products, the MD described it in the way of waves. Their product innovation activities are correlated to their sales. "Because of the recession in the construction industry in the last five years we decided to develop more new products for new markets. Therefore, we have to increase our innovation activities even further." This was also shown by their difficulty in creating a constant stream of transformational new products, as the R&D manager pointed out.

3.3 Key Drivers for the Individual Product Innovation Position

The reasons for their low product innovation rate and low revenues from new products can be explained as follows:

Market

- Because the life cycle of their products is between five and 10 years, they have a huge product portfolio with many variants.

Competition

- They are market leader (and are well known) in Europe. This in turn allowed them to sell their existing products successfully.

Product Innovation Strategy

- According to the definition of Johnson and Scholes they have a combination of three different strategies: Product development, diversification and protection-building. The fact that they do not have strong concentration on the development of new products is shown in their product portfolio. 80% of their product innovation activities focus on product improvements. As these new products are not counted as main product innovations in the terms of the given definition, their product innovation rate is low.
- Their investment into R&D activities are expected to be 2% to 3% lower than investments of their direct competitors.
- Because of their small size, they concentrate on the development of some few products. Additionally the board of management do not see the necessity of developing too many new products.
- New products are an enlargement of their portfolio. With these few new products they do not achieve high revenues. The most successful product within their product portfolio is an existing one which generates 16% of their turnover.
- The fact that new products are not seen as so important is shown by their well defined development process for variants.

Although Time Control saw themselves as an innovative company (statement of the MD), the interview identified several weaknesses.

New Product Process

- They have a detailed product innovation management process running over 10 stages and are working with interdisciplinary teams. However, the R&D manager stated that they have to improve their product innovation management processes even more.

- Because of limited personal resources (which is based on the low support of the NPD management activities by the board of management) only 2% of their NPD project are running on time.

Corporate Culture

- The commitment of the board of management to product innovation is low (as stated by the R&D manager). This in turn is reflected in the way how NPD projects are carried out – personal resources for NPD projects are strongly limited.
- Ideas are mainly created within the business unit – only 20% of ideas for new products come from customers. This indicates that innovative impulses from outside the business unit are not seen as important.

This case has shown, that the reasons for low product innovation rates could be based on a careful product innovation strategy combined with a moderate commitment to product innovation from the board of management. This in turn is given in their position in Field 1a in the diagram product innovation rate and the percentage of revenues from new products.

4. CASE BUSINESS UNIT BU 3 "BRAKE SYSTEMS"

4.1 Business Unit Overview

Break Systems is a business unit of a great international company. They currently employ 3,000 people in their German location, which has production, marketing and development. World-wide they have 14 plants and six joint ventures. Further, they have a net of service dependencies world-wide.

The business unit was founded in the late 18th century and started with the production of pneumatic break systems. Today the business unit produces brake systems for trucks and trailers (90%) and buses (10%). These brake systems include products such as ABS systems, road performance stabilisation, engine brakes, control and regulation valves, pneumatic and hydraulic brake systems, electronic chassis attenuation.

Brake Systems achieved revenues of Euro 306 million and achieved a growth over recent years of 7%. The price range for their brake systems varies between Euro 5.1 for spare parts to Euro 766 for complete brake systems.

4.2 Case Results

Market

The market is for truck brake systems which is characterised by customer specific products for original equipment manufacturers (OEMs). This is shown by the fact that 85% of their products are directly developed and delivered to OEMs. Only 15% are delivered indirectly, e.g., to vehicle garages and intermediate trade. The market is characterised by a close relationship between customers and supplier. The MM stated that they "have to follow customer demands and therefore they have a customer-team placed at the customer location." This team is directly linked to their business unit.

The product life cycle of their products is directly related to the life time of a truck modell – normally five years. For some parts it is possible to achieve a life time of about 15 years. The close contact to their customers makes it necessary to have their own active sales force. "We are selling systems which can only be sold by our own trained employees" stated the MD. With this sales structure they achieve a world-wide export rate of 50%. As they specialise in brake systems for trucks the MM stated that they are directly dependent upon the truck market. The market growth for their market segment was estimated with about 7% per year (average over the last three years) which is similar to their yearly growth of revenues over the last three years.

Competition

Their know-how and market acceptance has led to high market barriers for competitors. The MM stated that "Brake Systems has a strong market position in regard to their customers and have great know-how in the field of brakes for trucks. Furthermore with us other key players are in this segment." This was confirmed by the MD who said "know-how about markets, access to customers, development partnerships and compatibility makes it very difficult for new competitors to enter this market."

With dependency on specific products they have achieved a market share between 50% and 70% for ABS trailer systems. They have achieved 70% market share in the US. With 45% market share their main competitor in Europe is slightly less than Brake Systems.

Corporate environment

As mechatronic is one key tendency within this market, their new products are not very familiar with their previous ones. Although the function (brake system) is the same the design, components and applications are often quite different.

Although their new products have no familiarity with existing products, they are using their resources for development, production and marketing of their product innovations. One example is the introduction phase of new products: "Customers are trained on new systems which are introduced into the market systematically" (company brochure). For this training they use their world-wide network of service dependencies.

Nature of NPD projects

The MD defined their product innovation as follows: "New development as a changing process in terms of implementing new techniques, apparatus and products. Change of the organisation..." This comprehensive view was also seen by the R&D manager who stated that "innovation must continue in several areas as products, processes and working models, ...". However, a new product is characterised by a fundamentally reworked design, stated the R&D manager.

Most of their new ideas (60%) come from external resources. 40% of their ideas come from internal resources. Internal ideas are more transformational whereas external ideas are more incremental. The R&D manager stated that key technologies, prototypes for new systems have to be generated by internal resources. However, the transformation to customer demands is closely linked to their problems and ideas. Therefore, most of their new products are transformational ones.

New Product Process

The R&D department is organised in a functional way, but R&D teams are interdisciplinary. The R&D manager pointed out that they have a "process-organisation where project teams are interdisciplinary and overlapping because of cross-technology-families".

Their R&D organisation and NPD processes are documented with ISO 9000 and VDA 6 and their whole NPD process is described within project management guidelines with clear tasks (ISO form). The whole NPD process for each project is a clear structure and is divided into five processes with four review stages. The five different processes are: (1) definition phase, (2) concept phase, (3) prototype development, (4) series development, (5) series production. The R&D manager pointed out that "process orders in NPD project management are living – i.e., contents, check lists are improved and actualised regularly".

From the view of the R&D manager they have some problems with their R&D capacity and resources. However, in terms of the MD their product innovation processes are running very well. Looking at all R&D projects over the last three years 50% of their R&D projects are running on time and 15% of all projects were cancelled. However, the reasons for delays often depends on changing customer demands. And as they have R&D projects dealing with fundamentally new technologies, they are calculating with projects which have to be cancelled.

Product innovation strategy

The discussion why they are developing new products showed that they have a strong market focus. The MD stated: "We are forced by our customers – they want to increase their added value. Further, our role has changed from product deliverer to a system deliverer – therefore we have to develop our ideas further". And the R&D manager stated that they have an "organic growth" because "globalisation and expanded markets forces us to develop new products." The statement of the MM went in the same direction. He said that only with innovative products are they able to hold up their market share.

Their main aim with new products is product innovation leadership and first on the market. The MM stated that "first on the market is the most important factor. We want to have our feet in the door first". The answer of the MD went in the same direction. He answered "we want to gain innovation leadership and we want to be first on the market." This is shown by their aim to be first on the market with all their products (100%) pointed out the MD. However, this value was qualified by the R&D manager who stated that in reality 50% of their products are really first on the market.

One further reason for their strong focus on product innovation were changes in the technology. "In summary, electronic features increase and therefore our products move away from mechanical to electronic steering apparatus. Our aim is to integrate new technologies into our products. In consequence, our product strategy is to move away from brake systems with focus on wheels to brake systems integrated in the whole vehicle. Further, we are looking for niches and other [business] fields" (statement MD). And the MM sated that they have to "produce growth through our new products and to concentrate on core products and processes. Mechatronic is the new challenge – to integrate electronic control systems in our products."

In summary, the MD stated that their five years strategy plan is to position their business unit as a partner for excellent OEMs. Further, they want to improve the technology of their existing product ranges and to secure their high productivity at this location.

The reported general aims are also written down in several company brochures: "With innovative products and technologic perfection Brake Systems want to work for market leadership in electronic systems for trucks... The wide spectrum of reliable systems and components and a constant development speak a clear language....." Product innovation is also reflected in their slogan which is: "We are bringing security on the roads". As they have a clear product innovation strategy all new product innovations are planned and written down in their strategy plan.

The categorisation of their strategies according to the model of Johnson and Scholes (1999) shows a concentration on the strategy product development (Table 5). This is based on both existing and new competences (e.g., electronics). The strategies diversification, market development and protection building are not given.

Table 5: Strategies on Existing and New Competences at Brake Systems (analysis based on a framework of Johnson and Scholes, 1999)

Variable	Yes	No	Explanation
Product development	✓		They develop new brake systems to replace existing products.
Diversification		✓	They concentrate their activities on the development of brake systems for trucks.
Market Development		✓	They are suppliers for the automotive industry including the biggest truck producers. Therefore, market development is not seen as a necessary strategy.
Protection-building		✓	As the product life cycles are very short, protection building is not seen as an appropriate strategy.

Their strong focus on product innovation is reflected by their R&D investments of 7.2% (which is expected to be slightly lower than their competitors) and their high number of R&D employees (16%). The strong focus on transformational new products is shown by their project planning horizon for new products. 30% of their NPD projects are planned for a time period of 24 months. Most of their projects (60%) have a project planning horizon of 36 months and 10% of their R&D projects deal with a time horizon of more than 36 months. The MD pointed out that all future projects are "written down in an operating plan and in a strategic plan for the next three years, where all systems are described".

Product innovation output

Brake systems concentration on product innovations can not be seen in the variable product innovation rate. Only 4.27% of their products within the product portfolio are younger than three years. But with these new products they achieve 60% revenue. In the discussion of these variables with the board of management the R&D manager pointed out that 80% of their turnover is achieved with less than 1000 Products.

With their product portfolio they achieve a profit of 18.6% which is at the same level as for their new products. Dependent on the individual products, the break-even for new products is between three to four years.

Their low product innovation rate and their high revenue from the low number of new products was explained by the MD as follows: "We hold the position within this diagram, because we have many products in our portfolio which are necessary to have. But 80% of our turnover is achieved with less than 1000 products, where most of our new products are included. In contrast a low percentage of our turnover comes from a huge product range of existing products [older than three years]. Therefore, 60% of our turnover is achieved by products younger than three years." This statement of the MD was qualified by the R&D manager who pointed out that the "last 5% of their turnover is achieved with 3000 products".

The reason for this phenomenon is that they have contracts with their customers to supply spares for a 10 year time period. However, there are also some few products which are 30 years old. Therefore, they have a huge product portfolio with 6,162 existing main products. In consequence, some products are only ordered once a year. Taking these circumstances into account the R&D manager pointed out that in his opinion their product innovation rate would be 17% by taking only these main products into account which generates considerable revenue.

Their stream of new products can be described as a slightly increasing wave. "We develop our products in small waves. But we try to keep it as permanent as possible" the R&D manager stated. The reason for this is their dependency on new models in the truck market. However, the MD qualified this statement with his comment to "increase our number of new products slightly".

4.3 Key Drivers for the Individual Product Innovation Position

The case of Brake Systems has shown that a position in the field with low product innovation rates and high revenues from new products has several reasons. The main driver is:

Market

- Because of latest technological developments, more electronic elements are integrated into their mechanical products. Therefore they need to replace their mechanical products by new ones.

Competition

- Although their main competitor is smaller, they are convinced they can only hold up their market leader position with a high permanent stream of product innovations. Therefore their strategy is to be first to market and to achieve product innovation leadership.

Product Innovation Strategy

- According to the definition of Johnson and Scholes they concentrate their activities on product development. However, this can not be seen in the variable product innovation rate. The reason is, that they are forced by their customers to supply products for a long time period (in general for 10 years). Therefore, they have a huge product portfolio where the number of their new products is low.

- For developing a high number of new products they invest 7% of their revenues into R&D activities which are expected to be slightly lower than the investments of their direct competitors.
- They make 80% of their turnover with only 16% of their whole product portfolio (6,162 products). With this background information the proportion of new products within this reduced product portfolio is higher. Taking the reduced product portfolio (1000 products) and their new products (790 products) they achieve a product innovation rate of 79% over three years (= 26.33% per year).
- As their main focus is on product innovation they generate most of their revenue within the reduced product portfolio with products younger than three years.

This business unit has a well organised R&D organisation with detailed mile stones for product innovation. Their strength in systematically developing new product innovations for the market is based on drivers such as:

New Product Process

- Although they have a high cancellation rate of NPD projects (15%), their NPD process well defined. The analysis showed that their high cancellation rate is related to their product innovation strategy and corporate culture – they have planned for cancelling a percentage of NPD projects.
- All new products are developed in NPD project teams with members from different departments (e.g. R&D, marketing, production)

Corporate Culture

- The aim to achieve innovation leadership is reflected in their corporate culture. This is shown by the statement of the R&D manager who pointed out that their process orders in NPD project management are living. The strong commitment of the board of management on product innovation is also shown in their five years strategy plan for positioning them as a partner for excellent OEMs.

This case has shown that the reasons for low product innovation rates could be dependent on a huge product portfolio, influenced by customer demands. Therefore, their high demand for product innovation cannot be seen in the variable product innovation rate. However, as new products play a key role in this business unit, revenues from these products are very high. Therefore they are positioned in Filed 1b on the diagram product innovation rate and the percentage of revenues from new products..

5. CASE BUSINESS UNIT BU 4 "AUTOMOTIVE ELECTRONICS"

5.1 Business Unit Overview

Automotive Electronics is a family owned company with 160 employees which develops, produces and markets electronic parts for the automotive industry. This business unit constitutes the whole company which has its headquarters in Germany and one marketing subsidiary in the US.

The founder started in 1977 with the production of electronic lock systems for cars. Today they produce electronic modules for the automotive industry, e.g., speed control, light control, central locking systems, sliding roof and automatic seat adjustment. For all components both, software and hardware is made by Automotive Electronics.

They had a turnover of 44 million in 2000 and a growth of 15% over the last three years (5% per year). As they offer single products and systems, the price ranges between Euro 10.2 to Euro 143.

5.2 Case Results

Market

The product life time of their products is directly dependent upon the life cycle of cars (up to 15 years). The life cycle time for most of their products is dependent on the car model's replacement every three to four years. As they have products within their portfolio which are independent from model's replacement, the average life cycle is given with five years. Their main customers are OEMs which they deliver to directly. Their focus is on key players in the automotive industry stated the MM: "The whole turnover is made with only 10 customers and 60% with only one customer." Within their headquarters a customer centre has been installed working with one to two service employees for each customer.

Because all of their products are customer specific they sell their products with their own sales-force. In summary, 15% of all products of Automotive Electronics are exported world-wide. As they have concentrated their business on the automotive industry they have a strong dependency on this industry. Their concentration on this sector was commented on by the MM: "Because of limited capacities it is not possible for a small company to concentrate on more industry sectors". The market growth for their market segment was estimated lower than their yearly growth of 5% per year.

