

**CRANFIELD UNIVERSITY**

**NUMAN IQBAL**

**TECHNOLOGY CATCH-UP ACTIONS FOR MANUFACTURING  
COMPANIES IN PAKISTAN**

**SCHOOL OF ENGINEERING  
R&D MANAGEMENT CENTRE**

**Ph.D. THESIS**

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**Technology catch-up actions for manufacturing companies in Pakistan**

**Supervisor:**

**Dr. Richard Reeves**

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# **Abstract**

Technological development in manufacturing companies has been considered as a key contributor to the economic development of nations. Research has confirmed that the contribution of technological development to national wealth is more than 50 %.

The objective of this research was to explore the steps which could help manufacturing companies in Pakistan to catch-up in technology with the leading companies in the world.

The first step was the quantitative measurement of the status of technology in a sample of manufacturing companies in Pakistan through a new survey method.

Numerous interviews with experienced senior factory managers in Pakistan then explored the issues, including barriers to technology improvement, their solutions, actions that could promote technology, and stages required for catch-up in technology. Three case studies included in this process helped in understanding the issues. The outputs were the lists of barriers, solutions, and actions, each organised in a new-found framework of issues essential in technology development, and a four-stage technology catch-up path.

A survey then ranked the barrier and action factors in order of their importance. The most important ones were compiled in the form of action plans for factory managers and government policy makers.

Similar barrier, solution, and action factors were then explored in the literature on manufacturing companies in successful East Asian countries using content analysis, and ranked in order of importance. This also resulted in action plans and a four-stage technology catch-up path.

The results from the Pakistan research were then compared with the results from the literature, and combined to develop comprehensive action plans.

This research found that catch-up in technology was possible through specific actions in defined directions by the factory managers themselves without explicit help from the government, although such support can be very valuable.



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## Chapter 1

# Introduction

### 1.1 Research background

The world exhibits startling variations in the wealth and development of countries. This contrast has prompted a quest for development in the less developed countries. In the last half century, many of these have joined the ranks of developed countries. Among these, some of the East Asian countries have been clearly prominent. These have transformed from poor, primarily agricultural economies to rich, industrial countries in the time period of one generation.

Numerous researches conducted to understand the reasons for their rapid development have revealed that their success has pivoted around rapid technology acquisition and assimilation in manufacturing industries (e.g. Bae & Lee, 1986), which proved to be key contributors to the national wealth (e.g. Kim, 1997). Research in economic development confirmed that the contribution of technology to national wealth was more than 50 % (Rosenberg, Landau, and Mowery, 1992).

Pakistan obtained independence at roughly the same time as these successful East Asian countries, but Pakistan remains less developed. The following section compares Pakistan with four East Asian countries, especially in the manufacturing sector, and establishes the need for this research.

The remaining sections of this chapter describe the research project, elucidate its applicability and contribution, and describe the contents of the chapters of this thesis.

Appendix 1A to this chapter briefly describes some of the important concepts applicable in this research.

## 1.2 The economies of Pakistan and selected East Asian countries

Pakistan is situated in South Asia. Table 1.1 provides figures for area and population of Pakistan and selected East Asian countries.

**Table 1.1:** Population and area of Pakistan and selected East Asian countries  
Source: The Economist Intelligence Unit, Country fact sheets  
(<http://www.viewswire.com>)

Country	Area (Sq. Kms.)	Population (Millions) (Year 2000)
Pakistan	778,720	152.3
South Korea	99,434	47.7
Singapore	636	4.0
Malaysia	330,433	23.8
Taiwan	36,188	22.3

### 1.2.1 Comparison of the economic development of Pakistan with selected East Asian countries

Table 1.2 shows figures of GDP and GDP per capita of selected East Asian countries and that of Pakistan from 1960 till 1999. The table clearly shows that Pakistan and these countries were at similar level of economic development in 1960. In the next 40 years, these countries experienced rapid economic development while Pakistan improved only meagrely.



**Table 1.2:** GDP and GDP/capita growth of Pakistan and selected East Asian countries  
Source: World Tables 1983, World Development Report 2000-2001 (The World Bank), Taiwan Statistical Data Book 1986, 1999, and US Department of State.

Country	GDP Comparison									
	GDP (Billion US\$)					GDP per Capita (US\$)				
	1960	1970	1980	1990	1999	1960	1970	1980	1990	1999
Pakistan	3.7	10	23.9	40	59.9	81	165	291	354	444
South Korea	3.8	8.6	58.2	252	407	152	266	1525	5874	8790
Singapore	0.7	1.9	11.3	36.6	85	430	914	4680	12160	26545
Malaysia	2.3	4	23.8	42.8	74.6	280	370	1716	2378	3288
Taiwan	1.55	5.6	36.7	135	283	143	384	2061	6500	12866

### 1.2.2 Comparison of development in the manufacturing sector

Table 1.3 shows the share of manufacturing in the GDP of Pakistan and the same East Asian countries from 1950-60 till 1999. The table clearly shows that the share of manufacturing in GDP rose impressively for these East Asian countries but this share rose only slightly in case of Pakistan.

**Table 1.3:** Share of manufacturing in GDP of Pakistan and selected East Asian countries. Source: World Tables 1983 and World Development Report 2000-2001 (The World Bank)

Country	Manufacturing as percentage of GDP (%)				
	1950-60	1960-70	1970-81	1990	1999
Pakistan	12.1	14.8	16.3	17	17
South Korea	13.1	19	27	29	32
Singapore	11.6	16.3	23.3	27	26
Malaysia	8.7	10.8	19.2	26	35
Taiwan	16	27	36	43	43

Not only the share of manufacturing in the GDP of these countries has been rising but their manufacturing value-added (MVA) and MVA per capita has been increasing. This shows that their manufacturing has been moving to high value-added sectors as shown in table 1.4. For Pakistan, the value of MVA per capita is much less than average of developing countries.

**Table 1.4:** International Comparison of Manufacturing Value Added (MVA) at constant 1990 prices in US\$. **Source:** United Nations Industrial Development Organisation (UNIDO). **Footnotes:** a/ Including China b/ Excluding transition economies

	MVA per Capita (US\$)			Share of MVA in GDP (%)		
	1980	1990	1998	1980	1990	1998
Pakistan	36	51	57	14.1	15.5	15.7
Malaysia	338	636	1035	19.4	26.5	30.1
South Korea	658	1699	2492	22.8	28.8	30.4
Taiwan	1450	2577	3533	34.5	32.7	28.9
Singapore	2281	3955	5325	29.7	28.6	24.9
South & East Asia (Average)	84	154	267	21.1	24.6	28.9
Developing countries (Average) a/	161	203	291	19.5	21.2	24.0
Developed countries (Average) b/	3712	4430	4880	22.9	22.0	21.4

### 1.2.3 The manufacturing sector of Pakistan

Pakistan got independence from the British rule in 1947. The country had a meagre start. The majority of the population was poor and there was little industry. Madison (1995) has given the historical origins of poverty in areas that now comprise Pakistan. Haq (1963) and Madison (1971) provide the details of industrial and other development in Pakistan during the 1950s and the 1960s. Zaidi (1999) has provided details of economic and manufacturing sector development in Pakistan during its independent history.

**Table 1.5:** Major manufacturing sub-sectors in Pakistan (ISIC: International Standard Industrial Classification). Source: UNIDO

Sub-sector of manufacturing	ISIC Code	Value-added (M US\$) 1996	Share in total manufacturing (%)
Textile	321	1390	23.5
Food products	311	899	15.2
Chemicals, industrial	351	505	8.5
Chemicals, other	352	457	7.7
Machinery, electric	383	453	7.7
Other non-metallic mineral products	369	423	7.2
Tobacco	314	365	6.2

According to the last census of manufacturing industries (CMI) in Pakistan, textiles form about 25 % of Pakistan's manufacturing and approximately 65 % of its exports. The major sub-sectors in Pakistan's manufacturing are given in table 1.5. The dependence on low value-added sectors of textiles and food (section 1A.5) is clear.



### 1.3 The need for this research

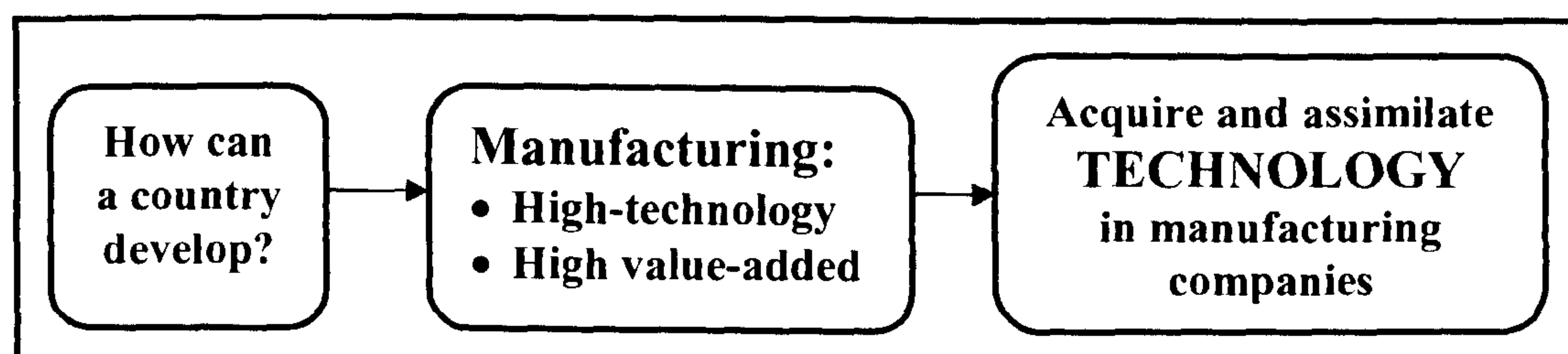
The facts and figures presented above strongly support the hypothesis that economic development in successful East Asian countries has been due to rapid progress in their manufacturing sectors. The manufacturing sectors comprise large number of companies whose outputs aggregate to form the total output of the manufacturing sectors. As various researchers have argued, the rapid development in their manufacturing sectors has been due to rapid technology acquisition and assimilation in their manufacturing companies. This hypothesis, shown in figure 1.1, formed the premise for this research.

It could be argued that the reasons for successful development in the manufacturing sectors of the East Asian countries were buried in the cultural and social values. Some authors have suggested a strong entrepreneurial culture in Taiwan or a strong nationalistic spirit in South Korea. While cultural reasons could be important, the literature has shown that despite differences in culture and social values, and even in the presence of ethnic problems, many countries in East Asia have been successful through industrial progress.

This research however does not concern social or cultural aspects but concentrates on the technology development issues at the company level.

Building on the premise that technology development in manufacturing companies was key to economic development, this research thus set out to explore the steps which could help the manufacturing companies in Pakistan catch-up in technology with the leading companies in the world.

**Figure 1.1: Research premise**





## 1.4 Brief description of the research project

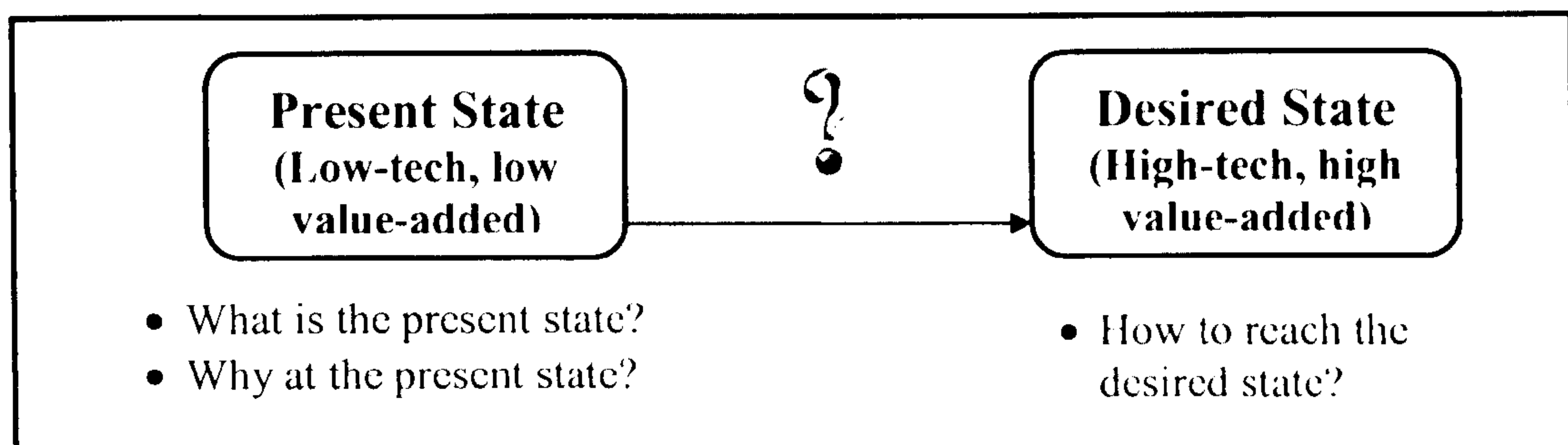
The research theme transformed into following formal research question:

“What steps should companies in the manufacturing sector of Pakistan follow and what help should the commercial environment of these companies (government, banks, other companies, research institutions, universities etc) provide so that catch-up in technology is helped?”

It was decided to break this question down into the following questions, and try to answer them by different components of the research project. Figure 1.2 elaborates the reasoning of these questions in the pictorial form.

1. **Status of technology in manufacturing companies.** How can we measure the level of technology in individual manufacturing companies of Pakistan in comparison to the leading companies of the world in their respective areas of work?
2. **Barriers to technology development.** What is holding these companies back from catching up with the leading companies of the world?
3. **Solutions to barriers.** How could these barriers in the path of technology development be overcome?
4. **Actions required for technology development.** What other steps should be taken so that these companies can catch up with the leading companies of the world?
5. **Stages for technology development.** What are the stages that these companies should follow in this catch-up process?

**Figure 1.2:** Pictorial elaboration of the reasoning of the research questions



## 1.5 Research plan

Figure 1.3 shows the components of the research project. The timeline on the left gives an idea of when the various stages were carried out. The research started with an extensive literature review, which was conducted at Cranfield. The main data gathering portion of the research was then carried out in Pakistan.

The measurement of technology status through a structured questionnaire-based survey, and the exploration of factors (barriers, solutions and actions) through semi-structured interviews were carried out in parallel, because the same managers were respondents for both. The interviews also explored the stages recommended for catch-up in technology. Some of the interviews were extended to generate case studies of three companies to have a better understanding of the issues and the results. Extensive lists of barriers, solutions and actions were compiled.

In the following stage of the research the relative importances of the factors were evaluated using a questionnaire-based approach. This information was then used to compile a technology development model for companies in Pakistan. The model consists of Action Plans for the factory managers and the government, and a map of stages towards catch-up.

The results obtained empirically in Pakistan were then systematically compared with the literature on East Asian economies by extracting similar barriers, actions and stages by content analysis of published case studies of companies from successful East Asian countries. This led to a technology development model for East Asia. The two models from Pakistan and East Asia were compared and contrasted, and finally were combined together to obtain a comprehensive model of technology development.

**Figure 1.3:** (Overleaf) Structure of the research project

that a company has to tackle, especially when it exists in a developing country like Pakistan.

The fourth contribution is the preparation of an inventory of possible solutions to these problems. The fifth is the enumeration of actions that have been found helpful in improvement in technology in manufacturing companies arranged in order of their relative importance. The lists of barriers and actions have been systematically compared with the literature.

The sixth is the proposition of stages that a company has to pass in the process of catch-up with the leading companies of the world, which has been compared with the literature. The last, but not the least, contribution is the development of a model for technology development for manufacturing companies in developing countries that wish to catch-up in technology. This model provides separate action plans to be followed by the company managers and government policy makers.

It is thus hoped that this research will be useful and applicable to managers of manufacturing companies and policy makers in the governments of developing countries who aspire to catch-up with the advanced world.

## **1.7 Structure of the thesis**

The structure of this thesis is elaborated in table 1.6. In this thesis there is a general chapter on the research methods employed, chapter 4, and more detail is given on methods where appropriate in the research chapters. References are given at the end of each chapter. Also many chapters have substantial appendices consisting mainly of the less important findings arising from the work. Captions have been given on top of the tables and figures instead of bottom because many of the tables spread over several pages.



**Table 1.6:** Structure of the thesis

<b>Chapter</b>	<b>Title</b>	<b>Description</b>
Chapter 1	Introduction	Research background, need for this research, description of research project, elaboration of concepts
Chapter 2	Literature review – Technology and manufacturing in the economic development	Process of economic development in theoretical perspective and real life examples, role of technology, technology development in successful countries
Chapter 3	Literature review – Issues in technology development	Technology development issues at the government level and in companies, examples of successful companies in East Asia, technology development issues in Pakistan
Chapter 4	Research Methods	Research methods used in this research, problems encountered in carrying out this research
Chapter 5	Technology Status Measurement	Method of measurement of technology status in manufacturing companies as developed in this research and its application in Pakistan
Chapter 6	Exploration of issues – semi structured interviews	Method of data gathering and data analysis for identifying issues, description of framework of technology development issues, and case studies of three manufacturing companies in Pakistan
Chapter 7	Barriers in technology development	Findings on barriers and problems in technology development as encountered by the manufacturing companies in Pakistan
Chapter 8	Solutions to barriers	Findings on recommended solutions to barriers presented in the previous chapter
Chapter 9	Actions for technology development	Findings on actions for technology development found useful by experienced managers in Pakistani manufacturing companies
Chapter 10	Ranking survey, stages and the Model for technology development	Model for development of technology in Pakistani manufacturing companies based on results of chapters 7, 8 and 9, and stages required for catch-up in technology
Chapter 11	Development of an East Asian Model from the literature	Barriers faced and technology development actions tried by East Asian companies, stages generally followed for catch-up in technology
Chapter 12	Comparison with literature – The Combined model	Comparison of Pakistani and East Asian models of technology development and construction of a combined model
Chapter 13	Conclusions	Conclusions of this research and suggestions for future research

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## APPENDIX 1A

### APPENDIX 1A                      Important concepts in this research

This section contains descriptions of some important concepts in this research.

#### 1A.1 Technology

Technology is the most important aspect of this research project. The literature provides various descriptions of technology. The Dictionary of Science and Technology (Morris, 1992) defines technology as follows:

“The application of scientific knowledge for practical purposes; the employment of tools, machines, materials, and processes to do work, produce goods, perform services, or carry out other useful activities.”

The Handbook of Technology Management (Gaynor (editor-in-chief), 1996) defines technology in the following ways:

- “1. Technology is the means of accomplishing a task – it includes whatever is needed to convert resources into products or services.
2. Technology includes the knowledge and resources that are required to achieve an objective.”

The essence of these and other definitions given in the literature is that ‘technology’ is means of transfer of ideas into reality. It includes the following:

- Hardware: Products, materials, equipment, machinery, tools etc.
- Processes: Manufacturing processes, quality control processes etc.
- Information: Drawings, documentation, process sheets etc.
- Systems: Manufacturing management, production management practices etc.
- Expertise: Skills, experience, creativity etc.



Technology is different and distinct from science. While science aims at developing an understanding of the way various things are and why some processes happen, technology applies knowledge for practical purposes in order to produce products and services. This product-oriented nature of technology explains the importance of technology in economic development.

### **1A.2 Economic development**

A country could be termed as 'economically developed' if it can provide all the necessities (and luxuries if possible) of life for the whole of the population of the country. Thus a rich country will have an abundance of 'goods and services', a good being a product or a physical necessity, such as rice, bread, water, computer, or electricity, and a service being an assistance such as healthcare service, banking service, dry-cleaning service etc. The process of economic development means producing better (higher quality, higher value and higher price) products and services.

Samuelson & Nordhaus (1985) define the following four elements that are inputs in the economic development process:

- Human resources (labour, education, discipline, motivation, ...)
- Natural resources (land, minerals, fuel, climate, ...)
- Capital formation (machines, factories, roads, ...)
- Technology (science, engineering, management, entrepreneurship,...)

Of these four elements, natural resources cannot be altered, so the developing countries are left with the utilisation of human, capital and technology resources to fulfil the dream of economic development.

### 1A.3 Measure of economic development

The common measure of economic development is GDP (Gross Domestic Product), which is the sum of the value or price of all the products and services produced within the geographical boundaries of any country, irrespective of whether they were produced by local people or foreigners. Another important measure that provides a better picture of the prosperity of any country is GDP per capita, which is the output of a country per head of the population.

### 1A.4 Manufacturing

The word manufacturing literally means “making by hand”, but a general definition is “To make, especially on a large scale using machinery”.

The recognition of the importance of manufacturing can be traced back to Adam Smith (1776) who pointed out the fact that a small manufactured output can purchase a lot of primary commodities. Researchers have argued that manufacturing is central to the prosperity of nations (For example, Parker (1985) and Brown (1996)).

### 1A.5 Value-addition

Another important concept is that of value-addition. It refers to the value that a company adds to the raw material or bought in components to manufacture a product. Thus the *value-added* to a product is sale price minus the price that has been paid to other companies for inputs to this product.

$$\text{Value-added} = \text{Sales revenue} - \text{Paid to outside companies}$$

Examples of low value-added products could be cotton, yarn or cloth, and those of high value-added products could be video camera, computer and electric kettle.

### **1A.6 Productivity**

Productivity is the ratio of output of goods and services to the input of resources used. Thus productivity measures how well these resources are being used (Gedye, 1979).

### **1A.7 Catch-up in economic development**

The term signifies the process of economic development of a developing country so that it becomes at par with the developed countries.

Pretorius and Wet (2000) contended that the ideal path for any country in the catch-up process is when economic growth is accompanied by technological development. They assert that technology development is imperative even for those countries that manage to attain economic growth without technological development using cheap labour or through natural resources. The other possibility of development of technology without enhancement in economic growth represents problems in technology strategy.

### **1A.8 Catch-up in technology**

The term signifies the process of technology development in a developing country so that its technology becomes at par with the technology in developed countries. At the company level, it signifies the process of technology development in a company such that it attains the level of technology of the companies that are leading the world in its area of work.

Lee and Lim (2001) have described the patterns of technological catch up. They have argued that there are three such patterns:



<i>Path of forerunner:</i>	<i>Stage A → Stage B → Stage C → Stage D</i>
Path following catch-up:	Stage A → Stage B → Stage C → Stage D
Stage skipping catch-up:	Stage A → ..... → Stage C → Stage D (Leapfrogging I)
Path creating catch-up:	Stage A → Stage B → Stage C' → Stage D' (Leapfrogging II)

‘Path following’ means that the latecomer companies follow the same steps as the forerunner. ‘Stage-skipping’ catch-up means that the latecomer firms follow the same path but skip some of the stages and thus save time. ‘Path creating’ catch-up means that the latecomer firms explore their own path of technology development.

## Chapter 2

# Literature Review –Technology and Manufacturing in the Economic Development of Countries

### 2.1 Introduction to literature review

This and the following chapter review all the literature that forms the background for this research. There were two main objectives of this literature survey:

1. To review the role of technology and manufacturing in the economic development of countries.
2. To review the published literature related to how technology can be developed in companies and whole countries.

This chapter covers the first objective. It summarises the stages in economic development of countries in Europe and East Asia that have been successful, understanding the role of technology and manufacturing. For comparison, theories of economic development have been reviewed to show their impracticability.

The following chapter concerns technology policy and actions taken at the government and the company level, and provides examples of the rapidly developed countries in East Asia. The literature on technology development and the manufacturing sector of Pakistan has also been reviewed.

### 2.1.1 List of searched databases

The following on-line databases were extensively consulted during this research:

- Compendex
- IEEE Xplore
- ProQuest
- Science Citation Index
- Science Direct
- Social Sciences Citation Index

### 2.1.2 List of consulted periodicals

Research papers from the following periodicals were consulted during this research. The periodicals with (\*) mark against their name were found very useful in this research.

- *Agricultural economics*
- *American Journal of Sociology*
- *Asian Pacific Economic Literature*
- *California Management Review*
- *Cambridge Journal of Economics*
- *Economics, Innovation and New Technology*
- *European Economic Review*
- *Harvard Business Review*
- *IDS Bulletin*
- *IEEE Software*
- *IEEE Spectrum*
- *IEEE Transactions on Components, Packaging, and Manufacturing Technology*
- *IEEE Transactions on Engineering Management*
- *International Journal of Pressure Vessels & Piping*
- *International Journal of Production Economics*
- *International Journal of Technology Management\**



- *Journal of Asian Economics*
- *Journal of Business Research*
- *Journal of Development Studies*
- *Journal of Economic Growth*
- *Journal of Economic Perspectives*
- *Journal of Engineering and Technology Management*
- *Journal of Policy Modelling*
- *Journal of Public Economics*
- *Journal of Science Society of Thailand*
- *Pakistan Economist*
- *Public Administration and Development*
- *R&D Management*
- *Renewable energy*
- *Research Policy*
- *Research Technology Management*
- *Robotics*
- *Singapore Economic Review*
- *Strategic Management Journal*
- *Structural Change and Economic Dynamics*
- *Studies in Comparative International Development*
- *Technovation\**
- *Technological Forecasting and Social Change\**
- *Technology Analysis & Strategic Management\**
- *Technology in Society*
- *Telecommunications Policy*
- *The Economist*
- *Third World Planning Review*
- *World Development*
- *World Economy*

## 2.2 Economic development theories

The start of literature search was based upon the knowledge that some countries in East Asia have attained rapid economic development in relatively short time spans. In order to find out if any theory could explain the process of rapid economic development that these countries experienced, literature on theoretical perspectives of economic development of nations was reviewed.

### 2.2.1 Evolution of economic development thought

Many economists have tried to theorise the process of economic development of nations. In the sixteenth and the seventeenth century, the **Mercantilist school** of economic thought was dominant in Europe, according to which gold and silver were the most desirable forms of wealth. Both power and riches could be achieved by accumulation of these precious metals.

In the middle of eighteenth century (1750s), the **Physiocratic school** of thought appeared in France. This theory proposed that a country can be made rich if it can produce a lot of agricultural output and sell it abroad.

This was followed by **Classical school**, which began with the publication of '*The Wealth of Nations*' by Adam Smith in 1776. This doctrine suggested the policy of 'laissez faire' for governments aspiring to economic development, i.e. it suggested that the government should not interfere in trade and business. The importance of industry was noted for the first time during this period.

The industrial revolution in Europe greatly increased the production of various products and made the entrepreneurs and industrialists rich as a result, but the life of workers in these industries was not improved as they were paid very low wages even after very long hours of work. This situation led to the **Socialist school** of thought in the

nineteenth century (1800s) that asked for public (government) ownership of the enterprises and regulation of trade and business by the government in the best interest of the public.

### 2.2.2 Development Economics

In the 1940s and the early 1950s, some economists started to explore the causes of relative poverty of under-developed countries and the possible route for these countries towards economic progress. This area of the economics was later termed ‘development economics’ or ‘the economics of the developing countries’.

Rosenstein-Rodan and Nurkse proposed ‘**balanced growth**’ perspectives in 1943 and 1952 respectively, that under-developed countries should progress in broad perspective, with simultaneous expansion of industries that support each other (hence the name ‘**balanced growth**’). They thought that industrialization was necessary to develop the poor countries, and that governments should organize and manage large-scale industrial investment programmes.

Gunnar Myrdal, the co-recipient of Nobel Prize in Economics in 1974, emphasized that governments in the under-developed countries should ensure economic development through planning and intervention in all the spheres of economic life.

**Dependency theory** emerged as an influential economic thought in the late 1960s and the 1970s. It argued that the under-developed countries were dependant on the advanced countries for technology, designs and other skills, and advanced countries were exploiting under-developed countries. It asked for development of local capabilities in the developing countries so that they could compete at the international level.

In Latin America, the United Nations Economic Commission of Latin America (UN-ECLA) was formed in 1948 under the auspices of the United Nations. ECLA



economists proposed that the way to progress was industrialisation through transformation in the domestic economic structure. Therefore it became known as ‘**Structuralist school** of thought’. The policies suggested by these economists were widely applied by various governments in Latin America in the 1950s and the 1960s. The result was rapid industrialization but these industries could only serve domestic demand and could not compete in the international market. There was sharp increase in the debt burden on Latin American countries because of the large imports of machinery and production equipment for industrialization in the 1960s and the 1970s resulting in debt crisis in the early 1980s.

### **2.2.3 Dominance of Neo-classical economic thought**

The increase in debt of Latin American countries during the 1970s, and the accompanying hyper-inflation and widespread unemployment in some countries, reduced the following of the Structuralist thought as the route to economic development by under-developed countries.

The economists opposing Structuralist thought argued that these problems were because of gross inefficiencies in the working of developing countries because of intervention by the governments. The alternative proposed by these economists was the neo-classical doctrine of free market economy, which suggested that the governments should follow ‘laissez faire’ and should restrict themselves to provision of physical infrastructure, national security, education (partially), legal system, and environmental protection. Trade should be free of all restrictions and tariffs.

This perspective became the dominant thought in the late 1970s and remained so for the rest of the 20<sup>th</sup> century. Most of the developing countries followed the policies based upon neo-classical perspective in the last two decades of the 20<sup>th</sup> century.

#### **2.2.4 Results of neo-classical policies**

The results of neo-classical policies could be perceived by the example of Pakistan, which has been a faithful adherent of these policies. According to Zaidi (1999), Pakistan's economic policies since 1988 have been completely determined by the IMF and the World Bank – sponsored structural adjustment programmes, which were based upon neo-classical policies of free-market, privatisation of state-owned enterprises, removal of trade barriers and deregulation.

The results of these policies have been disastrous. According to World Development Reports, in 1991, 11.6 per cent of the population of Pakistan was living below the international poverty line of US\$ 1 per day of income. In 1996, this figure had risen to 31 per cent. According to the World Bank reports, the GDP per capita remained more or less stagnant during the 1990s while the external debt on Pakistan increased from US\$ 20.7 billion in 1990 to US\$ 34.7 billion in year 2000. Not only the external debt increased, but the Pakistani currency was substantially devalued. According to United Nations' Statistical Year Books, the exchange rate increased from Rs. 21.6 per US\$ in 1990 to Rs. 61.9 per US\$ in year 2001.

The results of neo-classical policies in other countries were similar to those in Pakistan. Easterly (2001) pointed out that in the 1980-98 period when most of the developing countries followed the neo-classical policies, the median per capita income growth in these countries was 0.0 per cent while it had been 2.5 per cent during 1960-79 period when these countries were not following neo-classical policies.

### **2.3 Technology in economic development theories**

The Mercantilists and the Physiocrats considered industry as unimportant. Adam Smith was the first economist to include the importance of industry and the concept of productivity in economics. He thought that inputs to national wealth were land, labour,



capital and productivity. Marx (1867) was the first notable economist who clearly mentioned ‘technology’ in his writings. He argued that machine technology was capable of infinite improvements because of its capability to duplicate work of humans.

Schumpeter (1934) was one of the first twentieth century economists to appreciate the powerful role that technology plays in economic development. Kuznets (1954) termed ‘technical change’ as the most important factor in industrial development and economic growth of countries.

### **2.3.1 Quantifying the role of technology in economic development**

After 1950, ‘technology’ was termed as one of the most important ingredients in economic development of countries. Numerous researchers attempted to quantify the contribution of technological change in economic development.

The pioneering attempts in quantifying the role of technology in economic development were carried out by Abramovitz (1956) and Solow (1957), who quantitatively explored the role of the technical progress in the long-term economic development of the American economy. These studies provoked numerous other attempts, differing in methodology and time period coverage, in quantifying the effect of technological change in the United States economy. Rosenberg, Landau and Mowery (1992) have given a summary of all these studies.

The average result is that 52 % of the growth in output can be attributed to technological change, 22 % can be attributed to improvements in capital goods, and rest (26 %) is due to labour improvements. So technology improvements are the prime contributor to the economic development of any country.



## **2.4 Did successful countries follow policies based upon economic doctrines?**

Numerous countries have experienced economic development. Starting from the United Kingdom, other countries in Europe, the United States, Russia, and many other countries have become economically and technologically developed. In recent history, the countries in East Asia have astonished the world with their rapid economic development. Study of the development history of all these countries shows that they did not follow the widely accepted economic doctrines. They charted out their own paths.

Freeman (1988) has narrated the process of selection of development strategy in Japan against the neo-classical theory of free trade. Taiwan and South Korea adopted development strategies similar to that of Japan. Singapore opted to bring in multinational corporations (MNCs) against the ‘dependency school’ of economic thought (Yew, 2000). Malaysia, Indonesia and Thailand followed Singapore.

Wade (1990) argued that the rapid economic development of Japan, South Korea and Taiwan has been because of an unequivocal commitment of their governments, which have interfered in the market much more than prescribed by the neo-classical economic theories. Similar arguments have been made by Rodrik (1997).

Mathews (1997) reasoned that the policies followed by Taiwan were unorthodox. Etzkowitz and Brisolla (1999) argued that the development of South Korea, Taiwan and Singapore would have been much slower if they had followed neo-classical policies. Chu (1994) and Chu (1997) made the case that the governments had played pivotal roles in the development of East Asian countries. Barrett and Whyte (1982) tried to prove Taiwan to be a deviant case from the dependency theory.

All these researches supported the view that the successful East Asian countries did not follow influential economic theories but charted out their own developmental paths. The failure of countries following economic theories and the success of countries not

following them was evident from literature and thus necessitated detailed study of the developmental policies followed by East Asian countries.

The following sections provide insight into the developmental experience of various countries of the world. The developmental experience of the United Kingdom, France, Germany and Russia has been compared with that of countries in East Asia.

## **2.5 Development in Europe**

Europe was not very wealthy in the sixteenth and seventeenth centuries (1500s and 1600s), but in the eighteenth century (1700s) Europe was becoming richer because of the exploitation of colonies. China and the Indian sub-continent were considered to be rich countries in the seventeenth century. Kealey (1996) pointed out that even by 1750, as high as 73 per cent of world manufacturing output was from these areas.

### **2.5.1 Industrial Revolution in Britain – Leadership through technology advance**

In the middle of the eighteenth century (1730s to 1780s), many new machines were invented in Britain. These included the *steam engine*, which made mass production of goods possible as power could be supplied from it, the *flying shuttle* – a device added to hand-loom to speed up weaving, the *spinning jenny*, which could spin six threads of yarn at one time, the *water frame*, in which yarn was made using water wheel as power source, the *power loom*, and many others. All these machines made it possible to create factories where people could work together. These developments were later collectively termed as the *industrial revolution*, which is generally believed to be started in the 1780s.



The industrial revolution spread beyond just machines in factories. In 1804, the railway engine was invented, that provided industry with cheap transport facilities. Similarly, transition from wooden to steel ships during 1870-90 made the British merchant fleet the largest and the best in the world.

The result of industrial revolution was that Britain became the leader of the world of technology. This leadership was accompanied by political leadership and economic betterment. Kealey (1996) noted that per capita income in Britain increased from £11 in 1780 to £28 in 1860. Thus Britain became the first developed country in the world and this development was based upon industrialization and technology development.

### **2.5.2 Industrialization of France – Catch-up in technology encouraged by the state**

Although England tried to keep its technology developments to herself, they became known to the French and others in one way or another. Many industrialists and engineers visited Britain to gain knowledge about industrial machines. Another common strategy was to employ British workers to gain knowledge about these machines.

The French government itself became interested and took steps to make sure that the new technology was available to industries in France. Clapham (1968) explained the steps taken by the French government in the development of technology in France. These steps included creating machinery-making workshops through British engineers and workers, setting up training centres for machines incorporating new technology, setting up centres for technology development and encouragement to use new machinery.

### **Tariffs for industrial development**



Before the French revolution, a free trade treaty was made between France and Britain in 1786. Because of cheap higher quality products from Britain, French industry could not develop and there was high unemployment which added to the reasons for the French revolution in 1789.

Napoleon's government laid heavy tariffs on the import of cotton and cloth in 1806 and 1810, which resulted in the development of the textile industry in France. This was not limited to textiles. Similar tariffs were placed on the other industries like iron and steel. So the development of French industry was engineered by the French government behind tariff walls.

### **2.5.3 Industrialisation of Germany (Prussia) – Government sponsored development**

In the early nineteenth century, Germany was a poor country. Nearly three-fourths of the population was linked to agriculture and few industries existed.

After the industrial revolution in Britain, the Prussian government sent many civil servants and industrial spies to learn about the new developments in Britain. Englishmen were called in to teach the new methods to Germans. In 1821, the Prussian government created an Institute of Trades, to spread knowledge of new industrial methods. The government also created machine-making industry by establishing an institute at Berlin. Students from this institute established their own industries. Progress was however slow due to wars and it remained slow till the 1840s.

#### **The Zollverein– Increase in tariffs**

Germany was divided into small states. In 1818, these states began to form a union and by 1834, the *Zollverein*, a union for free trade, was formed. Between 1834 and 1848,

tariffs on manufactures were increased several fold, especially on British iron and cotton yarn.

Freeman (1987) wrote that a German scholar – Friedrich List, identified a strategy for Germany to catch up with British industrial dominance. The fundamental points of List's national strategy were as follows:

- The most advanced foreign technology should be imported by all possible means
- The manufacturing sector is of utmost importance for economic progress
- A national policy should be produced in order to promote long-term development.

### **The results of *Zollverein* policies**

After tariffs had been raised, German industry developed at a rapid pace over the 35 years between 1845 and 1880. With this rapid industrialization came prosperity in the population and a shift towards the cities.

By 1860, Germany was producing more coal than France and Belgium, and by 1914 it surpassed Britain. In 1873, tariffs were removed on iron. This resulted in the closing of 50 per cent of the iron foundries in Germany because of imports of cheap steel from Britain. In 1880, tariffs were put in place again. By the year 1900, Germany had beaten Britain in steel production.

Similar developments were seen in textiles. Quick developments were made in the 1850s and the 1860s. Here again tariffs helped in the development of local industry. The German chemical industry also developed rapidly during the 1860s and 1870s. The electrical industry also grew in the last two decades of the nineteenth century. By 1913, German exports of cables and electrical appliances were the highest in Europe.

The essence is that Germany developed and industrialized rapidly by acquiring industrial technologies and by erecting protective tariff walls, and was able to compete with the other developed nations of the time – Britain and France.

#### **2.5.4 Development of Russia**

The Russian Empire came into existence in the fifteenth century. It expanded its limits to the East with time. By 1762, most of the area that is now called Russia was under this state. By the middle of the nineteenth century Russia had an agriculture-based economy. The construction of railway began in the 1840s and by the 1860s six thousand miles of railroads had been built. Textile and iron industries, and coal mining had started even before that, but these were modest in comparison with those of Britain, France and Belgium.

#### **Developmental policies**

During the 1870s and the 1880s, several policy steps were taken by the Russian government. These included, among others, stimulation of industry through government orders, financing of railways, shifting from a liberal to a highly protectionist tariff policy, building of gold reserves, and generation of foreign exchange through forced grain exports and foreign borrowing.

These policies resulted in a wave of industrialisation in the 1890s. Technology and machinery were imported from Western European countries. There were certain sectors, like iron and steel, in which investors were not willing to invest. The Russian government either invested in these sectors itself or gave incentives. The result of this industrialization was that the industrial production of Russia tripled in about twenty years.



Rostow (1978) provided details of Russian development experience. According to him, the progress was slow until about 1928 because of political turbulence in Russia and the communist takeover in 1917.

During the period from 1929 to 1939, Soviet industrial production increased around 5 times under the communist dictator Stalin. This period was marked by stress on heavy industry, increases in armaments production and technological development. The latest Western technology was imported in this period at an enormous pace.

The essence is that Russian industrialization and development was based upon technology imports and was achieved through government support under a protectionist environment.

## **2.6 Development of Japan**

### **2.6.1 Early History and Meiji restoration**

The seventeenth century saw the beginnings of colonisation of many parts of the world by European countries. Scared of this fate, Japan separated itself from the rest of the world by closing its borders in 1639 and remained secluded for the next two centuries. In 1853, Admiral Perry of the United States reached the Japanese harbour with a US fleet, and Japan had to open its borders for trade with the Western countries.

According to Magaziner and Hout (1980), most of the local industries were badly hurt by imports from the West. This produced unrest in the local population. The result was that Emperor Meiji was brought to power in 1867. This change is generally called the ‘Meiji restoration’.

### **2.6.2 Industrialization and economic development in the Meiji era and afterwards**

The Meiji government selected industrialisation as the only viable option for catching up with the Western countries. To achieve this objective, the government recruited an elite central bureaucracy, which produced pragmatic plans for industrialization and economic development.

Kealey (1996) wrote that in the early period of Meiji government, Japanese government lured numerous Western teachers at vast expense, such that between 1868 and 1872, no less than 40 per cent of the Japanese government budget was spent on salaries to foreign experts.

In industry, technology was imported to create various factories and power plants. Foreign engineers and technicians taught the Japanese how to run these factories. As the private sector in the country was not very active, the Japanese government conceived and led the process of industrialization. It set up industries in the government sector and then sold them off to the private sector. The government also introduced technical education on a large scale.

One example of this industrialisation was Yawata – the state-owned iron and steel industry, which was created in 1901 with the help of Western technology. Horsley and Buckley (1990) and Shin (1996) argued that it was started clearly against the classical economic doctrines and was supported by the government in spite of it being a loss-making concern.