Competition

With 25% to 50% market share Automotive Electronics is a market leader in Germany for the specific product "bodywork electronics". In Europe they have 10% market share for the niche product automatic steering systems for rear spoilers. However, in general they are "one of thousands in the automotive electronic supply industry" stated the MD.

They estimated high market barriers for potential competitors because they "concentrate on niche products, have references in this area, have know-how about the processes and are well known as a high quality company who knows what the customers need" (MM). This was confirmed by the MD who pointed out "to act in this market it is necessary to have the capacity and to always offer interesting products for customers". However, he also pointed out that with their medium sized structure they are unusual in this branch.

Corporate environment

The new products of Automotive Electronics are similar to their existing products because they concentrate their business on electronic parts for the automotive industry in a specific niche. However, as they want to increase their product innovation activities with "radical" (statement MD) new products familiarity will decrease over time. This tendency is also shown by their slogan "Competency in Electronics" which indicates that they offer products for all electronic applications.

Synergies are also high because their products are developed, produced and sold by using internal resources intensively.

Nature of NPD projects

Asking for the definition of product innovation the MD said: "For me innovation is to offer technologies demanded by the market – not always new but always customer oriented. In the past we were focused on the improvement of functions for our products – today we are developing new products". The R&D manager argued in the same direction but with more focus on technology: "To take up new technologies, i.e., in the automotive area and for transferring these technologies to customer oriented products".

Looking at their whole product range their focus was on both incremental products and transformational ones. 20% of their ideas come from internal sources and 80% from their customers. However, the 80% also includes wage-manufacturing products where incremental product innovations are embedded. Therefore, the MD stated that they have to reduce this quota. "We have to develop key products with our own resources to be in the position to offer attractive problem solutions for our main customers. Our aim is to achieve a relationship of 50% external ideas for new products to 50% internal ideas". This was also stated in the company philosophy brochure: "Beneath the development of customer oriented products we will develop our own products. Every year we will place a new own product on to the market".

New product process

Although the whole company has a functional structure, NPD teams are interdisciplinary. As most of their new products are customer specific they organised their NPD process with a project management tool which they developed themselves. All R&D phases are also defined with ISO 9001.

The R&D department is divided into hardware, software, testing apparatus development and testing. Together with production and marketing they constitute NPD teams. One important fact is, that the project leader of an NPD project is always a member of marketing. They follow this philosophy because persons from marketing are located in the service centre which has closer contacts to the stated customer than the R&D manager.

The R&D manager reported that 90% of all projects are running on time and that they had cancelled only one project in the last 10 years (this project was not realisable). This fact is underlined by the R&D manager who pointed out that for a small company it is not easy to cancel an R&D project. In their NPD process they have some problems, but they are no more difficult to handle than in other projects stated the R&D manager.

Product innovation strategy

On the question why they are introducing new products into market the MD answered: "First we develop new products for OEMs. Second, we develop our own new products because we identified the market requirements. Third, the new technology mechatronic is the future. Fourth, systems are demanded by the market – we offer such systems." This was confirmed by the R&D manager who gave an answer going in the same direction.

With their product innovations they want to increase their market share. On the question for further aims the MD stated that their latest aims with new products is to achieve product innovation leadership too: "We want to increase our market share with our products and we want to achieve innovation- and cost-leadership." Although their focus on product innovation leadership is not clear, the R&D manager pointed out, that 100% of their new products are first onto the market. However, the discussion made clear that the main reason for product innovation is to achieve a stronger market position and to extend their activities side by side into further countries (statement of the MD).

This focus got clearer in the further discussion where the MD said that a vision of his is to secure their market position, "to achieve a stronger market position and to extend our activities into further countries (side by side) with our new products". He also pointed out that with new products they want to be able to exist in the market: "Mid-term we want to show that we are able to act as an independent company – this is our entrepreneurial aim." The MM also argued in the same direction and said: "We want to act as an independent company in the near future".

In general the MD summarised their strategy as follows: "To extend our know-how in the field of our core competences and to generate new product fields. We are developing customer specific products and are looking for partnerships with our customers".

In their company brochure they stated that "speed and flexibility are becoming the most important criteria for market success – independent development, production or distribution." Their aim is to increase their R&D activities further. This aim is written down in their company brochure: "Beneath the development of customer oriented products we will develop our own products. Every year we will place a new own product in the market".

Although they have a low product innovation rate, their focus on new products is high. This is shown by the categorisation of their strategies according to the model of Johnson and Scholes (1999). Table 6 shows that they mix the two strategies product development and diversification. The strategies market development and protection building are not given.

Table 6: Strategies on Existing Competences at Automotive Electronics (analysis based on a framework of Johnson and Scholes, 1999)

Variable	Yes	No	Explanation
Product development	✓		They develop new electronic systems to replace existing products
Diversification	✓		They develop new electronic systems for new applications (e.g., for different functions in cars).
Market Development		✓	Although their customers are some few car producers, they see no advantage to enter new markets in other countries.
Protection-building		✓	As the product life cycles are short, protection building is not seen as an appropriate strategy.

They invest 10% of their revenue in R&D activities and 18.75% of their employees are involved in R&D projects. The MD estimated that in general investments into R&D are not so high in their industry sector. 40% of their NPD projects have a project planning horizon of 12 months, 50% of 30 months and 10% are planned for more than 30 months.

Product innovation output

With their new products they achieve a product innovation rate of 7.3% per year. These new products generated 30.5% of their revenue. The profit with their whole product portfolio was given as 4.3%. The profits with their new products do not show a clear tendency. In comparison with existing products some make more and some make less profits. With regard to their profits, the MD pointed out that their margin is higher than the average margin of their competitors. The break-even point for new products is about three years.

The reason for their low product innovation rate and their high revenue was their concentration on specific innovative key products. With them they want to achieve a maximum of revenues. In the last years one of their new products was very successful and generated most of the 28% revenue from new products. In the discussion of the diagram with the MD he pointed out that they have to be careful with their product innovation resources and therefore they concentrate on few NPD projects. In detail the MD explained their position within the diagram product innovation rate and revenue from new products as follows: "Our aim is to develop a limited number of new products. With these few products we try to achieve high revenues. Consequently, with one new product (door protection for children) we will make about 40% turnover in the next year".

However, he also stated that one main reason for their careful product innovation activities is their company size. The MD pointed out that for their size it is not possible to do large and expensive experiments. Their financial resources forces them to select their NPD projects carefully. "Our position within the diagram product innovation rates and percentage of revenues shows us that we are going in the right direction." A further reason for their low product innovation rates is the latest orientation on product innovations "In the past we concentrated on the improvement of existing solutions and to produce these improved products. In consequence, the main focus in the past was on innovation in manufacturing processes" (MM).

As they want to increase their product innovation activities further, the R&D manager described their stream of new products as a continuous (increasing) stream of product innovations.

5.3 Key Drivers for the Individual Product Innovation Position

The case Automotive Electronics shows that their low product innovation rates and high percentage of revenues have different reasons. The main drivers are:

Competition

- To develop some few new products for specific applications is seen as the most appropriate way to survive in their highly competitive market.

Product Innovation Strategy

- According to the definition of Johnson and Scholes they concentrate their activities on the two strategies product development and diversification. However, because of their financial resources they focused on a few selected NPD projects. Therefore, they achieved a low product innovation rate.
- For developing new products they invest 10% of their revenues into R&D activities which are expected to be higher than investments in their branch.
- Their aim is to develop new key products and to generate high revenues with these key products - with one new product they make most of their 30.5% revenue.

Their ability to concentrate on the development on selected new products is given by following attributes:

New Product Process

- Their R&D processes are well structured and their NPD project teams are working in an interdisciplinary way. The stages of their NPD processes were developed together with the departments marketing, production and R&D.
- As they have a strong customer focus the project leader of their NPD projects is always a member of the marketing department.

Corporate Culture

- The business unit is driven by the visions of the owner who has a strong commitment to product innovation.
- The board of management have a strong focus on product innovation because they see new products as a basis to act as an independent company for a long time. This is also seen by their (fixed down) aim to introduce at least one new product per year.

This case has shown that product innovation activities are dependent on the size of a company which having influence on product innovation activities. Because of their limited financial resources they focus on few product innovations. However, they are focusing only on such products which will generate most of their new product turnover. These are the drivers which position them in Field 1b in the diagram product innovation rate and the percentage of revenues from new products.

6. CASE BUSINESS UNIT BU 5 "VACUUM PUMPS"

6.1 Business Unit Overview

This business unit is family owned and employ 325 people in Germany where the headquarters is located. In their German location they have development, manufacturing and marketing. They are part of a greater organisation with five manufacturing plants and 29 service subsidiaries world-wide.

The founder started in 1963 with the production of vacuum pumps in a garage. Nowadays they produce vacuum-pumps for all industries – their pumps and systems are suitable for different applications: e.g., chemical, pharmaceuticals, food, packaging, plastics, electronics, printing.

The investigated business unit of Vacuum Pumps achieved 107 million in revenue in 2000 and had an average growth of 7.6% per year over the last three years. 65% of their revenue came from products, 12% they earn with vacuum systems and 22% of their turnover was generated by service activities. The price for their products ranked between Euro 102 for components to Euro 0.766 million for vacuum systems.

6.2 Case Results

Market

Product life cycle in general is five years, however, there are a few product components which run for 15 to 20 years without any replacement. Their market is characterised by high technical demands in products and systems where their products are embedded. Therefore, they supply their products with their own sales force ".. Vacuum Pumps customers are assured of local sales, service and technical back-up wherever they are situated". Therefore, their sales people are trained intensively to sell their products successfully, stated the MM.

They achieve an export rate of 37% world-wide. Their economical influence is dependent upon general economic tendencies. However, the MM stated that food packaging is the biggest industry sector they deliver to, therefore they have a stronger dependency on this branch. The market growth for their market segment was estimated with about 2.7% per year (average over the last three years) which is lower than their yearly growth of revenues over the last three years.

Competition

For potential competitors they see high market barriers. The MD explained this as follows: " Knowledge for market applications has increased – to catch up on our know-how is almost impossible. Additionally, we have a very close customer relationship." The MM stated that "We have intensive training with our personnel, further we have very close customer contacts, we are a cost-leader and we offer a high number of variants for every application. This would be very difficult to achieve for new competitors." The R&D manager pointed out that the vacuum technology is very complex which makes it very difficult for competitors to compete.

In the area of industrial-vacuum systems they achieve a 10% market share worldwide. Their direct competitors often have a wider product portfolio and do not concentrate only on industrial vacuum applications. Therefore, they are difficult to compare with Vacuum Pumps. Taking only their competitive products into account they are smaller, stated the MD.

Corporate environment

Their focus is on vacuum pumps for industry. In comparison to their competitors they have a more concentrated product portfolio and in consequence their new products are more familiar to their existing ones.

For development, production and sales they use their own resources intensively. Therefore, synergetic effects of new product innovation with existing resources is high.

Nature of NPD projects

The MD of Vacuum Pumps saw product innovation in a broader context: "Innovation is not only the further development of existing products, it is the development of new products and processes to stay competitive". Looking at their whole product range their focus was on both, incremental on transformational products.

Most of their ideas for new product innovations came from their customers (70%) – these customer oriented products are more incremental. 30% are generated within an internal idea generation process. As they are developing new systems for new applications, internal ideas are more transformational.

New product process

Vacuum Pumps R&D department is functionally organised, but R&D teams are interdisciplinary. As many projects are complex their interdisciplinary R&D teams include members from "R&D, marketing, construction, QM and Service" stated the R&D manager. All R&D activities are located in the production facilities.

Their whole NPD process is certified with ISO 9000 and they divided their NPD processes into seven different phases: definition, conception, design, construction, prototype, documentation, going into the production line. The R&D manager stated that"...the NPD process is divided into clear parts to achieve a systematic and provable development-process" and the MD pointed out that "employees are involved very strongly in product innovation – it is a living culture within our company".

Although they have a clearly structured R&D project management only 30% of their NPD projects are running on time. The R&D manager pointed out that the main reason for this phenomenon was short planned development times. However, the MD stated that their main problem is the realisation of projects on time (in other words, personnel resources are limited). In summary, 5% of their products were cancelled because realisation was too complicated. Asking for problems within the R&D process the R&D manager stated that "one critical point is the transformation of new products to the sales force. Therefore, we have to improve our training for them in respect to new product introductions."

Product innovation strategy

Vacuum Pumps' intention as to why they are introducing new products is their "aim to fulfil customer demands. Because of market demands new products are created to achieve competitive advantages" stated the MD. Although customer satisfaction plays an important role they are also developing (transformational) products without an actual market demand, stated the R&D manager. The R&D manager pointed out: "We want to develop products which are difficult to copy. Further, the price pressure from the market forces us to produce innovative products which are difficult to produce more cheaply by our competitors – this is a very important success factor." However, one further reason why they are developing new products are changes in the technology. This was stated by the R&D manager who said: "In the past all products worked mechanically. In combination with electronics we can improve our products successfully – mechatronic is the key".

For the MD the aims with new products were "cost and technology leadership". Therefore, he saw 100% of their products with the strategy first to market. His vision is to be number one world-wide in three to five years. This was confirmed by the MM who pointed out that they have the clear company aim to achieve technology leadership, parallel to cost-leadership. "This leadership we take very seriously".

The market potential "present customers" plays an important role in their strategy. The MM showed this by a slogan in their business unit: "Our present customers are more important for us than new customers. We try to catch new customers but our present customers are staying with us." This was supported by the MD who stated "everybody within our company knows that it is much cheaper to keep a present customers than to gain a new one." He added that this is only possible with a continuous stream of new products.

In their company brochure their focus on product innovation is described as follows: "With our in-depth experience we are leaders in the development of new vacuum products using the latest technology in both design and manufacturing in order to give our customers complete confidence and satisfaction." Although they see themselves as an innovative company, no clear product innovation aims are written down within their business unit.

The categorisation of their strategies according to the model of Johnson and Scholes (1999) shows the concentration on the strategies product innovation and market development (Table 7). Further, it has to be noted that their new products are based on both existing and new competences.

Table 7: Strategies on Existing and New Competences at Vacuum Pumps (analysis based on a framework of Johnson and Scholes, 1999)

Variable	Yes	No	Explanation
Product development	✓		They develop vacuum pumps to replace existing products.
Diversification		✓	Their focus is on their existing product range.
Market Development	✓		Although they are mainly focusing on their present market, are looking for new markets too.
Protection-building		✓	Protection building is not seen as an appropriate strategy.

They invest 15% to 20% in their R&D activities which is expected to be higher than their competitors invest. In summary, 11% of their employees are working for R&D projects. Their strong focus on technology and new products can be seen in their project planning horizon for product innovations. 50% are planned with a time horizon of six months, 30% with a 24 month and 20% for a 60 month time horizon. Their focus on long term projects is necessary to develop transformational new products stated the R&D manager.

Product innovation output

In their product portfolio, Vacuum Pumps had 30 main products, including eight new products. With this portfolio they achieve a product innovation rate of 13.88% per year. The eight new main products generated 16% revenue from their whole turnover. As they do not measures profits from new products regularly they expected 12% profit with these new products. The break-even for new products was given with a maximum of 24 months. However, the MD pointed out that sometimes they develop new products for strategic reasons. In this case they do not measure profit and revenue from these products. Therefore, their focus is not to make more profit with new products.