### **2.6.3 Development in Japan between the two World Wars**

By 1920, Japan had become a major industrialised nation. After the First World War, Japan was included in the "Big Five" powers that took part in the Versailles Peace

Conference in 1919. Japan was also granted a permanent seat on the Council of the League of Nations.

After the First World War, economic activity expanded in Japan. Armament production and the heavy industries on which armament production depended, received highest priority in the 1930s. Thus coal mining, electric power, shipbuilding, metals, machinery and chemical industries flourished. During this period, family-owned large conglomerates, called *zaibatsu* developed in Japan.

#### **2.6.4 Development in Japan after the Second World War**

Japan was decisively defeated in the Second World War. It lost its political autonomy to US occupation forces, which occupied Japan from 1945 to 1952.

In 1945, the economic and infrastructure conditions were dismal. Unemployment was high, wages were low but the food prices were sharply rising. These conditions and economic policies imposed on Japan started recession in 1949. Japan was still under recession when the Korean War broke out in 1950. This war changed the attitude of the occupation forces and Japan became independent once again.

In clear deviation from the policy of ‘laissez faire’ suggested by neo-classical doctrine, after independence, imports of foreign manufactured goods were restricted through quotas and high tariffs and the process of industrialisation re-started under the guidance of the government.

#### **Technology Development in Industry**

In the early 1950s, when foreign exchange became available by virtue of the Korean War, the Japanese government started technology modernisation programmes.



Numerous incentives were given to industry for technology modernisation and the government actively supported industry in getting the right technologies.

As early as 1950, the Ministry of International Trade and Industry (MITI) had published a list of strategic technologies that were required for the modernisation of Japanese industry. By 1965, all of those technologies had been purchased or acquired by the Japanese companies, mostly from the United States. For example, the process of nylon production was acquired from the US firm DuPont, and the plastics and petrochemical industries were established with production technologies licensed from ICI, Dow Chemicals and others.

The role of the government, through the MITI, was decisive in almost all of these technology purchases as the MITI decided about the technology and its recipient firm. The technology once acquired was later disseminated in the whole industry.

Horsley and Buckley (1990) have explained that apart from technology purchases, the other most common strategy used by the Japanese was imitation. Japanese firms bought samples of the best products available on the market and took them apart to study and imitate them. The Japanese also monitored progress in process technologies throughout the world. They copied the best available processes.

### **Industrial targeting**

The Japanese government targeted specific industrial sectors for development during various time periods. The government took all sorts of measures: incentives, subsidies, cheap credit, and technological guidance, and it provided protection to specific industrial sectors until these sectors became competitive in the world.

In the 1950s and the early 1960s, steel, chemicals and shipbuilding were targeted by the Japanese planners as the base industries which provided inputs to other industries. The

emphasis changed to machinery, cars, and electronics industries in the late 1960s and the 1970s.

### **2.6.5 Development in the 1960s**

By 1960, Japan had achieved not only economic self-reliance but it also had become a major force in heavy industry. Wages and the living standards also improved in this process. In 1960, the new government of Prime Minister Hayato Ikeda came with a slogan ‘Double Your Income’ within ten years. It looked ambitious but practically it took only seven. By 1964, 90 per cent of the households had a TV set.

The National Development Plan was announced in 1962. It was a plan to establish and strengthen the heavy and chemical industries in four designated industrial regions along the Pacific Industrial Belt. By 1970, these regions were producing 90 per cent of the country’s industrial output.

Between 1954 and 1971, the Japanese economy grew at an average annual rate of 10 per cent, expanding by almost five times, which was unprecedented in modern history.

### **2.6.6 Development in the 1970s and beyond**

In 1971, the Ministry of International Trade and Industry (MITI) planned a major policy shift from heavy and chemical industries to electronics, semiconductors and robots. The new vision called for catch-up with the Western countries in high-tech industries. This plan was successfully completed over the 1970s.

### **Japanese tactics for technology sourcing in the 1970s**

All the big business groups, *keiretsu*, had developed trading arms for marketing and sales in foreign markets in the 1970s. These trading companies had offices all over the

world, which not only marketed products of their group but were also effective in gathering information for new technologies, new products and new processes. These trading companies also helped in making technology purchases from the West, and even worked as investors in the other countries for sources of raw materials, such as mines.

### **Example of technology development tactics in the 1980s and 1990s**

Japan continued to develop technology and employ unorthodox ways to be the world leader in technology. Witherick (1997) noted that one of the interesting developments in the late 1980s and the early 1990s had been the building of 40 new ‘technopolis’ or ‘technical cities’. Each of these towns was planned to have an industrial area of high-tech industries and support services, a university and a housing area for workers and their families.

#### **2.6.7 Japanese success – Based upon technology in the manufacturing sector**

Japan has clearly caught up with the Western countries after complete devastation in the Second World War. According to Magaziner and Hout (1980) and many other researchers, this economic catch-up has been the result of technological catch-up, engineered by the Japanese government through developments in the manufacturing sector.

## **2.7 Development of South Korea**

### **2.7.1 Creation of South Korea**

Japanese conquered Korea in 1905. During the occupation, they built the infrastructure and some industries in Korea but completely dominated the manufacturing sector. After



the War in 1945, the Korean peninsula was divided into two independent nations – North Korea and South Korea.

Reconstruction efforts started after the Second World War and major land reforms were introduced, but the attack by North Korea in 1950 and the subsequent war that lasted three years, again devastated the country. According to Kim (1997), around 44 per cent of the manufacturing facilities were destroyed during the war.

After the Korean War, South Korea has gone through various distinct periods of development. These phases are as follows.

1. Reconstruction and import substitution period 1953-61.
2. Export-oriented development period 1961-1973.
3. Heavy and chemical industry development period 1973-1980.
4. Technology-intensive development period 1980-Onwards.

### **2.7.2 Reconstruction and import substitution period 1953-61**

In 1953, South Korea was a rural economy. Agriculture, forestry and fishery accounted for 48.6 per cent of the GNP while manufacturing accounted for only 7.7 per cent. Patel (1993) explained that the United States and the other European countries provided financial assistance to South Korea so that it would not fall to the communists. This assistance amounted to a third of the budget in 1954, and increased to half of the budget in 1956, but later decreased to a third again by 1960.

The government adopted an industrial policy of import substitution (establishing industries to make products that substituted imports) by erecting import tariff walls. Due to the small size of the domestic market, this policy was not successful as the markets saturated after a short period of time. The average annual growth rate of the economy in spite of the reconstruction effort and the large inflow of foreign aid was only 3.1 per cent during the period 1953-61.

### **2.7.3 Export-oriented development period 1961-1973**

In 1961, Major General Park Chung Hee took over the government. He had a single-point agenda of development through industrialization. Soon after coming into power in 1961, the government established a highly powerful economic planning body – the Economic Planning Board (EPB). All commercial banks were nationalised to allocate resources for industrialization according to the government's priorities. The large business conglomerates ("*chaebols*") were coerced to follow government guidelines of production and export targets. The government made heavy use of the control of credit, monetary and fiscal incentives, and even informal persuasion and pressurization to achieve results on the set targets.

According to Choi (1981), a consensus existed in South Korea in the early 1960s that the quickest route to development was through technology import and its absorption in the local industry.

#### **Government-induced industrialisation through technology imports**

During the course of the Second five-year plan of 1967-71, the government of South Korea enacted many laws that provided incentives to develop key industrial sectors, including mechanical engineering, shipbuilding, electronic engineering, steel, oil and chemicals, and non-steel metal industries. The government itself initiated industrial development projects in capital-intensive and high-risk areas of Steel making, automobile and shipbuilding, as the private sector was not prepared to invest.

Despite the negative suggestions made by donor agencies including the World Bank, the government of South Korea initiated the Pohang Iron and Steel Company (POSCO) in 1968. Finance for this steel mill was provided by the Japanese government and technical assistance was provided by Nippon Steel and other Japanese corporations. The company went into production in 1972 and was a tremendous success. In 1987, the



same World Bank that had refused to fund the project described POSCO as “arguably the world’s most efficient producer of steel”.

The government started the first automobile assembly plant itself in 1962 with technical assistance from Nissan of Japan. Three years later, the plant was transferred to the private sector, and a new technology transfer agreement was made with Toyota. Two more car assemblers entered the market to take the benefits of a protected domestic market. Hyundai started assembling Ford cars in 1967, and Asia Motor started assembling Fiats in 1969.

The South Korean government announced the Shipbuilding Industry Promotion Act in 1967. It also funded the universities to establish shipbuilding departments. Finally the government asked Hyundai to enter shipbuilding. Hyundai entered the shipbuilding industry without any prior experience in 1972 and made several technology transfer agreements with the foreign firms. It also obtained foreign technical assistance in numerous other matters to compete with the established Japanese and other shipbuilders.

### **Development of an electronics industry – planned and executed by the government**

The Korean electronics industry started in 1965 when LG of South Korea entered into a technology transfer agreement with Hitachi of Japan for the manufacture of black-and-white TV sets. The government promulgated the Electronics Industry Promotion Act in 1968 and designated it as a strategic industry. It offered preferential financing, protection from foreign competition and other incentives. Progressive domestic content requirements were instituted and yearly production targets were established. An industrial estate specifically for electronics was also established.

### **Institutional measures for promotion of technology**

The government of South Korea also established various institutes for the development of industrial technology. These included, among others, Korea Institute of Science and Technology (KIST) as an autonomous multi-disciplinary industrial research institute,



and Korea Advanced Institute of Sciences (KAIS) as a post-graduate school in applied sciences and engineering, to create high calibre scientists and engineers.

### **Result of these policies**

The results of the policies followed over the 1960s were spectacular. South Korea's exports rose from US\$ 50 million in 1962 to US\$ 3.2 billion in 1973. According to Kim (1997), the share of manufacturing in GDP increased from 13.8 % in 1960 to 25.9 % in 1975.

The growth in GDP over the decade of 1963-73 was 13 % annually, which was the highest in the world. GNP per capita increased from US\$ 79 in 1960 to US\$ 253 in 1970 and to US\$ 594 in 1975.

#### **2.7.4 Heavy and chemical industry development period 1973-1980**

Kim (1997) explained that changes in international political scenarios prompted South Korean leaders to gain self-sufficiency in defence production and thus enter into heavy and chemical industries. The 'Heavy and Chemical Industry Development Plan' (the HCI plan) was thus announced in 1973. According to this plan, six sectors were targeted for development by importing technologies over a period from 1973 to 1981. These included steel, shipbuilding, heavy machinery, petrochemical, electronics and nonferrous metals.

#### **Development of automobile industry**

The automobile industry was identified as one of the priority industries in the HCI plan. In 1973, the government asked three major car assemblers to submit plans for the development of a 'Korean Car' that could be mass-produced by 1975. Significant incentives of tax exemptions and guaranteed local markets were associated with the

plan. This plan led to the development of two original new vehicles: The Pony from Hyundai and the Brisa from Kia.

In 1974, a ten-year industry-specific Long-Term Promotion Plan was announced. It asked for 90 per cent domestic content for small passenger cars by the end of the 1970s and to turn the industry into a major exporter by the early 1980s.

The result of these measures was that Korean manufacturers invested heavily in car manufacturing plants in anticipation of an export drive. They entered export markets by setting the price of the cars below even their production cost. This was achieved by selling the cars at higher prices in the protected domestic market.

### **Development of electronics and semi-conductor industry**

The electronics industry was selected as one of the six key industries to be promoted under the Heavy and Chemical Industry Plan of 1973, despite it being neither heavy nor chemical. A sector-specific Eight-Year Electronics Industry Development Plan was announced in 1974. It asked for the creation of mission-oriented research institutes in the public and private sectors and encouraged technology imports through licensing and consultants instead of foreign direct investment (FDI). Another six-year plan to promote the semiconductor industry was announced in 1975, but because of high risks involved, the private sector would not invest in it. The government therefore created Korea Institute of Electronics Technology (KIET) to import and disseminate various technologies.

### **Development of other industries and establishment of research institutes**

In addition to automobiles and electronics, heavy investments were made in metals, machinery, chemicals and petrochemicals. The armaments industry was also built up during the 1970s. It started producing tanks, armoured vehicles and even fighter aircraft. All these industries were developed through technology imports from foreign countries.

Along with the HCI drive, the government of South Korea established several specialized research institutes in the 1970s. These institutes were created in ships, ocean research, atomic energy, electronics and telecommunications, chemical technology, electrical equipment, solar energy, machinery and metals areas.

### **Results of HCI drive**

Although the hasty entry into HCI increased the debt burden on South Korea, it did provide the basic heavy industries required for sustained development. By 1980, the per capita income in South Korea had increased to US\$ 1597.

#### **2.7.5 Development after 1980**

President Park Chung Hee was assassinated in 1979 but the development momentum continued. The thrust in the 1980s was on technology-intensive industries, such as precision machinery, electronics and Information Technology. More attention was devoted to the manufacture of high-technology products that could be exported. In the 1990s, the goal was to develop high-technology fields, such as microelectronics, new materials, fine chemicals, bioengineering, optics, and aerospace.

#### **2.7.6 Development through technology acquisition**

Kim (1997) and other researchers have argued that economic development in South Korea was achieved through rapid industrialisation, which could be attributed to technological change in industries. Table 2.1 provides figures for technology acquisition by South Korean firms in three major forms of technology acquisition.



**Table 2.1:** Foreign technology transfers to South Korea, 1962-1993.

Source: Kim, Linsu (1997), *Imitation to innovation – The dynamics of Korea's technological learning*, Harvard Business School Press, Boston, USA, p. 40-41.

Mode of acquisition	1962-1966	1967-1971	1972-1976	1977-1981	1982-1986	1987-1991	1992-1993	Total
	(US\$ millions)							
Foreign Direct Investment (FDI)	45.4	218.6	879.4	720.6	1,767.7	5,635.9	1,938.8	11,208.5
Foreign Licensing	0.8	16.3	96.6	451.4	1,184.9	4,359.4	1,797.0	7,906.4
Import of capital goods	316	2,541	8,841	27,978	50,978	120,952	67,152	278,758

## 2.8 Development of Taiwan

### 2.8.1 Historical setting

According to Rabushka (1987), Taiwan reverted to China in 1945 after 50 years of Japanese colonial rule. China at that time was going through a civil war. In 1949, the Nationalist party (Kuomintang, or KMT) and its forces retreated to Taiwan after their defeat on mainland China, and established their rule in Taiwan.

### 2.8.2 Development in the initial period, 1949-58

The initial few years of the KMT rule were difficult, as they faced hyper-inflation due to monetary problems and feared attack from China, but with the start of the Korean War in 1950, Taiwan became important for the United States in its war against Communism. The United States provided Taiwan with massive economic and military aid that greatly helped the authorities in Taiwan to surmount their initial economic and financial problems.

### **Industrial development**

An Industrial Development Commission was set up in the early 1950s for the establishment of promising industries that were identified as plastics, rayon, cement, glass, and fertilizer plants. The government started many industries by itself and later handed these over to the private sector. In other cases, the government provided incentives in the form of import tariffs, cheap credit and allocation of foreign exchange. Institutions were set up to provide technical assistance to local industry.

The government started the first Polyvinyl Chloride (PVC) plant itself, which was handed over to the private sector later. The first rayon plant was also started by the government with technical assistance from the United States. The government also played a key role in the development of the textile industry by providing capital and buying all the cloth produced.

The electronics industry in Taiwan started in 1948 with the assembly of vacuum tube radios. In 1953, a Taiwanese firm (Tatung) entered into a technology transfer agreement with a Japanese firm to manufacture watt-hour metres using local components. Some other ventures also started with Japanese assistance during the late 1950s.

### **Development in the 1950s**

During the 1950s, the annual growth rate of manufacturing output increased at a rate of 10 % annually, and the share of industry in the GDP increased from 17 per cent to 25 per cent. The overall economic growth rate was 8.2 % annually, and per capita income more than doubled.

### **2.8.3 Export-led development in the period 1958 to early 1970s**

In 1958, a major shift in policies was made from labour-intensive import-substituting industries to export-oriented industries. The investment climate was improved and heavy and chemical industries were started.

#### **Policies in the 1960s**

The Statute of Encouragement of Investment, enacted in 1960, provided specific incentives to foster the business climate. Taxes on industry were reduced, export-oriented industries were given five-year tax holidays and taxes on them were drastically reduced. A major revision to this Statute was carried out in 1965. This revision provided further incentives for export-oriented industries including special facilities in the Export Processing Zones (EPZ). In addition to all these policy measures, the government actively attracted Foreign Direct Investment (FDI) especially from companies in the United States.

According to Wade (1990), during all this period, the government placed several tariff and non-tariff barriers to restrict imports into the country.

#### **Industrial development in the 1960s – Guided by the state**

Industrial development was carried out at a fast pace during the 1960s and the early 1970s. Synthetic fibres and plastics provided raw material to the export industries, so these sectors were developed. Nylon, polyesters, acrylics and rayon industries were created with technical help from the Japanese companies.

The development of a plastics industry was also based upon import of technology either in the form of licence agreements or in the form of joint ventures. The state-owned Chinese Petroleum Corporation (CPC) started several factories through joint ventures



with American firms. Following this lead, other private firms started, and so by the end of the 1960s, Taiwan's petrochemical industry had been substantially developed.

The first car was assembled in Taiwan in 1960 with assistance from Nissan of Japan. These initiatives were taken in the private sector under guidance and financial help of the state authorities. Between 1967 and 1969, four new companies entered the automobile sector, through joint venture or licensing arrangements with Japanese companies.

In 1962, a state-owned company began the assembly of televisions using Japanese components. Also in 1962, the authorities imposed local content requirements on the assembly of televisions, refrigerators, air conditioners, diesel engines and several other items. The result was that several agreements were made between local and Japanese firms for transfer of technology in electrical appliances and consumer electronics industries. In 1965, the state-owned China Data Processing Centre was established to push the use of computers in local industry.

The state also ventured into metals by starting an integrated steel mill. In addition, work on commercial nuclear power plant started. The defence forces created several factories for producing small and medium size arms and ammunition.

### **Result of these policies and initiatives**

The results of these export-oriented policies were very encouraging. The economy of Taiwan grew at a tremendous pace during the late 1950s and the 1960s. The real GNP (inflation adjusted GNP) grew at an average of 10 per cent during the 1960s and the early 1970s (till 1972). Wages increased at a rate of 6.2 per cent in the 1960s. This generated a marked improvement in the standard of living.

This development was because the share of the manufacturing sector in the economy of Taiwan increased from 22 per cent to 37 per cent between 1960 and 1977.

#### **2.8.4 Development from the early 1970s to the mid 1980s**

The Sixth four-year plan (1973-76), announced in 1973, indicated support of the state in petrochemical, electrical machinery, electronics, precision machine tools, computers and peripherals, and similar high-tech sectors. In addition, the state authorities reduced tariffs and taxes to increase economic activity, and initiated ten major public sector projects worth US\$ 7 billion.

A major step in improving the base of industrial technology was the establishment of the Industrial Technology Research Institute (ITRI) by the Ministry of Economic Affairs (MOEA) in 1973. In 1974, the Electronics Research and Service Organization (ERSO) was formed under ITRI to boost research in the electronics sector. ITRI grew in size and activity. By 1987, ITRI had a budget of US\$ 215 million and a staff of over 4,500 divided into six institutes.

#### **Industrial development**

Industry was developed further in this time frame. By 1981, small Taiwan was the World fourth largest producer of synthetic fibres. A large integrated steel mill, China Steel, was completed in 1977 in the public sector. Initially Krupp of Germany and later U.S. Steel were recruited as engineering consultants.

In shipbuilding, China Shipbuilding Corporation was established in 1973 to manufacture Very Large Crude Carriers (VLCCs). This was joint-venture between a US company and the state of Taiwan. Unlike steel, China Shipbuilding has not been a success story.

The machine tools industry started and developed in the 1970s and the 1980s. In the 1970s, the authorities in Taiwan provided subsidized credit, technology inputs and

training to the machine tool manufacturers, and ITRI helped the firms design Computerized Numerically Controlled (CNC) machine tools and machining centres.

Automobiles had been one of a few sectors that did not develop in Taiwan during the 1970s. By 1979, there were six local assemblers that assembled behind tariff walls, their average production being only 18,000 vehicles per year. In 1980, the state-owned Taiwan Machinery Corporation, and General Motors entered into a joint venture to manufacture heavy trucks.

Although in the 1980s Taiwan could not become a big name in the automobile industry, it was successful in the parts and assembly market. Nissan, Mitsubishi and Toyota established joint ventures with local companies.

In addition to above, electronics, semiconductors and computer industries developed in Taiwan in 1980s.

### **Economic development from the early 1970s to the mid 1980s**

Economic development spurred by development in the manufacturing sector increased living standards. In 1980, out of every 1000 households, 934 had refrigerators, 783 had motorcycles, 990 had gas stoves and 908 had electric cookers.

#### **2.8.5 Development since mid 1980s**

A policy change from protectionist to liberal economy started in the mid-1980s. Tariffs were gradually lowered. In the 1980s and the 1990s, Taiwan began to focus more on capital- and technology-intensive industries, like electronics, semiconductors, computers and chemicals. A major infrastructure development was Hsinchu Science-based Industrial Park (HSIP), which was the hub for high-tech industry.



### **2.8.6 Development of Taiwan – State guidance of manufacturing sector**

Thus Taiwan transformed from an agricultural economy to an advanced industrial economy in just 25 years. This was achieved through development of the manufacturing sector under state guidance.

## **2.9 Development of Singapore**

Singapore developed from a small trading port into one of the richest nations in the world in less than 30 years.

### **2.9.1 Development from 1958 to 1973 – Building the base**

After gaining independence from the British rule in 1958, Singapore faced numerous problems. The gravest of these was unemployment, running at 13.2% in 1960. The economy was geared towards trade, the market was too small, and manufacturing was insignificant.

A four-year development plan was launched in 1961 on the basis of recommendations of the UN Bureau of Technical Assistance. This plan contained numerous incentives to attract foreign investment, and set aside land for an industrial estate. In the same year, the Economic Development Board (EDB) was created to foster industrial development.

#### **Attracting foreign investment**

In 1968, the EDB was refocused to actively attract foreign investment. It opened new offices in financial centres of the world, and tried to interest investors.

As Yew (2000) pointed out, foreign investment in Singapore was attracted against the accepted wisdom of ‘dependency theory’ believed by leading economists at that time,

who suggested that multi-national companies should not be brought in the country as they were exploiters.

Shell built the first oil-refinery in Singapore in 1961. After 1965, other oil companies also came to Singapore, and so Singapore became the refining centre for oil in the South East Asia. By 1974, Singapore was the third largest oil-refining centre in the world outside the Middle East.

Apart from oil-refining, Singapore was not very successful in attracting foreign investment until 1968. The government itself started various projects to foster the growth of the Singapore economy, including a merchant shipping company in 1968 called the Neptune Orient Line (NOL) and an airline, the Singapore Airlines (SIA).

### **Start of foreign investment**

The efforts of the EDB bore fruit when Texas Instruments set up a semiconductor assembly plant in Singapore in 1968. Texas Instruments was followed by National Semiconductor and Hewlett-Packard (HP).

This was the promising beginning of a stream of investments from the United States. By 1970, 271 factories had started operation employing 32,000 workers, and more than 100 were under construction. The policy of attracting foreign investment had been successful.

### **Economic development until 1973**

The period from 1965 to 1973 witnessed unprecedented economic growth in Singapore, with an average annual growth rate of real GDP of 12.7 percent, meaning that the economy grew by 2.6 times in eight years. The basis for this economic development was industrialization brought about by a conscious effort to attract foreign investment.

### **2.9.2 Development from 1973 to 1979 – Selective industrialisation**

In 1973, unemployment was finally eliminated from the island state. Till that time, the government had followed a policy of attracting every investment that could bring in jobs, but in 1975, Singapore started its targeted promotion strategy, and published its first list of priority industries that would receive favoured treatment and more incentives. This list included electronics and semiconductors among others.

#### **Petrochemical, pharmaceutical, steel and other industries – government investments**

To capitalize upon the success of oil refining, the government decided to enter into the down-stream petrochemical industries. A joint venture between the Sumitomo of Japan and the government of Singapore started in 1977. It came to production in 1985 and was successful. Other companies including Esso, Mobil, DuPont and Glaxo also set up petrochemical and pharmaceutical plants in Singapore.

The government of Singapore also moved into the steel business by creating the National Iron and Steel Mills. A high-tech company in electronics products was created by the name of Chartered Technologies. In addition, a mint, a small ammunition manufacturing facility, and many other public enterprises were started by the government.

### **2.9.3 Development from 1979 to 2000 – capital and technology-intensive development**

By the late 1970s, wages in Singapore had risen to a point that it was no longer profitable for labour-intensive industries. In order to further expand the economy and increase wages and the standards of living, it was necessary that higher value-added



industries be opened in Singapore. Thus the government set upon restructuring the economy to achieve this objective.

One of the high value-added areas was the financial sector. The major expansion of the financial centre started in 1978 and till 1990, it had become an international financial centre. The Asian Dollar Market reached US\$ 54.4 billion in 1980 and grew to US\$ 390.4 billion by 1990, posting an annual growth rate of 21.8 %.

### **Development of high-tech centre**

The government of Singapore actively encouraged telecommunications, computers and peripherals, and semiconductor industries. Wong (2001) described that in the early 1990s, the government of Singapore established many institutes in high-tech areas that were important for Singapore. The government promoted computer-controlled production, industrial robots, and flexible manufacturing systems to increase productivity.

A national technology plan was started in 1991 and completed in 1995 with a total expenditure of S\$ 2 billion. The purpose of this plan was to take steps towards the transformation of the economy into a research-intensive economy.

### **Result of these policies**

The result of these policies was that the economy expanded at an average annual growth rate of 8.4 per cent, amounting to a growth of 2.6 times in 12 years. The value of high-technology domestic exports expanded from \$24 billion in 1990 to \$62 billion in 1998.

#### **2.9.4 Development of Singapore – Engineered by the government**

The GDP of Singapore increased from US\$ 0.7 billion in 1960 to US\$ 85 billion in 1999, while GDP per capita has increased from US\$ 430 to US\$ 26,545 during the same

period. The prime vehicle for this amazing growth has been manufacturing, although increases in trade and services have also played a significant part. Within manufacturing the role of machinery (including both electrical and non-electrical) was dominant. In 1985, machinery accounted for 39 per cent of manufacturing output. This share increased to 52.5 per cent in 1999.

## **2.10 Development of Malaysia**

Malaysia was awarded independence in 1957. According to Alavi (1996), Malaysia was an agricultural country before independence. During the period 1947-1955, rubber and tin formed approximately 85 % of total exports. Malaysia developed in the last four decades of the 20<sup>th</sup> century from a farm-based economy to a modern high value-added industrial economy. Its GDP per capita improved from US\$ 280 in 1960 to US\$ 3,724 in 2001. In 1960, manufacturing accounted for only 10 per cent of the GDP while agriculture contributed more than 40 per cent. By the turn of the century, the contribution of manufacturing increased to 32 per cent while that of agriculture decreased to 9 per cent.

### **2.10.1 Major development phases in the history of Malaysia**

The development history of Malaysia could be divided into the following phases:

1. Initial development phase 1957-1970.
2. Development with redistribution 1970-1980.
3. The heavy industry drive 1980-85.
4. Export-led development 1985-2000.

### **2.10.2 Initial development phase 1957-1970**

Under the guidelines of the World Bank, the Malaysian government made policies based upon the principles of neo-classical doctrines. Government restrained itself to providing tax subsidies and other incentives, uplift of the backward areas, and provision of the basic infrastructure. Industrial estates were created in the country and local and foreign private investments were encouraged.

In 1965, tariffs were increased to protect local industries. The increase in tariff did have a positive effect on industrialization. The share of the manufacturing sector in the economy was 8 per cent in 1955, which increased to 10 percent in 1965 (a period of 10 years). By 1970, this share had been increased to 13.7 percent. The industries that developed in this period were mostly consumer goods industries and those related to agriculture.

In terms of overall growth, the Malaysian economy grew at 5.0 per cent annually during 1961-65 and at 5.4 per cent annually during 1966-70.

### **2.10.3 Development with redistribution 1970-1980**

The less-than-expected success of the policies followed till 1970 called for change. In addition, the backwardness of majority Malay people caused racial riots and resulted in the New Economic Policy (NEP) – a 20-year plan in 1971 for the uplift of the Malay people. The plan called for an export-oriented industrialization (EOI) policy to increase economic growth while increasing the share of the local Malay (*Bumiputera*) population. Under the new policy, Export Processing Zones (EPZ) and Free Trade Zones (FTZ) were established.



### **Government initiatives**

The government started an extensive search for natural resources, which was successful when significant petroleum and natural resources were found in the eastern part of peninsular Malaysia and offshore Sabah and Sarawak. The extraction and refining of these resources was taken over by the government. Malaysia became a net exporter of oil in the mid-1970s.

### **Foreign investment**

The policies to attract foreign investment continued during this period. The results started to appear during this period. Many foreign companies invested in Malaysia. These investments were mostly in labour-intensive electronics and textile industries.

### **Development in the 1970-80 period**

The period from 1970 to 1980 was a golden period from the development perspective. The GDP increased from US\$ 4 billion to US\$ 23.8 billion. The GDP per head also improved from US\$ 370 to US\$ 1,716. Industry thrived, although this surge in industrial development was based upon foreign investment.

#### **2.10.4 Heavy industry drive 1980-1985**

The government was changed in 1975. Inspired by the success of Japan and South Korea, the new government believed that the development of heavy industry was necessary for further economic growth.

The Malaysian government initiated a state-sponsored heavy industry investment drive by establishing the Heavy Industries Corporation of Malaysia (HICOM) in November

1980 for creation of heavy industries. Under the *Look East* policy, joint ventures with foreign, mostly Japanese, companies were sought. By 1988, HICOM had set up 9 companies in the automobile, steel, fertilizers, petrochemicals, oil-refining and cement sectors.

Most of the projects of HICOM were financed by external borrowing. As all these investments were capital-intensive, external borrowing increased from RM 4.86 billion (9.46 % of GNP) in 1980 to RM 50.5 billion in 1986 (76 % of GNP).

The initial results of the heavy industry drive were not successful. Many of these projects suffered heavy financial losses. However, the government continued to promote these industries.

#### **2.10.5 Export-led development 1985-2000**

Poor performance of heavy industries and sluggish growth of the economy necessitated policy changes. The government considered the development of the manufacturing sector to be the prime objective. To achieve this objective, a ten-year Industrial Master Plan (IMP) was started in 1986. Under this plan 12 industrial sectors were targeted for development. The government also initiated an active policy to attract foreign investment, by giving more incentives.

According to Swee (1996), the results of IMP exceeded the objectives. Manufacturing value-added increased from RM 13,268 million in 1985 to RM 34,279 million in 1992, thus posting an annual growth rate of 12.6 per cent.

#### **Technology development plans**

According to Jegathesan et. al. (1997), the flow of foreign investment increased in the late 1980s but the Malaysian government realised that these investments were in labour-

intensive industries, which would not remain competitive due to rising wages, and a shift towards high value-added industries would be necessary. Several steps were thus taken in this regard.

The Malaysian Technology Development Corporation was created as a joint venture between government and private industry in 1992 to foster technological development in industries. An Action Plan for Industrial Technology Development (APITD) was initiated in 1990. The Malaysian Industry Government Group for High Technology (MIGHT) was established in 1993. It was a joint initiative of the government and the private sector to exploit research and new technologies for business opportunities.

### **Results of these policies**

By 1999, the Malaysian GDP had reached around US\$ 75 billion, and it had transformed into a respected middle-income nation. The GDP per head in 1999 was US\$ 3,288. This feat had been achieved through developments in the manufacturing sector initiated by deliberate efforts of the government.

## **2.11 Discussion - commonalities in the development of East Asian and European countries**

It can be seen that there have been many differences in the paths taken for development by the East Asian countries. Japan and South Korea restricted foreign direct investment (FDI), while Taiwan, Singapore and Malaysia actively sought it. Japan, South Korea and Taiwan got financial aid from the United States and other countries, while Singapore and Malaysia did not get this aid. But clearly the most common factor has been development of a manufacturing sector through technology acquisition, mostly from foreign sources. In addition, several other commonalities in the successful policies can be perceived, as follows:



- Industrialization – but not based upon economic doctrines
- Manufactured exports
- Government planning and guidance through an elite bureaucracy
- Government investment in capital-intensive and high risk areas
- Control of banks, capital sources and foreign exchange
- Restriction of imports through tariff and non-tariff barriers
- Shift from labour-intensive to high value-added manufacturing
- Industrial targeting

These policies are virtually the same as followed by the European countries when they were passing through the initial phases of economic and industrial development.

## **2.12 Conclusions from the case histories of the developed countries**

The prime conclusion from this chapter was that technology was the key factor in the development of nations. Technology assimilated by companies in the manufacturing sector was the main reason for improvement in products and their production, and when taken collectively, was the prime contributor to economic development of nations. In chapter 3 the literature on how to accomplish the assimilation of technology is reviewed.

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## Chapter 3

# Literature Review – Issues in Technology Development

### 3.1 Introduction

The last chapter reviewed the role of technology and manufacturing in the economic development of a number of countries, especially the successful East Asian countries.

This chapter reviews the literature on policies and actions by governments and manufacturing companies in their quest for technology development. It gives examples of the policies followed, and case studies of manufacturing companies from selected countries in East Asia. The literature on technology development and the manufacturing sector of Pakistan has also been reviewed.

The majority of the literature published on technology issues appears to be contributed by economists and covers only macro level issues, including the policies followed by governments for development of the manufacturing sector or its sub-sectors. Relatively few research papers deal with technology development issues at the company level.

### 3.2 Stages in Technology Development

Technology development means improvement or advance in technology. At the macro or government level, it means advancement in the general technology level in the

country. At the micro or company level, it refers to improvement in the technology level of the company.

Lee et. al. (1988) discussed the technology development process in developing countries. They provided a review of technology development stages described by various authors, as given in table 3.1.

**Table 3.1:** Technology development processes in developing countries  
Adapted from Lee et. al. (1988)

Authors	Technology Development Stages					
Enos (1962)	Alpha			Beta		
Kim (1980)	Implementation		Assimilation		Improvement	
Stewart (1979)	Development of capacity for independent search and choice			Minor technological change		New technology development and export
IDRC (1976)	Imports	Assimilation		Generation		
Cortez (1978)	Copying	Imitation		Adaptation and innovation		
Ogawa (1982)	Introductory	Assimilation		Adaptation		Generating
Judet and Perrin (1976)	Importation and Reproduction			Adaptation		Innovation
UNIDO (1980)	Selection and Acquisition			Adaptation and Absorption		Development
Raz (1983)	Initial			Learning		Third
Katz (1984)	Product Engineering	Process engineering and production planning			R&D	
Dhalman and Westphal (1981)	Production Engineering		Project Execution		Capital goods manufacturing	R&D
Fransman (1985)	Searching and Adaptation		Improving		Developing	Basic Research
Teitel (1981)	Adaptation		Continuous gradual improvement		Technical change	R&D
Lall (1980)	Elementary		Intermediate		Advanced	
	Learning by doing	Learning by adapting	Learning by design	Learning by improved design	Learning by setting up complete production system	Learning by innovation

Choi (1988), publishing at the same time as Lee, argued that technological development of a country starts with the importation of advanced foreign technology and proceeds



through the development of domestic variants of this imported technology to the final goal of technological self-reliance. He emphasised the importance of acquisition of local capability to modify imported technology for domestic applications.

The stages given in table 3.1 are generalised macro level stages assumed to be applicable to the whole country. They are based on the assumption that countries pass through these stages as a whole. No consensus exists among various authors. In chapter 11 a stages model applying to individual companies will be developed.

### **3.3 Technology development policies and strategies at the government level**

The topics of research in this area included suggested technology development policy measures for governments, instruments for these policies and industrial targeting.

#### **3.3.1 Policy measures for governments**

Many researchers have suggested policy measures for governments for development of technology in their countries.

Mitchell (1999) suggested a three phase approach.

1. Phase I: Development of an infrastructure base for foreign multinationals  
This phase includes luring of foreign investment through attractive investment terms and building IT, energy and transportation infrastructure in the country.
2. Phase II: Building the national economy through foreign technology acquisition  
This phase comprises of development of local technology by providing incentives for working as sub-contactors and suppliers to foreign companies.

3. Phase III: Development of indigenous R&D and commercialisation capability

This phase involves investments by the government for R&D, education, human resource development and commercialisation of technology developed in the country.

This approach was based upon neo-classical development perspective and does not recognise that government could itself become a direct industrial investor as was done in case of Singapore and Malaysia, which also followed policies of attracting foreign investment.

Lowe (1995) suggested a somewhat more active role of the government but stopped short of suggesting that government should invest in industry. According to him, government should act as a facilitator, providing tax incentives or low-interest loans or subsidies, and should also support industries through its procurements.

Lee and Lim (2001) suggested two major policy roles for the government.

1. Provision of a guaranteed market, through domestic market protection and export subsidies.
2. Joint R&D with the private sector to conduct product innovation.

Sharif (1992) prescribed the following framework for technology-based development of any country.

- Vitalise the science and technology management system
- Accelerate utilisation of available technologies
- Strengthen R&D activities
- Intensify technological human resource development
- Foster specialisation in national capability building
- Provide support for technological innovation
- Nurture innovation culture and future orientation

Yong (1985) stated the following measures for the promotion of technological advancement in any late industrialising country.

1. Sound overall macro-economic and trade policies.
2. Improvements in the education system.
3. Increasing resources available for national efforts in science and technology.
4. Liberal international exchange of goods, services and investments.
5. Facilitating the training and re-training of workers.
6. Encouraging consultation between employees, management, government and general public on the benefits to be gained from technological change.

Clark and Guy (1998) quoted the following policies for technological development.

- Subsidies for adoption (tax incentives for acquisition of special equipment)
- Information provision (awareness campaigns, technology demonstration, etc.)
- Strategy development (technology plans etc.)
- Government procurement (provision of confirmed market, defence procurement, etc.)
- Standardisation
- Technology transfer from foreign sources
- Encouragement of small-and-medium sized enterprises

Most of the recommendations by the researchers are general in nature (e.g. Strengthen R&D activities) and stop short of specific actions by the governments. Some of the recommendations may have been applicable in the past but may not be applicable in the era of reduction in tariff barriers.

### **3.3.2 Instruments for technology policies**

Many studies have concentrated on instruments used for implementing technology policies. Saeed and Prankprakma (1997) explored the effectiveness of technology



policy for developing countries. They argued that instruments used for technological development were a better alternative to traditional policy levers used for fostering economic growth. They proposed that technology-related investments should be made in industries.

Hahn and Yu (1999) quoted the following technology policy instruments for implementing technology policies, as given in table 3.2.

**Table 3.2:** Technology policy instruments  
Adapted from Hahn and Yu (1999).

<b>Policy tool</b>	<b>Examples</b>
Public enterprise	Innovation by publicly owned industries, setting up of new industries, participation in private enterprise
Scientific and technical	Research laboratories, support for research associations, learned societies, professional associations, research grants
Education	General education, universities, technical education, apprenticeship schemes, continuing and further education, retraining
Information	Information networks and centres, libraries, advisory and consulting services, databases, liaison services
Financial	Grants, loans, subsidies, financial sharing arrangements, provision of equipment, building and services, loan guaranties, export credit, etc.
Taxation	Company, personal, indirect, and payroll taxation, tax allowances
Legal and regulatory	Patents, environmental and health regulations, monopoly regulations
Political	Planning, regional policies, honours and awards for innovation, encouragement of mergers or joint consortia, public consultation
Procurement	Central or local government purchases and contracts, public corporations R&D contracts, prototype purchases
Public Services	Purchases, maintenance, supervision, and innovation in health services, public building, construction, transport, telecommunications
Commercial	Trade agreements, tariffs, currency regulations
Overseas agents	Defence sales organisation

Veloso & Soto (2001) explored the roles of incentives, infrastructure and institutions in late industrialising countries. They assert that all three dimensions are important for

technological development. They compare the examples of the auto industries in Mexico and Taiwan characterising the three dimensions, associated policies and their outcomes.

They pointed out that the outcome was that a strong industry developed in Taiwan that could not be done in Mexico. They asserted that the difference was that of government policy. Automotive policy in Taiwan provided protection (e.g., local content requirements and tariffs) as well as promotion (e.g., tax subsidies and technological assistance), while in Mexico the policy relied mainly on protection.

The policy instruments given above have been used effectively by some of the governments in East Asia. The core issue remains that how these instruments could be used effectively to foster technology development.

### **3.3.3 Industrial targeting by governments**

Industrial targeting means that a government selects certain industrial sectors for development and adopts policies specifically for development of those sectors. This targeting is based upon national economic development requirements. Japan, South Korea, Taiwan, Singapore, and Malaysia have all targeted various industrial sectors in various time periods.

Choi (1989) suggested that governments in developing countries should select certain industrial sectors according to their development priorities. Then they should concentrate on acquisition and utilisation of technologies and knowledge which has been established by the advanced countries. Only then they can enhance their own capability of innovation.