Asked about the position within the diagram product innovation rate and revenue from new products the MM said: "We have limited R&D resources and the number of new products in this sector is not infinite. The key technology does not change dramatically. Therefore, we focus on few new products." However, this statement was qualified by the MD who pointed out that their position "is not so bad".

In the further discussion the reasons for their low revenue with new products was discussed. The R&D manager stated that one reason could be that "we are customer oriented and therefore we know what they want. Additionally, we want to hold up technology leadership. Therefore, we are developing products without any actual market demand". The MD pointed out that their market is "more static" than other markets. Therefore, we concentrate our activities on both, optimising present products in terms of price and quality and developing new products". This was summarised by the MM who stated: "We try to have a mixture between old and new products. Further, we try to find new customers for our old products, too." This is reflected in their low turnover with new products.

Their stream of new products was described as a permanent one by the MD. However, the MM pointed out that "nowadays we are working together with OEMs, therefore small waves can be observed."

6.3 Key Drivers for the Individual Product Innovation Position

Their position within the diagram with high product innovation rate and low revenue is influenced by different key drivers as:

Market

- Because of latest technological developments, more electronic elements are integrated into their mechanical products. Therefore they need to replace their mechanical products by new ones.

Competition

- Because they are operating in a highly competitive market environment price pressure is very high. This is the reason why they are forced to develop new products which offers their customers a price advantage.

Product Innovation Strategy

- According to the definition of Johnson and Scholes they concentrate their activities on the two strategies product development and market development. They have a mix of customer oriented incremental products (for existing customers) and transformational new products including new technologies for both existing and new customers. As the number of new (transformational) products is high, they achieve a high product innovation rate.
- For developing a high number of new products they invest 15% to 20% of their revenues into R&D activities which are expected to be higher than investments of their direct competitors.
- Their aim is to achieve technological leadership. Therefore, they are developing new products without any actual market demand. Consequently their product innovation rate is high. However, this competence is seen as important to sell their existing products, too. This in turn is also a reason for the low percentage of revenues from new products.
- A further reason for their low percentage of revenues from new products is their concentration on present customers. Therefore, market potential is limited and this in turn had influence on the turnover with new products which is not high.

Although they are making low profits with their new products they see product innovation as a critical point for success. Their ability to develop a permanent stream of new products is characterised by following key drivers:

New Product Process

- Although only 30% of their NPD projects (because of limited personnel resources and very short development times) are running on time, their whole NPD processes are structured in a systematic way into seven phases. Further, new products are developed in teams with members from different departments.

Corporate Culture

- In the interview a strong commitment of the board of management for product innovation was recognised. This is reflected in their strategy to be number one world-wide in three to five years.

- There is a living culture to involve every employees into product innovation processes. This is shown by their well trained sales force to sell their products successfully.

This case has shown, that the position within the field with high product innovation rates and low percentage of revenues from new products is based on clear strategic goals. Vacuum Pumps is convinced that the position within the Filed 2a is the right way to perform in the market.

7. CASE BUSINESS UNIT BU 6 "X-Ray Inspections"

7.1 Business Unit Overview

X-Ray Inspections is a business unit with x-ray products for security with 524 employees. It is part of a greater organisation which is 54 years old. They have their headquarters in Germany with development, manufacturing and marketing. A further R&D technology centre is located in France. Additionally, they have subsidiaries all over the world

They started with the production of valves and x-ray equipment for medicine. In the early 70's X-Ray Inspections diversified into markets for security technology on the basis of x-ray technologies. At the beginning of the 60's they were sold to a greater organisation and were sold again to another organisation in the late 80's. Their product is specialised in x-ray inspection units for baggage screening. A new business field are buildings for the scanning of complete trucks and containers. Radiation, detection and image processing are key technologies for their products.

They achieved Euro 153 million revenue in 2000 and had a growth of 80% over the last three years (26.6% per year). Because of their wide product range, the prices for their product varied between Euro 1,789 for x-ray apparatus and Euro 12.78 million for x-ray systems, e.g., buildings.

7.2 Case Results

Market

The market for X-Ray systems is an increasing one, because security checks on airports are an important issue. The latest boom for new security inspection units at airports was brought about by a new law – till 2003 all airports have to use x-ray inspection systems. In general the product life cycle for their products is three to five years. However, for some few products it is up to 10 years (the mean life cycle is given with 6.5 years). X-Ray Inspections are independent from an economical situation but there is a strong dependency from legislation.

One tendency in their market is the change from hardware to software. Therefore, the MM stated that R&D have to move their focus away from developing hardware (100% in-house) to the development of software (40% in-house). This change in technology also led to a high market potential in this market.

They have an export-rate of 85%. To sell their products world-wide they have a mixture of direct delivery for complex installations and distributed their standard products with sales representatives world-wide. This structure was chosen, because "it is considered as important to have close contacts to local authorities world-wide" stated the MD. The market growth for their market segment was estimated with about 17% per year (average over the last three years) which is lower compared to their yearly growth of revenues over the last three years.

Competition

The MM stated that high market barriers exist for new competitors because "x-ray technology for security is very complicated and customers like airports or governments are very sceptical about new products. Therefore, it is necessary to run new systems with a long pilot running time. A big challenge is to build up close contacts to regional authorities. Therefore, it is difficult for new competitors to enter into this market."

Together with one other main competitor X-Ray Inspections is a market leader and has the technological leadership world-wide. They achieve 35% market share world-wide, while their main competitor in the US achieves 35% to 38% market share world-wide. As they have a strong focus on new products, the benchmark is their product innovation performance against their main competitor, i.e., number of new products, patents.

Corporate environment

Because software components play an important role in their new products, they are not very familiar with old ones (with limited software tools). For their new systems like x-ray security buildings for trucks it was necessary for them to get know-how in architecture and building engineering. These new competences are not very familiar to their previous core competences.

For their new product development and manufacturing they use present resources. However, as they are embedded within a big holding it is possible for them to get know-how from other sister companies. Therefore, synergies are very high between their NPD projects and their resources.

Nature of NPD projects

For the R&D manager new products are "something fundamentally new with a fundamentally reworked design" And the MM stated that "innovation at X-Ray Inspections is strongly driven by customer demands which are dependent on national guidelines and laws. Innovation for us is to develop general product concepts to offer to our individual customers the individual solution."

New ideas came from both customers (50% software) and internal groups (50% hardware). However, transformational products are developed on ideas from their internal groups, e.g., a three dimensional scanning machine for scanning travel packages. Incremental product innovation are product adaptations , i.e., software adaptations to fulfil national standards with their security products.

New product process

They have a functional R&D organisation, although all departments are involved in R&D projects. Teams with members from different departments (product manager, marketing, service, R&D) are responsible for developing a new product. Within the R&D process the MM saw himself as a co-ordinator: "I see myself as a moderator who brings all ideas together..."

The whole NPD process is certified with ISO 9000 and the different R&D stages are defined side by side. 80% of their R&D projects are running on time and only 5% of their projects over the last three years were cancelled. One problem in the R&D process came from developing more complex systems stated the MM. However, one other problem is the limited man power in R&D. The MM stated that "because of more complex products more R&D employees were necessary". Because of high costs or problems in realisation, some projects are cancelled.

Product Innovation Strategy

The reasons why they are introducing new product innovations were summarised by the MM as follows: "First we want to make profits with new products. And with new products including a new design we want to produce our products more efficiently. Additionally, the market and our competitors force us to introduce new products."

The argumentation of the R&D manager went in the same direction: "We want to be the leader in technology and quality. Because in the past our focus was on these two points, we were not first to market with the most products. Because the same product had to be adopted on regional demands, it is difficult to develop a unique product concept. However, our aim in the future is to introduce more products with the strategy first to market." This statement reflects that 40% of their products are first to market. "Because of more complex products and more individual products we want to increase our R&D activities even further". The vision of the MD was "to gain world-market leadership in all product areas for x-ray security and to be active in more new business areas" to extend their project business.

Their strong commitment to product innovation was also seen in their company brochure: "Faithful customer orientation and maintaining technological leadership calls for innovative corporate strategies. For the X-Ray Inspections group this means forging services beyond the world-wide sales and service network, achieving even closer customer contact by subsidiaries and joint ventures overseas.... Collaboration with universities, ongoing training programs and participation in international security conventions guarantee access to the latest technologies." Further, their specific aims for new product innovations are written down in their strategy plan.

Although they earn a low percentage of revenues from new products they have a strong focus on new products. This is shown by the categorisation of their strategies according to the model of Johnson and Scholes (1999). Table 8 shows that they are focusing on the two strategies product development and diversification.

Table 8: Strategies on Existing Competences at X-Ray (analysis based on a framework of Johnson and Scholes, 1999)

Variable	Yes	No	Explanation
Product development	✓		They develop x-ray inspections to replace existing products
Diversification	✓		They develop x-ray inspections for new applications (e.g., scanning systems for trucks).
Market Development		✓	As they are present on the markets world-wide, market development is not seen as an appropriate strategy.
Protection-building		✓	Protection building is not seen as an appropriate strategy.

Their investments into R&D are 15% and they employ 18.5% R&D employees. However, R&D investments from their competitors were estimated to be on the same level between 10 to 20%. 30% of their NPD projects are planned for six months, 60% for 12 months and 10% for 24 to 36 months.

Product innovation output

With their new products they achieve an product innovation rate of 11.9% per year. It decreased from 13% over the last three years because their product range increased but their R&D activities stayed on the same level. With their new products they are achieving 12% revenues. However the MM expected that the revenue will increase rapidly up to 45% in the next year. Their profits with new products (6.0%) are not so high as with existing products with actually 8.5.0%. Overall, the MM pointed out that the profits are higher than the profits of their competitors. The break-even point for new standard products (not for systems) is 1.5 years.

With their strong focus on new products to achieve world market leadership the reasons for their low revenue from new products was discussed in detail with the MM. He argued that the reason for this phenomenon based on the circumstance that most of their revenues for their x-ray systems comes later than three years after product introduction (although break-even is earlier). Their customers are very critical of how a new product is working. Therefore, they are asking for references. However, "to get references which are accepted by a wide range of customers we have to run our products for a time-period with few key-customers – this time period is often more than three years" stated the MM.

Looking not only at their products but additionally at their systems, the picture is changing. The MM argued that their systems have to be taken into account by looking at their revenue from new products. In this case, he stated, the revenue will increase from 12% to 45 to 60%. The reason is that they offer buildings for scanning complete trucks and containers. These buildings are very expensive and every building is fundamentally new and individual. Therefore, the MM argued that each system (building) can be counted as a new product. Certainly, each building is unique, but the infrastructure and the x-ray technique is always nearly the same. Therefore, it is not convincing to take these high number of revenues into account. To compare these systems with their standard products it would be necessary to look at the costs for the x-ray systems and its product innovation potential and not for the building as a whole.

Their stream of new products was described as a permanent one by the MD. He pointed out that only with a continuous flow of new products they are able to stay market leader.

7.3 Key Drivers for the Individual Product Innovation Position

This business unit had a strong focus on product innovation. Although they achieve high product innovation rates their revenues from new products are low. The key drivers for this position are:

Market

- Product innovations need more than three years to be accepted by most of their customers. As a result most of their revenues from new products come later than three years after product introduction. Therefore their revenues from new products (as defined in the current research project) are low.

Competition

- To hold up their market leadership (together with one other main competitor) they are forced to develop a permanent stream of new products. Therefore, product innovation rate is high.

Product Innovation Strategy

- According to the definition of Johnson and Scholes they concentrate their activities on the two strategies product development and diversification. Therefore a high product innovation rate is seen as essential to give world-market leadership in all product areas for x-ray security and to be active in more new business areas.
- For developing a high number of new products they invest 15% of their revenues into R&D activities which are expected to be similar to the investments of their direct competitors.
- Both product innovation and quality are the main aims of X-Ray Inspections. To achieve a high quality it is not possible to be innovation leader with all products. Therefore, only 40% of their products are first to market.

Although low revenues are achieved, this business unit has the ability to stay innovative on a high level and to develop a permanent stream of a high number of products. The key drivers identified are:

New Product Process

- R&D processes are structured systematically and interdisciplinary NPD project teams are working within NPD projects world-wide.
- However, because of more complex products and their limited R&D capacities, their product innovation rate decreased slightly over the last years.

Corporate Culture

- Their aim is to be world-market leader. To achieve this they have a strong commitment to developing new products. This is shown by their close collaboration with universities and on-going training programmes on the latest technologies.

This case has shown, that the position within the field with high product innovation rates and low percentage of revenues can be dependent on the market characteristics.

Although this business unit has the focus to make most revenue with their new products the diagram does not show this because most of their revenue came later then three years after product launch. This is reflected in their position in Field 2a in the diagram product innovation rate and the percentage of revenues from new products.

8. CASE BUSINESS UNIT BU 7 "GEARBOX"

8.1 Business Unit Overview

Gearbox is a business unit specialising in planetary gear boxes. With currently 160 employees it constitutes the whole company including production, marketing and development. They do not have further plants or service locations in Germany and in other countries but they have their own marketing settlement in US. The company is family owned and 72 years old. Both interview partners (MD and MM) are shareholders of the company.

In their founding years they started with the production of precision engineering for the clock industry. 35 years ago they concentrated their activities on the production of gears. Most of their business was the production of gears in the way of payment conditions for other companies. However, 10 years ago they started to develop and to produce their own gear-systems. Own products were created on their key competence "gear-technology". Today they produce three different planetary gearboxes: Standard gearboxes, low backlash gearboxes and custom made gears.

With their products they make Euro 13.9 million in revenue and achieved 15% growth in the last year. The price range for their products is between Euro 76 to Euro 4,601.

8.2 Case Results

Market

They are working within an increasing market, because their products for specific applications are demanded by more and more customers stated the MD. As gears are parts of machines or vehicles their life cycle is dependent on their life time. In general gears were replaced after four to eight years (dependent on the running time) but in some cases they are running 15 to 20 years. Dependent on the running time, products are replaced after six years.

They have direct delivery with four external commercial travellers in Germany and external sales dependencies in Europe. With this sales structure they export 32% of their products to European countries and into the US. The MD stated that there is no strong dependency from economical influence "because product mix is good and automation activities increase when an economical framework is decreasing." The market growth for their market segment was estimated lower than their yearly growth of 15% per year.

Competition

They expected high market barriers for new competitors, because the "time needed to get the know-how to develop own gears is long" stated the MD. They needed 10 years to build up a new product line and to gain the confidence of their customers. The core competence is to create high-tech gearboxes for specific applications, e.g., automatic wheel-chairs.

With 15% market share in Europe they are segment leaders together with three other companies in this specific niche. However, they have three main competitors with 30%, 20% and 10% market share. Although they are direct competitors they are difficult to compare because they have a more complex product range than Gearbox.

Corporate environment

Their new products are very familiar to their existing products. Their new products are directly based on their previous product lines and therefore familiarity is high. However, their aim is to develop a gear-box with electronic components which is not very familiar to their previous new products.

The synergies of the NPD process is high. They are using their own R&D resources, their own production and their own marketing structure for their new products.

Nature of NPD projects

The MD defined their new product innovations as "fundamental new gears with a new design". For him innovation is more than product innovation: "We try to stay flexible. We try to improve our processes use modern manufacturing processes and want to stay up to date". And the MM stated that innovation for him is to offer new products for new market demands. "Innovation for us is to offer new solutions for new types of problems for our target group".

New ideas for new products came from outside (50%) and from inside (50%) the company. However the MD stated that their transformational new products are developed on the basis of their internal know-how. These new products have to be adopted to customer demands – these product innovations are more incremental. Therefore, they have a mixture of incremental and transformational new products.

New product process

Their R&D is organised functionally and the MD has a strong influence on the whole R&D processes. He is involved with the development process for new products very deeply and he forces the development of new products intensively. However, for their NPD projects they have interdisciplinary R&D teams with development, manufacturing and marketing.

In 1999 they installed an R&D department which now has four employees. They are certified with ISO 9000 "but nobody controls whether or not ISO 9000 is implemented" said the MD. He pointed out that "because of the small size of the company communication between all persons who are involved in a research project is the most important point for success".

66% of all projects are running on time and only two projects were cancelled in the past. The delay of 34% of all R&D projects was seen as the most important problem by the MD who stated: "Time and personnel capacity was the biggest problem in our development process. Therefore, we built up an R&D department two years ago". The low number of cancelled NPD projects is based on the fact that all projects are planned very carefully.

Product innovation strategy

The reasons why they are developing new products was explained by the MD as follows: "We transferred our customer demands into our own development activities. However, we started 10 years ago to develop own products because we wanted to become independent from wage-manufacturing. Now, we have the image and the sales structure to sell our products successfully." The MM added that with their new products they want to increase their profits . The fact that it is working is shown in the last three years where their profits increased by 6%.

Their aim with new products was summarised by the MM as follows: "We always want to offer new products for new markets. And we are thinking with our customers to improve their products". The MD added that their vision is to increase their market share to become market leader. However, as their products are on a high technological level he stated: "We will first achieve product innovation leadership or technology leadership. We are on the way to achieving this, because 50% of our new products are introduced with the strategy first to market." To achieve product innovation leadership they want to stay on the same level with their R&D activities as now said the MM.

However, their aim is to become a specialist, too. The MM pointed out that in niches the competition is much smaller. And their strategy is to produce high numbers of products within these niches. He also stated that customers who are buying a new product often buy standard products at Gearboxes, too. This is a further aim to be active in product innovation.

They have a strong customer focus which was reflected by the following statements. The MM said "We do everything our customers want and therefore we do not always ask for the costs. With our new products we can show our ability to develop new products and our competence in the field gear-boxes". This strong customer focus was qualified by the MD who stated "we are active in two areas – the first area is customer oriented and the second area is the development of new products".

Their strong customer focus is also shown in their company brochure: "You as a customer, have a leading position. Your success is important for us... Flexibility, referred to your demand, enables us to co-operate with competent partners... Our company means customer-oriented / innovative / functional / co-operative." Within their company philosophy product innovation is seen as one main point to stay competitive: "In your interest we effectively and flexibly make use of the latest developments and manufacturing techniques in order to provide you with first-class products at any time." Although they have a clear commitment to new products the R&D manager stated that no detailed product innovation aims are written down, "but in the next two years we want to develop a further new product line". The categorisation of their strategies according to the model of Johnson and Scholes (1999) identified the two strategies product development and diversification (Table 9).

Table 9: Strategies on Existing Competences at Gearboxes (analysis based on a framework of Johnson and Scholes, 1999)

Variable	Yes	No	Explanation
Product development	✓		They develop new gearboxes to replace existing products.
Diversification	✓		They develop gear boxes for new applications (new customers).
Market Development		✓	They are focusing on their present market.
Protection-building		✓	Protection building is not seen as an appropriate strategy.

The strong involvement of the MD into all R&D processes and their limited resources is shown in the investments into R&D and the number of R&D employees. 5% of their revenues are invested into R&D and 2.5% of their employees are working in R&D projects. The MD estimated their R&D investments to be in the first third of the industry average.

The combination of incremental and transformational new products is shown in their project planning horizon. 50% of their projects are planned for 12 months (incremental new products), 20% for 24 to 36 months and 30% for 60 to 120 months (transformational new products).

Product innovation output

In their product portfolio they have three main products and two new products. With this product range they achieve 22.22% product innovation rate per year and 36% revenue. The actual profits with their whole product portfolio increased from 9.55% to 15% in the last three years. This was a result of their new products, stated the MD. The profits for new products and the break-even point is not measured and therefore no information for these variables is available.

Their position in Field 2b (high product innovation rates and high percentage of revenues) within the diagram product innovation rate and percentage of revenues was explained by the MM as follows: "It was our strategy over the last 10 years to increase our turnover with own new products. And we were lucky that the investments always re-paid us – now we are in a position where customers with their problems come to us because other competitors failed. Because of this situation we achieve a respectable amount of revenues from our new products". Therefore, they want to increase their permanent stream of new products even further, stated the MD.

8.3 Key Drivers for the Individual Product Innovation Position

The reasons for Gearbox's high product innovation rate and high percentage of revenues from new products can be explained by following key drivers:

Competition

- Although they concentrate their activities on a specific niche they have recognised that this niche gets more attractive for new competitors, too. Therefore they are forced to be innovative to hold up their actual market position.

Product Innovation Strategy

- According to the definition of Johnson and Scholes they concentrate their activities on the two strategies product development and diversification. Their strategy is to increase their turnover with own new products. As they have a strong focus on product innovation two third of their products within their portfolio are new. Although they are an old company they started 10 years ago to develop own new products (and experienced that the investments are re-paid). This consequent focus on new products led to a high product innovation rate.
- For developing a high number of new products they invest 5% of their revenues into R&D activities which are expected to be similar to the investments of their direct competitors.
- Because they are known to be innovative, more customers (in comparison to the past) are buying their new products. With these new products they achieve high revenues. However, many of these customers buy their existing products, too.

Their high product innovation potential is based on following key drivers:

New Product Process

- A few years ago they have installed an own R&D department and are on the way to improve their NPD management system even more. All new products are developed with interdisciplinary NPD project teams.
- Although they have some problems in the NPD process, these problems have no influence on their product innovation activities. The reason is the good information transfer between all persons who are involved into a research project.

Corporate Culture

- The strong commitment of the board of management (owners) to product innovation is seen in their decision 10 years ago to develop new products. Although the risk was high that the investments will be not repaid, they took this risk into account.
- Especially the involvement of all employees into the creation process of new products is one of their strengths.

This case shows how a small engineering company from the "old economy" is focusing on product innovation to increase revenues and profits successfully. However, the case also showed that it took 10 years to be in a position to sell own new products successfully and to position them from Filed 1a to 2b in the diagram product innovation rate and revenues from new products.

9. CASE BUSINESS UNIT BU 8 "ULTRASOUND"

9.1 Business Unit Overview

Ultrasound is a family owned company with 140 employees (the whole business unit constitutes the whole company). The company was founded in 1961 and develops, manufactures and markets machines and production lines to weld synthetic materials with ultrasound. They have only one location in Germany but a marketing dependence in US. Further, it is noted that the owner is not active in the management.

They started with the production of ultrasound machines for dry cleaning. In the 60s they began with the development of an ultrasound-generator for welding, and in 1974 they had a breakthrough with their ultrasound-generator. This was the starting point to concentrate their business activities on industrial welding with ultrasound. Today they specialise in ultrasound-generators for welding for the industry sectors synthetics, packaging and nonwovens.

In 2000 they made a turnover of Euro 16.8 million and achieved a 25 to30% growth over the last three years which is prognosticated for the next years, too. The price range for their products is very wide because they offer standard products and systems. Their cheapest standard product costs Euro 766 and their most expensive system Euro 1 million.

9.2 Case Results

Market

Their market is an increasing one, because the synthetics industry has a yearly growth of 5% to 6%. One further reason is that packaging technology is an increasing market, too. Their product's (machines) life time is normally 7-8 years. However, some products run for up to 15 to 20 years. Independent from the life time, the product life cycle of their products is between three to five years (on average four years).

Their distribution is based on an own salesforce with own sales engineers. The MD stated that this is necessary "because technical background is important to advise our customers, and no other way leads to success".

With their products they have an export rate of 50% world-wide. On the question if they are dependent on any branch the MD stated that in the past they had a strong dependency on the automotive sector. To decrease this dependency, they have looked for new products and markets. Today the dependency on automotive is 35%. Therefore, the R&D manager (who is also production manager) summarised that the economical influence is not so high. The market growth for their market segment was estimated lower than their yearly growth of 10% per year.

Competition

Their focus on ultrasound and their know-how in technology led to high market barriers for new competitors. One further reason is their manufacturing processes and their sales know-how with their high qualified sales engineers. The R&D manager stated that "the two years training of our sales engineers makes it impossible for new competitors to enter this market in a short time."

They have 30% market share in Europe, 15% world-wide (without Asia). Main competitors in Europe have fewer market shares in this special sector. However there a two competitors with a strong market position in the US and Asia – in these two regions their competitors are market leaders. However the MD saw them as market leader in Europe and technological leader world-wide.

Corporate environment

Although their products are technology driven, their new products are familiar to their existing product range (as stated by the MD). Although their basic know-how (technology) is included in every product, their new ultrasound systems are quite different in design, steering and electronic components.

For developing, manufacturing and marketing their new products they are using their present infrastructure intensively. Therefore, synergies of NPD processes with existing resources are high.

Nature of NPD projects

The MD defined their new products as "something new with a fundamentally reworked design". The R&D manager stated that innovation at Ultrasound included products, processes and organisation.

New ideas for new products came from different sources as with market supervision, suppliers, R&D and marketing. 30% of their ideas came from outside, whereas 70% of their ideas are created internally. The R&D manager stated that "we have our ear on our customer demands and therefore we developed the right product". However their focus is on transformational product innovations developed internally.

New product process

Their product innovation activities were driven by the founder who developed the basic know-how. This spirit is alive in the company which aims to be technological leader. The structure of the whole business unit is a functional one. They have installed an own R&D department and R&D phases are certified with ISO 9000. Core teams with members from different departments are responsible for developing a new product. However, although their processes are structured very well, the R&D manager pointed out that "personnel contacts are more important to co-ordinate all product innovation activities than formal controlling". Further, education and motivation of employees were seen as important by both the MD and the R&D manager.

The MD pointed out that only 20% of all R&D projects are running on time and 5% of all projects will be cancelled. The delay of R&D projects was seen as the most important problem in their processes. The reason for this is the fact that "most new products are developed apart from the daily work" said the R&D manager. The reason for cancelling a low percentage of projects is that some projects are too expensive to realise.

Product innovation strategy

The main reason why Ultrasound develops new products is "to gain market and technological leadership" stated the MD. The statement of the R&D manager was going in the same direction: "Not to be forced by market prices – we want to achieve good margins in the market. In other words we want to make more profits. But this is only possible with product innovations."

Their aim with product innovation "is not only in maintaining our technology leadership. It is the summary of our strong focus on customer demands, to employ the best persons and to have content employees" said the R&D manager. The MD explained their product innovation activities as follow: "We want to be the technological leader in our segment and we want to increase our market share. And we do not want to go into markets (branches) we do not know." This is also shown in their vision from the MD: "Our long term aim is to extend our international business, to hold up our technology leadership and to have a growth of 100% in the next five years". Their strong focus on technology is reflected in their strategy to be first to market with 100% of their new products.

Their high commitment to product innovation is documented in their company brochure, too: "Ultrasound is an area for few specialists. All-embracing pure research... is the basis for a remarkable performance-standard which is out of the ordinary". Further, headlines are: "Spectrum with high-tech through R&D..." and "general and all-inclusive consultants..." Their specific product innovation aims are documented in their five year strategy plan, where all new products for the next two years are laid down.

They have a strong focus on new products and mix three strategies (strategies according to the model of Johnson and Scholes). Table 10 shows that they see product development, diversification and market development as appropriate strategies to stay competitive.

Table 10: Strategies on Existing Competences at Ultrasound (analysis based on a framework of Johnson and Scholes, 1999)

Variable	Yes	No	Explanation
Product development	✓		They develop ultrasound systems to replace existing products
Diversification	✓		They develop ultrasound systems for new applications.
Market Development	✓		They are looking for new markets for their products (i.e., US, Asia).
Protection-building		✓	Protection building is not seen as an appropriate strategy.

Their high focus on product innovation was supported by their investments into R&D with 15% and their high number of 15% R&D employees. Looking at their R&D investments the MD stated that their R&D activities are extremely higher than from their competitors. As they have technology driven products, 30% of their project planning horizon is 24 months and 70% is 60 months.

Product innovation output

With a product innovation rate of 25% per year and 50% revenue from new products they are positioned in the field with the highest product innovation rates and highest percentage of revenues from new products. 31% profits for both old products and new products are respectively high. Although their profits are high the R&D manager pointed out that profits decreased over the last years because competition is higher than 10 years ago. Although profits decreased, the break-even point for new products with 0.5 years is respectively short.

Because the profits are respectively high for both new and existing products, this phenomenon was discussed with the MD in detail. He explained this as follows: "For new products the prices are higher than for existing ones. However, the profits for existing and new ones are nearly the same. The reason is, that the production of new products is more expensive. Manufacturing lead time is longer and often difficulties which were not recognised with the production of the prototypes arise. In comparison the manufacturing process for existing products is running without any difficulties. Production employees are trained very well and do not need as much time as for the manufacturing of new products. A further reason is, that in the transitional phase of replacing existing products with the new ones, the produced number of items for existing products is very high." He summarised the high profits for existing products with the words: "Because of cost reduction in manufacturing the margin for existing products is as high as for new products – although existing products are sold on a lower price level".

The MD explained their position within the diagram product innovation rate and percentage of revenues from new products as follows: "We want to be the technological leader. Therefore, we introduce more new products than our competitors and these products generate most of our revenue". In the discussion of their position the R&D manager said: "All companies in the other field within the diagram product innovation rate and revenues from new products will die. The only possibility of surviving is a position in the field with the highest product innovation rate and the highest revenues from new products."

Their products were introduced in the way of waves. Every three to five years old products were replaced with fundamentally re-designed new products. This is based on their philosophy to secure their technological leadership. The MD pointed out that in most cases they are not forced to develop new products. He stated: "Our customers are pleased with the existing products. By launching a new product, we have to convince them to buy the new one." However, the R&D manager stated that the aim is to have a permanent stream of new products on a high level.

9.3 Key Drivers for the Individual Product Innovation Position

The key drivers for their position within the field with the highest product innovation rates and percentage of revenues are:

Market

- Because of latest technological developments, more electronic elements are integrated into their mechanical products. Therefore they need to replace their mechanical products by new ones.

Competition

- Although they have a strong market position in Europe and in the US, they are convinced that the only possibility to survive in the market is to have a high product innovation rate and a high percentage of revenues from new products.

Product innovation Strategy

- According to the definition of Johnson an Scholes they concentrate their activities on the three strategies product development, diversification and market development. Because they follow all three strategies with new products, the number of existing ones in their product portfolio is low.

- For developing a high number of new products they invest 15% of their revenues into R&D activities which are expected to be higher than investments of their direct competitors.

Their focus is to have product innovation leadership. Therefore, they concentrate their marketing activities on their new products. With these products they generate most of their revenue.

Their possibility in achieving high product innovation rates and to sell their new products successfully is based on key drivers as:

New Product Process

- The whole NPD process is structured and all new products are developed with interdisciplinary NPD project teams.
- Although their R&D processes are not running optimally, they are highly innovative. The reason why these problems have no influence on product innovation processes are the short communication ways within the business unit.