Brahm (1995) asserted that state targeting of industries has been prevalent in the newly industrialising countries. He gave various policy measures for national targeting policies, as given in table 3.3.



**Table 3.3: Types of state targeting policies**  
Adapted from Brahm (1995)

		Goal of targeting policy	
		Promotion	Protection
<b>Nature of intervention</b>	<b>Direct</b>	<ul style="list-style-type: none"> <li>• Domestic subsidies</li> <li>• Export subsidies</li> <li>• Tax reductions</li> <li>• Preferential capital costs and exchange rate</li> <li>• Industry restructuring</li> </ul>	<ul style="list-style-type: none"> <li>• Tariffs and excise taxes</li> <li>• Quotas</li> <li>• Voluntary export restraints</li> <li>• Local content requirements</li> <li>• Rules of origin</li> <li>• Antidumping laws</li> <li>• Countervailing duties</li> <li>• Licensing restrictions</li> </ul>
	<b>Indirect</b>	<ul style="list-style-type: none"> <li>• Government procurement</li> <li>• Tied foreign aid</li> <li>• Foreign policy linkages</li> <li>• Subsidy spillovers</li> <li>• Weak protection for foreign intellectual property</li> </ul>	<ul style="list-style-type: none"> <li>• Government procurement</li> <li>• Competition policy</li> <li>• Foreign ownership limits</li> <li>• Technical standards and testing restrictions</li> <li>• Health and safety standards</li> </ul>

Industrial targeting has been used by most of the successful East Asian countries as a policy tool to effectively utilise scarce resources. The most recent example has been Malaysia.

### **3.4 Technology development policies and strategies followed at the government level by individual East Asian countries**

This section briefly describes the policies and strategies followed by some selected countries in East Asia that have experienced rapid economic and technological development. These include Japan, South Korea, Taiwan, Singapore and Malaysia.



### 3.4.1 Technology development policies and strategies followed by Japan

Freeman (1987) provided the main features of the Japanese technology policy. These included the following.

- A strong impetus from government to promote modernisation of Japanese economy.
- Identification of education and training as key factors in this modernisation.
- Intense efforts to import and whenever possible to improve upon the best available technology in the world.
- Close co-operation between government and large industrial concerns.

Sikka (1998) stated the following technology development policies as followed by Japan for the 21<sup>st</sup> century.

- Establishment of world-class research and technology capability.
- Reducing dependence on foreign energy by developing new energy sources.
- Reducing dependence on foreign raw materials by moving towards smaller high-tech products that require less raw material.
- Stimulating research in key areas of high technology.
- Upgrading innovative capability by encouraging co-operation among industry, government and universities.

Sletmo and Boyd (1994) described the Japanese policy as administrative-corporate solidarity supporting the macro-management strategy for superior global competitiveness. They argued that the continuous expansion of Japan into international markets was collective effort of manufacturers, suppliers, banks and trading companies, which worked in industry groups. They pointed out that foreign investment was discouraged in Japan rather than encouraged.

Yew (2000) explained that the Japanese technology development policies were based upon acquiring the most advanced technology for their industries and continuous training and re-training of their staff.

Dambrot (1991) argued that Japanese technological success was based upon science and technology policies followed by its Ministry of International Trade and Industry (MITI), import restrictions, and competitive export pricing.

Saxonhouse (1983) cited the following policy instruments of the government in Japan.

- Tariffs, quotas and standards.
- Direct subsidies and grants.
- Tax policy.
- Capital availability.

White and Wade (1988) summarised the industrial targeting policies followed by Japan. They pointed out that the Ministry of International Trade and Industry of Japan (MITI) decided to establish those industries in Japan which required intensive use of capital and technology, such as steel, oil-refining, industrial machinery of all sorts, and electronics. They argued that these were precisely the industries required for long-term development of the country.

Bowonder, Miyake and Linstone (1994a and 1994b) studied the Japanese institutional mechanisms for economic growth. Among these mechanisms were manufacturing facilities at the companies, availability of human skills and technology diffusion systems. They also explained the co-operative technology development carried out by various firms and the role of MITI in Japan.

### **3.4.2 Technology development policies and strategies followed by South Korea**

Dambrot (1991) pointed out the similarities between the policies followed by Japan and South Korea. Examples were Japan's MITI and Korea's Ministry of Trade and Industry (MTI), and Institutes of Science and Technology established in Japan and Korea.



Choi (1988), former minister of Science & Technology in South Korea, argued that the 1960s could be regarded as the take-off stage, the 1970s as the growth stage and the 1980s as the stage of self development in Korean industry. Table 3.4 details the direction of industrialisation and the corresponding technological development strategy followed in Korea.

**Table 3.4:** Technological development strategies in Korea by stages  
Adopted from Choi (1988)

<b>Period</b>	<b>Direction of industrialisation</b>	<b>Technological development strategy</b>
1960s	<ol style="list-style-type: none"> <li>1. Establishment of the foundation for industrialisation.</li> <li>2. Fostering of import-substitution industries.</li> <li>3. Expansion of export-oriented light industries.</li> </ol>	<ol style="list-style-type: none"> <li>1. Expanding education in science &amp; technology and training in skills.</li> <li>2. Establishment of the legal and the institutional basis for the promotion of science &amp; technology.</li> <li>3. Facilitating the importation of advanced technologies.</li> </ol>
1970s	<ol style="list-style-type: none"> <li>1. Enhancing the sophistication of industries and fostering the heavy and chemical industries.</li> <li>2. Shift in policy from introduction of capital to the introduction of technology.</li> <li>3. Promotion of small and medium sized industries.</li> <li>4. Strengthening of the competitiveness of industries in the international market.</li> <li>5. Promotion of rural industrialisation.</li> </ol>	<ol style="list-style-type: none"> <li>1. Upgrading technological and scientific training in priority areas.</li> <li>2. Facilitating the adaptation and improvement of imported technologies through the establishment of research entities in private industries.</li> <li>3. Improving activities related to the analysis and distribution of technical information and provide on-site technical assistance.</li> <li>4. Strengthening industrial technology research and development capability.</li> </ol>
1980s	<ol style="list-style-type: none"> <li>1. Enhance the quality of export goods.</li> <li>2. Expand the exports of technology-intensive goods.</li> <li>3. Promotion of brain-intensive industries (high-tech industries).</li> <li>4. Fostering of information industry.</li> </ol>	<ol style="list-style-type: none"> <li>1. Provide large-scale recruitment from abroad and training of highly qualified manpower.</li> <li>2. Strengthen plant engineering capability and liberalisation of technology imports.</li> <li>3. Active future-oriented, long-term, large-scale research and development projects, and emphasise on software development.</li> <li>4. Move towards computer-minded or information-oriented society.</li> </ol>



Choi (1981) described South Korean strategies for institutional development and legal measures taken by the government for advancement of science and technology.

Kim (1998) argued that the main Korean policy features for technology development were the following.

1. Expansion in investment on education.
2. Procurement of turnkey plants and capital goods instead of licensing and foreign direct investment, thus retaining the management control in the hands of local firms.
3. Adoption of an export promotion policy.
4. Development of a Science and Technology infrastructure.
5. Liberal policy on brain drain.
6. Establishment of Ministry of Science & Technology.
7. Fostering entrepreneurship.

Sikka (1998) argued that Korea has followed a three pronged approach for technological development, which was as follows.

- Capability build-up, particularly manpower development at various levels.
- Accelerated introduction of foreign technologies.
- Stimulation of domestic R&D activities.

Lee (2000) described the policies for technological innovations followed by South Korea. He divided them into two: traditional policies and new policies:

Traditional policies:

1. Protection of local market for innovative new technologies produced by local firms.
2. Supporting firms' R&D activities through building technological infrastructure, including public research institutes, technical training etc.
3. Motivating R&D activities through various financial and other incentives.

### New Policies:

1. Enacting laws for special measures to support venture business, for provision of capital, manpower and space for venture capital companies.

Ito (1996) explained the industrial targeting policies followed by South Korea. He reported that targeted industries received tax incentives, subsidies, and loans.

Etzkowitz and Brisolla (1999) also wrote about industrial targeting in South Korea. They argued that enhancement of human capital at all levels contributed to South East Asian economic success.

White and Wade (1988) have also written about industrial targeting. They argued that South Korea and Taiwan have followed Japan in targeting industries.

Chung and Lay (1997) compared the technology promotion schemes of South Korea and Germany. They described that in the 1980s, the South Korean government tried to shift the structure of Korean industry from traditional branches to high-technology areas by motivating companies to establish their own R&D institutes. The result was that the number of private research institutes rose dramatically from 53 in 1981 to 966 in 1990.

Pack and Westphal (1986) explained that the South Korean government used numerous measures, including tariffs, import restrictions and others to promote infant industries. They acknowledged the role of '*chaebols*' (large business conglomerates) in the Korean development.

Hyun and Lent (1999) also emphasised the role of '*chaebols*' in the South Korean policy especially in telecommunications industry.

Cho and Kim (1997) have provided details of various research institutions created by the Korean government in the 1960s and the 1970s to promote technological development.

Sikka (1998) described the legal measures taken by the South Korean government for the development of science and technology in the 1960s and the 1970s.

Chen and Sewell (1996) described various plans made by the Ministry of Science and Technology in South Korea for development of technology. They also acknowledged the role of information centres created in South Korea to facilitate technology transfer. They also pointed out that capital goods import had been the most used strategy for technology import into South Korea. This was also shown by Kim (1997b), as given in table 2.1 chapter 2.

### **3.4.3 Technology development policies and strategies followed by Taiwan**

Li (1988) summarised the policies of the government of Taiwan for the development of science and technology in a chronological manner from the 1960s to the 1980s. These included the creation of government bodies, research institutes, science parks, various science and technology development programs and legal measures.

Chu (1994) asserted that Taiwan government played a major role in the development of the country. The export-promotion and import-substitution policies were followed concurrently.

Rabushka (1987) gave a detailed account of the policies followed and investment incentives given by the Taiwanese government over the years. He wrote that the late 1950s saw an emphasis on the development of labour-intensive, import-substituting industries to create manufacturing jobs. During the 1960s, the emphasis was on establishment of export-oriented industries and encouragement of local and foreign investment. In the 1970s, government increased its attention to infrastructure development, and the establishment of intermediate goods and heavy industries. In the 1980s, the emphasis was on high technology industry concurrent with educational emphasis on science and technology.



Mathews (1997) described the strategies adopted in the development of the semi-conductor industry in Taiwan. He explained that there were three ingredients responsible for development of the semi-conductor industry.

1. Hsinchu Science-Based Industrial Park (Created in September 1979)
2. Industrial Technology Research Institute (Established under Ministry of Economic Affairs in 1973)
3. Government agencies including Ministry of Economic Affairs (MoEA), and Industrial Development Bureau (IDB), which was similar to the MITI of Japan.

Lee and Yang (2000) and Xue (1997) emphasised the contribution of Hsinchu Science-Based Industrial Park (HSP) as successful policy for the development of hi-tech industry in Taiwan.

Chang et. al. (1993) proposed a development model for improving technological change. They asserted that Taiwan used this strategy for development of its IC industry. According to this model, the first step is the selection of technology. Then the applied research institutes, working on generic technologies, conduct joint research programs with academic institutions, who work to develop basic technologies. The outputs of these programs are specific technologies. In the next step, the technology is transferred to industries that develop the specific technologies.

Hsu and Chiang (2001) emphasised the importance of the Department of Industrial Technology (DOIT) under the Ministry of Economic Affairs (MOEA), which was entrusted with the task of formulation of industrial technology development policies and distribution of the funding for the Technology Development Program (TDP) to research institutes. The new technology thus developed was transferred to various industries in order to establish new high-tech products.

Chen and Sewell (1996) explained the scope of various government ministries and other institutions in the development of science and technology in Taiwan.

#### **3.4.4 Technology development policies and strategies followed by Singapore**

Wong (2001) provided a historical overview of the science and technology policy in Singapore. He pointed out that the emphasis during the 1970s was on technological development and during the 1980s was on technological upgrading, but a serious effort in formalising various steps started after the recession of 1985. What followed were the National Information Technology Plan (NITP) in 1985 and the National Automation Masterplan in 1988.

Wong (2001) also gave the institutional framework for science and technology policy in Singapore in the late 1990s. In this framework, the Ministry of Education oversees education at all levels. Under the Ministry of Trade and Industry, Economic Development Board (EDB), Productivity and Standards Board (PSB), National Computer Board (NCB) and National Science and Technology Board (NSTB) work together to promote technological and economic development.

Tang and Yeo (1995) summarised the policies and strategies followed by Singapore government over the past decades. These strategies are detailed in table 3.5.

Dambrot (1991) described the policies followed by Singapore. He mentioned that specific governmental efforts for R&D in Singapore started in 1979, when the Government's Economic Restructuring Process formulated a long-term plan emphasising R&D in 11 key areas. These included biotechnology, microelectronics, information technology, robotics and artificial intelligence, lasers and opto-electronics, and communications etc.

Hobday (1994) reported that Singapore made consistent efforts to develop local technical manpower through various means, including creation of vocational institutes, government-industry training centres, apprenticeship schemes, Skills Development Fund (SDF) that provided training grants, technology support institutes and research institutes in various technology areas.



**Table 3.5:** Policies followed by Singapore government  
Adopted from Tang and Yeo (1995)

Period	Opportunities / Problems	Response
2 <sup>nd</sup> half of 1960s	<ul style="list-style-type: none"> <li>• Excess of low-skilled labour</li> <li>• Lack of industrial heritage</li> <li>• Political uncertainty in Hong Kong and Taiwan over China</li> </ul>	<ul style="list-style-type: none"> <li>• Drew in Multinational Corporations (MNCs) which were searching for labour-intensive operation bases</li> </ul>
Late 1960s	<ul style="list-style-type: none"> <li>• British military pull-out</li> <li>• Boom in shipping</li> <li>• Start of oil exploration in South East Asia</li> </ul>	<ul style="list-style-type: none"> <li>• Established shipyard and defence industry</li> <li>• Attracted petroleum related companies</li> </ul>
Late 1970s	<ul style="list-style-type: none"> <li>• Acute labour shortage</li> <li>• Low productivity and low value-added</li> </ul>	<ul style="list-style-type: none"> <li>• 10-year economic upgrading plan</li> <li>• Rapid expansion of technical tertiary education</li> </ul>
Early 1980s	<ul style="list-style-type: none"> <li>• World recession</li> <li>• Non-competitive factories closing down or shifting out</li> </ul>	<ul style="list-style-type: none"> <li>• Pulled in MNCs in new growth industries</li> </ul>
1986 and now	<ul style="list-style-type: none"> <li>• Other newly industrialising economies (NIEs) catching up in industrialisation and technological development</li> <li>• China, India, Vietnam opening up</li> <li>• Economic boom in Asia</li> </ul>	<ul style="list-style-type: none"> <li>• Encourage entrepreneurship</li> <li>• Overseas ventures and MNCs to use Singapore as regional hub</li> <li>• Push for research and development, and innovation</li> <li>• Economic alliances to capitalise on the boom in Asia</li> </ul>

According to Lan (2001), the government of Singapore pursued a strategy of state entrepreneurship, which helped Singapore to solve common problems of 'late industrialisation'. He mentioned that the government owned Singapore Airlines, INTRACO (a trading company), and held 100 % or majority equity in manufacturing firms in food, textiles, wood, printing, chemicals and pharmaceuticals, iron and steel, engineering, and shipbuilding and repair. According to an estimate, these state-owned enterprises (SOEs) and statutory boards (e.g. the Economic Development Board) generated \$5-7 billion in 1983.



Swee (1996) stated the benefits of a strategy of attracting foreign investment. The main benefits were eradication of unemployment, increase in demand for technical staff, transfer of technology at all levels and economic development in the region. He also mentioned the strategy of a shift toward high value-added industry and gave examples of development of electronics and semiconductor industries.

Chin and Wang (1989) provided details of Singapore government efforts for promotion of Information Technology and Software. They mentioned the role of the Institute of Systems Science, set up in 1981 under four-year partnership between National University of Singapore and IBM, and Information Technology Institute, set up in 1986 as an arm of National Computer Board.

Yeo (1995) described the role of national technology development and R&D planning in Singapore. He described the country's on-going strategy to meet the challenges at the macro level.

#### **3.4.5 Technology development policies and strategies followed by Malaysia**

Jegathesan et. al. (1997) gave a detailed account of the measures taken by the Malaysian government for increase in technological capabilities. The main efforts were:

1. Industrial Technical Assistance Fund (ITAF) in 1990 to provide matching grants to Small and Medium Enterprises (SMEs) for consultancy studies, product development and design, quality and productivity improvements and market development.
2. The establishment of Intensification of Research in Priority Areas (IRPA) Fund in 1988 to provide financing for research in emerging technologies.
3. The establishment of Malaysian Technology Development Corporation (MTDC), a government-industry joint venture in 1992, for commercialisation of local research results and introduction of strategic technologies in the country.

4. The establishment of Human Resource Development Fund (HRDF) in 1992, a levy/grant system jointly managed by the government and private sector to encourage industrial training.
5. The establishment of Malaysian Technology Park (TPM) in 1988, to encourage entrepreneurship in high-tech industries.
6. The establishment of Malaysian Industry Government Group for High Technology (MIGHT) in 1993, a joint initiative by government and private industry to exploit research and technology for new business opportunities.
7. The launching of Kulim high-tech park (KHTP) designed as a science city.
8. The introduction of various tax incentives for research and development.
9. Industrial building allowances granted to buildings used by approved research companies or institutions carrying out research.
10. Exemption of import duty, excise duty and sales tax on machinery/equipment, materials, raw materials and samples used for approved research projects and by research companies of institutions.

They also mentioned the strategy of the Malaysian government for promotion of foreign technology flows. These included acquisition of foreign companies, tapping foreign overseas original equipment manufacturing (OEM) markets etc.

Tidd and Brocklehurst (1999) argued that Malaysia has pursued a hybrid policy for industrial and technological development, which was a combination of direct government support and intervention, and foreign direct investment (FDI). The policy measures that ensured higher levels of domestic value-added contribution were industrial restructuring, technological upgrading, and human resource development.

They provided detailed accounts of incentives given by the Malaysian government and steps taken by it for development of high technology and for investment in R&D.

Sletmo and Boyd (1994) wrote that development of the manufacturing sector was targeted by the Malaysian government in 1981. The major efforts were the 1986



Industrial Master Plan supplemented in 1990 with the Action Plan for Industrial Technology Development.

### 3.5 Technology development policies and strategies followed by companies

The scope of researches that have studied technology development issues including the policies followed and the actions taken by companies has been limited. Very few researchers have examined the problems faced by companies in their quest for technology development and how those problems were solved.

Some researchers have dealt with actions (as opposed to barriers) required for technology development, but as these researchers have been mostly economists, they have taken a macro view of actions required for technology development.

The methods listed by Lee et. al. (1988) for technology development in manufacturing companies in the developing countries are given in table 3.6.

**Table 3.6:** Methods of technology development available in developing countries  
Adapted from Lee et. al. (1988)

Performer of Technology Development	Methods of Technology Development			Origin of Resources
Joint Venture	Technology Acquisition through Establishment of Joint Venture			Outside Resources of Firm
Local Firm	Adoption of Foreign Technology (Technology Transfer)	Formal Technology Transfer	Licensing-in	
			Purchasing Technology	
		OEM Production		
	Informal Technology Transfer	Subcontracting	Inside Resources of Firm	
Purchasing of Capital Goods				
		Imitation		
	Indigenous R&D			



Choi (1988) stressed that the most important aspect to foster technological development in companies was building of capabilities to select and assimilate technologies needed in the company. He suggested creation of an internal system for this purpose.

Bae and Lee (1986) recommended that large companies in less developed countries adopt formal technology transfer methods while small companies adopt imitation.

Lee and Lim (2001) described the concept of catching-up and leapfrogging. They gave several examples from the Korean industry. They emphasised that control of management was essential in joint ventures. In this respect, they gave the example of Hyundai and Daewoo automobiles. Hyundai did not share management control with any of its co-shareholders, and took sole responsibility for all the R&D projects. Its technological capability grew in a steady manner. In contrast, Daewoo shared its management responsibility with GM and in the process experienced management conflicts.

Tidd and Brocklehurst (1999) quoted various modes of technology transfer to Newly Industrialising Countries (NICs) with their cost of acquisition and potential for learning, as given in table 3.7.

**Table 3.7: Methods of acquisition of know-how**  
Adopted from Tidd and Brocklehurst (1999)

<b>Method</b>	<b>Cost of acquisition</b>	<b>Potential for learning</b>
Licensing	Low	Low
Purchase of equipment	Moderate	Low
Sub-contracting	Moderate	Low
Foreign direct investment (FDI)	Moderate	Moderate
Hiring foreigners	Moderate	Moderate
Hiring returning nationals	Moderate	High
Joint ventures / strategic alliances	Moderate	High
Original equipment manufacturers (OEM)	High	High
Acquisition of overseas firms	High	High
Research and development	High	High

Hobday (1995) stated the following modes of foreign technology acquisition in electronics in latecomer firms that sought to acquire advanced technologies.

- Foreign Direct Investment (FDI)
- Joint Ventures
- Licensing
- Original Equipment Manufacture (OEM)
- Own-Design and Manufacture (ODM)
- Sub-contracting
- Foreign and local buyers
- Informal means (overseas training, hiring, returnees)
- Overseas acquisitions / equity investments
- Strategic partnership for technology

Banerjee (2000) stressed the development of a technology roadmap for a company. He proposed a 'Decision Web' for technology decision making that had strategy, cost, time, core competencies, risk, organisational learning, appropriability, and organisational viability as its dimensions.

Kharbanda and Jain (1997) studied indigenisation and technological change at firm level using the examples of three Indian firms which acquired technology to manufacture black and white TV picture tubes. They proposed that the following aspects were important in the technological learning process.

- Technical environment (well-educated manpower, flow of information in the firm, and regular training)
- Support of top management
- Learning by doing

### **3.6 Case studies of technology development policies and strategies at the company level by companies in East Asian countries**

This section provides a sample of case studies of various companies, highlighting the policies followed and actions taken by these companies for technology development.

#### **3.6.1 Technology development policies followed and actions taken by Japanese companies**

##### **Technology development at Nissan – Design import**

Cusumano (1985) provided a detailed account of the development of the automobile industry in Japan before the Second World War. He wrote that the Japanese government provided subsidies to automobile manufacturers in 1918 but by 1932 only one company, DAT Motors, had been only partially successful.

Nissan was established in 1933 and it took over DAT Motors in 1934. Nissan began with producing parts and components for Ford and GM in Japan, as well as Harley Davidson and other firms. At the same time, it also started producing cars.

In 1935, Nissan decided to manufacture trucks for the army. It purchased an entire plant from Graham-Paige Company of the United States, which had been lying idle due to excess capacity in the company. It also bought the designs for a 1.5-ton truck and a 6-cylinder engine.

After facing problems in manufacturing the engine, Nissan entered into a contract with Ferro Machine Casting Company in Cleveland, USA, for purchase of machinery and technical know-how. This plant started working in March 1937. Nissan also imported the designs of the truck's front and rear axle, transmission shaft, propeller shaft, and piston castings from various suppliers to the Graham-Paige Company. Nissan hired



American engineers to run the production facilities. But despite all these efforts, it struggled to manufacture cars and engines.

In 1937, Nissan hired a professor at Osaka University, who had studied automotive design in London, Detroit and Massachusetts Institute of Technology. With the help of this professor, Nissan was able to modify the design of the truck and had a prototype made by mid-1940. This design was successful and Nissan produced it for the next 10 years.

### **Technology development at Toyota – Reverse-engineering**

Cusumano (1985) also provided the development history of Toyota. The founder of the Toyota Motor Company visited Britain and went to see several automobile plants during 1929-1930. In this visit, he decided to produce cars through reverse-engineering. He started with copying a 2-cylinder, 60-cc engine produced by Smith Motors of the United States.

Toyota bought a Chevrolet engine in 1932. By 1934, the company had reverse-engineered it. With some testing and modifications, the engine was made successful. This engine was the basis of all Toyota vehicles until 1951.

In 1933 and 1934, the company also started to reverse-engineer a new Chevrolet car and a new Chrysler DeSoto car. Some design changes were made in the copied designs so that patent laws were not violated. The result was a hybrid design of car that was completed in May 1935.

In order to produce high quality parts, Toyota bought German and American machine tools. The company sent a specialist on engine castings to the United States in January 1934 to study the plant layouts. When the first prototype had been made in 1935, the production plant started to be built, which was completed in May 1936.

The company also bought a Ford truck in March 1935. Within six months, they were able to copy the frame, the axle and the body. By August 1935, the first prototype was ready with a modified 'A' engine. This was the basis for eight new models between 1937 and 1956.

### **Japanese strategies for car manufacturing after the Second World War – Licensing**

Japan's Ministry of trade and industry (MITI) developed a policy to develop the car industry in 1952. The major points of this policy were as follows.

- Discouragement of foreign direct investment.
- Protection against car imports in the form of tariffs and quotas.
- Purchase of technology from friendly nations.

According to the plan produced by MITI, four Japanese firms entered the industry in 1952-53 and made technology import agreements with four different Western manufacturers: Nissan with Austin; Isuzu with Rootes (Peugeot's subsidiary); Hino with Renault; and Shin-Mitsubishi Heavy Industries with Willys-Overland. The government banks provided the necessary funds required for the investments.

Nissan started producing Austin cars in 1952 and by 1956 a complete car was being manufactured in Japan. This transition to local production was made possible not only by Austin engineers and inspectors coming to Japan but also Nissan sending their engineers to Austin plant.

Some of the materials used by Austin were not available in Japan. Nissan had to find replacements. Many of the parts were supplied by other sources that held the patents for these parts. Nissan either had to procure the patent rights separately or copy the parts.

Apart from the four manufacturers mentioned above, Toyota and Fuji Seimitsu decided to design and manufacture small cars without foreign assistance. Toyota had established a formal product development office in the mid-1930s. After the Second World War, Toyota re-established this office and produced a car design on the basis of European models through modified reverse-engineering.

### **Management of innovation at Hitachi**

Bowonder and Miyake (1994) provided the development history of Hitachi Ltd. of Japan. They discussed management of innovation in detail and compared Hitachi with NEC and Nippon Steel. According to them, innovation resulted from strong R&D orientation, development of strategic alliances, globalisation of design, research, production and marketing, strong future focus, information flow and working in project teams on multi-disciplinary projects.

### **3.6.2 Technology development policies followed and actions taken by South Korean companies**

Bae and Lee (1986) described the following successful technology development patterns in small and medium sized companies in the machinery industry of Korea.

1. Copy of foreign products without drawings (Reverse-engineering)
2. Imitation of foreign products with own drawings
3. Development of new products through drawings (Make or buy drawings)
4. Indigenous R&D for improved design

### **Technology development at Anam – Incremental development supported by clients**

Hobday (1995) provided the case of Anam Industrial of South Korea – the largest chip packaging company in the world. The company started in 1968 and entered into OEM



business through the son of the owner (studying at M.I.T. at that time). In the first year of operation, Anam exported 0.2 million US\$ worth of semiconductors. Exports grew steadily to US\$ 1.8 billion in 1992.

Hobday (1995) described four phases of Anam's technological development.

- Phase I (1968-80): Learning the art of assembly.

In this phase assembly techniques were learned through Original Equipment Manufacturer (OEM) business. Major US clients provided technical help.

- Phase II (1980-85): Learning process engineering skills.

This phase involved learning of engineering skills through joint engineering work with its larger US customers. Anam's own R&D department was initiated in 1984 with technical help from an expert from Texas Instruments.

- Phase II (1985-88): The switch to locally initiated learning.

This phase included small incremental improvements in production processes. Foreign engineering assistance was provided to Anam for more complex processes.

- Phase II (1988-onwards): Toward product innovation capabilities.

In this phase, Anam improved its in-house product development capabilities. Anam worked jointly with several leading chip manufacturers, including IBM, Texas Instruments and Motorola, on new packaging and test processes. The company also worked with equipment suppliers to modify systems to meet new specifications.

### **Samsung's entry into semi-conductors – Learning and licensing through foreign sources**

Kim (1997a) narrated the story of the entry of Samsung into the semiconductor market. Samsung started by manufacturing transistors and integrated circuits. It bought a

financially troubled local semiconductor firm in 1975. It decided to enter Very Large Scale Integration (VLSI) technology in 1982.

When Samsung attempted to licence 64K DRAM (Dynamic Random Access Memory) technology, it was turned down by the major US and Japanese companies. Samsung then organised a task force team in 1982 to formulate an entry strategy for VLSI. The task force collected information, analysed the technology and market, and formulated plausible strategies. After that, the team spent a month in the US meeting experts in the industry, particularly Korean-Americans.

Samsung then identified troubled small firms to buy VLSI technologies from. It licensed a 64 K DRAM from Micron Technologies in Idaho, and design for a high-speed MOS (Metal-Oxide Semiconductor) process was bought from Zytex of California.

Samsung set up an R&D company in Silicon Valley in the United States in 1983 and hired five expert Korean-Americans, who provided crucial knowledge required for VLSI technology to Samsung. Another task force team was organised in Korea with two Korean-American scientists who had 64K DRAM development experience at American companies, and Samsung engineers who had been trained in VLSI at firms that had sold technology to Samsung.

Samsung created crisis by insisting the production system be produced within six months. The team worked around the clock to achieve the target.

For the development of its 4M DRAM, Samsung joined a national consortium in order to avoid costly duplication in research and development.

Samsung Electronics had no R&D person in 1975 while the number of R&D personnel grew to 8919 in 1994 with a total of 1413 local and 752 foreign patents granted. Thus Samsung Electronics leapfrogged over established competitors to become the leading memory chip producer.



Kim (1997a) described that the process of Samsung's leapfrogging experience has the following lessons:

1. International technology transfer takes place through formal mechanisms such as licensing, or informal mechanisms such as literature, observation tours, sample products, and the mobility of persons.
2. Formal licenses may transfer knowledge to technology recipients but it is their own knowledge that enables them to assimilate and improve transferred knowledge.
3. Technological learning at one stage helps subsequent learning.
4. Intensity of effort is an important element in absorption of technology.
5. Catching-up company can use crisis creation to generate enormous energy.
6. Government help and promotional programs for acquisition of technology are essential for success.

### **Small technology-based firms in South Korea**

Lee (2000) cited three successful examples of technology-based small firms in South Korea. These firms were spun-off from Korea Advanced Institute of Science and Technology (KAIST) and LG Electronics. According to the author, the success of these firms was based upon the following factors:

- The founders were highly educated engineers.
- They had global visions and competed directly against international companies.
- They depended heavily upon in-house R&D.
- They experimented with new management ideologies and organisation designs.

### **Hyundai Motor Company – Foreign technology imports and technical assistance**

Hyun (1999) and Steers (1999) provided details of developments at Hyundai Motor Company (HMC), which was created in 1967. In February 1968, HMC started



assembling Ford cars through kits supplied by Ford Motor Company under a technology transfer agreement. Ford also provided assembly equipment and technical assistance.

In 1973, Mitsubishi Motor Company provided HMC the designs and technical assistance to manufacture the car parts through a licensing agreement. In the same year, the South Korean government issued a plan for the development of the Korean National Car with a majority of Korean parts.

HMC hired ex-President of British Leyland as the company's Vice President, who in turn, hired six European senior designers and engineers to design and produce various parts of the proposed car. Car styling was done by ItalDesign. An assembly plant and an engineering centre were established.

In 1976, Hyundai started the production of the new car, the Pony, in the newly built plant. Initially there were lots of problems: poor quality parts from suppliers, inexperienced workers and many technical problems. But gradually the conditions improved. This amazing result was achieved on the basis of financial backing from the government, and hard work and commitment of Hyundai workers.

In view of the import restrictions, the car quickly captured 60 per cent of the domestic market. In spite of all this success, HMC was a loss-making venture supported by other Hyundai companies even by 1977.

For the acquisition of front-wheel drive technology to enter the North American market, Hyundai approached several renowned automakers, but was turned down. In 1981, Mitsubishi agreed to license an engine, transaxle, chassis, and emission control technology to HMC. Hyundai acquired the body styling technology from Italdesign and constant velocity joint technology from the British GKN and the Japanese NTN. These efforts resulted in an improved version of the Pony – Pony II – in 1982. By 1986, HMC's sales had risen to 400,000 cars per year.

### **Development of the Alpha engine by HMC– Foreign technology imports and technical assistance**

HMC unsuccessfully tried to convert a gasoline engine to diesel through imported technology from ElKo of Germany in 1980. This project gave base knowledge for engine design to Hyundai engineers.

HMC decided to develop its own engine and transmission in 1983. An engine development team was created. In 1984, HMC signed a contract with Ricardo Engineering, UK, to import technologies necessary to develop a 1500 cc gasoline engine. Two Korean experts, who had prior experience in engine development at Chrysler and General Motors, and an expert from Ricardo Engineering, provided invaluable knowledge.

To reduce technological dependency, HMC also imported engine design technologies from another company, AVL. Similarly, Bosch supplied specifications and technology to accommodate its Engine Management System (EMS) in Alpha engine.

### **Development of microwave ovens by Samsung – Reverse engineering**

Magaziner and Patinkin (1989) described the process of development of microwave ovens by Samsung. According to them, in 1976, while on a visit to United States, Samsung's vice president saw this new type of oven and became interested in it solely as an export product. On his return to South Korea, he formed the microwave oven development team.

The team bought world leading microwave ovens, took them apart, and noted their best features. The prototype was made by purchasing a magnetron tube from Japan. This prototype melted in the first test. After many unsuccessful attempts, it was finally in June 1978 that the first prototype was successful.



In 1982, Samsung decided to manufacture the magnetron tube that it had been purchasing from Japan. After being turned down by the Japanese for transfer of technology, it bought Amperex, the America's sole manufacturer of magnetrons, which was going out of business, and transferred the whole factory to South Korea.

### **3.6.3 Technology development policies followed and actions taken by Taiwanese companies**

Chiang (1997) described that Taiwan's government has officially targeted the aircraft industry. He explained that domestic capabilities for military systems evolved in the following sequence: First maintenance and repair, then licensed production, then modification and independent production of sub-systems and finally indigenous design, development and production of whole systems.

Hobday (1995) provided the case of Microelectronics Technology Inc. of Taiwan – a supplier of integrated circuits that started in 1983 with eight founders, each of whom had worked for major US corporations. By 1992, turnover was US\$ 100 million. The skills and US connections of the founders played an important role in sourcing and acquiring technology. The firm worked initially as Original Equipment Manufacturer (OEM) with the US firms, but later started producing its own designs. It initiated two subsidiaries in the US and Canada.

Chu (1997) explained the development of the bicycle industry in Taiwan. He argued that large OEM orders from the US were the engines of growth. He mentioned that three factors – accumulated learning, favourable environment, and globalisation of production – have contributed towards the growth of the industry.

### **3.6.4 Technology development policies followed and actions taken by Singaporean companies**

Hobday (1994) described a Singaporean semiconductor firm, Chartered Semiconductor Manufacturing, which was the first Singaporean company to begin wafer fabrication. It



began in 1989 as a joint venture between state-owned Singapore Technology Industrial Corporation (STIC), Sierra Semiconductor and National of the US.

The company entered into problems when National pulled out of the operation in 1989 and Sierra departed in 1991. In the same year, the firm hired a new president, formerly the head of Taiwan Semiconductor Manufacturing Corporation. Under a revised strategy, the firm started producing semiconductors designed by small US chip firms. The company survived only because of the government backing.

Ghosh et. al. (2001) studied the success factors, distinctive capabilities and strategic thrusts of top small and medium enterprises (SMEs) in Singapore. They argue that the specific dynamic strategy components of top SMEs of Singapore are the following:

- Committed, supportive and strong management.
- Strong, visionary and capable leadership.
- Adopting the correct strategic approach.
- Ability to identify and focus on a market.
- Ability to develop and sustain capability.
- Good customer and client relationship.

### **3.6.5 Technology development policies followed and actions taken by Malaysian companies**

Yoshimatsu (2000) provided a detailed account of the automotive sector development in Malaysia. He mentioned that Malaysian car manufacturers, Proton and Perodua, started and developed because of the government help and backing.

Proton was established in May 1983 as a joint venture between the Heavy Industries Corporation of Malaysia (HICOM), Mitsubishi Motors Corporation (MMC) and Mitsubishi Corporation (MC). The Malaysian government emphasised local content requirement to foster the auto parts industry, and later intervened directly to develop

local small and medium enterprises (SMEs) for parts production through technology transfers from foreign companies.

### **3.6.6 Lessons learned from these case studies**

These case studies have been presented to highlight the policies and actions by individual companies for technology development. The most important aspects of these case studies have been acquisition of technology from foreign sources through various modes, acquisition of design capability, government encouragement and support, commitment of factory management and hard work of employees.

These and other case studies will be analysed through content analysis in chapter 11.

## **3.7 Literature published on technology or industrial development in Pakistan**

The major part of the scarce literature that has been published about Pakistan is related to its economy as a whole. The review reveals that little research has been done in the Pakistani industrial sector and research in the technology or technology management fields has been virtually non-existent. Only one research paper was found dealing with the technology aspect and that too was related to mostly informal technology acquisition by small workshops in Pakistan.

### **3.7.1 Facts about the manufacturing sector in Pakistan**

According to United Nations Industrial Development Organisation (UNIDO), in 1999 the basic facts about Pakistan and its manufacturing sector were as follows.

• Population	152.3 Million
• Gross Domestic Product (GDP)	US \$ 61.6 Billion
• Manufacturing Value Added (MVA)	US\$ 9.7 Billion
• MVA per capita	US\$ 64
• Share of MVA in GDP	15.8 %
• Manufactured exports	US\$ 8.375 Billion
• Share of manufacturers in total exports	95.1 %
• Manufactured imports	US\$ 8.757 Billion
• Share of manufacturers in total imports	84.0 %

Table 1.4 had provided an international comparison of manufacturing value-added (MVA) based upon the data provided by UNIDO. The table showed that MVA per capita (MVA per head of population) and growth rates of MVA for Pakistan's manufacturing sector were low even from the developing countries' point of view, and share of MVA in GDP was virtually stagnant.

### 3.7.2 Development of the manufacturing sector in Pakistan

Maddison (1995) wrote about industrial development before independence in the areas that now comprise Pakistan. According to him, industry had not developed in these areas for a multitude of reasons.

Haq (1963) provided a detailed account of national economic planning in Pakistan in the 1950s and the early 1960s. He wrote that the consumer goods industry, including cotton textiles, jute goods, sugar, paper and cigarettes developed during 1955-60 period. The contribution of industry to the national income was 10 percent in 1955 and 13 percent in 1960.

Maddison (1971) provided a brief account of industrial development in Pakistan during the 1950s and the 1960s. He pointed out that development had taken place in those



fields which were technically simple. He reported that government helped the development of industry by restricting imports, supplying cheap machinery and cheap raw materials, provision of cheap capital in the form of low interest loans and tax concessions, and ensuring the provision of cheap labour.

The 1960-70 period witnessed high industrial growth in Pakistan. Ziadi (1999) informed that the average annual growth rate in the manufacturing sector during this period was 12 per cent.

In 1972, all the capital and intermediate goods industries were nationalised, and so were all the vegetable oil, cotton ginning and rice milling industries. Due to this major policy change, private investment in large-scale manufacturing sector virtually stopped, and the growth rate of the capital goods industry became very small. According to Zaidi (1999), the average annual growth rate of the large-scale manufacturing during 1970-77 was 1.7 percent and that of small-scale manufacturing was 7.3 percent.

In 1978, under a new government, most of these industries began to be privatised. According to Zaidi (1999), the total average annual growth rate of industry during 1978-88 was 10.4 per cent, but it was mostly in low value-added and low-technology sectors.

### **3.7.3 Research on industrial and manufacturing sectors of Pakistan**

Few papers concerning the industrial sector in Pakistan have been found. These papers have been written on widely varying topics. Although these researches are not directly relevant, a summary review of these papers is presented here to show the kind of research that has been conducted.

Romijn (1997) made a quantitative case study of the technological capability acquisition process of small-scale light engineering workshops employing from 5 to 50 persons and employing general-purpose manufacturing machinery. He presented the following factors that are important in the acquisition of technological capability:

- General education
- Formal technical education
- Prior working experience
- Internal efforts to assimilate and improve products
- Search for new technological information outside the firm
- External technical assistance
- Age of firm

Dougar (1995) pointed out that Pakistan has been suffering due to an acute power shortage. He concluded that dependence upon fossil fuels should be reduced and instead clean alternate renewable energy resources should be used.

Henneberry et. al. (2000) analysed the relationship between Pakistan's industrial and agricultural sectors and pointed out that Pakistan is heavily dependent upon the agricultural sector.

Looney and Frederiksen (1995) concluded that the shortages in the infrastructure investment had a detrimental effect on the manufacturing output of Pakistan.

Wizarat (1988) studied the differences in industrial productivity of 20 different industries during the period 1970-71 and 1980-81. She found that wage, capital-intensity and size affect productivity differences.