Corporate Culture

- The strong commitment of the board of management to product innovation is reflected in their view that the only possibility of surviving is a position in Field 2b of the diagram product innovation rate and percentage of revenues from new products.
- They have a strong employee orientation. This is shown by their philosophy to have well educated employees who guarantee the product innovation leadership.
- Their technology is not well known. In some cases they have to convince new customers to buy their products. However, this is only possible with a well trained sales force.

This case shows how high profits are related to the aim of having high product innovation rates and high percentage of revenues from new products. It also shows that one basis to achieve this is the strong commitment of the board of management to product innovation leadership. However, in this case, problems in the NPD process have no influence on product innovation rates. In summary these drivers position them in Field 2b within the diagram product innovation rate and the percentage of revenues from new products.

10. CASE BUSINESS UNIT BU 9 “EXHAUST SYSTEMS”

10.1 Business Unit Overview

Exhaust Systems is part of a world-wide operating organisation with products for the automotive industry. The division exhaust systems has 3.160 employees world-wide and 14 business units with production. Within the whole organisation exhaust systems made 14% of their business, 68% is seating, 10% vehicle interiors and 8% front-end modules. Exhaust Systems employs 600 people at this location which has only manufacturing. R&D and marketing is centralised at the German headquarters.

The business unit at the investigated location started in 1901 with the production of mirror glass and was bought in 1946 by an automotive specialist to produce exhaust systems. In 1994 they were resold to another organisation. They are specialised in producing exhaust systems for all kinds of cars. This includes catalysts, sound absorbers and pipe systems.

The business unit made Euro 194 million turnover at 17% growth However, the whole company made Euro 3.8 billion in revenue. The price range of their products is between Euro 5.1 for small parts to Euro 1,278 for exhaust systems.

10.2 Case Results

Market

The automotive market is an increasing one and therefore they see very good chances to grow further. As their products are closely linked to car models they supply their products directly to car manufacturers (OEMs). The R&D manager stated that one main factor for the exhaust market are laws "Environmental aspects play a very important role when introducing new products into the market – our customers are forced to install the latest exhaust technology in their vehicles."

The life time of their products is dependent upon the motor running time of cars – in general after five to seven years the exhaust system has to be replaced. However, in some cases their products run for more than 15 years. The life cycle time of their products is between one to six years (on average 3.5 years).

All of their products are developed for specific customers. Therefore, they have only direct delivery, centralised in their headquarters. With their products they achieve 20% for exports in Europe. But as they are only one part of a world wide organisation they have exhaust production locations all over the word. As they are concentrated on the automotive industry, their business is directly linked to the economic situation in this branch. The market growth for their market segment was estimated with about 17% per year (average over the last three years) which is similar to their yearly growth of revenues in the last year.

Competition

The R&D manager stated that market barriers for new competitors are very high, "because in today's market it is necessary to be a global player and to be a system-supplier. Additionally, processes are very complicated and equipment is expensive. There are maybe some niches but not for cheap products". The MD stated that close contacts to customers who are convinced of the ability to be innovative is a further reason which made it difficult for new competitors to enter this market.

With 19% market share in Europe they see themselves as market leaders. However their direct competitors achieve as high a market share as Exhaust Systems but on a lower level. Their three main competitors have 16%, 15% and 15% market share within the European market.

Corporate environment

They concentrate their business on exhaust systems. Therefore, the familiarity between old and new products seems to be very high. However, for the production of new exhaust systems, they have to develop new production methods which are quite different from present methods. Further, electronics and new materials are playing an important role in new products. Therefore, in most cases familiarity is not given.

For their R&D projects they are using their resources within their division. Therefore, the synergies are very high. This is also shown in the brochure with the heading "competence through synergy".

Nature of NPD projects

The R&D manager stated that product innovation for him is "a new exhaust system for a customer, which was not produced before". As in this business unit manufacturing and R&D is not at the same location, the MD focused more on manufacturing processes. He stated: "On first sight we are only a location for production – therefore our main focus is on manufacturing processes. But only with new manufacturing processes, can high-tech exhaust-systems possibly be produced."

Their ideas for new products are generated from 70% inside the division and 30% from outside (customers). Especially transformational product innovations are generated within the business unit together with R&D. However, the MD pointed out: "Because we have to offer technical solutions to our customers it is necessary that we develop solutions which only have to be fitted to customer demands." But these new products are transformational too.

New product process

The business unit is organised functionally, but in R&D activities all departments are involved. Therefore, it is more of a matrix organisation. The MD pointed out that interdisciplinary R&D teams are necessary because "both, development in laboratories and manufacturing are important points in our products."

Although all R&D activities are centralised in the headquarters, the business unit (manufacturing) is deeply involved in the whole R&D process. Their R&D projects are run on the basis of a project management system which is separated into nine steps. Further, all stages are certified with ISO 9000 and VDA-6. The R&D manager stated that "our R&D detailed process is defined. It includes nine milestones with separate review stages. All processes must be documented in detail. In regular meetings (every milestone gives the framework of the participants) members of all departments meet together". To achieve this, communication between all departments is seen as an important point.

Within their R&D department they have installed a product innovation committee which is analysing previous NPD projects with the aim of learning from them. Additionally, human resource management and education plays an important role in their organisation.

"The main problem in our R&D process is the implementation of a new product in the manufacturing process" stated the MD. However, 100% of all R&D projects are running on time, because our customers give us the framework. However, because some projects are focused on pure research, 10% of all projects were cancelled in the past

Product innovation strategy

The reasons why they are innovative is their "aim to become market leader world-wide" stated the MD. He added that since 1994 they are market leaders in Europe but to grow internationally one important part is to have innovative products and service policy. In this context the R&D manager added "the market and our competitors forces us to improve our products." This aim is also reflected in their visions stated the MD: "We as a producer of exhaust systems want to become market leader world-wide in our branch."

Their aim is to be best in their class – "this is the aim of our whole group" said the MD. And the R&D manager added "we want to stay ahead of our competitors." This is also given in their brochure with the statement that they are "an automotive supplier with leadership in exhaust systems". In the discussion the MD pointed out that he has a strong focus on both new manufacturing processes and new products. "I have a strong focus on improving our manufacturing processes. I try to motivate our employees, use kaizen and other management techniques to achieve higher quality and stable processes. Nevertheless, product innovation is important where our plant is deeply involved." Because of this strong focus on product innovation all products (100%) are first to market.

A further challenge for product innovations are new materials, and new possibilities to use electronics for steering processes. To stay ahead it is necessary to start research projects dealing with these new technologies. The MD stated that one of their slogans is "always be among the leaders in our sector of activities". To achieve this they have the aim to work together with specific suppliers: "For each family of strategic purchases, at least two suppliers are among the world leaders in their market, and contribute with Exhaust Systems to the development of new technology".

Their high commitment to product innovation is reported in several company brochures and in their philosophy. To be "systems-supplier", "a first class partner for the automotive industry" and "global presence" are keywords within their publications. Their strong focus on new products is given in a further statement with the words: "...an innovative range of products for the automotive industry... the group deploys state-of-the-art technologies, testing and research resources all over the world... positions the group as a provider of innovative solutions compatible with environmental preservation." Additionally, their clear strategy for new products with detailed product innovation steps is written down in their strategic plan given by their headquarters.

The categorisation of their strategies according to the model of Johnson and Scholes (1999) shows that they concentrate on the strategy product development (Table 11). This is based on both existing and new competences.

Table 11: Strategies on Existing and New Competences at Exhaust Systems (analysis based on a framework of Johnson and Scholes, 1999)

Variable	Yes	No	Explanation
Product development	✓		They develop exhaust systems to replace existing products. As electronics get more important in their products, they need new competences to develop their products.
Diversification		✓	They are focusing on their present products (exhaust systems for cars)
Market Development		✓	As they are part of an international company, market development is not seen as an appropriate strategy.
Protection-building		✓	Protection building is not seen as an appropriate strategy.

They invest 6% of their revenue in R&D activities (comparable with the investments of their competitors) and 10% R&D employees are working within the exhaust systems division. Their R&D projects are more transformational which is seen by their project horizon where only projects lasting more than 12 moths are "managed in research mode" (statement in their mission handbook). 50% of their products are planned for 24 months, 30% for 36 months and 20% for 60 months.

Product innovation output

With their new products they achieved 17% product innovation rate per year and had 70% revenue from these new products. As they had a high percentage of new products in their product portfolio, their profits for both old and new products was 10%. Dependent on the products the break-even point for new products is one to two years. However, they also had some strategic R&D projects where the break-even is not calculated.

The reasons for their high product innovation rate and their high revenue from new products was explained by the MD as follows: "We have a high innovation rate because our group acts very aggressively in the market. And additionally, competition is very high. Therefore, we have no other chance of introducing new products with the latest technology." Consequently, he stated that with these new products we generate most of our revenue. This was confirmed by the R&D manager who stated that their focus on product innovation leadership and first to market drives them to introduce a permanent stream of new products. This stream of new products generates a high percentage of their revenues.

The MD added "because production processes are very complicated, it is dangerous to have waves – then the quality is not so good any more. Therefore, our group tries to balance the production of new products by regarding all plants."

10.3 Key Drivers for the Individual Product Innovation Position

Their high product innovation rates and high percentage of revenues from new products are based on the following key drivers:

Market

- Exhaust systems are influenced by environmental laws. Therefore, they are forced to develop new products with the latest technology for reducing harmful substances.
- Because of latest technological developments, more electronic elements are integrated into their mechanical products. Therefore they need to replace their mechanical products by new ones.

Competition

- Their aim is globalisation through product innovation. As they have three main competitors with similar market shares, they need to be innovative to become market leader world-wide.

Product Innovation Strategy

- According to the definition of Johnson and Scholes they concentrate their activities only on the strategy product development. Because of this strong orientation on new products, they achieve a high product innovation rate and a high percentage of revenues from new products.
- For developing a high number of new products they invest 6% of their revenues into R&D activities which are expected to be similar to the investments of their direct competitors.
- Because they have to supply spare parts too, they still have some products in their product portfolio which are older than three years.

Their ability to achieve high product innovation rates is based on key drivers as:

New Product Process

- The whole NPD process is structured in a systematic way into nine steps and new products are developed in interdisciplinary NPD project teams.
- They had a centralised R&D with well defined NPD processes and research centres are located all over the world.

Corporate Culture

- Their strong commitment to product innovation is seen in the selection process of their suppliers – they are selected on the basis of their product innovation abilities.
- To develop new products they have a culture of working with international and interdisciplinary teams.

This case has shown, that product innovation is linked to a clear strategy broken down to one individual business unit. Although the business unit was only a location for production the clear commitment to new products were seen in the statements of the MD and R&D manager. Overall their strong orientation on product innovation is given with their position in Field 2b in the diagram product innovation rate and the percentage of revenues from new products.

11. CASE BUSINESS UNIT BU 10 "VEHICLE ELECTRONICS"

11.1 Case Study Execution

In this business unit the managing director, the marketing manager with his assistant and the production manager were interviewed. As this business unit was part of a large company with centralised R&D, no R&D department was located at the business unit. However, as production is deeply involved into R&D activities, the production manager was able to answer this part of the questionnaire. After the visits some questions were still open and therefore the R&D manager in the R&D department was interviewed in a telephone call. Additionally, brochures and the internet presentation were analysed.

11.2 Business Unit Overview

This business unit manufactures and supplies electronic equipment for the automotive industry. The location was founded in 1959 and is part of a greater organisation. The investigated business unit employs 815 people. Development for all business units within the mother organisation is centralised. The whole organisation has further locations in Germany, the Philippines, China, Hungary and Mexico.

They started with the production of variable capacitors and drum turrets for radios. Since 1972 they have been producing electronic parts and equipment and for 6 years they have concentrated their activities on the automotive industry. The main technology is electronic equipment, e.g., powertrain and chassis, body electronics, passive safety, etc. Vehicles Electronics had a turnover of Euro 0.92 billion in 1998 and a growth over the last three years of between 20 to 40% per year – in the future about 15% was expected. The price range for their electronic parts ranged from Euro 5.1 to Euro 51.1.

11.3 Case Results

Market

Their market is an increasing one stated the MM, because electronic equipment in vehicles is increasing. There latest market research study showed that electronics components in cars makes 30% of the value – "tendency increasing" stated the MM. The high importance of electronics in cars was also shown in their internet presentation: "...the share of electronics in modern automobiles is steadily rising. Next, to improvements in design, up to 90 percent of all automotive innovations today are based on electronics".

Vehicles Electronics has an own sales force. With direct delivery and key-account-managers they advise their customers (all OEMs) in an "optimal way" said the MM. To be active in the automotive market it is important to look at future vehicles. The way in which they bring a new product on the market was explained by the MM as follows: "For example, we are going to Mercedes or BMW and are saying we have this and this new technology. On the basis of our suggestions we are developing a new product together with them" (it has to be stated hat this view is in line with the view of the MD too). Product life cycles of their products are dependent upon the life time of cars which is normally between three to five years. However, some products have a, life cycle of 2 years while others are replaced after six years – on average the life cycle is 3.5 years.

30% output is exported directly but together with the products of their customers where their products are included (indirect exports) the total figure is nearer 50%. Comparing with previous studies, the high market growth could be a reason for the introduction of many new products (e.g., Zarah 1993b). Further, they have a strong influence from the economical situation in the car industry – but as they have a wide range of customers they see it as not critical. However there are further influences from national security laws. The market growth for their branch was estimated lower than their yearly growth of 20% per year.

Competition
For new competitors high market barriers exist because investments into production are high. Another point is the close relationships between existing customers which were difficult to built up for new competitors (this was stated by both the MD and the MM). The close relationship to OEMs and their trust in the ability of Vehicles Electronics to develop and produce innovative products which run in the practice is the key stated the MD. However, although market barriers are high, a lot of other business units are active in the similar branch.

With 8% market share world-wide, they have a good market position but their main competitors have 16%. However, as they are more flexible and more innovative than their competitors they see themselves in a better market position for increasing their market share. With regard on product innovation rate their low market share could be a reason for their high product innovation position. For example, Loch et al (1996) identified competition as a driver for innovativeness.

Corporate environment
Their new products often includes other functions and their design is quite different from their previous ones. However, product type, market and technologies are similar for both existing and new products. Therefore, familiarity between new and old products is high. Further, the synergies are high too. To develop, manufacturing and marketing their new products they use their present resources (marketing salesforce and plant equipment) for their NPD processes. As they are part of a greater organisation synergies between NPD projects and present infrastructure is high.

As both familiarity and synergy is high, it can be concluded that this is a key to their high product innovation rate. However, Cooper and Kleinschmidt (1993) found, that in their sample both variables are high in all business units (which is also the case for Plastics with low product innovation rate). Therefore, a relationship to product innovation (i.e., product innovation rate) is questionable. However this need to be analysed in-depth through a cross-case analysis of all cases.

Nature of NPD projects / source of ideas
The MD defined product innovation as "something new with a fundamental reworked design for new applications". But looking at all innovation activities he had a comprehensive view of innovation in products, processes, organisation. For the production manager innovation is "new technologies and new products for new markets,

with a better price/performance relationship". This shows the different viewpoints on innovation and the necessity to interview different management functions within a business unit. However, all (MD, R&D manager, MM) defined new products as transformational ones.

New ideas for new products come from external sources (70%), i.e., customers, research institutes and 30% from internal sources, i.e., R&D and marketing. The MM explained their high proportion of external ideas (which are realised on new technologies developed by vehicle electronics) as follows: "In most cases our customers are coming to us with an idea. We prove this idea and we are looking for the best method to realise their ideas – cheap and functionally." This was also shown in the internet presentation where customers are seen as the main source for product innovations: "Together with our partners and customers we develop individual solutions tailored to solve various different problems." Further, their idea generation is related to a close partnership with suppliers. It based on four tools: "...The identification and selection of suitable suppliers as well as development and utilization of their abilities" (company brochure). In the product innovation literature no clear findings were given which relationship between internal and external idea sources support product innovation. However, important is a mixture of both, which is given for BU10.

New product process

Their R&D is organised as a matrix organisation. Within their NPD teams members from all departments are involved. Core teams with up to nine members from different departments are responsible in developing a product. Their products are developed in six defined phases from acquisition to production – at the end of every phase the project is reviewed. The NPD management processes were discussed with the production manager and the R&D manager. The interviews showed that the ability to handle the NPD process systematically is their basis to develop many new products i.e., act with a high product innovation rate. Within this process monthly discussions of all department leaders are installed. It is described in their brochures as follows: "Our highly motivated development team works in close co-operation with a cost-conscious sales department and state-of-the-art production to satisfy our customers' service, price, and quality needs."

Although their NPD processes are structured in a systematic way, only 50% of all projects are running on time and 30% of all projects are cancelled. The reasons for this was described by the production manager as follows: "As customer demands are changing during an R&D project many projects are delayed". He pointed out, that the high cancel rate of NPD products is related to their approach to develop pacemaking technologies. This was confirmed by the MD who stated that "this is the price we pay to be the most innovative producer of electronics parts for the automotive industry". As such a relationship was not expected, it is interesting to carry out a cross-case analysis to investigate how cancel rate is related to product innovation rate for a wider sample.

Product innovation strategy

On the question why Vehicle Electronics introduces new products into markets the MD answered: "Products get cheaper and therefore more features can be offered for the same price. Other reasons are to make customers more satisfied and to make more profits with new products. However, old products are replaced and therefore new product generations have to be offered (e.g., airbags since 1992 four generations)". This general statement is in line with the findings of Cooper and Kleinschmidt (1993) who found that product advantage is the "number one factor in success" (i.e., product's sales and profits impact on the business unit).

Typical for Vehicle Electronics's product range is the aim to "develop customer specific products and maintain the product innovation leadership (MD)". For the MM it is the aim "to be the only company which offers products first to market and to create market advantages and profits with pacemaking technologies" Therefore, they have 100% of their products first to market. However, the ability to operate with a high product innovation rate mainly basis on "the right customers" as the MM pointed out. He said: "product innovations are only possible with strategic customers. Therefore, a partnership with customers who stand behind the innovative (first to market) products from Vehicle Electronics are important. Only such partners are willing to pay more for innovative high-tech products. E.g., the philosophy in the three big German automotive companies fits this philosophy of Vehicle Electronics – in strong contrast, customers which act as followers are not so interesting for us." This was confirmed by the MD who pointed out that OEMs who introduce first to market products have to take into account that the new products "may have some minor mistakes in the first series". He pointed out, that only customers who are willing to fit innovative electronic parts into their cars accept such mistakes.

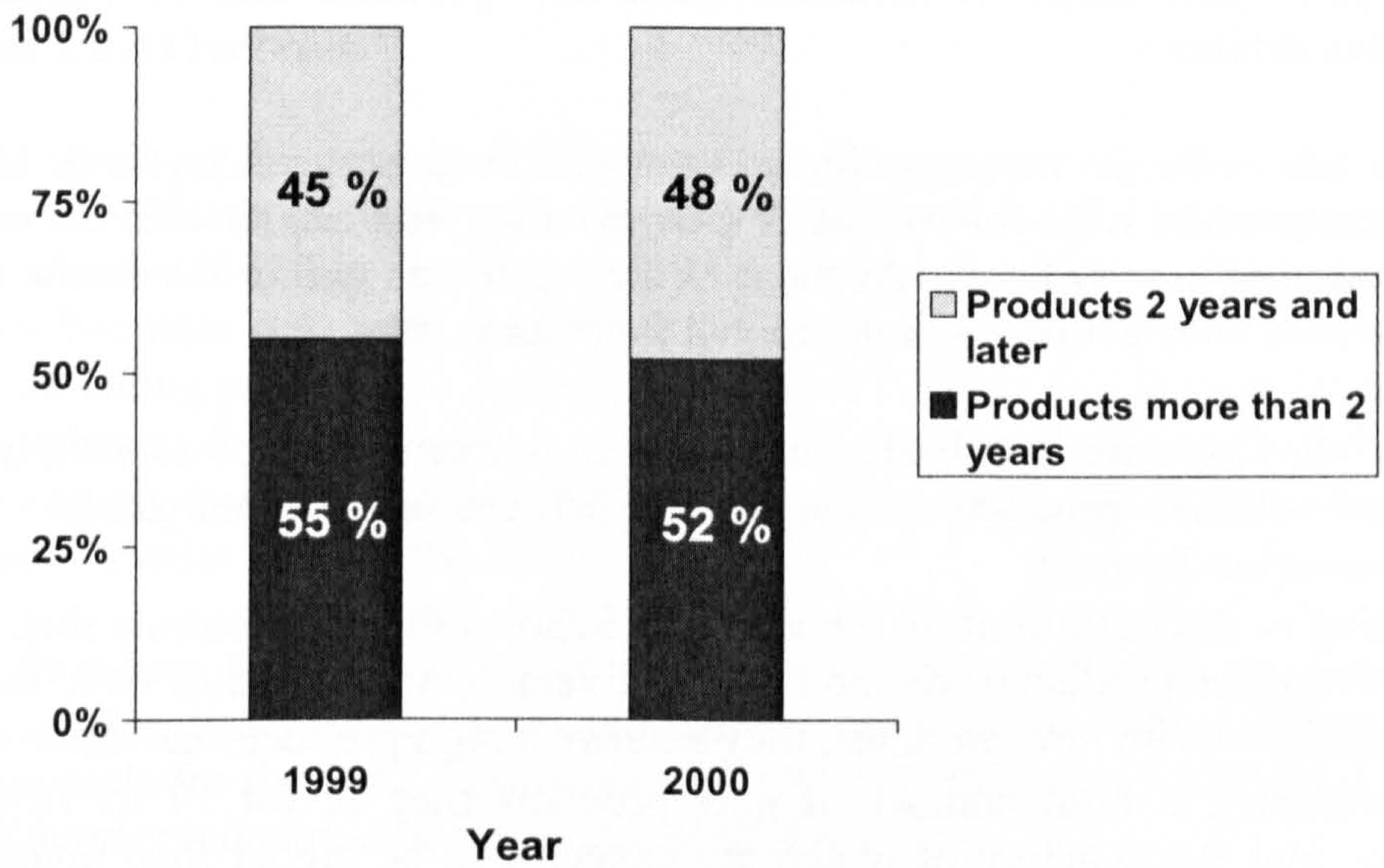
As a whole, the product innovation strategy is explained by the MD as follows: "To have an open leading style, strong concentration on self-sufficient business fields, creativity, and financial background". He followed: "The need for freedom is necessary to develop new ideas". This indicates that the ability to create a high number of new products is related to their corporate culture. Therefore, the leading style was discussed with the production manager. He stated that creativity and personnel freedom is one of their strength. The lived corporate culture was also reflected in the age of the managers interviewed – most of them were between 30 and 40 years old. The thinking and the behave of these young managers seems to be one basis for their innovative culture.

The categorisation of their strategies according to the model of Johnson and Scholes (1999) shows that they concentrate on the two strategies product development and diversification (Table 12). The strategies are market development and protection building are not given.

Table 12: Strategies on Existing Competences at Vehicle Electronics (analysis based on a framework of Johnson and Scholes, 1999)

Variable	Yes	No	Explanation
Product development	✓		They develop new electronics control systems to replace existing products
Diversification	✓		They develop new electronics control systems for new applications
Market Development		✓	They are working together with the biggest car producers and are well-known (world-wide) in the branch. Therefore, market development is not seen as an appropriate strategy.
Protection-building		✓	As the product life cycles are very short, protection building is not seen as an appropriate strategy.

Figure 2: Percentage of New Products at Vehicle Electronics
(Source: Vehicle Electronics, 2001)



With their new products they make 90% revenue. Their profits with all products is 2.4%. However, dependent on individual products the profits can be higher (up to 5%). The MD pointed out that although the profits seem to be very low they are much higher than the average profits of their competitors. Further, he pointed out that the competitive situation within their industry sector is very high. Consequently, the margins are lower than in other industries (that competitiveness has influence on profits was also found by Terwiesch et al, 1998). Although most products are planned to make profits the MD stated that some few strategic product innovations with no profits are developed too. Dependent on the products, the break-even-point is between 1.5 and two years.

Their high product innovation rates and percentage of revenues from new products are explained by the MD with the "ability to develop radical new products and therefore new markets can be generated". Their aims to achieve product innovation leadership, to offer products with first to market and to create market advantages and profits with pacemaking technologies are reflected by the product portfolio where most products are younger than three years. As all new products have the same priority, revenues are generated from all new products and therefore they achieve a high percentage of revenues from them. Not all existing products are replaced in a three years cycle and therefore they achieve 90% revenues from new products.

With regard on their product innovation position, the MM stated that one reason for the position within the diagram could be that "Vehicle Electronics is relatively new in the market and for six years it concentrated fully on automotive". However, in the view of the MD this is not the main reason for their position within the diagram.

11.4 Key Drivers for the Individual Product Innovation Position

The position of Vehicle Electronics in the field with the highest product innovation rates and the highest percentage of revenues from new products can be explained with following key drivers:

Market

- Product life cycle for most products is very short (average 3.5 years). Because of their short product life cycles most of their existing products are eliminated after the introduction of new products. As most of their products within the product portfolio are new ones, they achieve a high product innovation rate.

Competition

- Because they operate in a highly competitive market, price pressure is very high. However, with new products they are able to achieve satisfied margins.

Product Innovation Strategy

- According to the definition of Johnson and Scholes they concentrate their activities on the strategies product development and diversification. As they have the strategy to diversificate with new products, they achieve a high product innovation rate.
- For developing a high number of new products they invest 17 to 18% of their revenues into R&D activities which are expected to be higher than investments of their direct competitors.
- They are working together with selected customers who see the benefit of transformational and first to market products. Most of their new products are developed in close relationship to OEMs who are willing to pay for their pacemaking technologies.
- All new products have the same priority and therefore the percentage of revenues from new products is high.

However, to be innovative further key drivers are important:

New Product Process

- They have well defined NPD process differentiated in six defined phases from acquisition to production with interdisciplinary NPD project teams.
- They have the financial background to develop many new parallel products and to take the risk to cancel 30% of their NPD projects. This in turn is closely related to their strategy and corporate culture of developing pacemaker technologies.

Corporate Culture

- The board of management has a strong commitment to product innovation. The MD is convinced that freedom of employees is necessary to develop new products.
- Their product innovation driven culture is also shown in their philosophy that minor mistakes in the first series are acceptable. This in turn is shown by their culture of experimentation.

This company has high driven efforts to be innovative and to develop transformational (pacemaking) new products. However, this is only possible by working together with customers having the same innovation driven philosophy and an innovation driven culture. This strong focus may be one of the reasons why they have the highest product innovation rate and revenues from all cases (Position in Field 2b within the diagram product innovation rate and percentage of revenues from new products).

12. CASE BUSINESS UNIT BU 11 "PACKAGING FOILS"

12.1 Business Unit Overview

Packaging Foils is a business unit focused on the production of metal foils for packaging goods. They are part of a greater organisation with more than 30,000 employees. World-wide they employ 17,000 persons in the packaging division. However, this business unit with 1,150 employees is the largest location within their organisation including production, marketing, and R&D. However, it must be noted that the R&D department for pure research is not located within the business unit. World-wide the packaging division has 96 further production units, 12 in Germany and 84 further production units all over the world.

In their founding years (1912) they started with the production of endless thin aluminium foil for the packaging of chocolate bars. Today they produce market packaging materials for the food, healthcare and cosmetic markets as well as aluminium foil for the converter industry and for technical applications.

With their packaging foils they make a turnover of Euro 162 million and achieved a yearly growth of 2.4%. It has to be noted that they have concentrated their activities on foil production and not on the development of packaging machines. Because of this focus on foils they gave their prices in the dimension Euro/m^2. Dependent on the foils their prices rages from Euro/m^2 0.255 to Euro/m^2 2.55.

12.2 Case Results

Market

The packaging market, especially in the fields pharmacy and food is increasing. The MD prognosticated 10% growth in pharmacy and 3% in the food sector. Although the market is an increasing one, he pointed out that the packaging industry is a "conservative one which is mainly (90%) cost driven". The R&D manager estimated the product-life cycle of two to five years, dependent on the use-by date. However for non food the product life cycle of foils could be extremely longer (up to 10 years). Taking the life cycle of all products into account, the mean is given with three years.

They have an own sales-force and deliver their products directly all over the world. With this direct business they achieved an export-rate of 78% of their products world-wide. However, the MD qualified this variable with the comment that only 17% is exported into non EU countries. The R&D manager pointed out that they have a "big dependency on 2-3 key markets where concentration processes are increasing (e.g., pharmacy, food industry) and therefore price pressure is very high". The market growth for their market segment was estimated lower than their yearly growth of 2.4% per year.

Competition

Market barriers for new competitors are very high "because of customer loyalty (conservative branch), stability tests (material has to be proven over years and this is constantly review processes and products as part of a program of continuous improvement."

· The R&D manager reported that 31% of all projects were running on time and 33% of all projects were cancelled. Asked about the reasons for the high failure rate he stated that this high failure rate was based on changing customer aims, changes in costs or it was recognised that the developed technology was not realisable. This was qualified by the R&D manager who stated that "...there is a lot of work in transferring the laboratory processes into the real production process". At the beginning of this transfer phase in pilot trials it became clear whether a product innovation was marketable. The MD identified a further problem in their product innovation process: "There is a conflict of aims – researchers often want to transfer their ideas into reality very quickly, but often the organisation unit has other priorities".

Product innovation strategy

The reasons why Packaging Foils is introducing new products is given by the MD as follows: "We want to improve our profits through product innovation. Further, we want to achieve the highest flexibility to offer customer oriented products (variants). Our main aim is to develop new products for new markets. Further, new products are necessary to stay competitive – it is in response to high price pressure and the strong competition in the market." The R&D manager answered: "We are innovative in offering our customers new possibilities. With our new products we differentiate ourselves against the products of our competitors."

They concentrate on a few multinational organisations, and they have focused on a few product groups and branches and they have adopted their latest technologies to branch demands stated the MD (which is closely related to their markets). However, he pointed out that the first aim always is to develop a new product for a new market. A further aim is to maintain their market share. "With our pressure foils we work together with all big pharmacy companies and normally they remain customers for a longer time" sated the MD. He continued: "Our customer have a demand to go with their innovative products and therefore we are forced to be innovative in working with them continuously".