Barki and Terrell (1998) studied the production efficiencies of small firms in Pakistan. They found that the sampled firms could raise their output by 6 to 29 % by improving their overall technical efficiency. They also studied the relationship between inefficiency and the attributes of the firm. Their results indicated that functional literacy of firm owners and their experience positively affect technical and scale efficiencies.

Nadvi (1999) studied the effect of increase in pressure on quality by international importers on the small and medium scale stainless steel surgical instruments cluster in

Sialkot, Pakistan. He found that in response to the quality pressures, an upgrading in the manufacturing had occurred.

### **3.8 Critique**

Research in technology development has been mostly contributed by economists and business researchers, and generally revolves around macro aspects only. Although many success stories have been reported from several countries, these case studies only present some technology development aspects that have been considered dominant. Also these success stories have been reported long after the events, so there is a possibility that the reports have been filtered by time and hindsight. No comprehensive account exists for all the diversified actions that may in practice be required for technology development, gathered at source in companies while the events studied were happening.

Problems faced by companies in technology development have almost been neglected by the researchers, and strategies to solve these problems have been non-existent.

The scarce literature on the industrial sector of Pakistan does not provide research on technology aspects in the manufacturing sector.

### **3.9 Conclusion – Need for this research**

The following points formed the basis to conduct this research:

- Although technology has been shown to be the major contributor to economic wealth, and manufacturing companies have been shown to play the dominant role in East



Asian success, no compiled or consensus model exists that can be followed by manufacturing companies in other developing countries so that they can strive to catch-up.

- The problems faced by the manufacturing companies, and their solutions, have not been adequately considered.
- No literature is available that can provide guidelines for Pakistani manufacturing companies in their quest for catch-up.

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## Chapter 4

# Research Methods

### 4.1 Introduction

This chapter provides an overview of research methods followed during the course of this research, and the problems encountered in carrying out this research in a third world country like Pakistan. The research was carried out in a number of phases, and details of specific issues have been deferred to their respective chapters.

### 4.2 Research project

According to Kervin (1992), there are four stages in a research project:

1. Definition of research problem
2. Research design
3. Data gathering
4. Data analysis and interpretation

The research problem was defined in chapter 1. This chapter will elaborate research design. The last two steps will be described in later chapters.

#### 4.2.1 The phases of the research

Table 4.1 provides the phases in this research with their objectives and the research methods used. The chapters giving further details and the results have been mentioned.

**Table 4.1:** Research phases, their objectives and research methods used

<b>Phase</b>	<b>Phase Description</b>	<b>Research Method Used</b>	<b>Phase Objectives</b>	<b>Chapter</b>
1.	Technology Status Measurement	Structured questionnaire based survey	<ul style="list-style-type: none"> <li>To determine the current status of technology in manufacturing companies as compared to the leading companies of the world</li> <li>To determine if these companies are catching up or not</li> </ul>	5
2.	Barriers to technology development	Semi-structured interviews & Content analysis	<ul style="list-style-type: none"> <li>To identify barriers and problems holding back manufacturing companies</li> </ul>	6 & 7
	Solutions to barriers		<ul style="list-style-type: none"> <li>To identify possible solutions to these problems</li> </ul>	6 & 8
	Actions for technology development		<ul style="list-style-type: none"> <li>To identify actions effective in technology catch-up</li> </ul>	6 & 9
	Stages of technology development		<ul style="list-style-type: none"> <li>To identify the stages that need to be gone through in order to catch up in technology</li> </ul>	6 & 10
	Case studies		<ul style="list-style-type: none"> <li>To understand issues and results</li> </ul>	6
3.	Ranking of factors	Structured questionnaire based survey	<ul style="list-style-type: none"> <li>To quantify the relative seriousness of barriers</li> </ul>	10
	Ranking of actions		<ul style="list-style-type: none"> <li>To quantify the relative benefits of actions</li> </ul>	
4.	Action plans (based upon research in Pakistan)	Assembly of information from phase 3.	<ul style="list-style-type: none"> <li>To summarise information for factory managers and government policy makers</li> </ul>	
5.	Exploration of issues in literature	Content analysis	<ul style="list-style-type: none"> <li>To identify barriers, actions, and stages for catch-up in the literature on East Asia</li> </ul>	11
6.	Action plans (based upon literature on East Asia)	Assembly of information from phase 5.	<ul style="list-style-type: none"> <li>To summarise information for factory managers and government policy makers</li> </ul>	

The first three phases were on-the-ground research conducted in manufacturing companies in Pakistan.

#### **4.2.2 Research boundaries**

Kervin (1992) elaborates that an important step in defining the research problem is the specification of research boundaries. In case of this research, two factors were important in defining research boundaries:

- Type of industries
- Size of industries

##### **Type of industries**

It was decided that research would be conducted only in those sub-sectors of the manufacturing sector that have been main contributors to the development of East Asian fast-developing countries.

Data on manufacturing value-added (MVA) of different sub-sectors of manufacturing for Pakistan and four selected East Asian countries for the years 1985 and 1999 was extracted from Country Industrial Statistics of the United Nations Industrial Development Organisation (UNIDO). This data, attached as Appendix 4A to this chapter, revealed that the following four sub-sectors of the manufacturing sector generally had high shares of MVA in the total MVA of these countries, and their share of MVA was generally increasing. This showed that these sectors had been the main contributors to the development of East Asian fast-developing countries.

- 383 Machinery, electric
- 382 Machinery, except electrical



- 384 Transport equipment
- 381 Fabricated metal products

The numbers show International Standard Industrial Classification (ISIC) codes of these sub-sectors. Appendix 4B provides a list of further sub-sectors that are included in these sub-sectors, and Appendix 4C gives list of all sub-sectors of manufacturing according to the ISIC classification.

Table 4.2 shows the contribution of these selected sub-sectors in MVA in Pakistan and selected East Asian countries. It is clear that the contribution of these important sub-sectors has been quite low in the Pakistani manufacturing sector, when compared with rapidly developing East Asian countries.

**Table 4.2:** Contribution of leading sub-sectors to manufacturing value-added (MVA)  
Source: UNIDO, Country Industrial Statistics

Sector	Contribution of leading sub-sectors in manufacturing (%)				
	South Korea (1999)	Singapore (1999)	Malaysia (1999)	Taiwan (1996)	Pakistan (1996)
Fabricated metals (381)	4.1	5.8	3.2	7.3	0.7
Machinery, except electric (382)	9.1	31.5	5	4.6	1.6
Machinery, electric (383)	15.3	21	32.9	21.2	7.7
Transport equipment (384)	20.5	7.3	5.2	7.5	3.5
<b>Total</b>	<b>49</b>	<b>65.6</b>	<b>46.3</b>	<b>40.6</b>	<b>13.5</b>

### Size of industries

The central idea of the research was to determine how technology could be improved in the Pakistani manufacturing sector so that it could catch up and compete at the world level. Based on the thought that in Pakistan only sufficiently large companies could think of competing at the world level, it was decided that only those manufacturing companies would be approached that have more than one hundred employees. This

thought was based upon the fact that there are no venture capital or high-technology industries in Pakistan, which may be aspiring to compete at the world level even when they are small.

### **4.3 Research design**

Kervin (1992) defines the main elements of research design as the decision on type of research design, selection of data sources, selection of data gathering methodology, and sampling design.

Robson (2002) divides research design into five components. Two of these: purpose of the research and theory guiding the research, provide input to the preparation of research questions, which is the third component of research design. The outputs of the design process are two components of research design: methods or techniques for carrying out research and sampling strategy. These two components are similar to the research design stage proposed by Kervin (1992).

The following three sections briefly describe various standard research strategies, research purposes and sampling methods. These are followed by the purposes, strategies, and sampling methods used in this research.

#### **4.3.1 Research strategies**

Robson (2002) points out that multiple methods are generally used in real world research problems rather than single methods. He divides research strategies into fixed, flexible or combination of fixed and flexible. He mentions traditional fixed designs as experimental, in which the researcher deliberately changes the situation of participants with a view to producing change in their behaviour, or non-experimental, in which the

researcher only observes. The traditional flexible designs are the case study, which involves development of in-depth knowledge about certain 'cases', ethnographic study, which involves studying the way various groups or communities live, or grounded theory study, which intends to generate a theory.

### **4.3.2 Research purposes**

Kervin (1992) explains the following five purposes of research:

1. Description: To get information about characteristics of a current situation.
2. Prediction: To know what the situation will be like in the future.
3. Evaluation: To assess the effect of a certain action, programme or policy.
4. Explanation: To find the causes of any problem.
5. Exploration: The investigation step in any research. It seeks important dimensions of the problem and generates possible explanations.

Kervin (1992) points out that exploratory research is much less structured than other research purposes. It relies on subjective methods like interviews and may involve case studies. Robson (2002) points out that exploratory research generates ideas for future research.

### **4.3.3 Research methods**

Kervin (1992) describes interviews as a very common method in exploratory researches. He and Robson (2002) describe the following three types of interviews:

- Structured: Interviews having predetermined questions with fixed wording in a pre-set order.



- Semi-structured: Interviews having predetermined questions, but the order can be modified, wording can be changed and explanations given. Additional questions can be added or pre-set questions can be omitted with particular interviewees.
- Unstructured: Interviews in which researcher has a predetermined area of interest but the interview can be completely informal.

#### **4.3.4 Sampling methods**

Kervin (1992) describes that the sampling frame is the list of all cases in the target population. He provides the following types of samples:

##### **1. Probability samples:**

- Simple random samples: Based upon random selection in the population.
- Systematic samples: Select every  $i^{\text{th}}$  case.
- Stratified samples: Divide population into groups or strata, and draw random samples from each.
- Cluster or multistage samples: Divide the population into clusters, which are naturally occurring sets of cases that are physically close together.

##### **2. Non-probability samples:**

- Convenience samples: Whatever cases are conveniently available close by.
- Self-selection samples: When the researcher allows the respondents to choose whether to take part in research.
- Snowball samples: The research begins with finding a few respondents in the target population, and the researcher asks them to suggest other cases that have similar characteristics.
- Judgement samples: The researcher selects cases relying on his own opinion.
- Expert samples: One or more experts help in selecting cases from the population.
- Quota samples: Researcher establishes quotas for the number of cases having certain characteristics.

Robson (2002) describes the following additional non-probability sampling scheme:

- Dimensional samples: Various dimensions of the population thought to be of importance are incorporated in the sampling process.

#### **4.3.5 Research design for phase 1 – Technology Status Measurement**

##### **Research purpose**

The purpose of this phase of the research was clearly descriptive as the research was intended to get information about the current situation of technology in Pakistani manufacturing companies with reference to the technology level existing in the world.

##### **Research method**

The method used in this phase was a structured and quantified questionnaire-based survey. A pilot survey was conducted to fine tune the questionnaire, to develop on-the-ground understanding of the issues and to develop survey skills, which was followed by a quantified survey through a questionnaire administered in the designated sub-sectors of the manufacturing sector.

##### **Target population and sampling**

The technology status measurement and the exploration of issues (phases 1 and 2) were conducted concurrently. The target population for this research was high value-added manufacturing companies in the designated sub-sectors, that had more than one hundred employees.



In case of this research, the respondents had a choice whether to participate in the research or not, so it was a case of self-selection sampling. On various occasions the snowball sampling method was also resorted to; the respondents were asked to suggest other possible respondents having the required characteristics.

In order to reduce sampling error, the survey was conducted in three different areas of Pakistan. Two of these, Karachi and Lahore, are the largest industrial cities, while the area in and around Islamabad has many large industries. Figure 4.2 shows a map of Pakistan on which these areas have been marked.

**Figure 4.2:** Map of Pakistan showing Karachi, Lahore and Islamabad areas, where the research was conducted





#### **4.3.6 Research design for phase 2 – Exploration of issues**

##### **Research purpose**

The purpose of this phase of the research was exploratory, as the objectives were to:

1. explore barriers and problems that are holding back Pakistani manufacturing companies
2. seek possible solutions for these problems
3. explore actions required for development of technology in these companies
4. explore stages required for catch-up in technology with the leading companies of the world.

##### **Research Method**

The method used in this phase was the semi-structured interview-based survey. A pilot survey was conducted to fine tune the interviewer's checklist and to develop interview skills. This was followed by a series of interviews conducted in the designated sub-sectors.

As Kervin (1992) pointed out that exploratory research could rely upon both interviews and case studies, interviews in three companies were extended to generate case studies of these companies. The purpose of these case studies was to understand the problems faced by and actions taken for technology development by these companies in more detail, to provide a broader background understanding of the issues.

## **Analysis of interviews**

The Content Analysis technique was used to extract various factors from these interviews. The details of this technique are described in chapter 6.

### **4.3.7 Research design for phase 3 – Ranking the factors**

#### **Research purpose**

Large numbers of barriers, solutions and actions were identified in phase 2. In phase three, the significant of barriers and actions were compiled into a questionnaire, and managers were asked to identify which were the most important ones.

#### **Research method**

The method used in this phase was a structured and quantified questionnaire-based survey. A pilot survey was conducted to fine tune the questionnaire, and then it was administered in a larger sample of companies.

## **4.4 Research management**

This section briefly describes various steps in carrying out this research project and highlights the problems encountered in data gathering in Pakistan.

### **4.4.1 Initial interviews**

The Initial plan for on-ground research in Pakistan had been prepared during the stay at Cranfield in the first year of this research. This plan was based upon the literature

review and previous experience of the researcher about the conditions in Pakistan. It was thought wise to also seek the opinion of some knowledgeable and informed people in Pakistan about this initial research plan.

Meetings were held with the following high-placed government officials. These people generally appreciated the research plan and supported its methodology.

1. Chief Executive Officer, National Productivity Organization, Ministry of Industries and Production, Government of Pakistan.
2. Chairman, Pakistan Science Foundation, Ministry of Science and Technology, Government of Pakistan.
3. Financial Analyst, Experts Advisory Cell, Ministry of Industries and Production, Government of Pakistan.

In addition to these, contacts were made with the following government departments for help in getting information about the target population.

- Experts Advisory Cell, Ministry of Industries and Production.
- Engineering Development Board, Ministry of Industries and Production.
- Federal Bureau of Statistics.
- Ministry of Science and Technology.

#### **4.4.2 Problems in selection of industries**

The logical step before the start of the research was to prepare a list of candidate companies that fulfilled the stipulated criteria. It became apparent that it was very difficult to prepare such lists, as recent directories of industries providing the size and other details were not available in Pakistan.



The Census of Manufacturing Industries (CMI), prepared by Federal Bureau of Statistics (FBS), Government of Pakistan, could contain such data. The latest available CMI results were from 1996, and did not provide information about the number of employees in various industries.

The only source for number of employees in various industries was the 1994 Directory of Vendor Industries and Consultants, prepared by the Ministry of Labour and Manpower. In the year 2000, this directory was published again with the name Directory of Engineering Industries, but the new edition did not contain information about number of employees.

It was finally decided that the information on number of employees would be obtained from 1994 Directory of Vendor Industries and Consultants, but the contact addresses would be obtained from Directory of Engineering Industries, published in the year 2000, and Jamal's Yellow Pages of Pakistan. This approach was more or less successful. Lists of prospective industries that met the criteria were thus prepared. The only problem was that the number of employees in various companies had changed since 1994, but fortunately it had reduced to below one hundred only in a very few cases. It was later found out that the number of employees in these few cases was not very far off from one hundred, so the criterion of one hundred or more employees was relaxed in these cases.

In order to send letters to chief executive officers (CEOs) of companies, the companies were contacted by telephone. It was found during these contacts that in many cases the telephone numbers had been changed. Obtaining new telephone numbers proved to be difficult. In those cases where the numbers were correct, the situation was not easy either, as the people in the company were reluctant even to provide the names of their CEOs.

### **4.4.3 Carrying out the research**

For carrying out phases 1 and 2 of the research, letters were sent to all those industries for which the name of the CEO or any other senior management officer had been obtained. Phone calls were later made to all those people and requests were made for appointments. It was found during later phone contacts that it was difficult to obtain appointments from direct cold contacts.

Therefore the strategy of cold contacts was supplemented by obtaining appointments through personal contacts and also requesting the interviewees to refer to any other industry that met the criteria, which was the snowball sampling concept.

More details of the questionnaires and interview methods in various phases of the research are given in Chapter 5, 6, and 10.

## References

Kervin, John B. (1992) *Methods of business research*, Harper Collins Publishers, Inc.

Robson, Colin (2002) *Real world research (Second edition)*, Blackwell Publishers Ltd., Oxford, UK.



## APPENDIX 4A

### APPENDIX 4A Comparison of Manufacturing Value Added (MVA) in various sub-sectors of manufacturing

**Table A4.1:** MVA of sub-sectors of manufacturing for Pakistan and four selected East Asian countries. **Source:** UNIDO, Country Industrial Statistics.

Sub-sector	ISIC	Share in total value-added of manufacturing (%)									
		Pakistan		Malaysia		South Korea		Taiwan		Singapore	
		1985	1996	1985	1999 *	1985	1999 *	1985	1999 *	1985	1999 *
Food products	311	17.9	15.2	14.4	6.9	6.7	5.4	7.3	4.9	3.7	2.7
Beverages	313	2.3	1.6	2.5	0.8	2.5	1.4	3.1	2.5	1.6	0.8
Tobacco	314	11.5	6.2	4.2	1.0	4.7	1.6	2.2	1.4	0.7	0.00
Textiles	321	17.4	23.5	2.7	2.9	10.7	4.7	8.6	5.9	0.6	0.2
Wearing apparel, except footwear	322	0.6	1.4	2.1	1.7	4.2	2.1	6.3	2.3	3.2	0.6
Leather products	323	1.1	0.8	0.1	0.1	0.9	0.4	1.0	0.4	0.1	0.1
Footwear, except rubber or plastic	324	0.1	0.5	0.1	0.1	0.7	0.4	1.0	0.3	0.1	0.03
Wood products, except furniture	331	0.3	0.2	5.4	4.1	0.9	0.6	1.7	0.6	0.9	0.2
Furniture, except metal	332	0.2	0.04	0.8	1.1	0.7	1.0	1.0	0.8	1.3	0.6
Paper and products	341	1.0	1.6	1.1	1.4	2.2	2.2	2.8	2.0	1.7	1.2
Printing and publishing	342	1.1	2.0	4.0	2.7	2.4	1.9	1.1	1.2	4.7	4.2
Industrial chemicals	351	8.7	8.5	12.6	6.5	4.1	6.0	6.9	8.0	2.8	1.7
Other chemicals	352	7.1	7.7	3.1	1.9	4.6	4.3	1.6	2.0	5.5	8.8
Petroleum refineries	353	1.4	3.1	2.8	2.6	3.5	3.7	5.7	6.4	8.2	5.3
Misc. petroleum and coal products	354	0.5		0.4	0.3	0.9		0.1	0.6		
Rubber products	355	1.3	0.9	5.1	5.4	3.0	1.0	1.4	1.1	0.4	0.3
Plastic products	356	0.6	0.4	1.9	4.4	2.3	2.4	6.6	5.3	2.1	2.4
Pottery, china, earthenware	361	0.2	0.2	0.3	0.2	0.3	0.2	0.6	0.6	0.1	0.5
Glass and products	362	0.5	0.3	0.5	1.0	1.0	0.8	0.7	0.7		
Other non-metallic mineral prod.	369	6.1	7.2	6.1	3.6	3.5	2.7	2.5	2.5	2.9	1.5
Iron and steel	371	10.6	4.2	3.1	2.3	6.6	5.1	5.0	5.9	1.0	0.4
Non-ferrous metals	372	0.02	0.02	0.7	1.0	1.1	1.1	0.9	1.3	0.4	0.1
Fabricated metal product	381	1.0	0.7	3.0	3.2	4.0	4.1	4.4	7.3	6.1	5.8
Machinery, except electrical	382	2.5	1.6	2.0	5.0	4.7	9.1	3.0	4.6	7.6	31.5
Machinery electric	383	3.0	7.7	15.1	32.9	11.8	15.3	12.2	21.2	31.6	21.0
Transport equipment	384	2.6	3.5	4.3	5.2	9.1	20.5	5.5	7.5	9.7	7.3
Professional & scientific equipment	385	0.2	0.2	0.6	1.0	0.9	1.1	1.3	0.8	1.8	2.4
Other manufactured products	390	0.3	0.8	0.8	0.7	1.9	1.0	5.6	1.9	1.2	0.5

\* United Nations Industrial Development Organisation (UNIDO) estimates.

## APPENDIX 4B

### APPENDIX 4B Further sub-sectors included in the selected sub-sectors of the manufacturing sector according to ISIC classification

➤ 382 Machinery, except electrical

- 3821 Manufacture of engines and turbines
- 3822 Manufacture of agricultural machinery and equipment
- 3823 Manufacture of metal and woodworking machinery
- 3824 Manufacture of special industrial machinery and equipment
- 3825 Manufacture of office, computing and accounting machinery
- 3829 Machinery and equipment except electrical not elsewhere classified

➤ 383 Machinery, electric

- 3831 Manufacture of electrical industrial machinery and apparatus
- 3832 Manufacture of radio, television and communication equipment
- 3833 Manufacture of electrical appliances and house wares
- 3839 Manufacture of electrical apparatus and supplies not elsewhere classified

➤ 384 Transport equipment

- 3841 Shipbuilding and repairing
- 3842 Manufacture of railroad equipment
- 3843 Manufacture of motor vehicles
- 3844 Manufacture of motorcycles and bicycles
- 3845 Manufacture of aircraft
- 3849 Manufacture of transport equipment not elsewhere classified

➤ 381 Fabricated metal products

- 3811 Manufacture of cutlery, hand tools and general hardware
- 3812 Manufacture of furniture and fixtures primarily of metal
- 3813 Manufacture of structural metal products
- 3819 Manufacture of fabricated metal products not - elsewhere classified

## APPENDIX 4C

### APPENDIX 4C ISIC codes of manufacturing activities (300: Total manufacturing)

- 311 Food products
- 313 Beverages
- 314 Tobacco
- 321 Textiles
- 322 Wearing apparel, except footwear
- 323 Leather products
- 324 Footwear, except rubber or plastic
- 331 Wood products, except furniture
- 332 Furniture, except metal
- 341 Paper and products
- 342 Printing and publishing
- 351 Industrial chemicals
- 352 Other chemicals
- 353 Petroleum refineries
- 354 Miscellaneous petroleum and coal products
- 355 Rubber products
- 356 Plastic products
- 361 Pottery, china, earthenware
- 362 Glass and products
- 369 Other non-metallic mineral products
- 371 Iron and steel
- 372 Non-ferrous metals
- 381 Fabricated metal products
- 382 Machinery, except electrical
- 383 Machinery, electric
- 384 Transport equipment
- 385 Professional and scientific equipment
- 390 Other manufactured products



## Chapter 5

# Technology Status Measurement

### 5.1 Introduction

The first phase of this research was the measurement of the present status of technology in the manufacturing companies of Pakistan in comparison with that of the leading companies of the world.

A new questionnaire based approach was developed, which measured technology status based upon the experiences and responses of senior managers in the manufacturing companies. The responses from a sample of individual companies were then aggregated to determine the general technology level in the country.

The method is much simpler and direct than the methods of technology measurement and comparison previously proposed. In contrast to those methods, this approach also determines whether the companies are catching up or falling behind.

### 5.2 Approaches for technology status measurement in the literature

Measurement of technology level in the manufacturing companies of developing countries and then aggregating these results to assess a general measure of the status of technology in the country has not received much attention in the literature. Some work however has been done on technology assessment in companies.

Technology assessment has been seen as an audit of technologies being utilised in a company and comparison with the industry best practice in order to know the strengths and weaknesses of the company or to decide about introduction of new technologies in the company (Lowe, 1995).

At the country level, various indicators have been proposed to assess the technology level of the country. These have been stock of science & technology personnel, R&D expenditure, number of people having advanced level education, number of publications, and number of patents (The Technology Atlas Team, 1987a, Amsden & Mourshed, 1997 and Technology Atlas Project, 1989).

Alternative approaches to these measures came out of The Technology Atlas Project, which was funded by the United Nations – Economic and Social Commission for Asia and the Pacific. It was carried out in the mid-1980s by The Technology Atlas Team (1987a), which argued that these indicators lack important information including national capabilities regarding reverse engineering, adaptation and improvement of imported technologies, level and quality of scientific and technical information, technology gaps and levels of specific sectors/fields, technology level of national production systems, national capabilities regarding engineering services and quality assurance, national technology climate etc.

Sharif (1994) and The Technology Atlas Team (1987b) described ‘technology’ to consist of four components, as follows:

- Technoware (T): Tools, equipment, machinery, vehicles, structures, etc.
- Humanware (H): Skills, craftsmanship, expertise, intelligence, creativity etc.
- Infoware (I): Design parameters, specifications, reference manuals, theories etc.
- Orgaware (O): Methods, techniques, organisational networks, management practices etc.

They proposed that national technological capabilities could be evaluated from assessment of technology content added and strengths and weaknesses of the four



components of technology at any given 'technology transformation facility' (e.g. a factory). Qualitative analysis of information obtained from these two factors could then provide an idea about the overall situation in the country.

They proposed that the level of sophistication of the four components of 'technology' should be calculated. For this purpose the four components are divided into the following levels of sophistication, in ascending order:

- Technoware (T): Manual tools, powered equipment, general purpose machines, special purpose machines, automatic machines, computerized machines, and integrated facilities.
- Infoware (I): Familiarizing facts, describing facts, specifying facts, utilising facts, comprehending facts, generalising facts, and assessing facts.
- Humanware (H): operating ability, setting ability, repairing ability, reproducing ability, adapting ability, improving ability, and innovating ability.
- Orgaware (O): individual linkages, collective linkages, departmental linkages, enterprise linkages, industrial linkages, national linkages, and global linkages.

It is clear from these lists that the proposed method is difficult, if not impossible, to use in the practical industrial world. An industry may be using all sorts of tools and machines at one time. Similarly, all sorts of linkages may be active at any one time. In the case of infoware, the division of design specifications, drawings etc into various types of 'facts' is also not practical. The language and parameters are not useful for industrial managers. For example, a specification sheet can represent very old technology but yet it can provide comprehending facts.

The method also includes weighing the phases of the life chain of various components of 'technology'. In this case, the following factors were assigned specific weights:

- Technoware (T): Researching, developing, testing, demonstrating, producing defusing, and substituting.



- Humanware (H): Rearing, telling, teaching, training, educating, developing, and upgrading.
- Infoware (I): Collecting, screening, classifying, associating, analysing, synthesising, and emulating.
- Orgaware (O): Conceiving, preparing, designing, installing, operating, guiding, and evolving.

Again it is not clear how this method would be applied in the practical world as the phrases may not represent the actual life chains of various components of technology.

It is clear from the review of literature that no accepted method exists to assess the general technology level in manufacturing companies.

### **5.3 Method of measuring technology status**

The status of technology in companies was measured using a structured questionnaire.

#### **5.3.1 Facets of technology**

Eight facets of technology in manufacturing companies were compiled by the researcher after examining the various definitions of technology in the literature. The facets were:

- Product
- Product development process
- Input materials
- Production equipment
- Production processes
- Production management
- Data management and storage

- Expertise in the company.

### **5.3.2 Development of the questionnaire**

A draft questionnaire was prepared. Three of these were filled in by people from large manufacturing companies whom the researcher previously knew. People were selected who would give frank and vivid opinions on the questionnaire.

It was revealed that that the draft questionnaire was too lengthy and some of its questions were not clearly understandable by the respondents. It was thus revised to drastically reduce its length and replace ambiguous questions. The revised questionnaire was tested in a second pilot survey by the same persons. This time they liked the questionnaire and did not feel any difficulty in filling it. The results of the pilot phase were analysed and were found satisfactory. The final questionnaire is reproduced in Appendix 5A to this chapter.

### **5.3.3 The main survey**

The main survey was then carried out, in conjunction with the exploratory interviews which are the subject of chapter 6. Interviewees were asked to fill in a status questionnaire before the start of their exploratory interview. The respondents found the questionnaire purposeful and easy to fill in. In fact, a few respondents requested a copy of the questionnaire to keep.

Twenty two questionnaires were filled in. There were 42 interviews, but sometimes several were from the same company, only one questionnaire was asked for from each company.

## **5.4 Structure of the questionnaire for measurement of status of technology**

There were seven sections. The first three sections asked general questions about the respondent and his company.

**Section A** included the date, time, and place of filling in the questionnaire and the sub-sector and area in which the company being surveyed was operating.

**Section B** was optional. It asked company name, address, telephone numbers, web URL and e-mail address.

**Section C** enquired respondent's name (optional), job title, academic qualification and total work experience.

**Section D** tried to ascertain the size of the company in terms of annual sales and number of employees, and enquired about the ownership type of the company and the share of exports in total sales.

**Section E** asked background questions about products, input materials, production equipment, production processes and production management. The first of these questions asked for the major product lines. The next two questions asked the number of different product types and number of models in each product type. The following two questions asked the number of completely new products and upgrades in products in the last five years. These questions were intended to ascertain the level of innovation in products in relation to the number of product types and models asked earlier.

The next question was regarding the sources of product design. Its purpose was to know the product design capability in the company, which would give an idea about the level of technology in the company. The subsequent question enquired about the source



of input materials in the company. This gave some idea about the supply of input materials within the country.

The next three questions measured the level of innovation in production equipment, production processes and production management practices, by requesting the number of changes within the last five years.

**Section F** enquired about the level of computer usage in the storage of data in design, production, quality, inventory, personnel, accounts and administration areas. The usage of computers was considered as a necessary condition for technology development and this question was thus seen as one key to assessing whether the company had a basic ingredient for technology development or not.

**Section G** formed the core of the questionnaire. It was divided into six sub-sections which enquired the following aspects for each of the facets of technology:

Section G1: Importance of the eight facets of technology to the company.

Section G2: Whether the company did technology assessment exercises or not.

Section G3: Presence or absence of knowledge of best technology in the world.

Section G4: Rating of present level of technology as compared to the world.

Section G5: Whether steps had been taken to improve technology or not.

Section G6: Whether the technology gap with the world had increased or decreased.

Sections G2 and G3 were intended to check attitudes towards various facets of technology. A company not carrying out technology assessment or not knowing about the best technology available in the world was considered unlikely to reach the level of leading companies of the world in its area of work.

## **5.5 Results from the survey**

### **5.5.1 The respondents**

All the respondents were chief executive officers, managing directors, or senior managers in their companies. Except one, all of them had a minimum of graduate level education. Most of them either had a degree in engineering or in business administration. The average total work experience was 23.2 years.

The companies of the respondents were located in three geographical areas. Six of these were in or around Islamabad; nine were in or around Lahore, while seven were in or around Karachi.

Fourteen of the twenty two companies were privately owned, four were state owned limited companies, two were multinationals, one was a cooperative society, and one did not provide this information.

### **5.5.2 A note on data presented in the tables that follow**

In the tables of results that follow, three aspects have been tabulated for each category: number of companies, percentage of companies, and estimated standard error of the percentage.

The number of companies represents the number opting for that category; the percentage has been calculated to have general idea about the distribution of companies among various categories; and the estimated standard error of the percentage provides an idea about the spread of the data.

These estimated standard errors have been calculated based upon the formulas for categorical data given in Sanders and Smidt (2000, p. 268), and Levine, Berenson and Stephan (1999, p. 400).

### 5.5.3 Annual sales (Question: D2)

Except for one company, all the companies had more than 10 million rupees of annual sales. Table 5.1 provides data about annual sales of the companies.

**Table 5.1:** Annual sales of the companies in the survey. (100Rs = £1)

Category	Number of companies	Percentage of companies (%)	Estimated standard error of the percentage (%)
Less than Rs. 10 Million	1	5 %	4 %
Rs. 10 Million – Rs. 100 Million	8	36 %	10 %
Rs. 100 Million – Rs. 1000 Million	8	36 %	10 %
More than Rs. 1000 Million	5	23 %	9 %
<b>Total</b>	<b>22</b>	<b>100 %</b>	

### 5.5.4 Exports as a percentage of total sales (Question: D3)

Table 5.2 shows that the vast majority (77%) of the responding companies had exports below 25 % of total sales.



**Table 5.2:** Exports as percentage of total sales

<b>Exports as percentage of total sales</b>	<b>Number of companies</b>	<b>Percentage of companies (%)</b>	<b>Estimated standard error of the percentage (%)</b>
Nil	8	36 %	10 %
Less than 25 %	9	41 %	10 %
25 % – 50 %	3	14 %	7 %
More than 50 %	2	9 %	6 %
<b>Total</b>	<b>22</b>	<b>100 %</b>	

#### 5.5.5 Total number of employees (Question: D4)

Table 5.3 shows the total number of employees in the companies. Although four companies had fewer than 100 employees and so did not strictly belong to the target population, the number of employees in all these cases was very near to 100, and the condition of 100 was somewhat relaxed in these cases.

**Table 5.3:** Total number of employees

<b>Category</b>	<b>Number of companies</b>	<b>Percentage of companies (%)</b>	<b>Estimated standard error of the percentage (%)</b>
Less than 100	4	18 %	8 %
100 – 500	10	46 %	11 %
More than 500	8	36 %	10 %
<b>Total</b>	<b>22</b>	<b>100 %</b>	

#### 5.5.6 Number of major upgrades in products in last five years (Question: E4)

It can be seen from table 5.4 that almost two thirds of the companies who provided this data had 4 or fewer upgrades in products in the last five years. This shows the low level of innovation in products in manufacturing companies of Pakistan.

Unfortunately many companies did not give accurate data in Question E2 and E3 about their total number of products, so the rate of upgrade per product could not be calculated. For those companies that did provide their total number of products it was found that on the average they had upgraded 8 % of products in the last five years. This was very low rate of innovation in products.

This question was somewhat weak as the meaning of the word ‘major’ was not very clear. The questions used for comparison were also weak, as they asked ‘roughly’ how many product types and models in each type were present. In some cases, the respondents were not sure of the exact numbers. Thus the average innovation level calculated in this and the next sub-section only provides a rough idea about the situation.

**Table 5.4:** Number of major upgrades in products in last five years

<b>Category</b>	<b>Number of companies</b>	<b>Percentage of companies (%)</b>	<b>Estimated standard error of the percentage (%)</b>
None	3	15 %	8 %
1 – 4	10	50 %	11 %
5 – 8	1	5 %	5 %
9 – 12	3	15 %	8 %
13 or more	3	15 %	8 %
<b>Total</b>	<b>20</b>	<b>100 %</b>	

#### **5.5.7 Number of completely new products in the last five years (Question: E5)**

It can be seen from table 5.5 that more than half of the companies who provided this data had 4 or fewer completely new products in last five years. This again shows the low level of innovation in products.

For the companies that provided clear data about their total number of products for comparison, on the average 8 % new products had been introduced in last five years. This again represented a very low level of introduction of new products.

One possible explanation of this finding was that these companies were making matured products and did not need to innovate in products that often. A counter argument could be that in face of reduction in tariffs, these companies should have innovated at a much higher rate.

**Table 5.5:** Number of completely new products in last five years

Category	Number of companies	Percentage of companies (%)	Estimated standard error of the percentage (%)
None	3	14 %	8 %
1 – 4	9	43 %	11 %
5 – 8	3	14 %	8 %
9 – 12	1	5 %	5 %
13 or more	5	24 %	10 %
<b>Total</b>	<b>21</b>	<b>100 %</b>	

### 5.5.8 Source of product designs (Question: E6)

The capability to design products is an important level of the technology development ladder as identified in the East Asian Technology Development Model to be explained in chapter 11.

Table 5.6 shows that a lot of companies were producing in-house designs, and some were producing designs through reverse-engineering. About 38 % of the companies are using in-house designs or designs from local sources. This shows that a sizable number of companies had acquired local design capability. This means that these companies have achieved an important requirement for catch-up, as determined by the stages of catch-up (given in chapters 10 and 11).



Similarly a sizable number of companies have foreign procured or foreign licensed designs. This is a healthy sign as acquiring technology from foreign sources has been one of the most cited actions in case studies from literature on East Asia.

**Table 5.6: Sources of product design**

Category	Number of companies	Percentage of companies (%)
In-house only	4	18 %
In-house and reverse engineered	1	5 %
In-house, reverse engineered and locally acquired	1	5 %
In-house and foreign licensed	1	5 %
In-house, foreign procured and foreign licensed	2	9 %
In-house, reverse engineered and foreign licensed	1	5 %
Reverse-engineered only	1	5 %
Locally acquired only	1	5 %
Foreign procured only	1	5 %
Foreign licensed only	2	9 %
Multiple sources	4	18 %
Other foreign acquisition mode	2	9 %
Any other mode of acquisition	1	5 %
<b>Total</b>	<b>22</b>	

### 5.5.9 Source of input materials (Question: E7)

Input materials availability is another important aspect of the general technological advancement in any country. Table 5.7 shows that the vast majority of companies are using input materials from both national and international sources in spite of the problems during import (mentioned in barriers to technology development, chapter 7), which confirms the problems in availability of material in Pakistan.

**Table 5.7:** Source of input materials

Category	Number of companies	Percentage of companies (%)	Estimated standard error of the percentage (%)
National sources only	0	0 %	0 %
International sources only	3	14 %	7 %
Both national and international sources	19	86 %	7 %
<b>Total</b>	<b>22</b>	<b>100 %</b>	

#### 5.5.10 Number of major production equipment acquired in last five years (Question: E8)

It can be seen from table 5.8 that more than half of the companies who provided this data acquired 5 or more major production equipment in last five years. This shows the trend to acquire new or better production equipment in manufacturing companies of Pakistan.

This and the next question, about major process changes, have the weakness that these have not been correlated to a total number of production equipment pieces or total number of production processes, so the level of innovation in these areas cannot be ascertained.

**Table 5.8:** Number of major production equipment acquired in last five years

Category	Number of companies	Percentage of companies (%)	Estimated standard error of the percentage (%)
None	1	5 %	5 %
1 – 2	3	14 %	8 %
3 – 4	6	29 %	10 %
5 – 6	2	10 %	6 %
7 or more	9	43 %	11 %
<b>Total</b>	<b>21</b>	<b>100 %</b>	

### 5.5.11 Number of major production process changes made in last five years (Question: E9)

It can be seen from table 5.9 that more than two thirds of the companies who provided this data made 4 or fewer production process changes in last five years. This shows that relatively less emphasis is placed on production processes than on production equipment in manufacturing companies of Pakistan.

**Table 5.9:** Number of major production process changes made in last five years

Category	Number of companies	Percentage of companies (%)	Estimated standard error of the percentage (%)
None	3	16 %	8 %
1 – 2	3	16 %	8 %
3 – 4	7	37 %	11 %
5 – 6	0	0 %	0 %
7 or more	6	32 %	11 %
<b>Total</b>	<b>19</b>	<b>100 %</b>	

### 5.5.12 Number of new or improved production management practices adopted in last five years (Question: E10)

It can be seen from table 5.10 that 70 percent of the companies who provided this data adopted 4 or fewer new or improved production management practices in the last five years. This shows that relatively less emphasis was placed on production management practices than on acquiring production equipment.



**Table 5.10:** Number of new or improved production management practices adopted in last five years

Category	Number of companies	Percentage of companies (%)	Estimated standard error of the percentage (%)
None	1	5 %	5 %
1 – 2	4	20 %	9 %
3 – 4	9	45 %	11 %
5 – 6	0	0 %	0 %
7 or more	6	30 %	10 %
<b>Total</b>	<b>20</b>	<b>100 %</b>	

**5.5.13 Computer usage (Question: F1-F7)**

Table 5.11 shows that cumulatively around 11 % of the companies do not use computers at all, 71 % use them, and 18 % use them partially. The data of percentages is also shown in figure 5.1.