Their aim with new products is "To be market leader in some sectors and to maintain our leading position – e.g., 60% for packaging foils in the healthcare industry" stated the MD. "We are innovative in maintaining our innovation leadership and to hold on to our market share.". This was the reason why 54% of their new products are first to market stated the MD. The R&D manager qualified this evaluation and pointed out that some new products are more incremental and therefore they are not first to market with every new product.

On the questions of their visions the R&D manager stated: "We have two trends: First, we have to take up the challenge for product innovation – therefore we have planned the development of more new products. Second, we try to reduce our variants to increase our product output (of one variant)". Especially the second trend was pointed out by the MD, because he saw an ability to stay competitive in the production of a fewer number of products.

Their whole product innovation strategy is explained in their company brochure as follows: "Widely varying needs for packaging characteristics require individual solutions developed by Packaging Foils. A package is developed as a complete concept with defined economical and ecological parameters. Packaging Foils creates innovative solutions for new packages and for technical applications in co-operation with customers and package machine manufacturers. As part of the comprehensive service offered we provide support consultancy and applications technology through expert employees. In developing new technologies, Packaging Foils works closely with the nearby research institute of the whole organisation." For transformational R&D projects clear aims are written down. However, for their incremental product innovations they react to customer demands stated the R&D manager.

The categorisation of their strategies according to the model of Johnson and Scholes (1999) shows the two strategies product development and diversification (Table 13).

Table 13: Strategies on Existing Competences at Packaging Foils (analysis based on a framework of Johnson and Scholes, 1999)

Variable	Yes	No	Explanation
Product development	✓		They develop new packaging systems to replace existing products
Diversification	✓		They are looking for new applications for their packaging systems.
Market Development		✓	As they are part of an international company, market development is not seen as an appropriate strategy.
Protection-building		✓	Because of very short product life cycles protection building is not seen as an appropriate strategy.

Their strong focus on product innovations and new technologies is also shown in their project planning horizon. Only 10% of their projects were planned for 12 months. 30% were planned for 24 months and 60% have a project planning horizon of 48 months.

They invest 4% of their revenues in R&D. The MD stated that this is more than the industry average which invest only 2% in R&D activities. In their business unit they employ 3.3% R&D persons. Together with specialists from the centralised R&D department they achieve a percentage of about 5% R&D employees.

Product innovation output

With their new products they achieved an innovation rate of 32.5%. This high percentage of new products was discussed intensively with the board of management because in their first figure 45% were given. However, after a detailed discussion and a differentiation between incremental and transformational new products the MD and R&D manager agreed that a product innovation rate of 32.5% per year is realistic.

Although they had a clear understanding what product innovation is, both, MD and R&D managers had difficulties in identifying new product innovation within their business unit. Therefore, a long discussion about product innovation rate was held. Although they gave their corrected product innovation rate in Phase 2 of the research they often mixed variants with new product lines. The MD pointed out that "every product line includes many different combinations of plastic and metal foils. And we count these combinations as new products." Taking all these new products into account they make more than 100% new products over three years. However, in the discussion of the differentiation between main products and variants they agreed to take a product innovation rate of 32.5% for positioning them within the diagram product innovation rate and percentage of revenues from new products. This was seen as a more realistic product innovation rate than the higher value.

With their new products they achieve 72% revenue. Although they introduce 32.5% of new products they make a significant turnover with existing producs. The R&D manager explained this as follows: "Introducing new products does not automatically mean that all products are replaced. There are still products in our portfolio older than 3 years." They do not differentiate between profits of new and old products and the MD gave the profits in general as 7,2% (profits of their business unit are higher than the profit margin for the whole industry segment). The break-even for new products was given as 2.5 years.

The MD interpreted the diagram product innovation rate and percentage of revenues from new products as follows: "We achieve a high product innovation rate (45%), when every incremental new product is counted. This includes slight changes in the foil combination, too." However, he pointed out that their product innovation rate is also high by counting only their transformational new products (32.5%). Further, he said: "We develop transformational new products for our customers who normally have high product innovation rate too – especially in pharmacy, beauty and hygiene product innovation rate is high. In summary, we achieve most of our revenue with our new products". The R&D manager pointed out that they have a permanent stream of new products to achieve such a high product innovation rate.

12.3 Key Drivers for the Individual Product Innovation Position

Their high product innovation rates and high revenues from new products are dependent upon the following key drivers:

Market

- With three years, their average product life cycle is very short. Consequently their product innovation rate and revenues from new products is high. However, as some products have a life cycle of 10 years they achieve some revenues with existing products, too.
- Their focus is on multinational customers within a few branches operating with high product innovation rates. This in turn forces them to develop new products, too.

Competition

- They are developing a high number of new products to avoid price pressure and to achieve good margins. Only with the ability to differentiate against the products of their competitors they have the ability to remain market leaders.

Product Innovation Strategy

- According to the definition of Johnson and Scholes they concentrate their activities on the strategies product development and diversification. As they have the strategy to diversificate with new products, they achieve a high product innovation rate.

- For developing a high number of new products they invest 6% of their revenues into R&D activities which are expected to be higher than investments of their direct competitors.
- They want to improve their profits with product innovations. This strong demand on product innovation is reflected in the high percentage of revenues from new products.

Their ability to achieve high product innovation rates depends on further key drivers as:

New Product Process

- NPD processes are divided into seven steps and they are working with interdisciplinary NPD project teams. It has to be noted that their high cancellation rate of NPD projects (32.5%) is related to their strategy and corporate culture for experimentation and not on difficulties in their NPD processes.

Corporate Culture

- The commitment of the board of management to product innovation is high. This is shown by their highly (planned) percentage of cancelled NPD projects which is a indication for a culture of experimentation and openness for new things.
- They have a strong focus on customer demands which is shown by their high percentage of ideas based on this information source (95%).

This case has shown that high product innovation rates and a high percentage of revenues are not dependent upon the strategy first to market. This business unit is market (customer) driven and is developing new products to avoid the price pressure. However, it also shows that this business unit had the financial resources to start NPD projects with a failure rate of 33%. This is reflected in their position in Field 2b within the diagram product innovation rate and percentage of revenues from new products.

APPENDIX C

SURVEY QUESTIONS PHASE 1

Section F of the International Best Factory Awards questionnaire includes the questions on innovation and product development given below.

F: Product Innovation

A significantly new product is one which the plant has not made previously and which represents more than a simple change of material, colour or design variant. For example, in garment manufacturing a pair of trousers made in a new material for the new season would not be regarded as significant. However, if the trouser manufacturer started making overcoats this would be regarded as significant for the plant.

F1 How long does it typically take to bring a significant product innovation to market (from start of detail design to market launch)?

F2 (a) How many significantly new products (not including material or minor model changes) have you launched in the last three years?

F2 (b) Of theses new products how many would you regard as:
- Extensions to existing product range(s)
- Totally new (to plant) product Range(s)
- Other (please specify)

F2 (c) How many significantly new products (not including material or minor model changes) do you expect to launch in the next three years?

F3 For those products made to a unique customer specific design. What is the typical level of (please circle one of the numbers on the scale for each item):

	Low				High
Technological novelty	1	2	3	4	5
Specific Applications Engineering	1	2	3	4	5
Number of drawing changes required	1	2	3	4	5
Use of new materials	1	2	3	4	5

APPENDIX D

SURVEY QUESTIONS PHASE 2

Improved questions of Section F of the International Best Factory Awards questionnaire to get a valid dataset of product innovation rates and percentages of revenues from new products.

The profits made with the whole product portfolio (new and existing products) were taken from section C of the International Best Factory Awards Questionnaire.

PRODUCT INNOVATION POSITION

A significantly new product is one which the plant has not made previously and which represents more than a simple change of material, colour or design variant. For example, in garment manufacturing a pair of trousers made in a new material for the new season would not be regarded as significant. However, if the trouser manufacturer started making overcoats this would be regarded as significant for the plant.

F1. How many main products (not including material or minor model changes) are currently "live" within the business unit product portfolio?

F2. How many significantly new main products (not including material or minor model changes) have you launched in the last three years?

F3. Please calculate the product innovation rate (%) over three years of your manufacturing plant:

$$\frac{\text{Question F2 (number of new main products launched in the last 3 years)}}{\text{Question F1 (number of main products within your portfolio)}} \times 100$$

F4. What proportion of your entire revenues are achieved with significantly new products launched in the last three years (products given in F2) in the last budget year?

APPENDIX E

STRUCTURED QUESTIONNAIRE PHASE 3

CRANFIELD SCHOOL OF MANAGEMENT
(EXPORT-AKADEMIE BADEN-WÜRTTEMBERG)

Product Innovation Research Interview Questionnaire

General Introduction
I am from Cranfield School of Management (and the Export–Akademie of Baden Württemberg) and I am conducting research on product innovation at companies in the engineering and electrical & electronics engineering industries. Thank you for agreeing for us to visit and talk to you in detail about new product development at your company.

Please note that all information gathered by this research study will be treated confidentially and presented without the names of the companies being identified. In addition, to taking notes we would like to record this interview, as otherwise I will be unable to write down all of the points that you raise. Are you in agreement with me making a recording? Note that the recordings will only be used to make a transcript of the interview.

I will be asking questions on a number of topics, including the market background, product characteristics, reasons for innovation, innovation strategy and will have the opportunity to talk to several of your management team including:

- *MD Manager*
- *R&D Manager*
- *Marketing Manager** *[* refer as appropriate]*

You receive all publications from this research automatically.

Company:

____

Interviewer:

____

Start time:____________________ Finish:____________________

Interviewees' names / positions:

____
____
____

Questionnaire-Version: 11 January 2000

MANAGING DIRECTOR (MD)

Interviewees' names:
Duration of the interview:

Company Background

1) Company's products

____
____
____

2) What is the size of your company (total employees world–wide) ? ____________

3) Employees per function approx.:

Development..........................	FTE	(% part-time..............) Temporary?
Production.............................	FTE	(% part-time..............)
Marketing..............................	FTE	(% part-time..............)
Sales....................................	FTE	(% part-time..............)
Other....................................	FTE	(% part-time..............)
Total.....................................	*FTE*	*(% part-time..............)*

4) Short history of the company / philosophy. Have you a company brochure?

____
____
____

5) Current organisation (main characteristics can we have an organisation chart?)

____
____
____

Innovation Strategy

6) How would you define "product innovation" at your company (Discussion of the degree of new products and familiarity/synergy of new products with existing products)?

____
____
____

7) What are your reasons for introducing new products?

8) How do you introduce your products to the market: Continuous / waves / customer specific?

9) What are your aims with new products (First-to-market, innovation leadership, increased market share)?

10) Do you have clear innovation aims at your company. Are these aims written down as a company philosophy?

11) How do you personally promote innovation?

12) How are individual employees measured on their contribution to innovation?

13) What are your visions? What is your company's aim for the next 10 years?

Innovation Measures

14) Innovation variables: Discussion of the product innovation variables – data sheet.

15) Do you measure these innovation variables regularly? ____________________

Comments

16) What are the reasons for your innovation rate and your turnover with new products? Discussion of the diagram product innovation rate / percentage of revenues from new products.

____
____
____

17) How would you describe your product innovation strategy (according to the model of Johnson and Scholes)?

____
____
____

18) Have you any comments about the reasons for the current product innovation position at your company which we have not covered?

____
____
____

Thank you very much for your time.

R&D Manager (R&D)

Interviewees' names:
Duration of the interview:

General / Technology

1) What are the key technologies in your products (familiarity and synergy of existing and new technologies)?

2) How do you monitor developments in technology? Acquire technology? Working together with Universities and research institutes? What are the associated costs (compared to in-house development)?

Innovation Strategy

3) How would you define "product innovation" at your company? (Discussion of the degree of new products and familiarity/synergy of new products with existing products)?

Questions 4-5 only as cross check questions when R&D manager separately is interviewed

4) What are your reasons for introducing new products?

5) What are your aims with new products (First-to-market, innovation leadership, increased market share)?

6) How do you personally promote innovation?

Stream of Product Innovation over the last five years

7) How the stream of product innovations products can be described (waves, continuous stream)? How is the influence on product innovation rate?

Human Resource Management

8) How are creative new ideas stimulated / source of ideas?
   a) external: customer, supplier?
   b) Internal: employees?

9) How are individual employees measured on their contribution to innovation?

NPD Projects

10) What type of process do you use to manage in NPD projects? Phases / Responsibility
    Can I have a copy of your NPD process documentation?   Yes / No

11) Do you document the results of your NPD projects? Yes / No
    When Yes, how?

Problem Analysis

12) Are there any phases in the NPD process where you have problems? Problems with communication / personnel?

____
____
____

Innovation Measures

13) Innovation variables: Discussion of the product innovation variables – data sheet.

14) Do you measure these innovation variables regularly? ____________________

Comments

15) What are the reasons for your innovation rate and your turnover with new products? Discussion of the diagram innovation rate / turnover with new products.

____
____
____

16) How would you describe your product innovation strategy (according to the model of Johnson and Scholes)?

____
____
____

17) Have you any comments about the reasons for the current product innovation position at your company which we have not covered?

____
____
____

Thank you very much for your time.

MARKETING MANAGER (MM)

Interviewees' names:
Duration of the interview:

Background Information

1) Detailed questions for the products: Do you have brochures / prospects? ___________

Innovation Strategy

Question two and three only as cross check questions when M&M manager separately is interviewed

2) How would you define "product innovation" at your company? (Discussion of the degree of new products and familiarity/synergy of new products with existing products)?

____
____
____

3) What are your aims with new products (First-to-market, innovation leadership, increased market share)?

____
____
____

Market Information

4) What kind of market research for new products do you use?

____
____
____

5) How was your branch dependent from the general economic situation?

____
____
____

Competitive Position

6) Are there market barriers for new competitors? Can you describe them?
How attractive is the market for new competitors?

____
____
____

Innovation Measures

7) ***Innovation variables: Discussion of the product innovation variables – data sheet.***

8) Do you measure these innovation variables regularly? ____________________

Comments

9) What are the reasons for your innovation rate and your turnover with new products?
Discussion of the diagram innovation rate / turnover with new products.

____
____
____

10) How would you describe your innovation strategy (according to the model of Johnson and Scholes)?

____
____
____

11) Have you any comments about the reasons for the current product innovation position at your company which we have not covered?

____
____
____

Thank you very much for your time.

Questionnaire: Product Innovation Variables

General Information

1) How old is your company (years)? ☐

2) Employees per function approx.:

Development	☐	FTE	(% part-time	☐)
Production	☐	FTE	(% part-time	☐)
Marketing	☐	FTE	(% part-time	☐)
Sales	☐	FTE	(% part-time	☐)
Other	☐	FTE	(% part-time	☐)
Total	☐	*FTE*	*(% part-time*	☐*)*

3) How many of your yearly revenues are invested into R&D (%)?
Own company? ☐ Industry average? ☐

4) How do you manage your R&D project Portfolio (e.g., long and short projects)?

Short-term,	share% ☐	☐	years
Medium-term,	share% ☐	☐	years
Long-term ,	share% ☐	☐	years
	100%		

5) What is your own market share(%) ☐
What is the market share of your main competitors (%) A: ☐
B: ☐
C: ☐

6) Average company growth in the last three years – own company (%) ☐
Average company growth in the last three years – industry sector (%) ☐

7) Average company profits in your industry sector (%) ☐

8) Whole exports; EU countries included (%) ☐

9) Range of prices for your products from Euro ☐ to Euro ☐

10) What is the product life cycle of your products (years)? ☐

<u>Product Innovation in the last three years</u>

11) How many major products do you have in your portfolio? ☐

12) How many new products have you introduced in the last three years? ☐

13) How much of your revenues is generated from new (< 3 years old) products? ☐

=> *Product Innovation Rate*

Innovation rate over three years = $\frac{\text{number of new products x 100}}{\text{number of major products}}$ ☐

14) What is profit from <u>all products</u> (whole company)?

Profit whole company (Euro)	last reported year	☐
Turnover whole company (Euro)	last reported year	☐

15) What is the profit from <u>new products</u>, which are not older than three years?

Profit new products (Euro)	last reported year	☐
Turnover new products (Euro)	last reported year	☐

16) When is the break-even-point of new products typically (years) ☐

17) Number of patents which are registered in the last three years. ☐

18) Percent of significant products that were first to market in the last three years? ☐

19) How many of your NPD projects are on-time in the last three years? (number and %)? ☐

20) How many of your NPD projects are cancelled in the last three years? (number and %)? ☐

APPENDIX F

PRODUCT INNOVATION VARIABLES

In the product innovation literature a huge rage of product innovation variables was identified. A summary of the most important ones are given in Appendix F.

Source	DEFINITION OF VARIABLES
Adler et al, 1996	**Projects** • How many types of projects does your group handle? • How many new projects of each type does your group undertake each year? • What tasks are involved in each project type, and is there a specific order which they must be carried out? **Resources** • To which phases of product development does your group contribute? • How many people are in your group? • How many hours do they work in a week? • What project-related tasks does your group perform? • What non-project tasks (administrative and support) does your group perform? • How many hours does your group spend in each task? **Processes** • For projects of average complexity within each type of project, how many iterations does each task require? • What is the probability of task processing times and of number of iterations across projects? • What proportion of projects in each type are easy, intermediate, and complex? • How does each person decide which project or task to work on next?
Boag et al, 1989	**Organisational Structure for NPD** • What is the role of research and development in the company? • How is the company organised for new product development? Has it changed recently? • How many employees are involved in research and
... Boag et al	development activities? **R&D Planning** • Do you have a written, long-term R&D plan? • What is the planning cycle, e.g.,, who and when are various people involved in the planning process? • How satisfied are you with the planning process? What changes (if any) is the company considering? **Idea Selection** • How are new product ideas evaluated? By whom? What criteria or methods are used? • Does this process change by type of research, e.g.,, fundamental, applied or developmental? By project size? • How satisfied are you with your project selection methods? What, changes (if any) is the company considering? **Project Management** • How often are projects evaluated? By whom? Is this formal or informal? • What criteria are used to evaluate projects? • What forms (if any) are filled out? • How are adjustments in time, cost or specification handled? • How satisfied are you with your management methods? **Project Evaluation** • Is the performance of R&D evaluated after a product is completed? By whom? • What criteria are used to evaluate R&D's performance? • How are you satisfied with your postevaluation methods? **R&D Effects** • What is your company's annual R&D investment? • What is the focus of research at your company, e.g.,, fundamental, applied or development research;

... Boag et al	modifications, extensions or radically new products? • What is the rate of new product introduction? **Measurement of NPD Success** Measured on a 5 point ordinal scale • How successful is your company's new product development program? • How successful are your company's NPD procedures in identifying, terminating, etc.? • How satisfied are you with your company's current method for long term planning, project selection, etc.?
Chiesa et al, 1996	**Product Innovation** • Number of new product ideas and product enhancement ideas evaluated last year. • % sales / profits from products introduced in the last three/five years. • % sales / profits from products with significant enhancements in the last three / five years. • Product planning horizon. • Market share – global , EU, local. **Product Development** • Time to market: average concept to launch time and time for each phase; (concept, design, initial production, launch); average over-run and % of projects over-running planned finish date; average time between product enhancements and redesigns. • Design performance: manufacturing cost, manufacturability, testability. **Process Innovation** • Process parameters: cost, quality, work in progress, manufacturing lead times. • Installation lead times. • Number of new processes or significant process
... Chiesa et al	enhancements in the last year. • Continuous improvement: number of suggestions per employee; % implemented. **Technology Acquisition** • Number of licences/patents in/out over the last three years. • R&D/technology acquisition cost per new product. • Failed projects: % of projects; R&D spend; % of projects killed too late. **Market Focus** • Sales/margin by market segment and product range. • Market share by target segment/geographical area. • % sales/profit from new products/customers. • % orders delivered on time. • % product returns and customer complains. **Leadership** • Number/percentage of members from product development and technical functions on board. • % employees aware of and sharing company innovation policies and values. • Number of pages in annual report devoted. **Resourcing** • % of projects delayed or cancelled because of lack of human resources. • % of personnel in product development who have worked in more than one or two functions. • % of projects delayed or cancelled due to lack of funding. **Systems and Tools** • % designers and engineers with access to CAD. • % of products on CAD database. • % of teams using specific techniques (e.g., experimental design methods).

... Chiesa et al	• % of team leaders trained in creativity techniques. • % of development projects using ISO 9000 certified processes.
Cooper et al, 1993 and 1994 ... Cooper et al	A total of 298 measures were identified – the significant variables are given. Most variables are measured via 0-10 anchored scales. **Project Organisation** • Cross-functional project team. • Accountable team – undertook project from beginning to end. • Strong champion driving / leading project. • Top management commitment to project. **Product Definition** How well defined the following items were prior to beginning of development: • Precise target market. • Product concept – what product is and does. • Products benefits to be delivered to the customer. • Product features, performance requirements. **Quality of Execution of Predevelopment Activities** • Idea-screen - first review of the venture. • Preliminary market and technical assessment. • Detailed market study / marketing research. **Quality of Execution of Marketing Activities** Quality of execution of each of the following: • Detailed market study / marketing research. • Customer tests of product; field trails. • Trial sell; selling to limited customer set. **Launch Quality** • Sales force – good quality, well trained, right people, large effort, enough sales people. • Advertising – good quality program; large effort

... Cooper et al	(magnitude). • Promotion, (shows, events, etc.) - good quality; large effort. • Customer service and technical support - good quality; large effort. • Product availability – on time, reliable shipments. **Quality of Execution of Technological Activities** Quality of execution of each of the following: • Preliminary technical assessment. • Product development – the physical product. • In-house product tests or lab testing. **Synergies** Strong fit between the needs of the project and the firm's resource base, skills etc., in terms of: • Manufacturing skills and resources. • Distribution resources. • Customer service and tech support resources and skills. Market research and market intelligence skills / recourses. **Project familiarity** • Product was in an existing product category in the firm. • Used familiar customer service and technical support. **Market Attractiveness Measures** • Essential product for solving customer problems. • Stable demand in marketplace. • Large markets. • Positive economic conditions in market. • Many potential customers. • Growing markets. • Price insensitive customers. **Competitive Situation** • Domestic (10) vs. foreign competitors (0). • Few/no competitors (10) vs. many (0).

... Cooper et al	• High profit margins earned by competitors in this market. • Barriers to market entry for others. • Product heterogeny in the market place.
Cooper et al, 1995	**Measurement of NPD performance** • Success rate = the percentage of projects that entered development and were ultimately considered commercial success. • Percent sales = the percentage of company sales represented by new products introduced during the previous 3 years. • Profitability relative to spending = the rated profitability of the company's new product program (previous 3 years) relative to how much was spent on it. • Technical success rating = the rated technical success of the program relative to spending. • Sales impact = the impact of the new product program on the company's annual profits. • Success in meeting sales objectives = the degree to which the company's new product program has been successful in meeting corporate sales objectives for new products. • Success in meeting profit objectives = the degree to which the company's new product program has been successful in meeting corporate objectives for new products. • Profitability relative to competitors = the rated profitability of the company's new product program relative to its competitors. • Overall success = the overall rated success of the program, relative to competitors.
Griffin, 1993	**Development Cycle Time** Different approaches for measuring: 1) Development time (how efficiently you take a product through production). 2) Concept to customer time (how difficult it is for a firm to

...Griffin	figure out what the right product should be). 3) Total time (time from knowing what the product is to do to time of product introduction). **Project Characteristics** • Complexity = function (number of product functions, number of technical specialities). • Amount of change = % new over previous generation. **Outcome Variables** • Process =>time through each phase; cost of development. • Product => commercial success; customer satisfaction. **Development Process Variables** • Strategic driver of development, deliver customer needs, competitive reaction; technology-driven; management edict. • Type of process used; no process used; phase review process; quality function deployment; stage gate. • Organisational variables. • Organisational structure; cross-functional teams, co-location of team members; project leader champion. • Tools and techniques used; number, type and timing of market research projects; computer-aided design, computer-aided engineering; design for manufacturability; design for assembly; computer-integrated manufacturing. **Product Success** • A subjective measure is used instead of the ideal, which would be market share, profitability and customer satisfaction.
Griffin et al, 1993	**Measurement of NPD Performance** • Percent of sales by new products. • Break-Even-Time. • Margin goals met. • Profitability goals met.

... Griffin et al	• Return on Investment (ROI). • Market share goals met. • Revenue growth over a time period.
Kulicke et al, 1997 Fraun-hofer Institute, Karlsruhe (ISI)	**Innovation Loans for SMEs** • Typical activities at beginning of a innovation project (e.g., miles-stones, etc.). • Sources for conception of a innovation project (e.g., own R&D department, etc.). • R&D activities (e.g., regularly, improvement of products, etc.). • R&D co-operation partners (e.g., Customer, supplier, etc.). • Contribution of R&D partners (e.g., key know-how, etc.). • Factors hindering R&D process (e.g., economic situation, no capacity, information lacks, etc.). • Difficulties for loan application.
Lay, 1997; Kinkel et al, 1997 Fraunhofer Institute, Karlsruhe (ISI)	**New Organisation Principles** • Simultaneous engineering. • Decentralisation. • Working groups. • Etc. **Innovative Management** • No entrance control of goods. • ISO 9000. • Etc. **New Creation of the Manufacturing Added Value Chain** • Just in time delivery. • Supplier / customer integration. • Etc.
Licht et al, 1997 ZEW Innovation Panel	A lot of variables are measured on a scale 1 – 5. **Innovation R&D** • Expenditure for R&D. • Expected exports. • Development of R&D expenditures. • R&D activities in the last three years. • Valuation of innovation performance. **Economical Effects of Innovation** • First to market. • Turnover with new products. **Aims Pursued with Innovations** • Creation of new products. • Creation of new markets. • Improvement of product quality. • Lower costs. **Sources for Innovations** Suppliers. • Customers. • Competitors. • Own employees. Innovation and Environment (Ecology) • Innovations for protecting the environment. • Recycling. **Cost Structure** • Expenditure for employees. • Expenditure for engines. • Expenditure for equipment.
Loch et al, 1996	**Firm Success** • Profitability = ROS (Return on Sales) in the last year reported before extraordinary items and taxes. • Profitability growth over the last three years. • Sales growth from the last three years.

... Loch et al	**Development Outputs** • Proportion of products first to market. • Proportion of significant changes in product introduction. • Technical product performance. • Strategic performance position. • Proportion of sales from products introduced in the last 13 years. • New major products compared to industry. • Unit cost reduction compared to industry. **Focus and Structure of R&D** • Teams vs. functional structure. • Focus = number of parallel projects in the department. • Project duration. **Project Management** • Team size. • Meeting schedules. • Meeting budgets. • Early use of prototypes. • Concurrence of project phases. • Change of specifications. • Number of milestones. • Number of design reviews. **Cross-Functional Integration** • External sources of ideas. • Early marketing involvement. • Reverse engineering = number of reverse engineering analysis. • Preferred part lists. • Early manufacturing involvement. • Design complexity = number of parts normalised by number of finished goods.

... Loch et al	• Early supplier involvement. • Co-operation with basic research. **People Management and learning** • Job rotation. • Training per employee. • Cross-functional training.
Murr-mann 1994	Questions were answered on base of a self-selected project (by person asked) in a company. **Aims of the Projects (1-7 scale)** New technology, new markets, lower prices, competitor advantage, ... **Project Data (Overall)** • Development time, costs, capacity, ... **Project Structure** • How many new parts were developed. • Customer specific project? **Factors Influencing the Project (1-7 scale)** • No project planning, no co-ordination. • No communication. • Technical uncertainty. **Measures for Reducing R&D Time (1-7 scale)** • Using customer know-how. • Knowledge improvement of employees. • Shorter development steps. • Time- and cost-controlling. • Improvement of co-ordination processes. **How Time Reduction was Achieved** • Fictitious time reduction if all listed measures were used. • Is it important for you to reduce development time?
Oliver et al, 1997	Summary of "stable" benchmark measures. **Productivity Performance** • Hours per project.

...Oliver et al	• Development costs as % of revenue. • Revenue per development hour. • Development hours per new part. **Quality Performance** • Change notes. • Scrap rates in the factory. • Warranty claims. **Time performance** • Concept to production time. • Percentage late against forecast. **Practices** • Team composition. • Involvement of functions. • Use of electronic tools. • Project team leadership. • Intensity of communication.
Tham-hain, 1990	Culture effects only could measured by observing the team over a longer time period. **Team Performance** • Communication / information transfer. • Individual innovation performance / stimulation of ideas (number of ideas). • Qualification level of employees. • Team composition. • Involvement of functions. • Project team leadership.
Terwiesch et al, 1998	**Firm Success (Dependent) Variable** • Profitability = ROS (Return on Sales) in the last year reported before extraordinary items and taxes. **Development Performance Variables** • Market leadership = percent of significant products innovations that were first to market in the reported

... Terwiesch et al	period. • Technical product performance = technical product performance relative to competition, as perceived by Marketing, R&D and Top Management. • Product line freshness = Proportion of sales from products introduced the previous three years, as of the last year reported. • Innovation rate = number of significant product line changes over the last three years reported, multiplied by product life cycle in years, and normalised as the relative deviation from the industry mean. • Development intensity = development personnel for the product group in question divided by product group revenues in the last year reported. **Market Context Variables** • Industry profitability = average ROS over the respondents industry in the last year reported. • Market growth, average over all respondents per industry = market size in the last year reported divided by market size two years ago. • Market share = world-wide volume for the product group in question, divided by world-wide volume market size, in the last year reported. • Product life cycle = duration of the product life cycle (in months) in the last year reported, average per industry.
Voss et al, 1996	Each question resulted in a ranking of site practice or performance on a 1-5 scale, with 5 representing world class performance, and 1 representing poor performance. **Innovation Management** • Technology strategy. • Generation of new product concepts.

... Voss et al	• Product life planning cycle. • Cultural innovations. **Innovation Performance** • Product technical performance. • Significant changes to product lines. • Innovativeness (sales from new products). **Product Development Process** • Industrial design. • In service monitoring feedback. • Design for production. • Product development process. • Resources allocation and management. • Understanding product development costs. **Current Engineering** • Integration between company functions. • Teamwork. • Overlap of development activities. • Involvement of external partners. **Engineering and Manufacturing Systems** • Bill of materials management. • Access to relevant data. • Engineering change order & release process. • Engineering application tools. • Computer added design tools. • Integrated systems. **Product Development Performance** • Avoiding late product cancellation. • Customer satisfaction. • Time to market. • Design cycle time. • Market share change.