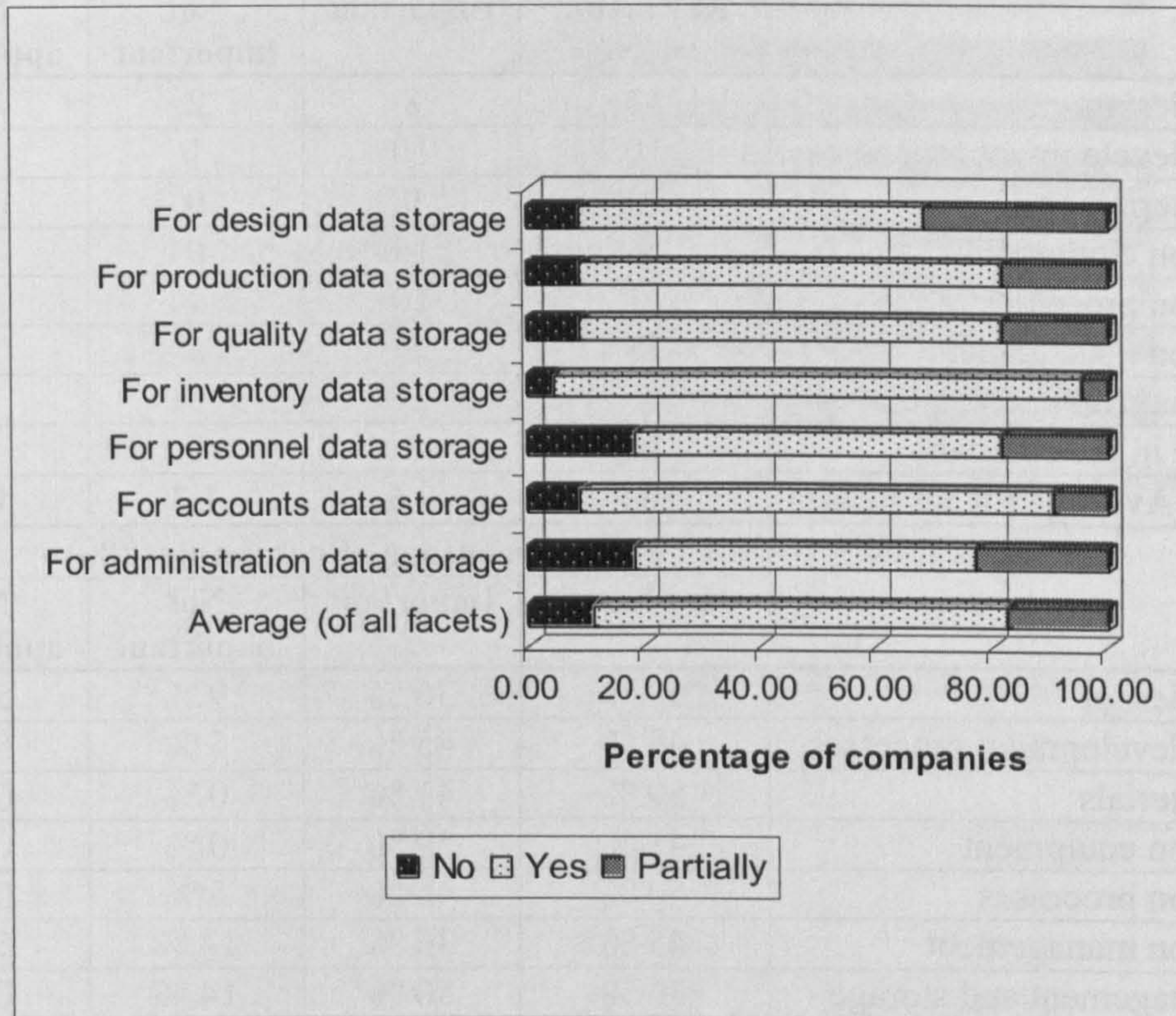
**Table 5.11:** Usage of computers in various departments

	Number of companies			Percentage of companies (%)			Estimated standard error of the percentage (%)		
	No	Yes	Partially	No	Yes	Partially	No	Yes	Partially
For design data storage	2	13	7	9 %	59 %	32 %	6 %	10 %	10 %
For production data storage	2	16	4	9 %	73 %	18 %	6 %	10 %	8 %
For quality data storage	2	16	4	9 %	73 %	18 %	6 %	10 %	8 %
For inventory data storage	1	20	1	5 %	91 %	5 %	4 %	6 %	4 %
For personnel data storage	4	14	4	18 %	64 %	18 %	8 %	10 %	8 %
For accounts data storage	2	18	2	9 %	82 %	9 %	6 %	8 %	6 %
For administration data storage	4	13	5	18 %	59 %	23 %	8 %	10 %	9 %
<b>Average (of all facets)</b>	<b>2.4</b>	<b>15.7</b>	<b>3.9</b>	<b>11 %</b>	<b>71 %</b>	<b>18 %</b>	<b>3 %</b>	<b>4 %</b>	<b>3 %</b>



Thus the vast majority of the companies are using computers in their operations and hence they do have one of the basic ingredients for catching-up.

**Figure 5.1:** Computer usage in manufacturing companies



#### 5.5.14 Importance of technology (Question: G1)

This question was asked to find the relative importance of the various facets of technology. Table 5.12 provides summary of responses and figure 5.2 gives pictorial view of the percentages of companies giving different options.

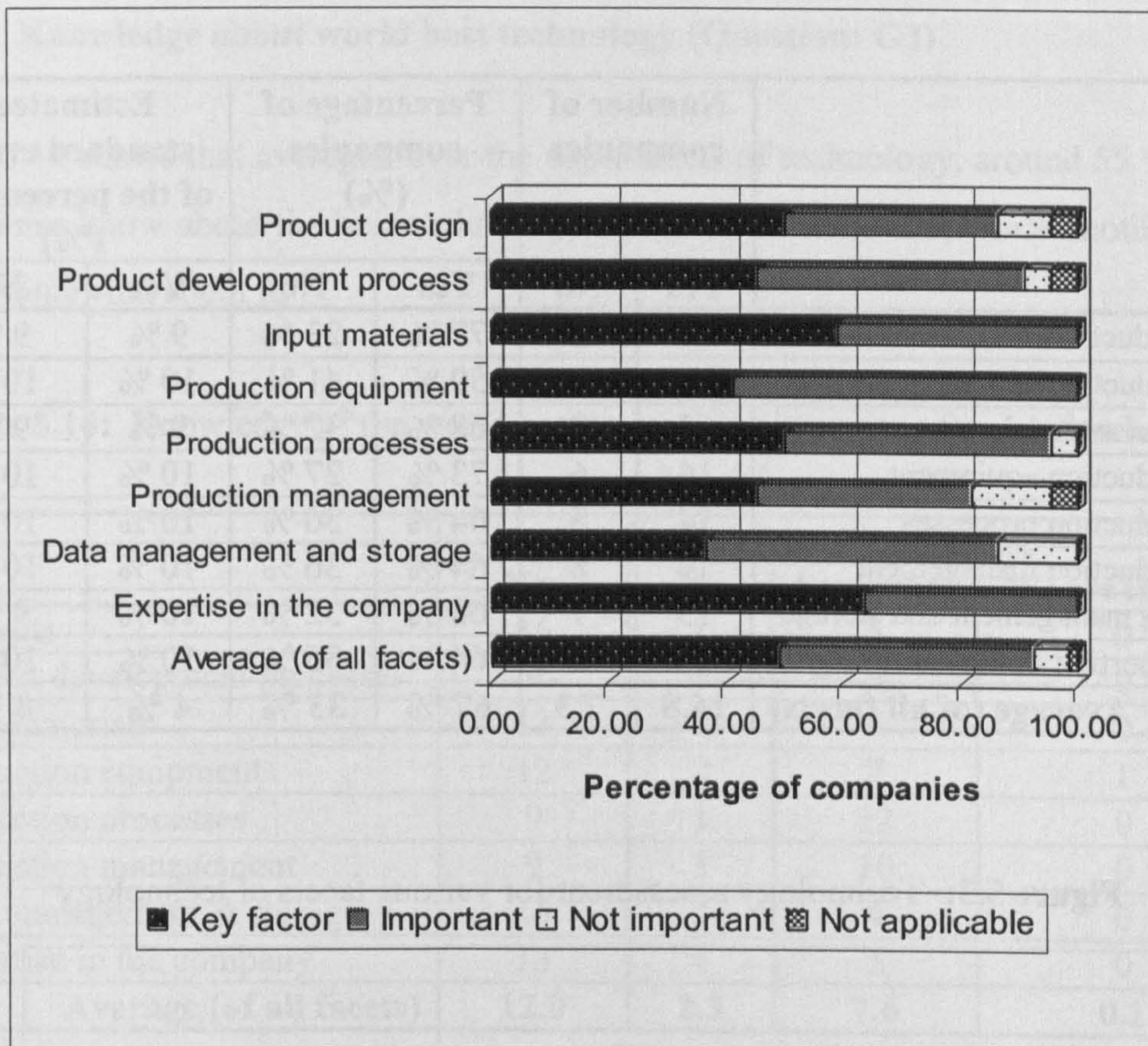
The results are generally as expected. The interesting aspect is that a sizable percentage of companies (14 %) consider that production management and data management are not important. Some of the companies also consider product design as unimportant or not applicable.



**Table 5.12:** Importance of the eight facets of technology

	Number of companies			
	Key factor	Important	Not important	Not applicable
Product design	11	8	2	1
Product development processes	10	10	1	1
Input materials	13	9	0	0
Production equipment	9	13	0	0
Production processes	11	10	1	0
Production management	10	8	3	1
Data management and storage	8	11	3	0
Expertise in the company	14	8	0	0
<b>Average (of all facets)</b>	<b>10.8</b>	<b>9.6</b>	<b>1.3</b>	<b>0.4</b>
	Percentage of companies (%)			
	Key factor	Important	Not important	Not applicable
Product design	50 %	36 %	9 %	5 %
Product development processes	45 %	45 %	5 %	5 %
Input materials	59 %	41 %	0 %	0 %
Production equipment	41 %	59 %	0 %	0 %
Production processes	50 %	45 %	5 %	0 %
Production management	45 %	36 %	14 %	5 %
Data management and storage	36 %	50 %	14 %	0 %
Expertise in the company	64 %	36 %	0 %	0 %
<b>Average (of all facets)</b>	<b>49 %</b>	<b>44 %</b>	<b>6 %</b>	<b>2 %</b>
	Estimated standard error of the percentage (%)			
	Key factor	Important	Not important	Not applicable
Product design	11 %	10 %	6 %	4 %
Product development processes	11 %	11 %	4 %	4 %
Input materials	10 %	10 %	0 %	0 %
Production equipment	10 %	10 %	0 %	0 %
Production processes	11 %	11 %	40 %	0 %
Production management	11 %	10 %	70 %	40 %
Data management and storage	10 %	11 %	70 %	0 %
Expertise in the company	10 %	10 %	0 %	0 %
<b>Average (of all facets)</b>	<b>4 %</b>	<b>4 %</b>	<b>2 %</b>	<b>1 %</b>



**Figure 5.2:** Importance of various facets of technology

### 5.5.15 Technology assessment (Question: G2)

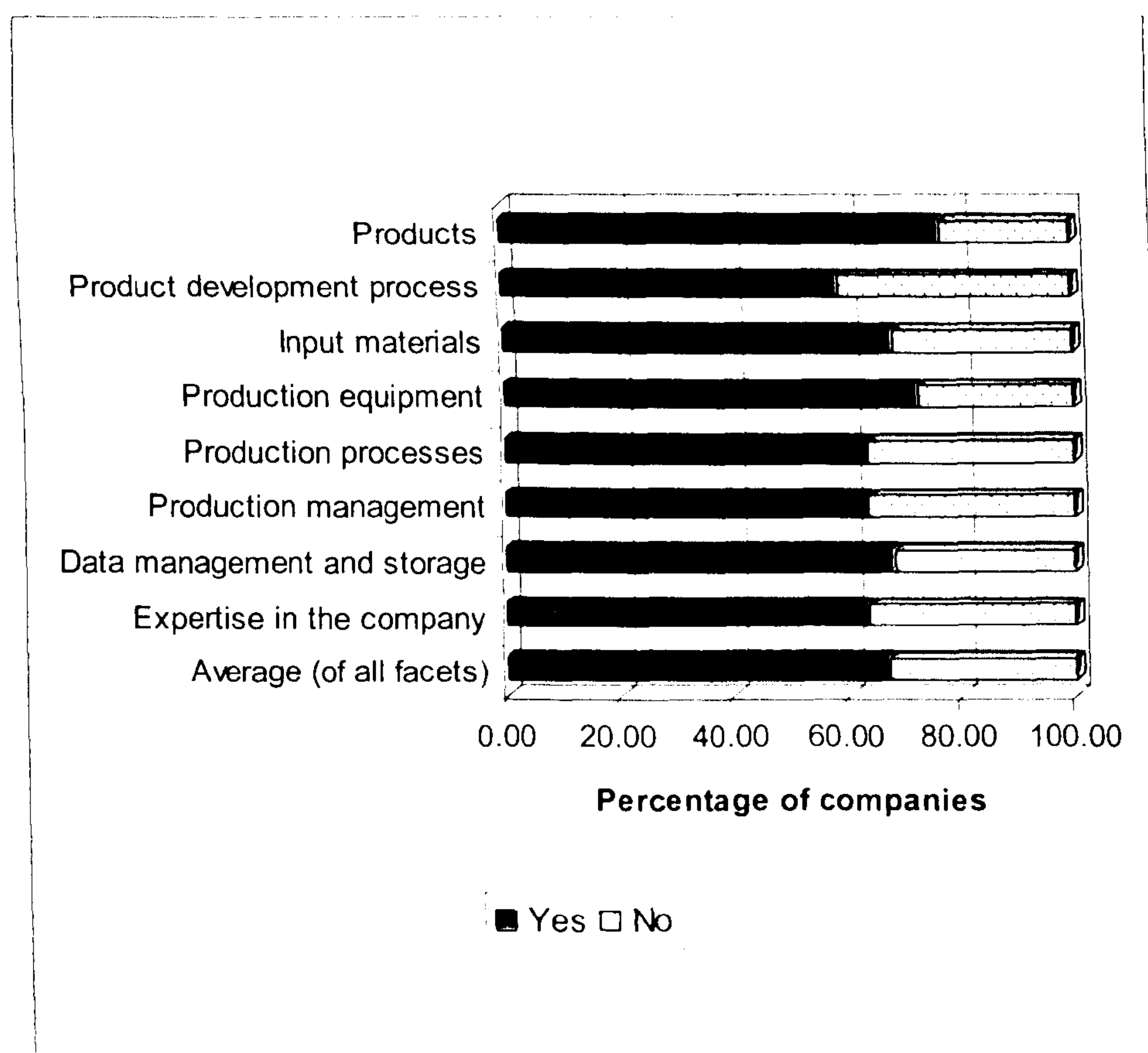
Table 5.13 and figure 5.3 show that cumulatively around two-thirds of the companies carry out technology assessment exercises. Expectedly, the biggest percentage of companies performs technology assessment exercises for products, followed by production equipment. Technology assessment exercises are least done for product development processes.

There was a weakness in the question that it did not ask about whether these technology assessments were carried out formally or just informally.



**Table 5.13:** Technology assessment for various facets of technology

	Number of companies		Percentage of companies (%)		Estimated standard error of the percentage (%)	
	Yes	No	Yes	No	Yes	No
For Products	17	5	77 %	23 %	9 %	9 %
For product development process	13	9	59 %	41 %	10 %	10 %
For input materials	15	7	68 %	32 %	9 %	9 %
For production equipment	16	6	73 %	27 %	10 %	10 %
For production processes	14	8	64 %	36 %	10 %	10 %
For production management	14	8	64 %	36 %	10 %	10 %
For data management and storage	15	7	68 %	32 %	10 %	9 %
For expertise in the company	14	8	64 %	36 %	10 %	10 %
<b>Average (of all facets)</b>	<b>14.8</b>	<b>7.3</b>	<b>67 %</b>	<b>33 %</b>	<b>4 %</b>	<b>4 %</b>

**Figure 5.3:** Technology assessment for various facets of technology

### 5.5.16 Knowledge about world best technology (Question: G3)

Table 5.14 shows that averaged over the eight facets of technology, around 55 % of the companies know about the best technology available in the world, while another 35 % know somewhat about it.

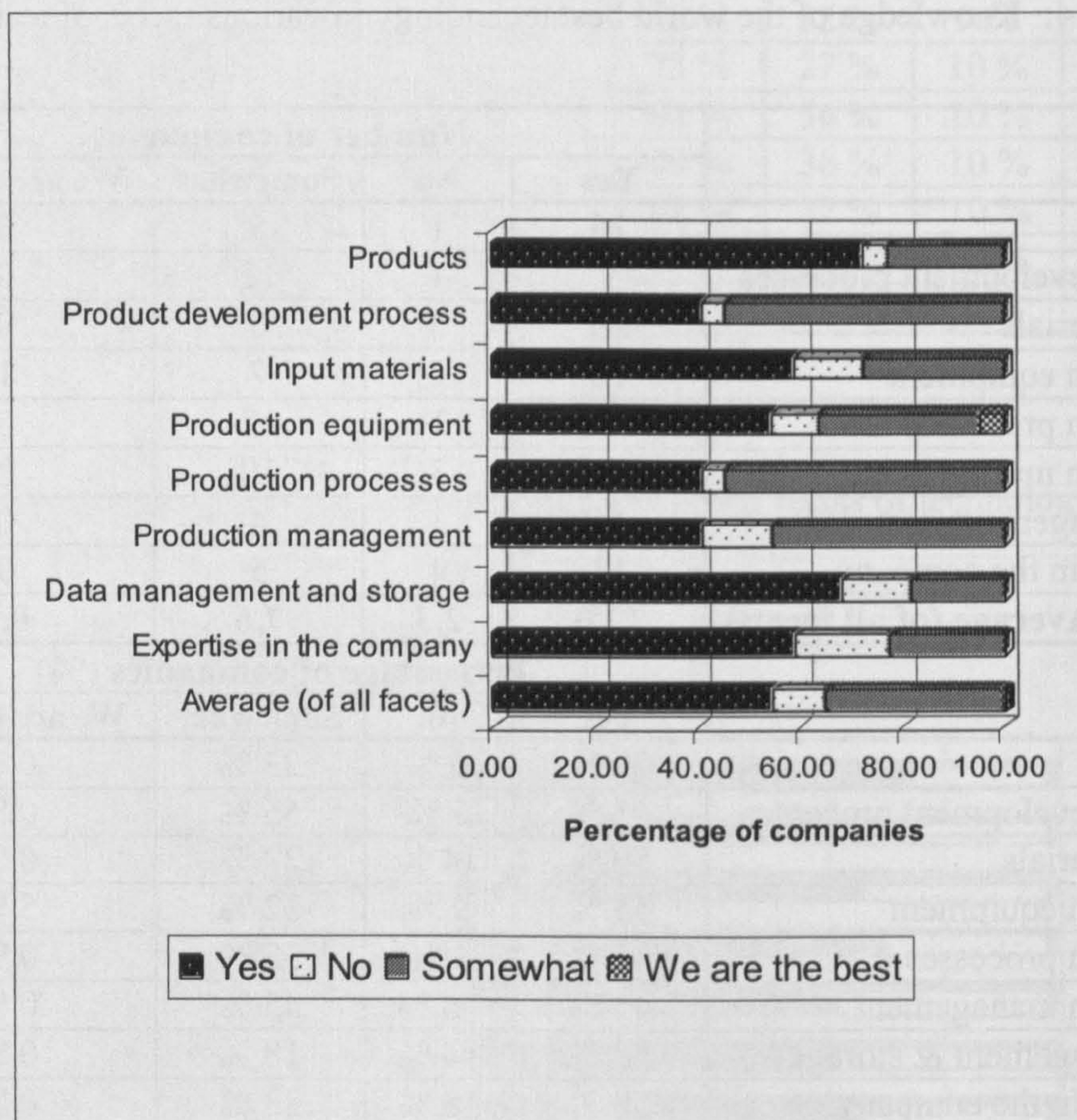
**Table 5.14:** Knowledge of the world best technology in various facets of technology

	Number of companies			
	Yes	No	Somewhat	We are the best
Products	16	1	5	0
Product development processes	9	1	12	0
Input materials	13	3	6	0
Production equipment	12	2	7	1
Production processes	9	1	12	0
Production management	9	3	10	0
Data management & storage	15	3	4	0
Expertise in the company	13	4	5	0
<b>Average (of all facets)</b>	<b>12.0</b>	<b>2.3</b>	<b>7.6</b>	<b>0.1</b>
	Percentage of companies (%)			
	Yes	No	Somewhat	We are the best
Products	73 %	5 %	23 %	0 %
Product development processes	41 %	5 %	55 %	0 %
Input materials	59 %	14 %	27 %	0 %
Production equipment	55 %	9 %	32 %	5 %
Production processes	41 %	5 %	55 %	0 %
Production management	41 %	14 %	45 %	0 %
Data management & storage	68 %	14 %	18 %	0 %
Expertise in the company	59 %	18 %	23 %	0 %
<b>Average (of all facets)</b>	<b>55 %</b>	<b>10 %</b>	<b>35 %</b>	<b>1 %</b>
	Estimated standard error of the percentage (%)			
	Yes	No	Somewhat	We are the best
Products	10 %	4 %	9 %	0 %
Product development processes	10 %	4 %	11 %	0 %
Input materials	10 %	7 %	10 %	0 %
Production equipment	11 %	6 %	10 %	4 %
Production processes	10 %	4 %	11 %	0 %
Production management	10 %	7 %	11 %	0 %
Data management & storage	10 %	7 %	8 %	0 %
Expertise in the company	10 %	8 %	9 %	0 %
<b>Average (of all facets)</b>	<b>4 %</b>	<b>2 %</b>	<b>4 %</b>	<b>1 %</b>



Understandably, products are the facet for which the knowledge is best. Products are easily available for examination, in contrast with production processes for example. Figure 5.4 gives pictorial view of the percentages of companies giving various options.

**Figure 5.4:** Knowledge of the world best technology in various facets of technology



#### 5.5.17 Rating of technology (Question: G4)

Respondents were asked to rate various facets of technology in the companies in comparison with the world best technology, which was given a score of 100. This was the crux of the technology status measurement exercise.



Figure 5.5 gives the mean score of the ratings of all the facets of technology. It can be seen from figure 5.5 and table 5.15 that the technology level in the sample of manufacturing companies is around 60 % of that of the world best technology.

It can also be seen that products, input materials and expertise in the company get higher ratings than other facets, while product development processes get the least ratings.

**Figure 5.5:** Rating of various facets of technology

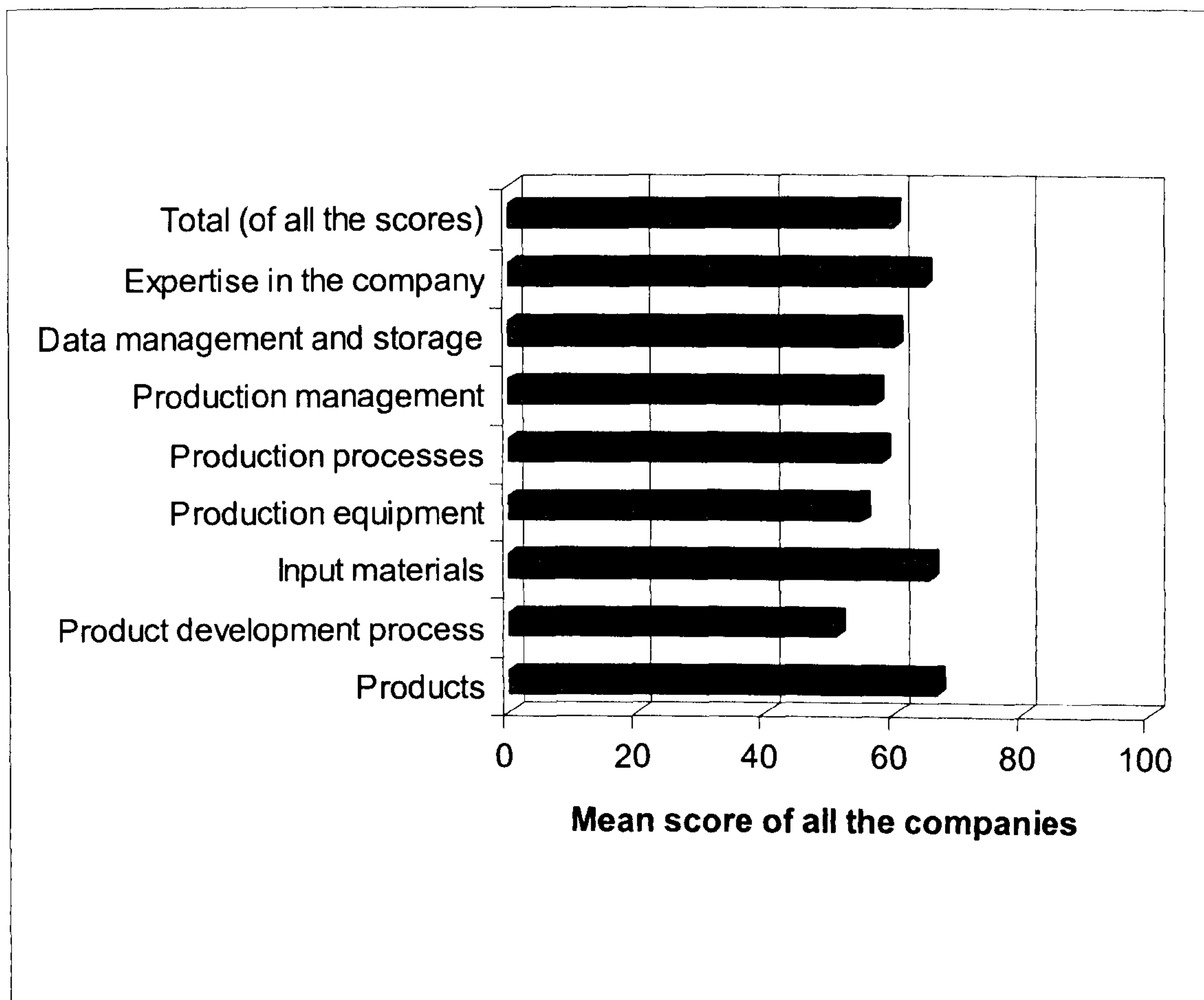


Table 5.15 provides the mean and standard deviation of the sample, as well as the estimated standard deviation of the mean of the whole population and the upper and lower bounds of the confidence interval for the population mean. Details of the statistical formulas have been provided in the Appendix 5B.



### A comment on the responses to the rating of technology

It was observed that some respondents who stated that they did not know what the best level of technology in the world was, still felt able to rate their technology in comparison with the best in the world, which shows a contradiction. It could be argued that these respondents had some perception of the best technology and could provide a vague answer, as in most of such cases; the rating given was very low.

**Table 5.15:** Rating of various facets of technology in comparison with the world best.

Technology facet	Sample mean ( $\bar{X}$ )	Sample standard deviation ( $\sigma$ )	Estimated standard deviation of population mean	95 % confidence interval of population mean ( $\mu$ )	
				Lower bound	Upper bound
Products	67	21	4	57	76
Product development processes	51	20	4	42	60
Input materials	66	20	4	57	74
Production equipment	55	24	5	45	65
Production processes	58	24	5	47	69
Production management	57	18	4	49	65
Data management and storage	60	28	6	47	73
Expertise in the company	65	16	3	58	72
<b>Combination (of all facets)</b>	<b>60</b>	<b>22</b>	<b>2</b>	<b>56</b>	<b>63</b>

### 5.5.18 Improvement in technology in the last five years (Question: G5)

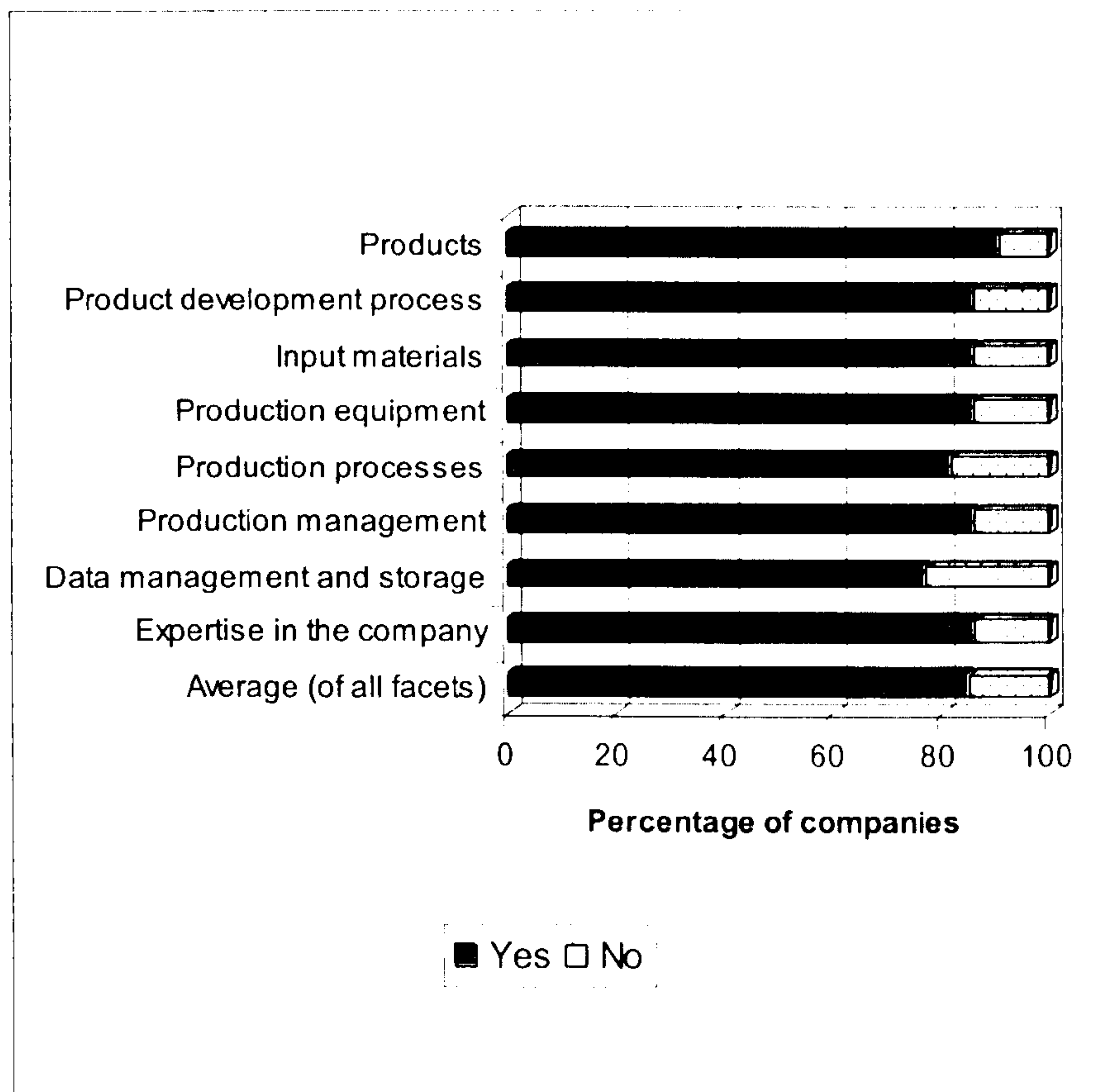
Table 5.16 shows whether concrete steps have been taken for improvement of the facets of technology or not. Figure 5.6 gives pictorial view of the percentages of companies selecting different options.

Cumulatively around 85 percent of the companies have taken concrete steps for technology improvement. Expectedly, the biggest percentage of companies has tried to improve its products, while the least have tried to improve its data management and storage.

**Table 5.16:** Concrete steps taken for improvement of technology or not

	Number of companies		Percentage of companies (%)		Estimated standard error of the percentage (%)	
	Yes	No	Yes	No	Yes	No
For Products	20	2	91 %	9 %	6 %	6 %
For product development process	19	3	86 %	14 %	7 %	7 %
For input materials	19	3	86 %	14 %	7 %	7 %
For production equipment	19	3	86 %	14 %	7 %	7 %
For production processes	18	4	82 %	18 %	8 %	8 %
For production management	19	3	86 %	14 %	7 %	7 %
For data management and storage	17	5	77 %	23 %	9 %	9 %
For expertise in the company	19	3	86 %	14 %	7 %	7 %
<b>Average (of all facets)</b>	<b>18.8</b>	<b>3.3</b>	<b>85 %</b>	<b>15 %</b>	<b>3 %</b>	<b>3 %</b>



**Figure 5.6:** Concrete steps taken for improvement of technology or not

### 5.5.19 Gap with the best in the world (Question: G6)

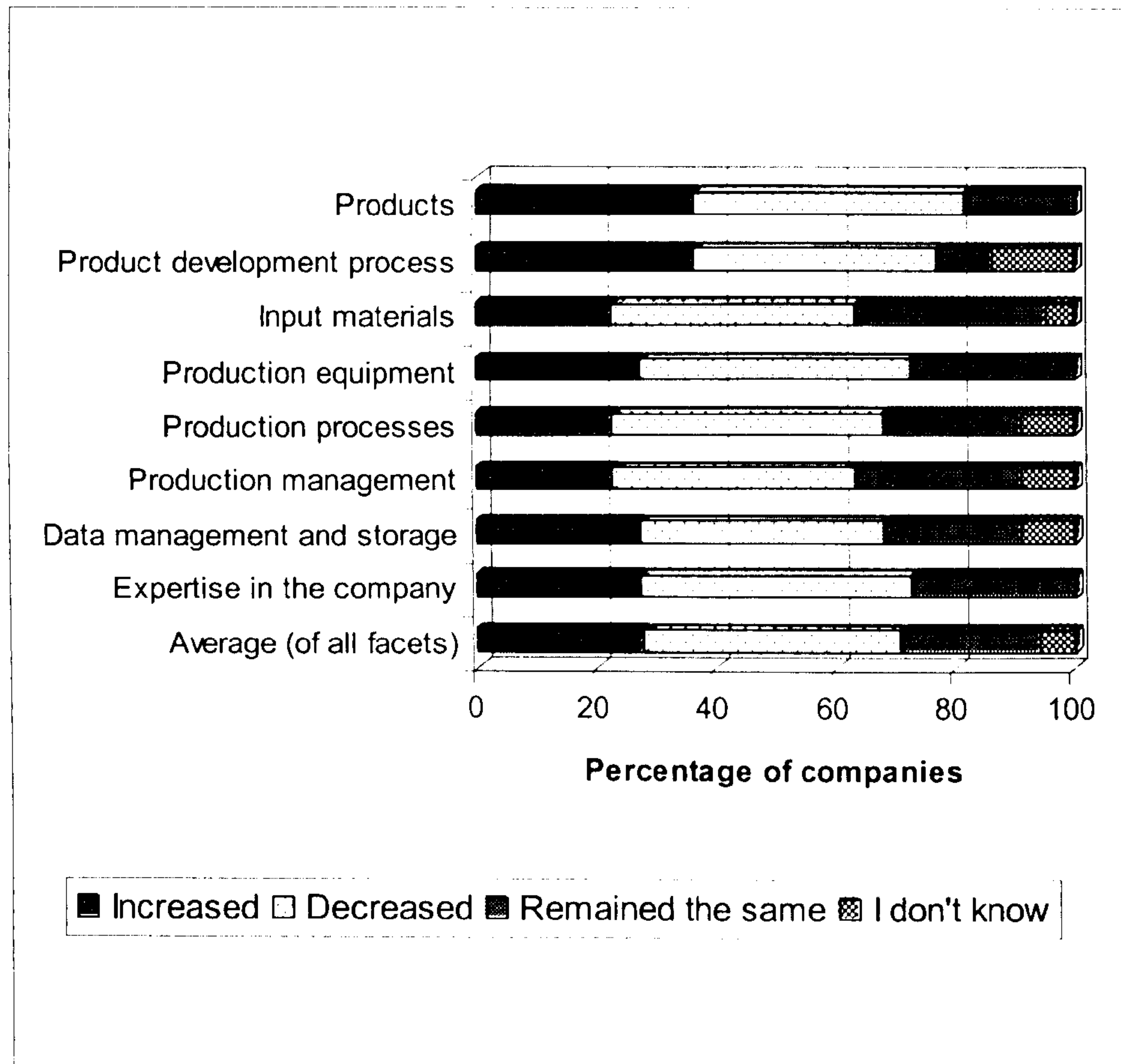
Table 5.17 Shows whether the gap with the best technology available in the world was thought to have increased, decreased or remained the same for the eight facets of technology. Figure 5.7 gives pictorial view of the percentages of companies giving various options.

Cumulatively, around 28 % of the companies believe that the gap with the best technology available in the world has increased, 43 % believe that it has decreased, while 23 % think that it has remained the same. Unexpectedly, many more people think that gap with the world has increased in products and product development processes than other facets of technology.

**Table 5.17:** Gap with world best technology in various facets of technology

	<b>Number of companies</b>			
	<b>Increased</b>	<b>Decreased</b>	<b>Remained the same</b>	<b>Don't know</b>
Products	8	10	4	0
Product development processes	8	9	2	3
Input materials	5	9	7	1
Production equipment	6	10	6	0
Production processes	5	10	5	2
Production management	5	9	6	2
Data management and storage	6	9	5	2
Expertise in the company	6	10	6	0
<b>Average (of all facets)</b>	<b>6.1</b>	<b>9.5</b>	<b>5.1</b>	<b>1.3</b>
	<b>Percentage of companies (%)</b>			
	<b>Increased</b>	<b>Decreased</b>	<b>Remained the same</b>	<b>Don't know</b>
Products	36 %	45 %	18 %	0 %
Product development processes	36 %	41 %	9 %	14 %
Input materials	23 %	41 %	32 %	5 %
Production equipment	28 %	45 %	27 %	0 %
Production processes	23 %	45 %	23 %	9 %
Production management	22 %	41 %	27 %	9 %
Data management and storage	27 %	41 %	23 %	9 %
Expertise in the company	27 %	45 %	27 %	0 %
<b>Average (of all facets)</b>	<b>28 %</b>	<b>43 %</b>	<b>23 %</b>	<b>6 %</b>
	<b>Estimated standard error of the percentage (%)</b>			
	<b>Increased</b>	<b>Decreased</b>	<b>Remained the same</b>	<b>Don't know</b>
Products	10 %	11 %	8 %	0 %
Product development processes	10 %	10 %	6 %	7 %
Input materials	9 %	10 %	10 %	4 %
Production equipment	10 %	11 %	10 %	0 %
Production processes	9 %	11 %	9 %	6 %
Production management	9 %	10 %	10 %	6 %
Data management and storage	10 %	10 %	9 %	6 %
Expertise in the company	10 %	11 %	10 %	0 %
<b>Average (of all facets)</b>	<b>3 %</b>	<b>4 %</b>	<b>3 %</b>	<b>2 %</b>



**Figure 5.7:** Gap with world best technology in various facets of technology

## 5.6 Cross-tabulation of some factors against questions about facets of technology

Five different factors were cross-tabulated against the questions in section G of the questionnaire. These factors were:

- Annual sales
- Exports
- Number of employees
- Number of major production equipment obtained in last 5 years

- Number of major production process changes in last 5 years

These factors were cross-tabulated against the following questions:

- Importance of various facets of technology
- Existence of technology assessment exercise for various facets of technology
- Knowledge about world best technology for various facets of technology
- Rating of various facets of technology
- Steps taken for improvement of various facets of technology in last 5 years
- Gap with the world best technology in various facets of technology

### 5.6.1 Results of cross-tabulation

Cross-tabulation generated large amount of data, which was analyzed for relationships.

The important results of cross-tabulation were the following:

- Companies that performed technology assessment exercise generally had higher annual sales.
- Companies that took concrete steps for improvement of technology in the last five years had higher annual sales.
- Gap with the world leading manufacturers generally decreased for companies that have higher annual sales.
- The gap with the world leading manufacturers decreased for those companies that had made more production process changes in the last five years.
- Companies that did technology assessment carried out more number of process changes in last five years.
- Generally larger companies carried out technology assessment exercise.
- Larger companies generally had better knowledge about world best technology.



### **5.6.2 Discussion on results from cross-tabulation**

The results of cross-tabulation were more or less as expected. The importance of technology improvement and technology assessment were reflected. One important aspect was that the importance of production process changes emerged, which is not very prominent in results of interviews from Pakistan but had been considered important in the case studies from East Asia. That is why it was specifically mentioned in the model of stages for catch-up from experience of East Asian companies (chapter 11).

The result that larger companies had better knowledge of world technology supported the decision of considering companies with 100 or more employees in the research boundaries.

## **5.7 Discussion and inferences from the technology status measurement exercise**

### **5.7.1 Summary of the findings**

The following were the important results from this technology assessment exercise:

- The general technology level in the manufacturing companies of Pakistan was around 60 % of the world best technology. It was estimated that 95 % confidence interval for the population mean ranged from 56 % to 63 %.
- Many more people (43 %) thought that the gap of Pakistani manufacturing companies was decreasing as compared to the leading technology in the world, than those people (28 %) who thought that this gap was increasing, while a sizable number of people thought that this gap remained the same during the last five years (23 %).
- The innovation level in products was very low.

- A sizeable number of companies had acquired some capability in product design, which will be seen to be an important component in catch-up.
- The majority of the companies had made few changes in management practices in last five years. This reflects either absence of professional management or lack of urge for innovation in management practices.
- The overwhelming majority of companies were using computers in most of their operations. This reflects that these companies have an important ingredient in technology infrastructure.
- About two-third of the companies carry out technology assessment exercises.
- The majority of the companies had knowledge about best technology available in the world, while some had partial knowledge of it.

### **5.7.2 Critique of the survey method**

The method of technology status measurement as proposed by this research proved practical and useful to get an idea about the technology level in manufacturing companies of the developing countries. The respondents were comfortable in filling the questionnaire.

The idea of dividing technology into the eight facets proved to be practical as most of the companies marked these facets as a 'key factor' or 'important'. There was however relatively little variation in the results for the eight facets in each section. It will be seen in chapter 6 that a broader classification scheme has value.

A number of the questions were revealed as having weaknesses when the analysis was done, and could be modified in the future, but fortunately the most important questions gave clear results.

This method is simple and applicable to companies in the developing countries which may not have patents or publications to their credit, as these are results of R&D and the companies may not have reached that level. Similarly, stock of science & technology



personnel, R&D expenditure, and number of people having advanced level education are all indirect methods that do not provide direct picture of level of technology in manufacturing companies.

### **5.7.3 Status of Pakistan's manufacturing companies in the model of stages for catch-up**

Comparing the results of this technology status measurement exercise with the stages required for catch-up (chapter 10 and 11) revealed that the majority of the sampled companies are at stage 2 or 3 in the 4-stage catch-up model. They have entered into local manufacturing and some have the capability to design their own products.

This observation supports the result of 60 % of technology level as compared to leading companies of the world measured in this exercise.

## **5.8 What next?**

Having measured the status of technology in manufacturing companies, the next chapters would ascertain the reasons for being at this level (barriers in technology development) and steps required for catch-up (actions required for technology development).

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**APPENDIX 5A****APPENDIX 5A Questionnaire used in Technology Status Measurement phase**

**Research project:** Technology options for the manufacturing sector of Pakistan in the catch-up process  
**Researcher:** Numan Iqbal, TROSS scholar  
**Research supervision:** R&D Management Centre, Cranfield University, UK

**Survey Questionnaire - Technology Status**

This questionnaire is designed to measure your view of the status of technology in your company and to determine whether or not your company is catching up with world standards in technology.

***This portion to be filled in by the interviewer***

A1: Interview / survey number: \_\_\_\_\_  
A2: Place: \_\_\_\_\_ A3: Date: \_\_\_\_\_  
A4: Time: \_\_\_\_\_ A5: Duration: \_\_\_\_\_  
A6: Sub-sector of manufacturing (e.g. textile, machinery etc) \_\_\_\_\_  
A7: Area within sub-sector (e.g. spinning, agro machinery etc) \_\_\_\_\_

**Company information – optional questions**

B1. Company name \_\_\_\_\_  
B2. Company address \_\_\_\_\_  
B3. Tel. No. \_\_\_\_\_ Fax No. \_\_\_\_\_  
B4. Company Web URL \_\_\_\_\_  
B5. E-mail address \_\_\_\_\_

**About you**

C1: Your name (**optional**) \_\_\_\_\_  
C2: Job title (production manager, general manager etc) \_\_\_\_\_  
C3: Academic Qualification (BSc, MBA etc) \_\_\_\_\_  
C4: Total work experience (years) \_\_\_\_\_

**About your company**

D1: Company ownership (e.g. public, private, multinational) \_\_\_\_\_  
D2: Annual sales:  
<sub>1</sub> Less than Rs. 10 Million  
<sub>2</sub> Rs. 10 Million – Rs. 100 Million  
<sub>3</sub> Rs. 100 Million – Rs. 1000 Million

<sub>4</sub> More than Rs. 1000 Million

D3: Exports as a percentage of total sales

<sub>1</sub> Nil      <sub>2</sub> Less than 25 %      <sub>3</sub> 25 % – 50 %      <sub>4</sub> More than 50 %

D4: Total number of employees (at this plant)

<sub>1</sub> Less than 100      <sub>2</sub> 100 – 500      <sub>3</sub> More than 500

### **Products and changes**

E1. Your three major product lines

\_\_\_\_\_

E2. Roughly how many different product types do you produce? \_\_\_\_\_

E3. Roughly how many models are there in each type? \_\_\_\_\_

E4. Number of **major upgrades** in products in **last five years**

None <sub>0</sub>      1 – 4 <sub>1</sub>      5 – 8 <sub>5</sub>      9 – 12 <sub>9</sub>      13 or more <sub>13</sub>

E5. Number of **completely new** products in **last five years**

None <sub>0</sub>      1 – 4 <sub>1</sub>      5 – 8 <sub>5</sub>      9 – 12 <sub>9</sub>      13 or more <sub>13</sub>

### **Product design**

E6. Please indicate the **source of product designs** (please tick *all* that applies):

- <sub>1</sub> Produced in-house  
<sub>2</sub> Reverse-engineered  
<sub>3</sub> Locally acquired  
<sub>4</sub> Acquired from foreign sources  
     <sub>41</sub> Foreign procured  
     <sub>42</sub> Foreign licensed  
     <sub>49</sub> Other foreign acquisition mode, please specify \_\_\_\_\_  
<sub>9</sub> Other, please specify \_\_\_\_\_

### **Input materials**

E7. Your **sources of input material**

- <sub>1</sub> National sources  
<sub>2</sub> International sources  
<sub>3</sub> Both



**Production equipment**E8. Number of **major production equipment** acquired in **last 5 years**?None <sub>0</sub>      1 – 2 <sub>1</sub>      3 – 4 <sub>3</sub>      5 – 6 <sub>5</sub>      7 or more <sub>7</sub>**Production processes**E9. **Major production processes changes** in **last 5 years**?None <sub>0</sub>      1 – 2 <sub>1</sub>      3 – 4 <sub>3</sub>      5 – 6 <sub>5</sub>      7 or more <sub>7</sub>**Production management**

E10. Number of new or improved production management practices adopted in last 5 years

None <sub>0</sub>      1 – 2 <sub>1</sub>      3 – 4 <sub>3</sub>      5 – 6 <sub>5</sub>      7 or more <sub>7</sub>**Data management and data storage**

Please indicate whether computers are used in each of the following functions:

- F1. For **design data storage**?      No <sub>0</sub>      Yes <sub>1</sub>      Partially <sub>2</sub>
- F2. For **production data storage**?      No <sub>0</sub>      Yes <sub>1</sub>      Partially <sub>2</sub>
- F3. For **quality data storage**?      No <sub>0</sub>      Yes <sub>1</sub>      Partially <sub>2</sub>
- F4. For **inventory data storage**?      No <sub>0</sub>      Yes <sub>1</sub>      Partially <sub>2</sub>
- F5. For **personnel data storage**?      No <sub>0</sub>      Yes <sub>1</sub>      Partially <sub>2</sub>
- F6. For **accounts data storage**?      No <sub>0</sub>      Yes <sub>1</sub>      Partially <sub>2</sub>
- F7. For **administration data storage**?      No <sub>0</sub>      Yes <sub>1</sub>      Partially <sub>2</sub>

**Importance of technology**

G1. How important are each of the following to your company?

1. Product design      <sub>1</sub> Key factor      <sub>2</sub> Important      <sub>3</sub> Not important      <sub>4</sub> Not applicable
2. Product Development Process      <sub>1</sub> Key factor      <sub>2</sub> Important      <sub>3</sub> Not important      <sub>4</sub> Not applicable

- 
- |                                |  |   |   |  |
|--------------------------------|--|---|---|--|
| 3. Input materials             | <input type="checkbox"/> <sub>1</sub> Key factor | <input type="checkbox"/> <sub>2</sub> Important | <input type="checkbox"/> <sub>3</sub> Not important | <input type="checkbox"/> <sub>4</sub> Not applicable |
| 4. Production equipment        | <input type="checkbox"/> <sub>1</sub> Key factor | <input type="checkbox"/> <sub>2</sub> Important | <input type="checkbox"/> <sub>3</sub> Not important | <input type="checkbox"/> <sub>4</sub> Not applicable |
| 5. Production processes        | <input type="checkbox"/> <sub>1</sub> Key factor | <input type="checkbox"/> <sub>2</sub> Important | <input type="checkbox"/> <sub>3</sub> Not important | <input type="checkbox"/> <sub>4</sub> Not applicable |
| 6. Production management       | <input type="checkbox"/> <sub>1</sub> Key factor | <input type="checkbox"/> <sub>2</sub> Important | <input type="checkbox"/> <sub>3</sub> Not important | <input type="checkbox"/> <sub>4</sub> Not applicable |
| 7. Data management and storage | <input type="checkbox"/> <sub>1</sub> Key factor | <input type="checkbox"/> <sub>2</sub> Important | <input type="checkbox"/> <sub>3</sub> Not important | <input type="checkbox"/> <sub>4</sub> Not applicable |
| 8. Expertise in the company    | <input type="checkbox"/> <sub>1</sub> Key factor | <input type="checkbox"/> <sub>2</sub> Important | <input type="checkbox"/> <sub>3</sub> Not important | <input type="checkbox"/> <sub>4</sub> Not applicable |
- 

### **Technology assessment**

**G2. Have you ever done a technology assessment exercise (determining your technological position)?**

- 
- |   |   |  |
|---|---|--|
| 1. For products                         | <input type="checkbox"/> <sub>1</sub> Yes | <input type="checkbox"/> <sub>0</sub> No |
| 2. For product development process      | <input type="checkbox"/> <sub>1</sub> Yes | <input type="checkbox"/> <sub>0</sub> No |
| 3. For input materials                  | <input type="checkbox"/> <sub>1</sub> Yes | <input type="checkbox"/> <sub>0</sub> No |
| 4. For production equipment             | <input type="checkbox"/> <sub>1</sub> Yes | <input type="checkbox"/> <sub>0</sub> No |
| 5. For production processes             | <input type="checkbox"/> <sub>1</sub> Yes | <input type="checkbox"/> <sub>0</sub> No |
| 6. For production management            | <input type="checkbox"/> <sub>1</sub> Yes | <input type="checkbox"/> <sub>0</sub> No |
| 7. For data management and data storage | <input type="checkbox"/> <sub>1</sub> Yes | <input type="checkbox"/> <sub>0</sub> No |
| 8. For expertise in the company         | <input type="checkbox"/> <sub>1</sub> Yes | <input type="checkbox"/> <sub>0</sub> No |
- 

### **Knowledge about world best technology**

**G3. Do you know about the world best technology in your major product area?**

- 
- |                                   |   |  |  |   |
|-----------------------------------|---|--|--|---|
| 1. In products                    | <input type="checkbox"/> <sub>1</sub> Yes | <input type="checkbox"/> <sub>0</sub> No | <input type="checkbox"/> <sub>2</sub> Somewhat | <input type="checkbox"/> <sub>3</sub> We are the best |
| 2. In product development process | <input type="checkbox"/> <sub>1</sub> Yes | <input type="checkbox"/> <sub>0</sub> No | <input type="checkbox"/> <sub>2</sub> Somewhat | <input type="checkbox"/> <sub>3</sub> We are the best |
-



---

3. In input materials	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No	<input type="checkbox"/> <sub>2</sub> Somewhat	<input type="checkbox"/> <sub>3</sub> We are the best
4. In production equipment	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No	<input type="checkbox"/> <sub>2</sub> Somewhat	<input type="checkbox"/> <sub>3</sub> We are the best
5. In production processes	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No	<input type="checkbox"/> <sub>2</sub> Somewhat	<input type="checkbox"/> <sub>3</sub> We are the best
6. In production management	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No	<input type="checkbox"/> <sub>2</sub> Somewhat	<input type="checkbox"/> <sub>3</sub> We are the best
7. In data management and data storage	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No	<input type="checkbox"/> <sub>2</sub> Somewhat	<input type="checkbox"/> <sub>3</sub> We are the best
8. In expertise in the company	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No	<input type="checkbox"/> <sub>2</sub> Somewhat	<input type="checkbox"/> <sub>3</sub> We are the best

---

### **Rating of your technology**

**G4. If the world best technology is given a score of 100, please rate your technology?**

---

1. Products	<input type="checkbox"/> 0	<input type="checkbox"/> 20	<input type="checkbox"/> 40	<input type="checkbox"/> 60	<input type="checkbox"/> 80	<input type="checkbox"/> 100	DN <input type="checkbox"/> I don't know
2. Product development process	<input type="checkbox"/> 0	<input type="checkbox"/> 20	<input type="checkbox"/> 40	<input type="checkbox"/> 60	<input type="checkbox"/> 80	<input type="checkbox"/> 100	DN <input type="checkbox"/> I don't know
3. Input materials	<input type="checkbox"/> 0	<input type="checkbox"/> 20	<input type="checkbox"/> 40	<input type="checkbox"/> 60	<input type="checkbox"/> 80	<input type="checkbox"/> 100	DN <input type="checkbox"/> I don't know
4. Production equipment	<input type="checkbox"/> 0	<input type="checkbox"/> 20	<input type="checkbox"/> 40	<input type="checkbox"/> 60	<input type="checkbox"/> 80	<input type="checkbox"/> 100	DN <input type="checkbox"/> I don't know
5. Production processes	<input type="checkbox"/> 0	<input type="checkbox"/> 20	<input type="checkbox"/> 40	<input type="checkbox"/> 60	<input type="checkbox"/> 80	<input type="checkbox"/> 100	DN <input type="checkbox"/> I don't know
6. Production management	<input type="checkbox"/> 0	<input type="checkbox"/> 20	<input type="checkbox"/> 40	<input type="checkbox"/> 60	<input type="checkbox"/> 80	<input type="checkbox"/> 100	DN <input type="checkbox"/> I don't know
7. Data management and data storage	<input type="checkbox"/> 0	<input type="checkbox"/> 20	<input type="checkbox"/> 40	<input type="checkbox"/> 60	<input type="checkbox"/> 80	<input type="checkbox"/> 100	DN <input type="checkbox"/> I don't know
8. Expertise in the company	<input type="checkbox"/> 0	<input type="checkbox"/> 20	<input type="checkbox"/> 40	<input type="checkbox"/> 60	<input type="checkbox"/> 80	<input type="checkbox"/> 100	DN <input type="checkbox"/> I don't know

---

### **Improvement in last 5 years**

**G5. Have you taken concrete steps during the last 5 years to improve the following facets of technology?**

---

1. Products	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No
-------------	---	--

---

---

2. Product development process	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No
3. Input materials	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No
4. Production equipment	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No
5. Production processes	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No
6. Production management	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No
7. Data management and data storage	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No
8. Expertise in the company	<input type="checkbox"/> <sub>1</sub> Yes	<input type="checkbox"/> <sub>0</sub> No

---

### **Gap with the best in the world**

G6. During the last 5 years, what has been the effect on your technology gap with the internationally best manufacturers? The gap:

---

1. In products	<input type="checkbox"/> <sub>1</sub> increased	<input type="checkbox"/> <sub>2</sub> decreased	<input type="checkbox"/> <sub>3</sub> remained the same	<input type="checkbox"/> <sub>DN</sub> I don't know
2. In product development process	<input type="checkbox"/> <sub>1</sub> increased	<input type="checkbox"/> <sub>2</sub> decreased	<input type="checkbox"/> <sub>3</sub> remained the same	<input type="checkbox"/> <sub>DN</sub> I don't know
3. In input materials	<input type="checkbox"/> <sub>1</sub> increased	<input type="checkbox"/> <sub>2</sub> decreased	<input type="checkbox"/> <sub>3</sub> remained the same	<input type="checkbox"/> <sub>DN</sub> I don't know
4. In production equipment	<input type="checkbox"/> <sub>1</sub> increased	<input type="checkbox"/> <sub>2</sub> decreased	<input type="checkbox"/> <sub>3</sub> remained the same	<input type="checkbox"/> <sub>DN</sub> I don't know
5. In production processes	<input type="checkbox"/> <sub>1</sub> increased	<input type="checkbox"/> <sub>2</sub> decreased	<input type="checkbox"/> <sub>3</sub> remained the same	<input type="checkbox"/> <sub>DN</sub> I don't know
6. In production management	<input type="checkbox"/> <sub>1</sub> increased	<input type="checkbox"/> <sub>2</sub> decreased	<input type="checkbox"/> <sub>3</sub> remained the same	<input type="checkbox"/> <sub>DN</sub> I don't know
7. In data management and data storage	<input type="checkbox"/> <sub>1</sub> increased	<input type="checkbox"/> <sub>2</sub> decreased	<input type="checkbox"/> <sub>3</sub> remained the same	<input type="checkbox"/> <sub>DN</sub> I don't know
8. In expertise in the company	<input type="checkbox"/> <sub>1</sub> increased	<input type="checkbox"/> <sub>2</sub> decreased	<input type="checkbox"/> <sub>3</sub> remained the same	<input type="checkbox"/> <sub>DN</sub> I don't know

---



**APPENDIX 5B****APPENDIX 5B Statistical formulas used in calculation of rating of technology**

Mean score ( $\bar{X}$ ) and standard deviation (S) of the sample for all the companies in the sample were calculated first. From this information, standard deviation of the mean of the whole population was estimated by using the formula:

$$\hat{\sigma}_{\bar{x}} = \frac{S}{\sqrt{n}}$$

where

S = Standard deviation of the sample

n = Sample size

$\hat{\sigma}_{\bar{x}}$  = Estimated standard deviation of the mean of the whole population

Using this standard deviation of the mean of the whole target population, 95 % confidence interval of the mean for the target population was calculated using the following confidence limits, assuming the population to be normally distributed:

$$\bar{x} - t_{\alpha/2} \hat{\sigma}_{\bar{x}} < \mu < \bar{x} + t_{\alpha/2} \hat{\sigma}_{\bar{x}}$$

where

$\mu$  = Mean of the target population

$\bar{x} - t_{\alpha/2} \hat{\sigma}_{\bar{x}}$  = Lower confidence limit

$\bar{x} + t_{\alpha/2} \hat{\sigma}_{\bar{x}}$  = Upper confidence limit

$t_{\alpha/2}$  = Value of t determined by the confidence coefficient (1- $\alpha$ ) associated with the interval estimate.

For 95 % confidence interval and for 21 degrees of freedom,  $t_{\alpha/2} = 2.08$

where

Number of degrees of freedom = size of the sample (n) - 1 = 22 - 1 = 21.

## Chapter 6

# Exploration of Issues – Semi Structured Interviews

### 6.1 Introduction to exploration of issues and the case studies

The next phase in this research was to explore the reasons why individual companies were at their present status, and to determine the ways in which they could improve their technology and catch-up with the leading companies of the world.

#### 6.1.1 Semi-structured exploratory interviews

The issues mentioned above were explored through semi-structured interviews conducted in conjunction with the status survey. The interviews looked for four types of concepts:

- **Barriers** to development of technology which respondents had experienced in their companies
- **Solutions** to these problems that they had found effective
- **Actions** that they had found successful in developing technology
- **Stages** that they envisaged in the process of catch-up in technology.

Solutions in principle are actions that happen to solve identified problems, while actions are beneficial in a more pro-active sense. Therefore solutions are subset of actions.



This chapter deals with the method and process of data collection in the exploratory interviews, and also presents the framework of issues in technology development that emerged from these interviews. The findings on these four types of concepts are presented in chapters 7, 8, 9 and 10 respectively.

### **6.1.2 Case Studies**

In most cases only one interview was conducted in a company. The interviews conducted in three of the companies were expanded into case studies. Several managers were interviewed in each of these companies and additional questions were asked about the company history and process of improvement of technology. These case studies are also reported in this chapter.

These case studies helped in understanding not only the situation in the country but also the results obtained in this research. The literature cites many success stories of companies in East Asia, and it was useful to be able compare and contrast the situation in Pakistan through the case studies.

## **6.2 A discussion of research methods**

Since there was already some idea of what was being looked for in the interviews, it was decided that they would be semi-structured. Robson (2002) suggested that the contents of semi-structured interviews should be prepared in advance and will generally consist of:

- A set of questions, often with alternative subsequent items depending upon the responses obtained
- Suggestions for so-called probes and prompts

- A proposed sequence of questions which may be changed during the course of the interview.

### **6.3 Implementation of the exploratory research**

The first step was the preparation of an interviewer's agenda questions (appendix 6C), followed by a pilot phase in which three interviews were conducted with respondents whom the researcher previously knew.

The procedure of arranging interviews in both pilot and main round of interviews was that letters (shown in appendix 6A) were sent to prospective respondents requesting them to participate in the research. The letters included a briefing sheet about the research and a short discussion agenda so that respondents would know what was expected of them. A few days after sending the letter, phone calls were made to request an interview appointment. After the interviews, the respondents were thanked for their participation in the research through an appreciation letter placed as Appendix 6B.

#### **6.3.1 Interviewer's agenda questions used for exploratory interviews**

The interviewer's prompt sheet had three main portions. The first asked the respondent about the general level of technology in his company, and his opinion about the relative importance of various facets of technology.

The second portion contained questions about the experiences in technology improvement, with emphasis on barriers or problems, their solutions, and steps required for technology development. It also asked the stages envisaged to reach the world level.



The third portion contained questions on technology development related to the company itself and its environment, including national and international conditions and national and international policies, rules and regulations.

As the case studies were meant to understand the technology development process in some detail in particular companies, additional questions about the company history and technology development process were added to the main questionnaire agenda for interviews in these companies.

The interview agenda questions turned out to be helpful only as general guidelines. As the interviewees were briefed in the letter sent to them and briefed again before the start of the interview about the purpose of the research, they needed little prompting during the interviews. In most cases, the discussion started even before the start of the formal interviews and went much beyond these initial guides.

As these were exploratory interviews, questions were asked according to the flow of the discussion keeping in view the objectives, instead of following the prompt sheet.

It may be mentioned that during the planning phase, the researcher expected to find the barriers and their solutions, and some proactive actions. The initial interviewer's prompt sheet was prepared in view of that. But it was observed during the interviews that the respondents offered many more proactive actions than the solutions.

### **6.3.2 Details of interviews conducted**

Forty two interviews were conducted in this phase, in three different areas of Pakistan. Twenty two were conducted in and around Islamabad, eleven in and around Lahore, and nine in and around Karachi.

### **6.3.3 Recording and coding of interviews**

In the beginning of the interviews, the interviewees were asked for their permission to record the interviews. This permission was awarded in most cases and interviews were recorded on cassettes. In a few cases, the interviewees did not allow recording the interviews. Notes were extensively taken during these interviews and in many cases, statements of the interviewees were noted down as they were said.

After completing the interviews, the recorded interviews were transcribed completely into the computer. In most cases the interviews were in mixture of English and Urdu languages. The English sentences were written as they had been in the cassette records. Urdu sentences were translated into English before entering them. In total, the interviews formed around 160,000 words!

## **6.4 Analysis of exploratory interviews using content analysis**

Next the contents of the interviews were analysed using the content analysis technique. The following paragraphs briefly describe this technique and how it was applied in this research.

### **6.4.1 The Content Analysis technique**

Content analysis is a research technique used to determine the presence of certain words or concepts within texts. These concepts may be explicit or implicit. Researchers analyze the presence, meanings and relationships of such words and concepts, and then draw conclusions from this information about the topics under study. Texts in a single study may use a variety of forms, such as written material and recoded communication.



According to Stemler (2001), who has quoted numerous researchers, content analysis is a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding.

### **Types of content analysis**

According to Colorado State University's guide on content analysis, there are two major types of content analysis technique – conceptual analysis and relational analysis. Conceptual analysis establishes the existence and frequency of concepts in a text, while the relational analysis examines the relationships among concepts.

#### **6.4.2 Steps for conducting content analysis**

The following paragraphs describe different steps in content analysis technique and how these steps were followed in this research.

##### **Step 1: How many concepts? What relations?**

After the research has been conducted and data transcribed in a format ready for analysis, the content analysis technique for conceptual analysis begins with decisions about the level of coding – words or phrases, and how many concepts to code for. These concepts could be predefined or interactive. In case of relational analysis, the decision about which relations to look for has to be made at this stage.

In case of this research, the concepts to look for included barriers to technology development, actions supporting technology development, and stages to catch-up. The list of candidate relations included the relation of barriers and actions, where an action is cited to solve a barrier. Such actions were called solutions.

### **Step 2: Existence or frequency?**

The next step is to decide whether to look for existence of the concepts or their frequency. The frequency could provide an idea about the importance of a concept.

As this phase of research was exploratory rather than explanatory, and semi-structured interviews were the method of data collection, which could result in factors being repeated due to flow of conversation, it was decided that only existence would be counted in a particular interview and not frequency. On the other hand, frequency would be counted across interviews. That is, how many interviewees cite a certain factor or concept? This information would then form the basis of selection of factors for the next phase of the research.

### **Step 3: Distinguishing between concepts**

The next step is to decide about level of generalisation. That is, whether the concepts would be coded exactly as they appear in the text or could be coded as the same even if they appear in different forms.

The researcher decided that for this research concepts would be coded as the same even if they appeared in different forms or different wording.

### **Step 4: Develop rules for coding**

The next step in the analysis is to define rules that would organise the content analysis process and ensure consistency.

The basis of the initial rules was the definition of 'technology'. The eight facets of technology which were explained in chapter 5 were initially used as a set of category headings for the concepts found.



The **content analysis** of the interviews thus **started with the following rules**:

- All aspects visualised as barriers to the progress or development of any of the facets of technology would be recorded. This would include all directly affecting or explicit barriers and indirectly affecting or implicit barriers.
- These barriers would be accumulated in the form of lists under categories, which would be the facets of technology.
- Relationships of barriers or problems and the actions that solved these problems (solutions) would be sought. Only explicit or directly affecting solutions proposed in the same interview would be listed.
- All aspects visualised as supporting progress or development of any of the facets of technology would be recorded. This would include all directly affecting or explicit actions and indirectly affecting or implicit actions.

#### **Step 5: Coding the text**

The next step is to code the text. This is done either manually, reading through the text and writing down concept occurrences, or through the use of computer programs. Computer coding is possible when looking for explicit information only. When implicit information is to be taken into account, as was the case with this research, manual coding is preferable.

Manual coding method was thus resorted to for this research. All the concepts and relations were recorded manually into a word-processor.

#### **Step 6: Analyse the results**

The last step in the process is to generate results and analyse them.

### **6.4.3 Implementation of content analysis – emergence of new categories**

It was found during the analysis process that the eight facets of technology did not provide a broad enough set of headings for all the factors emerging. The initial rules needed to be modified. The major reason for this change was that more logical categories of factors emerged. For example, market-related factors were logically combined under one heading. So the rules were modified on the job, and as various categories of barriers or actions emerged, these were added to the emerging new list of categories.

Initially separate lists of categories were made for barriers and actions, but when the analysis was complete, it was found that they were almost the same. The minor differences in the two lists of categories were then removed, which resulted in a single list of categories related to both barriers and actions.

These categories were thus organised into a framework of ‘issues for technology development’, the details of which are given in section 6.5.

### **6.4.4 Descriptions**

Each barrier or action factor was given a name or phrase to describe it. In addition slightly longer descriptions were written for all the factors obtained, based on the interview statements and the context in which this factor appeared in the interviews. These descriptions helped ensure that all factors were unique. The descriptions formed the rules for coding in the content analysis process, so that various factors could be differentiated and their frequency of occurrence could be obtained.



After all the descriptions had been formed, the content analysis process was repeated to ensure the occurrence of the barriers in accordance with their descriptions under various headings identified in the framework.

The results of the content analysis process are given in chapters 7, 8 and 9.

#### **6.4.5 Example of coding**

The factors were coded as one factor even if they appeared in different explicit or implicit forms. For example, a barrier ‘brain drain from Pakistan’ appeared in three interviews in the following forms:

- “brain gets 100,000 dollars, environment and facilities, he produces the product there”
- “brain drain keeps on and people keep leaving”
- “people interested in coming back home all made a U-turn either by getting back from wherever they came from after getting qualified from the West”

### **6.5 Emergence of a new framework for issues in technology development**

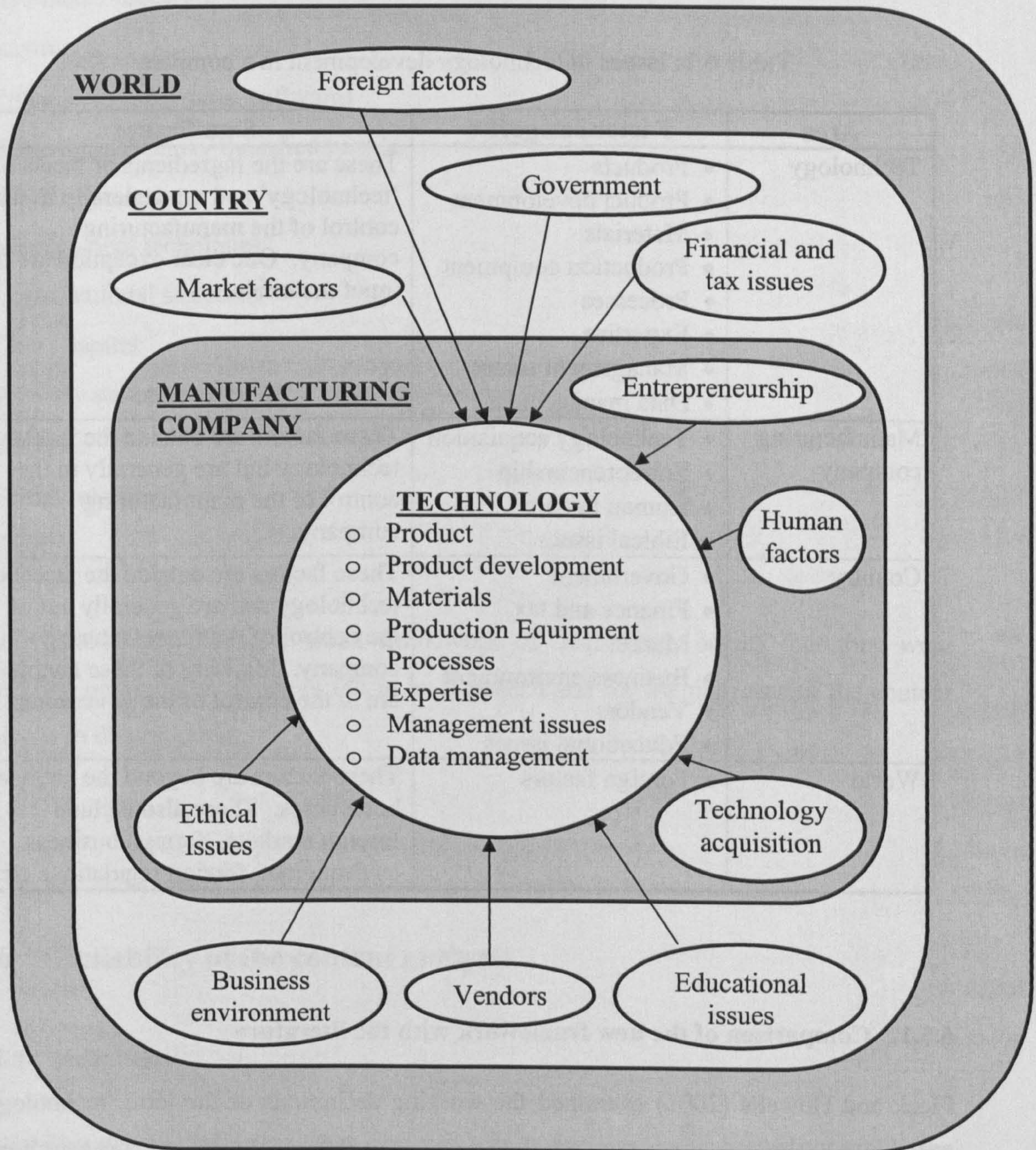
As mentioned in section 6.4.3, the content analysis of interviews started with the facets of technology as the list of categories but many factors appeared that could not be allocated to any of these eight categories. Therefore new categories kept on being added to the initial list until a total of 11 new categories had been added.

This new list of 19 categories formed a novel framework of issues that are of consequence in the process of technology development. This framework is shown in



figure 6.1. It should be noted that the category ‘technology acquisition’ is not a facet of technology but a category in the issues of technology development.

**Figure 6.1:** Framework of issues for technology development in a company.





The categories could be termed as the dimensions of the framework. Thus it could now be seen that technology development was multi-dimensional problem that had dimensions not only beyond technology itself, but beyond the company and also beyond the country boundaries. Table 6.1 illustrates these dimensions.

**Table 6.1:** Issues in technology development in a company

Area	Factor categories	Significance
Technology	<ul style="list-style-type: none"> <li>• Products</li> <li>• Product development</li> <li>• Materials</li> <li>• Production equipment</li> <li>• Processes</li> <li>• Expertise</li> <li>• Management issues</li> <li>• Data management</li> </ul>	These are the ingredients or facets of 'technology' and are generally in the control of the manufacturing company. One clear exception are the input materials.
Manufacturing company	<ul style="list-style-type: none"> <li>• Technology acquisition</li> <li>• Entrepreneurship</li> <li>• Human factors</li> <li>• Ethical issues</li> </ul>	These factors are outside the facets of technology but are generally in the control of the manufacturing company.
Country	<ul style="list-style-type: none"> <li>• Government</li> <li>• Finance and tax</li> <li>• Market</li> <li>• Business environment</li> <li>• Vendors</li> <li>• Educational issues</li> </ul>	These factors are outside the facets of technology and are generally out of the control of the manufacturing company. Majority of these factors are in the control of the government
World	<ul style="list-style-type: none"> <li>• Foreign factors</li> </ul>	These factors are beyond the national boundaries. These also include foreign markets, foreign business environment, foreign regulations etc.

### 6.5.1 Comparison of the new framework with the literature

Fleck and Howells (2001) examined the working definitions of the term 'technology' across publications in a range of disciplines such as industrial relations, organisational behaviour, operations management and development economics. They proposed a conceptual device, called 'technology complex', which covered all the definitions of technology. This 'complex' included the following components:



- Basic purpose or function
- Material
- Energy source
- Artefacts / hardware
- Layout
- Procedures (programs, software)
- Knowledge / skills / qualified people
- Work organisation
- Management techniques
- Organisational structure
- Cost / capital
- Industry structure (suppliers, users, promoters)
- Location
- Social relations
- Culture

This research also found a broad framework of ‘technology issues’ but they were identified empirically, which is felt to be a better basis for the purposes of the content analysis in this research.

## **6.6 Reliability of the content analysis**

### **6.6.1 Reliability**

Reliability can be defined as the extent to which the measuring procedure yields the same results on repeated trials (Neuendorf, 2002). Stemler (2001) described reliability in the following terms:

1. *Stability*, or intra-rater reliability. Can the same coder get the same results try after try?
2. *Reproducibility*, or inter-rater reliability. Can two different coders arrive at the same result?

### **Intra-rater reliability**

To ensure that the results possessed intra-rater reliability, the content analysis process was repeated by the researcher on three randomly selected interviews. The outcome was that the number of barriers obtained was the same except in one case where the difference was only of one barrier. The differences were that the wording of the barriers had been slightly different in the repeated analysis, but the meaning of the barrier had been the same.

### **Inter-rater reliability**

In order to ensure that the results were reliable, inter-rater reliability tests were conducted on two randomly selected interviews. The second rater had done his MS in mechanical engineering from USA and had been working in Pakistani industry for the last five years. He was fluent in both English and Urdu and had some knowledge about content analysis technique. The purpose of the research was explained to him and the coding rules in detail, and he was given on-the-job training through numerous examples.

The results of the reliability tests are given in the table 6.1, which shows that the inter-rater reliability has been quite high, although the researcher found more factors than the second rater in the second test interview. This could be attributed to the higher involvement of the researcher in the research than the second rater. In some cases, wording of factors was a little different but the meaning was the same. For example, one factor was worded by the researcher as “resistance to change” while the second rater worded it as “aversion to change”.



**Table 6.1: Inter-rater reliability test**

		<b>Researcher</b>	<b>Second rater</b>
Test interview no. 1	Number of Barriers	14	14
	Number of Actions	9	9
Test interview no. 2	Number of Barriers	17	15
	Number of Actions	12	11

### 6.6.2 Representativeness of the sample

It was not possible to take a simple random sample of managers to interview, as the interviews were dependent upon self-selection of the interviewees. At the same time, due to the absence of such research in Pakistan, it was difficult to get to senior executives and to convince them for an interview without some reference. In the absence of data about the target population, it was also difficult to select industries for approaching. So snowball sampling was also resorted to.

The following steps were taken to make the sample representative.

- Data was collected in three main industrial centres of Pakistan – Karachi, Lahore and Islamabad, which were geographically far apart.
- It was tried that data was gathered from various sub-sectors of the targeted portion of the manufacturing sector. The interviews were thus made in widely varying areas, such as fire-fighting equipment, cars, cycles, heavy machinery, home appliances, telecommunication equipment, motorcycles, fabricated metals parts, air conditioners etc.

## **6.7 Case Studies**

As mentioned in section 6.1.2, additional questions about the company and its history were asked while interviewing in three companies. The following sections provide results of those additional questions.

### **6.7.1 Case Study A**

The first case study was of company A, which was manufacturer of communication equipment and other electronics products. It had around 140 employees and its annual sales were around US\$ 1.7 million. Three interviews were made in this company.

#### **Company history**

Company A started in the late 1970s as an IC manufacturing facility by some people who had been running a similar company in the USA or had worked there. Their idea was to develop a labour-intensive industry for making electronic circuits in Pakistan. They approached the government of Pakistan, which invited them to invest in Pakistan. The government provided them with premises and a building to install the factory. The IC manufacturing factory thus started working.

The factory used to import gold wires for IC manufacturing. Due to allegations on the company of gold smuggling, the import license was cancelled and the factory was forced to close down.

Instead of IC manufacturing factory, another factory making communication equipment for army, police and paramilitary forces was established. The equipment was made but the company had a hard time getting it accepted by the government. The company had



to face lot of problems from adverse government policies and unhelpful government officials who created bureaucratic hurdles for the company.

In spite of the problems, because of support for the company from the top level of the government, the company prospered and created two factories – one in Lahore and one in Karachi. The company made VCRs and cassette players for cars, in addition to other products. It also started manufacturing computers. By the mid-eighties, there were more than 450 workers and more than 70 engineers. Despite all these successes, the company was stopped from selling cassette players and VCRs in the national market.

After the change in the government in 1988, the government support vanished and conditions were created so that the company ran into deep financial troubles. The owners thus sold the majority shares of the company. The new owners slowly turned the original owners out of the factory.

The production of the factory drastically dropped and the number of employees radically reduced.

### **Analysis of case history**

The most apparent aspect of this case study is the negative policies of the government and the hurdles created by the government functionaries at every step. This was a very high-tech company from a third world perspective, and thus was aptly supported by the top level of the government. Despite this support, problems were created by the government functionaries. When the government changed and the support ceased, the running of the factory was made impossible.

This case study makes it easy to understand the results of this research in which the role of the government and its functionaries is seen as the major problem in technology development. This is in sharp contrast to East Asian success stories, where the government has been portrayed as the prime agent of success.

### **6.7.2 Case Study B**

Company B was a manufacturer of refrigeration and air conditioning equipment. With local annual sales of 1.5 billion rupees and exports worth 5 million dollars, it claimed the second largest annual turnover in Pakistan. Seven interviews were carried out with top executives in the company.

#### **Company History**

The company was established as a small repair and maintenance shop of refrigeration and air conditioning equipment by three brothers in 1968, who were not highly educated but had lot of experience in this area. The first major project of this company was the air conditioning of a cinema in 1969, which paved the way for other projects. By 1975, the work had expanded and the company had purchased two more shops. In 1975 the company shifted to industrial area in Islamabad.

The company did not have funds to buy machinery and production equipment, so the owners started to manufacture many types of equipment that it required for the production of air conditioning equipment. A separate machine tool division was thus started in the company.

The company kept on expanding. Over time, it was awarded bigger and bigger projects. By 1986, the sales had reached 80 million rupees. In 1987, the company launched the first mini-split air conditioner in Pakistan. The sales forecast was 200 units in the first year but they ended up selling about 750. In 1992, new models were introduced and other products were added to the production line. Export also started in 1992. This was achieved through some Pakistanis living in Kuwait, Qatar, UAE, and Saudi Arabia.

In early 1990s, the second generation of the original founders came into management. The young blood started to make changes in the company. In 1994-95, the first CNC



machine was produced. This was achieved through collaboration with a Spanish company. The computer controller was imported. The machine tool division had grown to the level that there were 100 people working there by that time.

Major changes were made in the company in 1995-96. A plant was set up in an industrial estate near Lahore. The objective was to mass produce and export in large quantities. But in 1995, the government imposed heavy taxation on value-added products, which was around 37 per cent of the total product value. The company suffered heavy losses and by the following year, the company was in major financial crisis. To come out of this crisis, company had to borrow 380 million rupees.

By 1999, the company had come out of the financial crisis; it made a six-year development plan. The plan was to enter into global markets and venture into many new areas. Some companies were made in the UAE. Two companies were established in China. One unsuccessful attempt was made in creating a company in Saudi Arabia.

Major efforts were made to reduce the cost of mini-split air conditioners so that the price could be made comparable with window-type AC. Year 2001 saw the introduction of new brands in the national market. It was a thumping success. In 2002, sales increased by 386 per cent compared with 2001. In 2003, another 200 per cent increase over the previous year was anticipated.

The company plans to manufacture microwave ovens, electric cycles, LCD TVs and plasma TVs. It is also thinking of making microprocessor based controllers and GPS based systems for cars.

### **Analysis of company history**

This was a success story, which could be compared to successful companies like Hyundai and Daewoo in South Korea, as they also had similar meagre beginnings. The major difference has been the role of the government. While the South Korean

government out rightly supported manufacturing companies and encouraged them to export, the government of Pakistan slammed heavy taxation to limit the growth of local companies.

### **6.7.3 Case Study C**

Company C was a manufacturer of industrial plant and other machinery. This company started as a government-owned company in the late 1960s. After about thirty years of its existence, it was semi-privatized and was asked to be financially self-supporting. The number of employees was reduced to about one-fourth. Presently it is operating as a semi-government autonomous company. Six interviews were carried out with top executives in the company.

#### **Company History**

Company C was established in the late 1960s as the first heavy industry in Pakistan producing capital goods. It was erected with the help of China to make industrial plants and machinery, road rollers and other heavy engineering products. The factory went into production in the early 1970s. The market of the company was protected by the government through various regulations. Businessmen required No Objection Certificates if they wanted to import plants similar to those made by this company. Financial incentives were given by the government if industrialists bought plants manufactured within the country.

Under the protection of the government, the company was successful. It went into making sugar plants of various sizes, then cement plants of various capacities, and then went into cranes and road rollers. Joint ventures started with many companies of western origin. It was a success story in the late 1970s and through the 1980s.

In the 1980s, competitors started evolving. Even worse, under pressure from donor agencies, the government of Pakistan removed incentives and subsidies on the products



from this company in the 1990s. At the same time, the government favoured other industries in this sector due to political reasons. The downfall of this company thus started.

In the late 1990s, the government deregulated the company and made it financially autonomous. Many voluntary leaving schemes were started, and so the number of people in the company started to reduce. With this, the skill level in the company also reduced. Ultimately the strength of the company was reduced to less than one-fourth.

Now the company is facing a survival struggle. It is financially weak but has to generate revenue to cover all costs. There is no help from the government, but the government regulations partly remain, which are making things worse for this company.

### **Analysis of the company history**

This case study reflects the conditions in the government sector of Pakistan. The company prospered when it was protected by the government but declined when this support ceased. This is in contrast with South Korea or Singapore, where the companies in government sector were supported by the government, but the protections were systematically phased out and the companies were made to compete in the world market.

The major reason of this contrast has been that companies in South Korea and Singapore were started and run as private companies managed on corporate principles, while in this case the company was run under tight government regulations and pressure was exerted on it due to political reasons.

## 6.8 Summary

- The semi-structured interview technique used has been described. The results on barriers, solutions, actions and stages will be presented in chapters 7, 8, 9 and 10.
- The three case studies developed by extending the interview process have been reported here. They highlighted the negative role of the government of Pakistan in contrast to the success stories from East Asia. An important aspect is that the case of the manufacturer of refrigeration equipment was a success story despite this negative role.
- In chapter 9 another important finding will emerge. The majority of actions required for technology development are found to be in the control of the factory managers. The role of the government is an important factor, but by no means the whole story.
- When the analysis of the interviews was done a new framework of issues for technology development appeared.



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## APPENDIX 6A

### APPENDIX 6A Cover letter and briefing paper for status survey and exploratory interviews

#### R&D Management Centre

School of Engineering  
Cranfield University  
Cranfield  
Bedford MK43 0AL, UK

Email: [rdman@cranfield.ac.uk](mailto:rdman@cranfield.ac.uk)  
[www.cranfield.ac.uk/sme/rdman](http://www.cranfield.ac.uk/sme/rdman)

#### Numan Iqbal

House No. 1, Street No. 2,  
A-3/4, Islamabad.

Tel : (051)-1234567  
Email: [n.iqbal.2001@cranfield.ac.uk](mailto:n.iqbal.2001@cranfield.ac.uk)

10 January, 2003

Mr. ABC  
CEO  
XYZ Company  
Technology Development Road  
Pakistan

Dear Sir,

I am a PhD student at Cranfield University, UK, working in the field of Management of Technology. My PhD research is funded by the Ministry of Science and Technology, Pakistan.

I am writing to ask for an hour of your time to assist in my research into how manufacturing companies in Pakistan can best set about catching up with world standards. I am particularly interested in your experiences with regard to technology in your operations.

So far in this work, I have studied published reports about countries such as South Korea, Singapore and Taiwan, whose companies have been able to develop rapidly. I now need to find out what the situation actually is in a sample of companies in Pakistan, and to seek the views of experienced managers as to what their problems are, and what approaches have been successful.

There would be two components to the meeting. Firstly I would ask you to fill in a short questionnaire regarding the status of technology in your company, and secondly to undertake a discussion focusing on your experiences. I attach an agenda for the discussion. If permitted by you, this discussion would be recorded so that important factors could be extracted at the analysis stage. After the analysis, the tapes would be erased. The contents of the discussion and answers to the questionnaire will be kept



anonymous when the results are analysed and presented. I would be pleased to provide you a copy of the final results of the research.

I would be highly obliged for your participation and co-operation in this research project. I will phone you in a few days for an appointment. In case you have commitments and cannot spare time, please ask another member of the management team to participate in this important research.

With best regards,

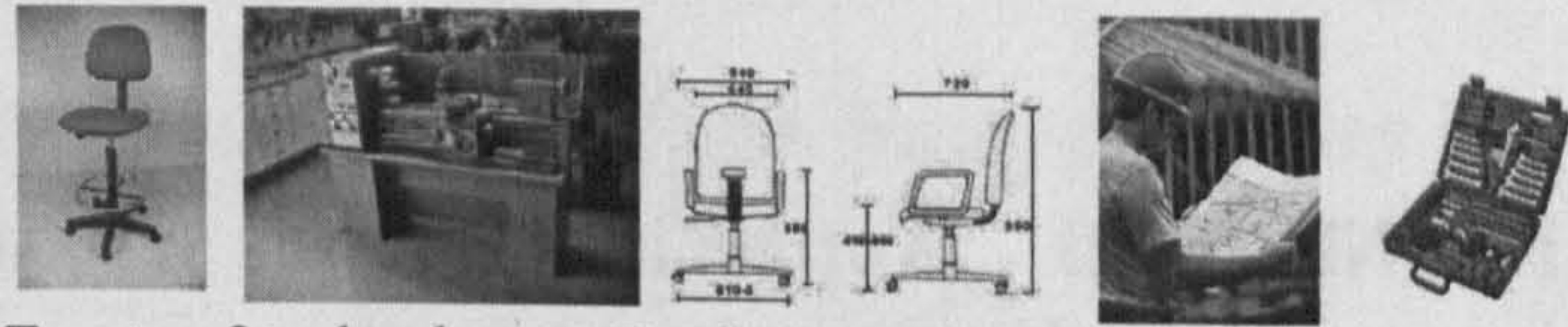
Sincerely yours,

Numan Iqbal.



**Definitions:**

**Technology:** Technology is the means of transfer of an idea into reality. This includes products; equipment, machinery and tools; processes; materials; drawings, process sheets and specifications; human expertise; and the system that combines the other forms of technology to produce products.



Facets of technology – Product, equipment, tools, drawings, expertise, processes, management etc.

**Technology acquisition:** The process of purchasing or otherwise obtaining different facets of technology.

**Technology absorption:** The process of incorporation of different facets of technology in the company.

**Catch-up in technology:** The process through which the companies can get closer to the companies leading the world in their business in various facets of technology.



## APPENDIX 6B

### APPENDIX 6B Appreciation letter sent to respondents of status survey and exploratory interviews

R&D Management Centre  
School of Engineering  
Cranfield University  
Cranfield  
Bedford MK43 0AL, UK

Email: [rdman@cranfield.ac.uk](mailto:rdman@cranfield.ac.uk)  
[www.cranfield.ac.uk/sme/rdman](http://www.cranfield.ac.uk/sme/rdman)

**Numan Iqbal**  
House No. 1, Street No. 2,  
A – 3 / 4, Islamabad.

Tel : (051)-1234567  
Email: [n.iqbal.2001@cranfield.ac.uk](mailto:n.iqbal.2001@cranfield.ac.uk)

10 January, 2003

Mr. ABC  
XYZ Company

Dear Mr. ABC,

I am writing this letter to express my sincere appreciation and to thank you for taking time out of your busy schedule to take part in the research concerning the technology development in the manufacturing companies of Pakistan.

Your contribution and views have been exceedingly useful for me and would help a lot in the current research.

Thank you.

Sincerely yours,

Numan Iqbal.

## APPENDIX 6C

### APPENDIX 6C Interviewer's agenda questions for exploratory interviews

*This interviewer's agenda or prompt sheet was prepared as a guide to ask about the experiences of the interviewee in technology development in his company. It turned out that the interviewees were able to discuss their experiences and issues with little prompting and wanted to set their own sequence and style. Thus the sequence given in this prompt sheet was not used in most cases.*

#### **Semi-structured interview (Barriers to technology development, solutions and steps)**

##### **P – Barriers to technology improvement, solutions and steps**

If technology includes products, equipment, machinery and tools, processes, materials, drawings, process sheets and specifications, human expertise and the system that combines the other forms of technology to produce products, then:

- P1. In your opinion, what is the standing of your company in terms of technology as compared to the leading companies of the world?
- P2. In your opinion, which of the following facets of technology are more important than others in the process of catch-up with the leading companies of the world:
- Products
  - Product development processes
  - Input materials
  - Production equipment
  - Production processes
  - Production management
  - Data management and storage
  - Expertise in the company
- P3. What is the basis of your selection? Why are these more important than others?



**Q – Barriers to technology facet improvement, solutions and steps**

Please consider an experience of technology facet improvement or a new technology facet introduction and describe its story to identify the barriers and problems that you encountered in this process and how these barriers or problems were removed or should have been removed.

***Introduction and selection***

- Q1. What technology facet was it and what improvement was sought?
- Q2. What was the motivation for this improvement?
- Q3. How this improvement was selected?
- Q4. What problems were faced at this stage?
- Q5. How these problems were solved?

***Acquisition***

- Q6. How was the technology facet acquired?
- Q7. What problems were faced at the acquisition stage?
- Q8. How these problems were solved?

***Absorption***

- Q9. What steps were taken to absorb the technology facet?
- Q10. What problems were faced in absorption of the technology facet?
- Q11. How these problems were solved?

***Result***

- Q12. Was the improvement successful?
- Q13. What was achieved?

If the improvement was *successful*:

- Q14. What factors made the improvement successful?
- Q15. If it wasn't a complete success, what could have been done to achieve a complete success?

If the improvement was *not successful*:

- Q16. What went wrong?
- Q17. What could have been done to transform it into a success?

***General***

- Q18. What are the main barriers in making improvements in this technology facet to reach at the world level?
- Q19. How these barriers could be removed?
- Q20. What help can be provided by the outside environment (government, banks, other industries, research institutes, universities etc.)
- Q21. *What stages can be envisaged to reach at the world level in technology?*

### **General Questions**

- R1. In general, what factors could be considered as the barriers in the technological development of your company from within a company?
- R2. What should be done to overcome these barriers? Who should do it?
- R3. What factors could be considered as the barriers in the technological development of your company due to local market, local conditions and local institutions?
- R4. What should be done to overcome these barriers? Who should do it?
- R5. What factors could be considered as the barriers in the technological development of your company due to government regulations?
- R6. What should be done to overcome these barriers? Who should do it?
- R7. What factors could be considered as the barriers in the technological development of your company due to international markets, international conditions and international institutions?
- R8. What should be done to overcome these barriers? Who should do it?
- R9. What factors could be considered as the barriers in the technological development of your company due to international regulations?
- R10. What should be done to overcome these barriers? Who should do it?
- R11. What other factors could be considered as the barriers in the technological development of your company?
- R12. What should be done to overcome these barriers? Who should do it?
- R13. Can you visualise various stages that your company should follow and the help that the external agencies and the government provide at each stage so that your company can become competitive with the leading companies of the world?
- R14. Any other aspect that you would like to tell me about technology development in manufacturing companies?



## Chapter 7

# Barriers in Technology Development

### 7.1 Introduction

This chapter is the first of the three chapters that present the results of the exploratory interviews described in the last chapter. This chapter describes the barriers and problems facing the manufacturing companies in their quest for technology development, found during content analysis of the exploratory interviews.

### 7.2 Barriers to technology development in the literature

The issue of barriers in technology development in the developing countries has not received much interest in the literature. Very few references were found on the subject. The following paragraphs provide a summary of the available literature.

Swierczek and Nourie (1992) conducted a survey of international and Thai executives on technology performance of their companies and barriers they perceived in the process. They found the following barriers, in order of their impact:

1. Shortage of skilled people
2. Inadequate information services
3. Inadequate government funding for R&D
4. Lack of specialized technology research centres
5. Government policies

6. Few supportive industries
7. Lack of intellectual property protection
8. Poor infrastructure
9. No R&D facilities
10. Managerial attitudes
11. Limited private financial support
12. Limited raw materials

They also quote the findings of Thailand Development Research Institute (TDRI) about technology capability problems:

- Scarce technical personnel at various levels in quality and quantity
- Lack of information systems
- Inaccessibility of systems that do exist
- Inadequate supportive technical services
- Lack of industrial linkages – lack of component industries, and limited raw materials
- Attitudes of entrepreneurs towards the use of technology
- Structure of the tax system
- Bureaucratic regulations

Perez and Soete (1988) defined the following barriers in catching-up in technology, each of which has a cost associated with it:

- Lack of scientific and technical knowledge required to assimilate the innovation.
- Lack of experience of handling the technology.
- ‘Locational’ disadvantages.



Madanmohan (2000) studied the difficulties in developing plant-level indigenous technology in India. He surveyed 92 firms and found that failures had technical, managerial or market-related reasons. He divided the failures into four categories.

1. Failure due to inappropriate choice of technology.
2. Failure due to inappropriate planning and support for innovation.
3. Failure due to inappropriate processes.
4. Failure due to market-product mismatch and inadequate market survey.

Vinas (2001) attempted to develop a conceptual model for development of technological management process in manufacturing companies of Cuba. He described that the main obstacles to innovation were lack of financial resources, lack of communication between research, development and marketing, and lack of motivation in personnel.

The researches cited above had a few drawbacks in their applicability to this research. Firstly, they had cited relatively few barriers, while the researcher expected that there would be numerous other barriers. Secondly, they had not mentioned solutions to these barriers, and lastly, their findings may not be applicable to the Pakistani manufacturing companies. As this research concerned the manufacturing companies in Pakistan, it was considered necessary to explore the barriers facing them.

### **7.3 Results – Counting of barriers to technology development**

The content analysis of forty two exploratory interviews found 226 distinct barriers. The complete list of barriers is shown in appendix 7A. Table 7.1 shows the number of interviews in which the various barriers appeared. Any number of mentions of a barrier in any one interview was counted as one appearance. 63 % of the barriers appeared only once, and 14 % appeared only twice. The most frequently mentioned barrier appeared in only 14 of the 42 interviews.

The picture that emerges is of a large number of possible problems experienced by different managers rather than a small number of problems experienced by them all. A barrier experienced by only one manager might well be very critical to him, but it was sensible to concentrate on the most popular ones in this research. In order to deal with a smaller number, it was decided to designate as 'significant' those barriers that appeared in three or more interviews, i.e. more than 5 % of the interviews. There were 52 of these, just under a quarter of the whole. The list of these significant barriers is shown in table 7.2

**Table 7.1:** Number of mentions of the barriers in the exploratory interviews

Percentage of barriers (%)	Number of barriers	Number of interviews in which a particular barrier appeared
63 %	142	1
14 %	32	2
8 %	18	3
6 %	13	4
4 %	10	5
2 %	4	6
0.5 %	1	7
0.5 %	1	8
1 %	2	10
0.5 %	1	11
0.5 %	1	13
0.5 %	1	14
	<b>226</b>	<b>Total</b>

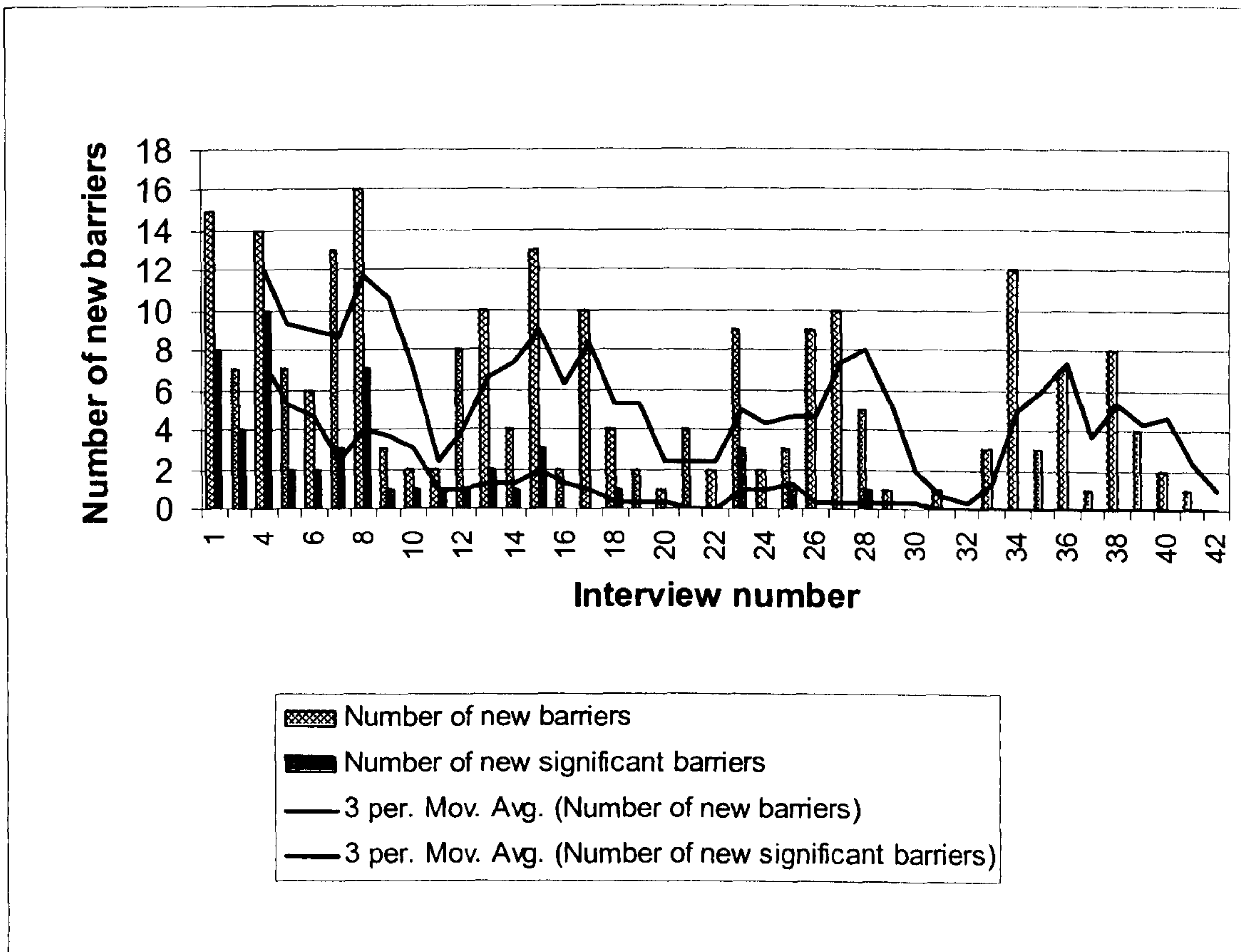
### 7.3.1 Sufficiency of exploratory interviews to account for all significant barriers

Figure 7.1 shows the frequency of getting new barriers and the frequency of getting new significant barriers as the interviews progressed. The figure also shows trend lines based upon three period moving averages.




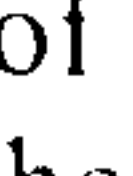
It can be seen in the figure that although new barriers kept appearing even in the last interviews, the vast majority of significant factors were obtained within the first twenty interviews and the last significant barrier was obtained in the twenty eighth interview. This shows that enough interviews were done to list all the significant barriers, and the probability of getting another significant barrier through further interviews would have been extremely small.






**Figure 7.1:** Frequency of getting new barriers and new significant barriers in the exploratory interviews, with three period moving averages in each case














## 7.4 Results – Descriptions and jurisdictions of barriers











In Table 7.2 the significant barriers are listed. Each has a name and a description. Also each is identified as being in the control of factory management or of government or of neither of them. The table also shows the number of interviews in which each barrier appeared. The barriers are ordered under headings, and as explained in chapter 6, the headings arose as the content analysis was being performed.

**Table 7.2:** Significant barriers, their descriptions, and identification of their being in control of factory management or government. (N = Number of interviews in which this factor appeared,  = In control of factory management,  = In control of government, O = In control of neither the factory management nor the government)













	Significant barrier	Description of significant barrier	N	Control
<b>Technology and its acquisition</b>				
1.	Lack of information and knowledge about technology	There is general lack of knowledge and information in the company about technology and its development.	6	
<b>Production Equipment</b>				
2.	Inadequacy of production equipment	Lack of adequate equipment is hindrance in production of the products.	5	
<b>Methods and processes</b>				
3.	Technical problems in production processes	Technical problems arise in production processes.	3	
<b>Input materials and components</b>				
4.	Lack of availability of electronic components in Pakistan	Electronic components are generally not available in national markets.	3	
5.	Difficulties in import	Import of materials is difficult and time-	3	



	of raw materials	consuming process.		
6.	Non-availability of raw materials in Pakistan	Availability of input materials is poor in the country.	5	
7.	Difficulty in import of electronic components	Import of electronic components is long and tedious process.	3	
8.	Poor or inconsistent raw material quality available in Pakistan	Quality of raw material available nationally is poor and/or inconsistent.	3	
<b>Management issues</b>				
9.	People resisting technology changes	People generally resist changes to better technology.	11	
10.	Opposition of senior management for technology changes	Board of Directors or senior management of the company opposes technology changes.	4	
11.	Lack of teamwork	Teamwork generally lacks in the company.	3	
12.	Lack of professional management	The management of the company is in the hands of the people who are not professional managers.	4	
<b>Expertise in the company</b>				
13.	Shortage of trained human resource	There is shortage of trained human resource in the company.	5	
14.	Lack of good human resource	There is shortage of good human resource in the company.	3	
15.	Illiteracy of employees	Illiteracy of employees in the company creates problems in technology development.	4	
<b>Human factors</b>				
16.	Large number of employees leaving the company	Large number of employees leaving the company creates problem in development of technology.	7	
17.	Brain drain from	Talented young people go to different countries in search of better	3	○




	Pakistan	opportunities. This results in less capable people working in national industry.		
<b>Financial and tax issues</b>				
18.	Duties / sales tax high on national products than on imports	Duties and sales taxes are higher on nationally produced products than on imported products.	6	
19.	Problems in getting finance from banks	It is difficult to get finance from national banks as their conditions are strict.	3	
20.	Shortage of funds and resources	Lack of resources or funds doesn't allow technology improvement.	13	
21.	High price of utilities (electricity, gas, telephone and water)	Price of utilities is higher in the country as compared with competing countries.	5	
22.	High prices of machinery	High machinery cost makes it difficult to buy.	5	○
<b>Educational issues</b>				
23.	University curricula not related to industry	University curricula are not relevant to industry, so graduates produced are not useful for industry.	6	
24.	R&D by government and other institutions unrelated to industry	Research and development carried out in the country is not of applied nature, and is unrelated to industry.	4	
<b>Issues related to government</b>				
25.	Corrupt government functionaries	Government functionaries dealing with industry are generally corrupt.	10	
26.	Government policies change frequently	Government policies change frequently, which discourages industrialists to make long-term plans.	10	
27.	Long and difficult government procedures	Lot of time and effort is wasted in trivial matters because of lengthy and time-consuming government procedures.	8	
28.	Bad attitude of government inspectors	Government functionaries coming to industry for inspection generally have	4	



		negative or bad attitude towards industry.		
29.	Lack of government support	Government does not provide help and support to industry.	3	
30.	Incapable government functionaries	Government functionaries are either unqualified or incapable for their assignments.	4	
31.	Problems at customs during imports or exports	Industries generally face problems and wastage of time at customs during imports or exports.	5	
32.	Hurdles by lower level staff in government procedures	Lower level government staff creates hurdles for businesses.	3	
33.	Large number of government inspectors	Large number of government inspectors creates problems for industry.	5	
34.	Government incentives are not enforced	Government announces financial incentives for industry but those are not enforced.	3	
35.	Bad government policies	Government policies are bad for technology development in manufacturing industries.	4	
<b>Business environment factors</b>				
36.	Lack of technological infrastructure in the country	Technological infrastructure including basic and vendor industries, knowledge base, know-how, service providers, basic and applied research etc, is generally weak in the country.	5	
37.	Lack of standards in Pakistan	Standards about various products are not followed in the country.	4	
<b>Market factors</b>				
38.	Poor marketing of products	Marketing of products and services is poor in the company.	3	
39.	Smuggling	Smuggling of goods without import duties adversely effect national products.	3	
40.	Competition of our products with cheap	Nationally manufactured products have	4	

	imports	to compete with cheap imports.		
41.	Preference of foreign brands by people	People generally patronize imported brand names instead of nationally produced products.	4	○
42.	Small national market	The market for products within the country is small.	14	○
43.	Conditionalities imposed on Pakistan on tariff, trade and industry issues by IMF and World Bank	Conditionalities imposed on Pakistan on tariff, trade and industry issues by IMF and World Bank result in policies that are bad for industries.	3	○
44.	WTO regulations	WTO regulations would hamper national technology and product development.	5	○
<b>Foreign factors</b>				
45.	Restriction on foreign visits or contacts by the government	Government sometimes places restrictions on foreign contacts or visits that create problems in imports and exports.	3	🏢
46.	Bad perceptions about Pakistan in world market	Pakistani products have poor perception in foreign markets.	4	○
47.	Restrictions on export of technology by some countries or companies	Some countries or companies put restrictions on export of technology to Pakistan that hampers technology development in Pakistan.	5	○
48.	Geopolitical situation or sanctions against Pakistan	Due to current world political situation, many times sanctions have been enforced upon Pakistan that make foreign trade difficult.	4	○
<b>Entrepreneurship</b>				
49.	One-man-show (Owner or one person making every significant decision himself)	Owner or one person makes every significant decision himself in the company, which is detrimental for improvement of technology.	3	🏢
<b>Vendors</b>				



50.	Vendors ignorant about quality	Majority of the vendor industries in the country are ignorant of quality.	3	
51.	Vendors lack technical skills	Vendor industry lacks technical skills required to do quality work.	3	
52.	Illiterate vendors	People in vendor industry are uneducated.	4	

## 7.5 Discussion of barriers to technology development

### 7.5.1 Types of barriers found

Numerous barriers to technology development were found. Out of 52 significant barriers, 15 (29 %) are ones on which factory management could take corrective action, 28 (54 %) are in the control of the government and 9 (17 %) are in the control of neither.

Eleven of the 52 factors (21 %) were barriers directly related to the government, while 7 (13 %) were market-related barriers. Five of the factors (10 %) are linked to input materials and components. The rest of the barriers are divided among thirteen other categories.

Relatively few barriers (29 %) were linked to the facets of technology that were defined in chapter 5. The majority (71 %) were related to other dimensions of the framework of technology development issues which were defined in chapter 6 section 6.5.

### 7.5.2 Discussion of the findings

One part of the findings endorsed the research of Swierczek and Nourie (1992), who found that a majority of barriers companies face in developing technology in Thailand

are government related. By government related, they meant in control of the government. This research also found that barriers in control of the government are more than half of the total significant barriers. Even barriers directly related to the government formed a sizable fraction (21 %) of significant barriers in technology development.

The barriers on which only the government can take corrective action are generally the following:

- Issues directly related to government departments
- Finance and tax issues
- Issues related to business environment in the country
- Issues related to input materials
- Some of the market related barriers

The issues related to input materials are in control of the government because the basic metal industries in Pakistan are government-owned.

But this research went far beyond the government issues and empirically found that there are many important barriers (29 % of total number of significant barriers) that are in the control of the manufacturing companies themselves. These barriers are of the following types:

- Factory management related barriers
- Knowledge related barriers
- Production equipment and processes related barriers
- Expertise related barriers
- Entrepreneurship related barriers
- Some of the vendor related barriers



In addition, some (17 %) of the important barriers are neither in control of the factory managers nor the government. These generally include market related factors and issues beyond the boundaries of the country.

## **7.6 Conclusions from the findings**

One important conclusion is that the majority of the problems in technology development in manufacturing companies of the developing countries are not because of technology itself but because of other issues affecting technology development.

The second conclusion is that the role of the government is important in solving the problems of manufacturing companies. On the one hand the government should not create problems for these companies and on the other hand it should try to help the companies solve other problems.

## **7.7 What next?**

The next chapter will present the solutions found to be effective for the significant barriers reported here.

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## APPENDIX 7A

## APPENDIX 7A Complete list of barriers found during exploratory interviews













Table 7A.1 provides a complete list of all the barriers found in the content analysis of the exploratory interviews. For completeness, this list also includes the significant barriers listed in table 7.2. The table also provides description of barriers, the number of interviews in which various barriers appeared, and identifies barriers to be in the control of the factory management or the government or neither of them.













**Table 7A.1:** Barriers, their description, and identification of their being in control of factory management or government. (N = Number of interviews in which this factor appeared,  = In control of factory management,  = In control of government, ○ = In control of neither the factory management nor the government)

	Barrier	Description of barrier	N	Control
<b>Technology and its acquisition</b>				
1.	Lack of information and knowledge about technology	There is general lack of knowledge and information in the company about technology and its development.	6	
2.	Technology improvement is neglected	Technology improvement is generally neglected in the company.	2	
3.	Lack of interest in basic research	People and management in the company are generally not interested in basic research that can develop new technologies.	1	
4.	Lack of engineering libraries	Engineering reference libraries are not present in the country.	1	
5.	Unavailability of technical books	Technical books are generally difficult to obtain in the country.	1	










6.	Lack of technical support in the country	Sources that can provide technical support to industries are generally not available in the country.	1	
7.	Limited internet access from Pakistan	Access to internet is relatively limited from Pakistan and its speed is relatively slow.	1	
8.	External experts not familiar with business processes	If external experts are called to solve managerial and technical problems, they may not be completely effective as they are not accustomed to national business processes	1	○
<b>Products</b>				
9.	Lack of product diversification	Inability to diversify into new products in the same area or into new areas.	1	
<b>Product development</b>				
10.	Technical problems in product development	Technical problems of various types hinder product development process.	2	
11.	Shortage of design engineers	Design engineers are in shortage in the country.	1	
12.	Lack of design houses	Design houses are rarely available in Pakistan, and so product design cannot be sourced out.	1	
13.	Lack of awareness of design	There is general lack of awareness in the country about product design technology.	1	
14.	Regulations prohibit reverse-engineering	International regulations prohibit reverse-engineering.	1	○
<b>Production Equipment</b>				
15.	Inadequacy of production equipment	Lack of adequate equipment is hindrance in production of the products.	5	
16.	Lack of automation	Manual labour-intensive methods of production hinder production of new high quality products.	2	















17.	Problems in maintenance of imported machines	Problems are faced in maintenance of imported machines as long delays may occur if the machines develop faults or spares are required to be imported	1	
18.	Problems in maintenance of old equipment	Problems are faced in maintenance of old equipment as it is generally not in production with the manufacturer and spares are difficult to arrange.	2	
19.	Low accuracy machinery	Machinery available in the company has low accuracy.	1	
20.	Problems of transition to new machines	When new machines are introduced, difficulty is faced in switching from old machines to these new machines.	1	
21.	Lack of knowledge to maintain equipment	Information and knowledge to maintain production equipment is generally not present in the company.	1	
22.	Non-availability of equipment in Pakistan	Production equipment is not available in the country.	1	
23.	Lack of tool and die making sources	There is shortage of sources to design and manufacture production tools and dies.	1	
24.	Long time required in import of equipment	Long lead-time is required in import of new production equipment.	1	○
<b>Methods and processes</b>				
25.	Technical problems in production processes	Technical problems arise in production processes.	3	
26.	Shortage of process design engineers	Process design engineers are in shortage in the company.	1	
27.	Lack of experience	People in the company lack experience of certain production processes.	2	
28.	Lack of quality culture	Culture of quality control is lacking in the company.	2	
29.	Shortage of heat treatment service companies	Very few companies exist that provide heat treatment services.	1	














<b>Input materials and components</b>				
30.	Small volume requirement of components	Electronic components required for product development are generally required in small quantities but companies generally agree in selling only large quantities.	1	
31.	Lack of availability of electronic components in Pakistan	Electronic components are generally not available in national markets.	3	
32.	Difficulties in import of raw materials	Import of materials is a difficult and time-consuming process.	3	
33.	Non-availability of raw materials in Pakistan	Availability of input materials is poor in the country.	5	
34.	Difficulty in import of electronic components	Import of electronic components is long and tedious process.	3	
35.	Poor or inconsistent raw material quality available in Pakistan	Quality of raw material available nationally is poor and / or inconsistent.	3	
36.	Government requirement to procure poor nationally-produced materials	In order to support the incompetent national material industry, government compels industry to buy poor quality material from it.	2	
37.	Electronic components available in the country are unreliable	Electronic components available in the country are unreliable.	1	
38.	Components with fake markings sold locally	Sometimes electronic components available in the market are not of the type marked on them.	1	
39.	Raw material supply in national market is intermittent	Supply of raw material in the national market is not continuous but intermittent.	1	
40.	Restriction on import of raw materials	Government has imposed restriction on import of raw materials.	1	
41.	Single source of steel in Pakistan	There is only one source of steel in Pakistan. Unfortunately, its product	1	
















		quality is not good.		
42.	High price and large minimum order quantity in national market	Electronic components available in the country are generally accompanied by higher prices and large minimum order quantities.	1	○
43.	Long lead time in imports	Import of materials requires long lead times that slows down product development and production.	2	○
<b>Management issues</b>				
44.	People resisting technology changes	People generally resist changes to better technology.	11	
45.	Opposition of senior management for technology changes	Board of Directors or senior management of the company opposes technology changes.	4	
46.	Lack of teamwork	Team work generally lacks in the company.	3	
47.	Lack of professional management	The management of the company is in the hands of the people who are not professional managers.	4	
48.	Lack of system	Work in the company is not according to defined systems or procedures.	1	
49.	People lack commitment	People in the company or management lack commitment with the objectives of the company.	2	
50.	On-site management not empowered	Top management is away from the factory but the decision making power has not been delegated to management present in the factory.	1	
51.	Poor management procedures	Procedures employed for managing the factory are faulty and not helpful in technology development.	2	
52.	Lack of motivation	Management or workers in the company are not motivated for technology development in the company.	1	














53.	Lack of planning	Company is being run without elaborate plans or without long-term plans	1	
54.	Lack of vision	There is no long-term vision of the company	1	
55.	Lack of managerial capabilities	The people managing the company matters are void of managerial capabilities.	2	
56.	Lack of correspondence between salaries and skill	Mismatch between salaries of people and their skill level exists in the company.	1	
57.	Lack of coordination	Coordination amongst various sections of factory is poor.	1	
58.	Lack of communication	Communication between various sections of factory is lacking.	1	
59.	Lack of technically skilled manpower in the vicinity	Technically skilled manpower is not available in the vicinity of the company.	1	
60.	Lack of confidence for work never done before	People generally lack confidence for work that has not been done before.	1	
61.	Reactive style of work	Companies generally improve in reaction to other companies rather than developing their own development plans.	1	
62.	Unions don't consider company's advantages	Unions are not considerate of company and its well being. They are only interested in benefits at personal level.	1	
63.	Negative attitude of colleagues	Less capable colleagues create problems and have negative attitude towards those who take initiatives for technology improvement.	1	
64.	High management away from plant	Top management is away from the factory and is not directly involved in running the factory.	1	














65.	Hiring people without requirement	People are hired in the company even when they are not required in the company.	1	
66.	Hiring incompetent people	Incompetent people are hired in the company.	1	
67.	Nepotism	Nepotism is followed in hiring process in the company.	2	
68.	Managerial mistakes	Management mistakes result in poor management of technology.	1	
69.	Trying to make everything yourself	Company tries to make every part of the product by itself without using the services of other vendors.	1	
70.	Not giving due importance to lower staff	Due importance is not given to lower level staff and workers who do on-ground work.	1	
71.	Lack of people for quality management	There is shortage of people who understand quality management procedures and can implement them.	1	
72.	Lack of stability in the company	Company is not managerially or financially stable.	1	
73.	Administrative problems	Problems exist in administration of the company.	2	
74.	Negative attitude of expert people	Expert people in the company try to retain knowledge to them and don't disseminate it.	1	
75.	Stress on short-term benefits	Companies generally focus on short-term monetary gains and not on long-term development.	1	
76.	Lack of engineering approach	Companies try to solve technical problems through 'make-shift' approach and don't follow engineering approach.	1	
77.	No realisation of importance of human resource	Management of the company lacks realisation of importance of human resource development.	1	










78.	High labour cost in public sector	Content of labour cost in the product cost is high in the public sector.	1	
79.	Restriction on hiring	Government has put restrictions on hiring in the companies in the public sector.	1	
80.	Restriction on salary structure	Government has put restrictions on the salary structure in the companies in the public sector.	1	
<b>Expertise in the company</b>				
81.	Shortage of trained human resource	There is shortage of trained people in the country.	5	
82.	Lack of good human resource	There is shortage of good human resource in the company.	3	
83.	Illiteracy of employees	Illiteracy of employees in the company creates problems in technology development.	4	
84.	Lack of training of lower level staff	Although technical people in the higher positions are trained but training of lower level staff is generally neglected.	1	
85.	Lack of encouragement for R&D	Management of the company does not encourage research and development work.	1	
86.	Lack of expertise	People lack expertise to do required technical work.	1	
87.	Illiterate supervisors cannot document technology	Supervisors in the company are illiterate. They can give ideas but cannot document those ideas.	1	
88.	Lack of familiarity of people with new technology	Very few people in the company are familiar with latest technology.	1	
89.	Experts have been placed in wrong fields	People who have specialization in certain fields have not been placed in their respective fields.	1	
90.	Management is reluctant about training	Management is reluctant to train people especially about sending people abroad	1	














		for training.		
91.	Lack of manufacturing engineers	Shortage of manufacturing engineers exists in the company.	1	
92.	Lack of qualified technicians	Shortage of qualified technicians exists in the company.	2	
93.	Engineers shy of working with their hands	Engineers in the company are shy of working with their own hands. They only want to supervise other people.	1	
94.	Engineers reluctant to work under illiterate supervisors	Engineers are reluctant to work under illiterate but experienced supervisors as they think that they are more qualified.	1	
95.	Lack of skilled labour	Skilled labour is in shortage in the company.	1	
96.	No system of training	No system exists in the company for training of workers on regular basis.	1	
97.	Engineers not given right kind of job	Engineers are not placed on the kind of jobs for which they have been trained.	1	
<b>Human factors</b>				
98.	Large number of employees leaving the company	Large number of employees leaving the company creates problem in development of technology.	7	
99.	People lack opportunities	People are not given opportunities for improvement in technology.	1	
100.	People are content at existing position	People are content at their present state, so they don't make effort for improvement in technology.	1	
101.	People lack initiative	People lack initiative and so they don't make effort for improvement in technology.	1	
102.	Dissatisfied workers	Workers are generally dissatisfied in the company.	1	
103.	Hot temperament of top management	Top management has hot temperament.	1	













104.	Ego problems widespread	Many people in the company have ego problems.	2	
105.	People moving to secure government jobs	People prefer to move to secure government jobs.	1	○
106.	Brain drain from Pakistan	Talented young people go to different countries in search of better opportunities. This results in less capable people working in national industry.	3	○
<b>Financial and tax issues</b>				
107.	Duties / sales tax high on national products than on imports	Duties and sales taxes are higher on nationally produced products than on imported products.	6	
108.	Problems in getting finance from banks	It is difficult to get finance from national banks as their conditions are strict.	3	
109.	Shortage of funds and resources	Lack of resources or funds doesn't allow technology improvement.	13	
110.	High price of utilities (electricity, gas, telephone and water)	Price of utilities is higher in the country as compared with competing countries.	5	
111.	State financing is not available	State financing is not available in the country.	1	
112.	More duty on components, less on finished goods	Duties on finished products are higher and on components are lower, which makes manufacturing in the country uneconomical.	2	
113.	Electronics components are expensive	High cost of electronics components make them difficult to buy.	1	
114.	Bad tariff structure making things expensive	Tariff structure enforced by the government is such that it makes products expensive.	1	
115.	Problem in taxes	There are inconsistencies in tax structure that creates problems.	1	
116.	Funding agencies don't	Banks and other institutions providing	1	















	fund software projects	finance don't provide finance for software projects.		
117.	High raw material price	Raw material prices are high in the national market.	1	
118.	Companies cannot afford R&D	It is difficult for the manufacturing companies to pay for high cost of research and development.	2	
119.	Banks not lending to engineering industry	Banks don't lend to engineering industry. They prefer to lend to popular industries like textiles.	1	
120.	People are not interested in investing in engineering industry	The common trend of people is that they tend not to invest in engineering industries.	1	
121.	High prices of machinery	High machinery cost makes it difficult to buy.	5	○
122.	Expensive software	Software used for design and manufacture of products are costly.	2	○
123.	High cost of transfer of technology or technology licensing	Cost associated with import of technology through licensing or otherwise is high	2	○
<b>Educational issues</b>				
124.	University curricula not related to industry	University curricula are not relevant to industry, so graduates produced are not useful for industry.	6	
125.	R&D by government and other institutions unrelated to industry	Research and development carried out in the country is not of applied nature, and is unrelated to industry.	4	
126.	No system of producing technicians	There is no system to produce technicians in the country, which has created gap between engineers and workers.	1	
127.	Polytechnics not producing manufacturing people	Polytechnics that are producing technicians are not producing technicians for manufacturing industry.	2	
128.	University teachers	University teachers are ignorant of	1	














	ignorant of industry practices	industry practices, and so are not in position to provide consultancy.		
129.	Engineering graduates lack industry knowledge.	Engineering graduates lack practical knowledge useful for industry.	2	
130.	Lack of motivation in universities	People in universities lack motivation to improve technology.	1	
<b>Issues related to government</b>				
131.	Corrupt government functionaries	Government functionaries dealing with industry are generally corrupt.	10	
132.	Government policies change frequently	Government policies change frequently, which discourages industrialists to make long-term plans.	10	
133.	Long and difficult government procedures	Lot of time and effort is wasted in trivial matters because of lengthy and time-consuming government procedures.	8	
134.	Bad attitude of government inspectors or functionaries	Government functionaries coming to industry for inspection generally have negative or bad attitude towards industry.	4	
135.	Lack of government support	Government does not provide help and support to industry.	3	
136.	Incapable government functionaries	Government functionaries are either unqualified or incapable for their assignments.	4	
137.	Problems at customs during imports or exports	Industries generally face problems and wastage of time at customs during imports or exports.	5	
138.	Hurdles by lower level staff in government procedures	Lower level government staff creates hurdles for businesses.	3	
139.	Large number of government inspectors	Large number of government inspectors creates problems for industry.	5	








140.	Government incentives are not enforced	Government announces financial incentives for industry but those are not enforced.	3	
141.	Bad government policies	Government policies are bad for technology development in manufacturing industries.	4	
142.	Inactivity of government research institutes	Government research institutes are inactive and thus are not supporting national manufacturing industry	2	
143.	Lack of infrastructure facilities	Infrastructure facilities are poor in the country.	1	
144.	Bureaucratic controls on industry.	Government has placed lot of bureaucratic limitations and controls on the working of the industries.	1	
145.	No role of stakeholders in policy making	Industry representatives have no role in making policies for industry.	1	
146.	Government not implementing standards	Government does not implement product standards in the country.	1	
147.	Government powers used against businessmen	Government generally uses its powers against businessmen.	1	
148.	Wrong methods of technology development in the Govt	Government takes steps that are not helpful for technology development in industry.	1	
149.	Lack of continuity in government research institutions	Lack of continuity of people exists in government research institutions.	1	
150.	Unrelated R&D in government institutions	Government research institutions are doing R&D that is unrelated to industry.	1	
151.	Old regulations on electronics create problems	In a dynamic field like electronics, government is still using old regulations.	1	



152.	Govt not permitting national products to sell in Pakistan	Government does not permit national products to sell in Pakistan.	1	
153.	Government not paying outstanding bills	Government does not pay its outstanding bills for work done by the company.	1	
154.	Government demand is intermittent	The demand of the government is intermittent.	1	
155.	Government not promoting national products	Government does not take steps to promote nationally manufactured products.	1	
156.	Non-technical people in government	Non-technical people in the government are taking decisions for industry.	1	
157.	Government-businessman corrupt partnership	A corrupt partnership exists between government and businessman.	1	
158.	Lack of trust of bureaucracy on industrialists	Bureaucracy does not trust industrialists.	2	
159.	Government does not allow offering credit to foreign customers	Government does not allow offering credit to foreign customers.	1	
160.	Long time required for court cases	If industrialists decide to go in court against decisions of govt inspectors, the court takes very long time to settle the cases.	1	
161.	Changing SRO numbers in every budget	SRO numbers change in every budget, which creates problems at customs.	1	
162.	Government officials do a lot of lip service but fail to act	Government officials do a lot of lip service but when it comes to act on ground, they fail to facilitate industry	1	
163.	Lack of dynamic industrial package from government	Government has not provided any motivating industrial package for technology development in industry.	1	



164.	Lack of effective forums in government	No forums exist in government for discussion of problems faced by the industry.	1	
<b>Business environment factors</b>				
165.	Lack of technological infrastructure in the country	Technological infrastructure including basic and vendor industries, knowledge base, know-how, service providers, basic and applied research etc, is generally weak in the country.	5	
166.	Lack of standards in Pakistan	Standards about various products are not followed in the country.	4	
167.	Transportation is expensive	Transportation cost is high in the country that increases cost of products.	1	
168.	Bonded carrier is very expensive	Cost of bonded carriers is high in the country that increases cost of products.	1	
169.	Problem of law and order	Law and order situation in the country is not good, which creates problems for industries.	2	
170.	No collaboration among each other	Companies don't collaborate with each other.	2	
171.	Lack of copyright concept	Copyright regulations are not followed in the country resulting in insufficient return on original work.	1	
172.	No forum for OEM suppliers	No forum exists for OEM suppliers to discuss their common issues and problems.	1	
173.	Lack of metallurgy based industry	Shortage of metallurgy based industry exists in the country.	2	
174.	Weak basic engineering technology	Basic engineering industry and technology is generally weak in the country.	1	
175.	Lack of plastics base	Basic industries of plastics and other associated industries are lacking in the country.	1	
176.	Shortage of utilities	Utilities are in shortage in the country.	2	

177.	Changing world technology standards	Technology standards change in the world making it mandatory for national manufacturers to shift to them at heavy expense.	1	○
178.	Cost of certifications is very high	Cost of certification of products for exports is high, which increases their costs.	1	○
179.	Certification from Pakistan is not acceptable	Certification of products from Pakistan is not acceptable in advanced countries.	1	○
180.	Investment frauds	Many investments are only made in papers resulting in lack of trust of the government upon industrialists.	1	○
181.	Aid agencies not funding private sector	Aid agencies don't provide funding to private sector for technology development projects.	1	○
182.	Shortage of other companies in the same business	Companies introducing innovative concepts face problems because too few companies work in their area resulting in few people educated about latest technologies	1	○
<b>Market factors</b>				
183.	Poor marketing of products	Marketing of products and services is poor in the company.	3	
184.	Smuggling	Smuggling of goods without import duties adversely effect national products.	3	
185.	Competition of our products with cheap imports	Nationally manufactured products have to compete with cheap imports.	4	
186.	Conditionalities imposed on Pakistan on tariff, trade and industry issues by IMF and World Bank	Conditionalities imposed on Pakistan on tariff, trade and industry issues by IMF and World Bank result in policies that are bad for industries.	3	
187.	Lobbies of foreign companies work	Foreign companies play unethical negative tactics against national	2	





	against national companies	companies to sell their products in the country.		
188.	Afghan transit trade has damaged industry	Afghan transit trade is a source of smuggling and thus harmful for national products.	2	
189.	High import tariffs	High import tariffs on raw materials and components tend to increase the prices of goods produced nationally.	1	
190.	Preference of foreign brands by people	People generally patronize imported brand names instead of nationally produced products.	4	○
191.	Small national market	The market for products within the country is small.	14	○
192.	WTO regulations	WTO regulations would hamper national technology and product development.	5	○
193.	Reduction in investment in the country	General trend of reduction in investment exists in the country.	1	○
194.	Restriction on exporting to Pakistan	Many countries / companies have put restrictions in exporting products and services to Pakistan.	2	○
195.	9-11 scenario affected badly	9-11 scenario has put Pakistan as front line state fighting against terrorism and thus has repelled investments in national industry.	1	○
196.	Dumping policy of foreign countries	Foreign countries sometime have policies of dumping cheap goods in Pakistan.	1	○
197.	Competitors discouraging clients	Some competing companies play negative tactics and discourage customers.	1	○
198.	Lack of continuous flow of products / cyclic demand	Demand of products is not continuous or it keeps increasing or decreasing.	2	○
199.	Foreign customers	Some foreign customers don't want to	1	○

	discriminate against defence related companies	deal with those companies who also work for defence forces.		
200.	Problems in exports	Problems are faced in exporting goods.	1	○
201.	Uncertainty in the market	Uncertainty generally prevails in national investment climate.	1	○
<b>Foreign factors</b>				
202.	Lack of interaction with developed countries	Pakistani industries lack interaction with developed countries.	1	
203.	Restriction on foreign visits or contacts by the government	Government sometimes places restrictions on foreign contacts or visits that create problems in imports and exports.	3	
204.	Restrictions on collaboration	Government sometimes put restrictions on collaboration with foreign companies.	1	
205.	Changing foreign exchange rates	Unstable foreign exchange rates make it difficult for investors and industrialists to make long term investments.	1	
206.	Foreign investment in projects	Projects with foreign investment don't aspire to develop or use nationally available technology.	1	
207.	No collaboration with neighbouring countries	Collaboration with neighbouring countries may result in faster technology development but in our case this collaboration is not there.	1	
208.	Bad perceptions about Pakistan in world market	Pakistani products have poor perception in foreign markets.	4	○
209.	Restrictions on export of technology by some countries or companies	Some countries or companies put restrictions on export of technology to Pakistan that hampers technology development in Pakistan.	5	○
210.	Geopolitical situation	Due to current world political situation,	4	○



	or sanctions against Pakistan	many times sanctions have been enforced upon Pakistan that make foreign trade difficult.		
211.	Foreign pressures for unfair duties	Foreign governments providing financial assistance to Pakistan sometimes pressurize for unfair duties for imports that are detrimental for national industry.	1	○
212.	Vicinity to Afghanistan	Due to vicinity of Afghanistan, investment climate is poor in Pakistan.	1	○
<b>Entrepreneurship</b>				
213.	One-man-show (Owner or one person making every significant decision himself)	Owner or one person makes every significant decision himself in the company, which is detrimental for improvement of technology.	3	
214.	Industrialist not interested in R&D	Industrialists are not interested in research and development.	1	
215.	Industrialist having no trust in national technology	Industrialists don't have trust in national technology.	1	
216.	Lack of opportunities of entrepreneurship	Lack of opportunities of entrepreneurship exists in the country.	1	
217.	Culture of entrepreneurship does not exist	Culture of entrepreneurship doesn't exist in the country.	1	
218.	Job mentality of people	Generally people have job mentality that hampers in encouraging people for business ventures and development.	1	
219.	Lack of experience of running a public limited company	People lack experience in running public limited companies. This results in poor business development.	1	
<b>Vendors</b>				
220.	Vendors ignorant about quality	Majority of the vendor industries in the country are ignorant of quality.	3	
221.	Vendors lack technical	Vendor industry lacks technical skills	3	

	skills	required to do quality work.		
222.	Illiterate vendors	People in vendor industry are uneducated.	4	
223.	Lack of qualified people in vendor industry	There is shortage of qualified people in the vendor industry.	1	○
224.	Inconsistency in quality of suppliers	Inconsistency exists in quality of products produced by vendor industry.	1	○
225.	Low reliability of supplies from suppliers	Reliability of supplies provided by vendor industry is low.	1	○
<b>Ethical issues</b>				
226.	Lack of ethics	There is general lack of ethics in the people of the country.	1	



## Chapter 8

# **Solutions to Barriers in Technology Development**

### **8.1 Introduction to ‘solutions’**

The enormous literature on technology development, especially related to East Asian countries, has not generally mentioned barriers in the path of technology development and their possible solutions. This research has attempted to fill this void. The barriers were presented in the previous chapter. This chapter deals with the solutions to those barriers.

During the interviews conducted with high-ranking experienced managers in high value-added manufacturing companies in Pakistan the interviewees were asked about possible solutions for the barriers that they had cited. The content analysis of these interviews thus resulted not only in a compiled list of barriers, but a list of solutions to various barriers was also obtained. Actions independent of barriers were also obtained.

### **8.2 Two sources of solutions**

In preparing for the content analysis, it was decided that only those solutions would be included which had been explicitly mentioned to be solutions to a specific barrier cited by the same interviewee who cited the barrier. Solutions were not obtained this way for all the barriers, but fortunately solutions were mentioned for the majority of the



significant barriers. Some of these solutions seem to be fairly straightforward but others may not be thought very obvious.





After the content analysis process had been completed, the researcher then selected possible solutions to the barriers from the list of actions cited by all the interviewees (chapter 9), even when these were not explicitly cited as solutions to particular barriers. These additional solutions were added in order to make the list of solutions as comprehensive as possible.

### 8.3 Solutions to significant barriers






















Table 8.1 lists the solutions to the significant barriers, i.e. barriers identified in chapter 7 as being found in 3 or more interviews. The solutions written in normal typeface are those mentioned by the same interviewee who cited the barrier, and those written in italics are the solutions selected by the researcher from the complete list of actions.

















**Table 8.1:** Solutions to significant barriers, obtained during the content analysis of the exploratory interviews. Normal font = Solution nominated by interviewee who nominated the barrier. Italic = Solution assigned by researcher.

 = In control of factory management,  = In control of government

























	Significant barrier	Solution to significant barrier	Control
<b>Technology and its acquisition</b>			
1.	Lack of information and knowledge about technology	<ul style="list-style-type: none"> <li>• Send people in existing plants for know-how</li> <li>• Develop complete knowledge about technology to develop</li> <li>• <i>Invest in &amp; study published technical material</i></li> <li>• <i>Take help from consultants</i></li> </ul>	   























		<ul style="list-style-type: none"> <li>• <i>Take help from the Internet</i></li> <li>• <i>Visit and / or take part in industry exhibitions</i></li> <li>• <i>Take membership of technical institutes</i></li> <li>• <i>Create professional society in your area of work</i></li> <li>• <i>Get information from media</i></li> <li>• <i>Obtain information by meeting people</i></li> <li>• <i>Liaison with R&amp;D companies in your area</i></li> </ul>	      
<b>Production equipment</b>			
2.	Inadequacy of production equipment	<ul style="list-style-type: none"> <li>• <i>Modify products according to infrastructure available in the company</i></li> <li>• <i>Devise innovative solutions for lack of equipment</i></li> <li>• <i>Change to better equipment</i></li> <li>• <i>Modify equipment according to requirement</i></li> </ul>	   
<b>Methods and processes</b>			
3.	Technical problems in production processes	<ul style="list-style-type: none"> <li>• <i>Obtain consultancy</i></li> <li>• <i>Collaborate with foreign manufacturers</i></li> </ul>	 
<b>Input materials and components</b>			
4.	Lack of availability of electronic components in Pakistan	<ul style="list-style-type: none"> <li>• <i>Create an office in an advanced country</i></li> <li>• <i>Collaborate with foreign suppliers for components</i></li> </ul>	 
5.	Difficulties in import of raw materials	<ul style="list-style-type: none"> <li>• <i>Develop materials industry in the country</i></li> <li>• <i>Create an office in an advanced country</i></li> </ul>	 
6.	Non-availability of raw materials in Pakistan	<ul style="list-style-type: none"> <li>• <i>Develop materials industry in the country</i></li> <li>• <i>Materials industry should be supported by the government</i></li> <li>• <i>Create an office in an advanced country</i></li> </ul>	  
7.	Difficulty in import of electronic	<ul style="list-style-type: none"> <li>• <i>Government should help in import of components</i></li> </ul>	

















	components	<ul style="list-style-type: none"> <li>• Create an office in an advanced country</li> <li>• <i>Collaborate with foreign suppliers for components</i></li> <li>• <i>Source components from wherever suitable</i></li> </ul>	  
8.	Poor or inconsistent raw material quality available in Pakistan	<ul style="list-style-type: none"> <li>• Develop material testing facilities</li> <li>• <i>Develop materials industry in the country</i></li> <li>• <i>Minimal import duties on raw materials</i></li> </ul>	  
<b>Management issues</b>			
9.	People resisting technology changes	<ul style="list-style-type: none"> <li>• Convince people for change</li> <li>• Make people feel that they are important</li> <li>• Give people chance to speak their mind</li> <li>• Give monetary benefits to people</li> <li>• Train people on new machinery</li> <li>• Change-management program</li> <li>• Recruit new blood</li> </ul>	      
10.	Opposition of senior management for technology changes	<ul style="list-style-type: none"> <li>• Convince Board of Directors or senior management for technology improvements</li> </ul>	
11.	Lack of teamwork	<ul style="list-style-type: none"> <li>• Teamwork should be followed</li> <li>• <i>Remove communication gaps</i></li> </ul>	 
12.	Lack of professional management	<ul style="list-style-type: none"> <li>• Install professional management</li> <li>• <i>Development of management capability</i></li> <li>• <i>Arrange meetings to discuss management issues</i></li> </ul>	  
<b>Expertise in the company</b>			
13.	Shortage of trained human resource	<ul style="list-style-type: none"> <li>• Train people</li> <li>• Invest in human resource</li> <li>• Get knowledge yourself and transfer to workers</li> <li>• Send people abroad for training</li> <li>• Make training institute in the company</li> </ul>	   

















		<ul style="list-style-type: none"> <li>• <i>Acquiring skilled manpower from other companies</i></li> </ul>	 
14.	Lack of good human resource	<ul style="list-style-type: none"> <li>• Employ good human resource</li> <li>• Maintain and retain human resource</li> <li>• Plan careers of people</li> <li>• <i>Invest in human resource</i></li> <li>• <i>Train people</i></li> <li>• <i>Acquiring skilled manpower from other companies</i></li> </ul>	     
15.	Illiteracy of employees	<ul style="list-style-type: none"> <li>• Provide education</li> <li>• Provide training</li> </ul>	 
<b>Human factors</b>			
16.	Large number of employees leaving the company	<ul style="list-style-type: none"> <li>• Hire people in batches and then select</li> <li>• Pay high salaries</li> <li>• <i>Respect the workers</i></li> <li>• <i>Make the workers satisfied</i></li> <li>• <i>Give sense of participation to workers</i></li> <li>• <i>Facilitate workers especially in hour of need</i></li> </ul>	     
17.	Brain drain from Pakistan	<ul style="list-style-type: none"> <li>• Forcefully stop brain drain</li> </ul>	
<b>Financial and tax issues</b>			
18.	Duties / sales tax high on national products than on imports	<ul style="list-style-type: none"> <li>• Taxes should be on retailer</li> <li>• <i>Duty structure conducive to development of national industry</i></li> </ul>	 
19.	Problems in getting finance from banks	<ul style="list-style-type: none"> <li>• Finance should be available from the banks</li> <li>• <i>Banks should have experts for evaluation of industry proposals</i></li> <li>• <i>Invest profits, don't borrow from bank</i></li> </ul>	  
20.	Shortage of funds and resources	<ul style="list-style-type: none"> <li>• Depend upon available resources</li> <li>• Look for cheaper alternate solutions</li> </ul>	 

21.	High prices of machinery	<ul style="list-style-type: none"> <li>• Manufacture the required machinery yourself</li> </ul>	
22.	High price of utilities (electricity, gas, telephone and water)	<ul style="list-style-type: none"> <li>• <i>Produce electricity yourself</i></li> </ul>	
<b>Educational issues</b>			
23.	University curricula not related to industry	<ul style="list-style-type: none"> <li>• Universities should work for industry</li> <li>• <i>Get associated with universities</i></li> <li>• <i>Try to improve technology level in universities</i></li> </ul>	  
24.	R&D by government and other institutions unrelated to industry	<ul style="list-style-type: none"> <li>• University people should have industrial backgrounds</li> <li>• <i>Get associated with universities</i></li> <li>• <i>Try to improve technology level in universities</i></li> </ul>	  
<b>Issues related to government</b>			
25.	Corrupt government functionaries	<ul style="list-style-type: none"> <li>• Don't pay bribes</li> <li>• Give these people minimal bribes</li> <li>• Try to avoid dealing with the government</li> <li>• Fight cases in courts</li> <li>• Government should protect businessmen</li> </ul>	    
26.	Government policies change frequently	<ul style="list-style-type: none"> <li>• Government should not change its policies frequently</li> <li>• <i>Involve stakeholders in policy making</i></li> <li>• <i>Appoint industry-related people in ministries</i></li> <li>• <i>Communication between government and business should be close</i></li> </ul>	   
27.	Long and difficult government procedures	<ul style="list-style-type: none"> <li>• Eliminate procedures</li> <li>• <i>Appoint industry-related people in ministries</i></li> <li>• <i>Communication between government and business should be close [This was followed in Japan and South Korea]</i></li> </ul>	  



28.	Bad attitude of government inspectors	<ul style="list-style-type: none"> <li>• Be open to inspectors</li> </ul>	
29.	Lack of government support	<ul style="list-style-type: none"> <li>• Government policies should support industry</li> <li>• <i>Appoint industry-related people in ministries</i></li> <li>• <i>Communication between government and business should be close [This was followed in Japan and South Korea]</i></li> <li>• <i>Involve stakeholders in policy making [This was followed in Japan and South Korea]</i></li> <li>• <i>Engineering Development Board is positive effort</i></li> </ul>	    
30.	Incapable government functionaries	<ul style="list-style-type: none"> <li>• Government functionaries should be engineers [This is what was followed in Japan after the Second World War]</li> <li>• <i>Appoint industry-related people in ministries</i></li> </ul>	 
31.	Problems at customs during imports or exports	<ul style="list-style-type: none"> <li>• Work with customs and get an SRO [Special Revenue Order] issued</li> </ul>	
32.	Hurdles by lower level staff in government procedures	<ul style="list-style-type: none"> <li>• <i>Eliminate procedures</i></li> </ul>	
33.	Large number of government inspectors	<ul style="list-style-type: none"> <li>• <i>Be open to inspectors</i></li> </ul>	
34.	Government incentives are not enforced	<ul style="list-style-type: none"> <li>• <i>Communication between government and business should be close</i></li> </ul>	
35.	Bad government policies	<ul style="list-style-type: none"> <li>• <i>Involve stakeholders in policy making</i></li> <li>• <i>Appoint industry-related people in ministries</i></li> <li>• <i>Communication between government and business should be close</i></li> </ul>	  
<b>Business environment factors</b>			
36.	Lack of	<ul style="list-style-type: none"> <li>• Copy &amp; Absorb old technology</li> </ul>	

	technological infrastructure in the country	<ul style="list-style-type: none"> <li>• Enter into joint ventures</li> </ul>	
37.	Lack of standards in Pakistan	<ul style="list-style-type: none"> <li>• Follow standards</li> <li>• National standards body should be there</li> <li>• <i>Government should ensure compliance to standards</i></li> </ul>	  
<b>Market factors</b>			
38.	Poor marketing of products	<ul style="list-style-type: none"> <li>• Products should be aggressively marketed</li> </ul>	
39.	Smuggling	<ul style="list-style-type: none"> <li>• Stop smuggling</li> </ul>	
40.	Competition of our products with cheap imports	<ul style="list-style-type: none"> <li>• <i>Government should give equal opportunities to national companies</i></li> <li>• <i>Protect industry through tariff barriers</i></li> </ul>	 
41.	Preference of foreign brands by people	<ul style="list-style-type: none"> <li>• <i>Create local brand</i></li> <li>• <i>Products should be aggressively marketed</i></li> </ul>	 
42.	Small national market	<ul style="list-style-type: none"> <li>• Government should give equal opportunities to national companies</li> </ul>	
43.	Conditionalities imposed on Pakistan on tariff, trade and industry issues by IMF and World Bank	No solutions cited	
44.	WTO regulations	No solutions cited	
<b>Foreign factors</b>			
45.	Restriction on foreign visits or contacts by the government	<ul style="list-style-type: none"> <li>• Government controls on visits should be removed</li> </ul>	
46.	Bad perceptions about Pakistan in world market	<ul style="list-style-type: none"> <li>• Export products</li> <li>• <i>Work as OEM with foreign manufacturer</i></li> </ul>	 



		<ul style="list-style-type: none"> <li>• <i>Make joint ventures with foreign companies</i></li> <li>• <i>Prove your capability of entering into joint venture</i></li> <li>• <i>Establish overseas companies</i></li> </ul>	  
47.	Restrictions on export of technology by some countries or companies	<ul style="list-style-type: none"> <li>• Government should give subsidies for technology import</li> <li>• Government should protect market to force foreign manufacturers for technology transfer</li> <li>• <i>Work as OEM with foreign manufacturer</i></li> <li>• <i>Make joint ventures with foreign companies</i></li> <li>• <i>Prove your capability of entering into joint venture</i></li> </ul>	    
48.	Geopolitical situation or sanctions against Pakistan	<ul style="list-style-type: none"> <li>• <i>Establish overseas companies</i></li> </ul>	
<b>Entrepreneurship</b>			
49.	One-man-show (Owner or one person making every significant decision himself)	<ul style="list-style-type: none"> <li>• No one-man-shows</li> </ul>	
<b>Vendors</b>			
50.	Vendors ignorant about quality	<ul style="list-style-type: none"> <li>• Educate vendors on quality</li> <li>• <i>Testing &amp; inspection facilities should be at suppliers' factories</i></li> <li>• <i>Crte a vendor development cell in the company</i></li> </ul>	  
51.	Vendors lack technical skills	<ul style="list-style-type: none"> <li>• Engineering graduates should be entrepreneurs</li> <li>• <i>Educate industrialists to hire qualified people</i></li> <li>• <i>Crte a vendor development cell in the company</i></li> </ul>	  
52.	Illiterate vendors	<ul style="list-style-type: none"> <li>• <i>Educate vendors on quality</i></li> </ul>	

## **8.4 Discussion of the solutions**

It can be seen from table 8.1 that the majority of the solutions are ones that can be followed by the factory management themselves. Even some of the solutions mentioned for issues related to the government are in the control of the factory managers. This is on the one hand a surprising result as the government may be thought of as responsible for solving problems related to manufacturing companies. On the other hand, considering the general thinking of the factory managers in Pakistan, this is not a surprising result, as majority of them perceive the government to be problem-creator rather than problem-solver.

It should be noted that although other solutions could easily be imagined for the particular barriers, table 8.1 only provides those solutions that emerged from content analysis during this research. During the interviews, the factory managers were asked to give only those solutions that worked in their experience. Therefore this is a list of what has been tried successfully.

## **8.5 Summary of the chapter**

This chapter has presented the solutions to various significant barriers cited during the exploratory phase of this research. These solutions have the attribute that they have been tried successfully in the manufacturing companies in Pakistan. Solutions to substantial barriers have been used in formulating action plans for factory managers and government policy makers, to be explained in chapter 10.



## Chapter 9

# Actions for Technology Development

### 9.1 Introduction to 'actions'

In addition to identifying the barriers that hinder technology development, the exploratory interviews explained in chapter 6 yielded actions that had been found helpful for developing technology in the companies. In this chapter the actions are presented and discussed.

#### 9.1.1 Actions include solutions

As mentioned in sections 6.1.1 and 6.4.2, the solutions are a subset of the actions, and the actions of this chapter include all the solutions of the previous chapter. Solutions in principle are actions that happen to solve identified problems.

#### 9.1.2 Actions for technology development in the literature

A detailed review of the literature dealing with actions for technology development was presented in chapter 3. The inference of this review was that although numerous researches have been conducted on East Asian success, they are limited to a retrospective examination of government actions and analysis of individual case studies.

No compiled account exists that could give specific suggestions to factory managers or government policy makers.

This research has compiled a list of such actions in an empirical way, and has ranked them in order of their importance.

## 9.2 The number of actions for technology development found

The content analysis of the 42 interviews resulted in 272 actions. Table 9.1 shows the number of interviews in which the different actions appeared. It can be seen that 166 (61 %) of the actions appeared in only one interview and 47 (17 %) appeared in only two interviews. The actions which appeared in three or more interviews, (i.e. more than 5 % of the interviews), were designated as Significant actions. There were 59 (22 %) of these.

**Table 9.1:** Number of interviews in which actions appeared

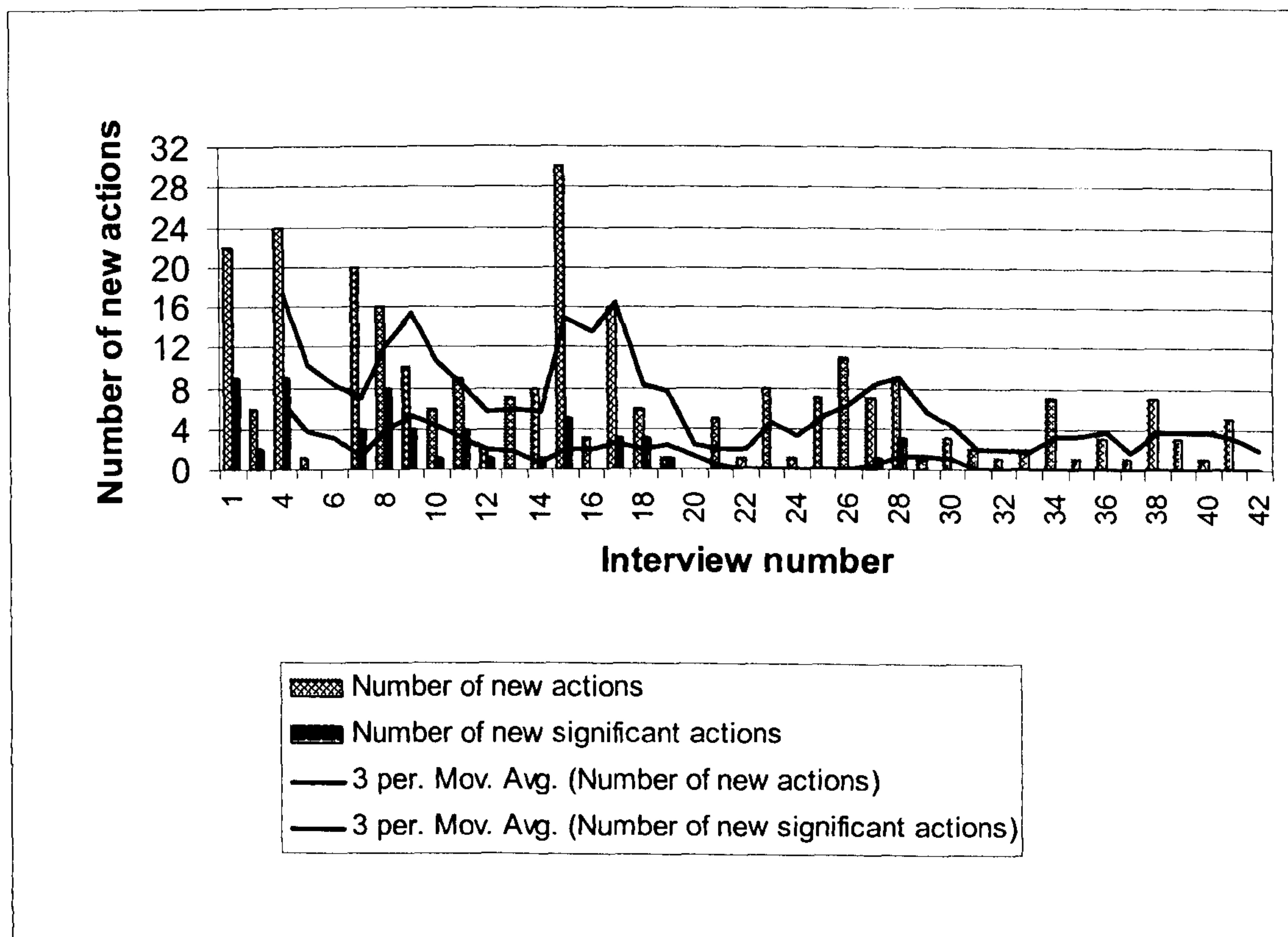
Percentage of actions (%)	Number of actions	Number of interviews in which a particular action appeared
61 %	166	1
17 %	47	2
6 %	17	3
2 %	6	4
5 %	13	5
3 %	7	6
1 %	3	7
2 %	5	8
0.4 %	1	9
0.7 %	2	10
0.4 %	1	11
0.7 %	2	12
0.7 %	2	13
0.4 %	1	19
	<b>272</b>	<b>Total</b>



### 9.2.1 Sufficiency of exploratory interviews to account for all significant actions

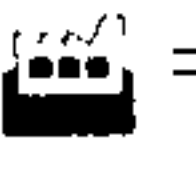
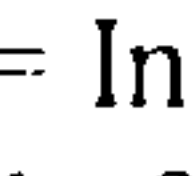
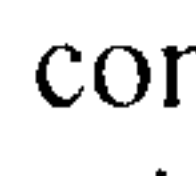
Figure 9.1 shows the rate at which new actions appeared as the series of exploratory interviews progressed. It can be seen that although new actions kept on appearing until the last interview, the vast majority of significant actions were obtained in the first twenty interviews. The last significant action was found in the 28<sup>th</sup> interview. (By coincidence the last significant barrier occurred in this interview too). Clearly the probability of getting another significant action after 42 interviews would be extremely small. Therefore this number of interviews was sufficient to list all significant actions.






**Figure 9.1:** Frequency of finding new actions and new significant actions in the exploratory interviews, with three period moving averages in each case














### 9.3 Descriptions and jurisdictions of the various actions














Table 9.2 lists descriptions of the significant actions found, and identifies them as being in control of factory management or government or neither of them. The table also provides the number of interviews in which each action appeared. Appendix 9A provides this data for all of the 272 actions.

**Table 9.2:** Significant actions, their description, and identification of their being in control of factory management or government. (N = Number of interviews in which this factor appeared,  = In control of factory management,  = In control of government,  = In control of neither the factory management nor the government)













	Significant Actions	Description of significant actions	N	Control
<b>Technology and its acquisition</b>				
1.	Acquire complete knowledge about technologies to develop in the company	Acquire complete and in-depth knowledge about specific technologies to develop in the company.	3	
2.	Keep knowledge of the technology developments in your area	Keep knowledge of technological developments in the area of your business.	8	
3.	Develop or acquire core technologies	Develop or acquire the core technologies that form the foundation or are the mainstay for the business of the company.	8	
4.	Consult published material about technologies in your company	Invest in and study published technical material, which may include books, journals, magazines etc.	6	
5.	Take help from consultants	Take help from consultants to	5	



		improve technology.		
6.	Use Internet	Search the Internet for technological information.	6	
7.	Copy and improve imported technology	Copy and improve upon technology imported earlier in the company.	3	
8.	Buy engineering and other software	Buy or develop engineering and other relevant software.	3	
9.	Visit or take part in industrial exhibitions	Visit and/or take part in industry exhibitions.	3	
<b>Products</b>				
10.	Diversify into new products	Diversify the product range of products being made in the company.	10	
<b>Product development</b>				
11.	Acquire complete capability of product design locally	Acquire or develop complete capability to design products in the company.	10	
12.	Modify products according to infrastructure available in the company	Make or modify products according to existing infrastructure in the company.	3	
13.	Reverse engineer products and production equipment	Companies should adopt reverse-engineering of products and production equipment.	11	
<b>Production Equipment</b>				
14.	Change to better production equipment	Obtain improved production equipment with aim to increase production and/or improve quality.	8	
15.	Adopt automation	Adopt automation or low cost automation to replace manual activities.	7	
16.	Make production equipment inside your company	Make required production machines and equipment within the company.	4	









<b>Methods and processes</b>				
17.	Improve production processes	Adopt better production processes.	5	
18.	Gain experience of production processes being used in the company	People in the company should acquire experience of various processes so as to produce better products.	4	
19.	Adopt and emphasize quality control	Emphasize and adopt quality control in the company.	5	
<b>Management issues</b>				
20.	Convince people for change	In order to make technology and management changes successful, convince people for those changes.	3	
21.	Develop proper systems and procedures	Develop proper systems and procedures in the company.	5	
22.	Adopt teamwork	Teamwork should be followed in the company.	4	
23.	Develop commitment in management and employees with objectives of the company	Commitment with objectives of the company should be developed in people and management of the company.	8	
24.	Motivate workers	Motivate workers so they can perform better.	5	
25.	Make proper plans for development	The company should make proper plans of development.	5	
26.	Work with dedication	Work with dedication.	7	
27.	Recruit young people	Recruit young people in the company.	3	
28.	Generate vision of the company	The company should generate its vision.	8	
29.	Empower middle and junior management in day-to-day operations of the company	Senior or top management of the company should empower middle and junior management in day-to-day operations of the company.	4	



30.	Pay high salaries to employees	Pay high salaries to employees of the company.	3	
<b>Expertise in the company</b>				
31.	Train employees locally	Provide training to employees locally.	19	
32.	Send employees abroad for training	Send employees abroad for training.	9	
33.	Invest in R&D	Invest in research and development activities.	7	
34.	Employ good human resource	Employ best available human resource.	5	
35.	Develop local expertise of technologies imported from abroad	Develop local expertise of technologies acquired from abroad.	5	
<b>Human factors</b>				
36.	Facilitate workers financially especially in the hour of need.	Facilitate workers financially especially in the hour of need.	3	
<b>Financial and tax issues</b>				
37.	Finance should be made available from the national banks	Finance should be made available to engineering industries from the national banks, as well as to the traditional industries.	3	
38.	Pay taxes completely	Pay all the taxes completely.	3	
<b>Educational issues</b>				
39.	Universities should work for industry	Educational institutions should work for industry on its technical and managerial problems.	3	
<b>Issues related to government</b>				
40.	Pay no bribes to people	Bribes should not be paid to government functionaries.	5	
41.	Lobbying in the	Chamber of Commerce and industry	3	

	government by Chambers of Commerce & Industry	associations should lobby in the government for policies and regulations helping industry and businesses.		
42.	No frequent changes in government policies	Government should not frequently change its policies affecting industries and businesses.	3	
43.	Supportive government policies for development of industry	Government policies should be such that they help industries improve in technology and grow.	10	
44.	Financial incentives of the government	Government should give financial incentives to industry.	5	
45.	Investments made by the government in the industry	Government should itself invest in engineering companies.	3	
46.	Government Common Facility Centres or CAD / CAM centres	Government should create common facility centres & CAD/CAM centres to help industries develop technologies.	4	
<b>Business environment factors</b>				
47.	Government should develop basic metals and plastics industries	Basic industries for metals and plastics should be developed in the country by the government.	3	
48.	Collaborate with other industries in your area	Industries should collaborate together and help each other in improving technologies.	3	
<b>Market factors</b>				
49.	Market products aggressively	Industries should aggressively market their products.	6	
50.	Export products	Industries should export their products.	5	
51.	Tariff barriers placed by the government for protection of industry	Government should protect industry through tariff barriers.	6	
<b>Foreign factors</b>				



52.	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies so that they can guide in improving technology standards.	6	
53.	Make joint ventures with foreign companies	Work in association with foreign companies in business arrangement that involves local production and thus transfer of know-how and expertise to the company.	13	
54.	Import technology through licensing and other means	Import of know-how of various facets of technology from foreign companies through various means including licensing.	12	
55.	Get foreign consultancy in technical matters	Get help from foreign consultants in technical matters related to design, manufacture, management and marketing	12	
56.	Prove to your foreign joint venture partners that you were capable of working with them	Prove to your joint venture partners that you are capable of entering into joint venture with them.	4	
57.	Visit foreign countries or foreign companies	Visit foreign manufacturers or countries with an aim to obtain knowledge about their technology.	6	
<b>Entrepreneurship</b>				
58.	Involvement of owners in technical matters	Owners should themselves get involved in technological matters of the company.	5	
<b>Ethical Issues</b>				
59.	Be fair and honest in business	The company should be completely fair and honest in business.	6	

## 9.4 Discussion on actions required for technology development

### 9.4.1 Summary of the findings from the compilation of actions

- As in the case of barriers, numerous actions to technology development were cited.
- These actions could also be segregated in the same categories or dimensions which were developed for barriers, and were described in section 6.5 of chapter 6.
- Fifty of the 59 significant actions could be taken by the factory managers themselves.
- The number of significant actions in various categories were as follows:

○ Technology and its acquisition:	9
○ Products:	1
○ Product development:	3
○ Production equipment:	3
○ Production processes:	3
○ Management issues:	11
○ Expertise in the company:	5
○ Human factors:	1
○ Financial and tax issues:	2
○ Educational issues:	1
○ Issues related to government:	7
○ Business environment factors:	2
○ Market factors:	3
○ Foreign factors:	6
○ Entrepreneurship:	1
○ Ethical issues:	1

This shows that management factors, technology acquisition factors, government factors, foreign factors, and expertise in the company were considered more important than other issues for technology development.



### 9.4.2 Discussion of the findings

A clear and possibly surprising finding is that the overwhelming majority of the actions required for technological development in manufacturing companies are in the control of the factory managers themselves. Few of the actions are in the jurisdiction of the government.

This means that factories can be successful even in the absence of clear support from the government. This finding was supported by the case study of the maker of refrigeration equipment (Case Study B), which was successful despite the perceived negative role of the government and its functionaries.

One reason relatively very few actions were in the jurisdiction of the government is that private factories in Pakistan do not have many expectations from the government. This aspect was discussed in many of the interviews. Almost all the interviewees from the private sector responded that they did not look towards the government for help. They would only like that the government did not create problems for them. Some said that they considered the government to be the worst enemy of manufacturing companies. Others thought that the policies of the government were not that bad, the problems were in the implementation of those policies by officials.

This finding partly disagrees with the general trend of the literature on the success stories from East Asia, in which the role of the government has been clearly seen as dominant. But on the other hand it can be argued that the reason for fast development in East Asia has been because of this positive role of the government, and if this role was absent, the pace of progress would be slower.

Thirty five out of 59 significant actions were from those categories that have been designated as facets of technology in chapter 5. The other 24 actions were from those categories that were outside these facets of technology, but in the new categories described in chapter 6.

Products, product development, production equipment and production processes that have been traditionally considered important in technological progress were relatively less represented in the list of actions.

The literature on technology development has not clearly divided technology into facets, and thus does not provide a clear framework of issues for technology development.

## **9.5 Conclusions from the findings**

It can be concluded that if industrialists in Pakistan want to improve technology and catch-up with the leading companies of the world, they could themselves take most of the necessary steps without explicit support from the government. If this explicit government support is there, the pace of the process of catch-up would be faster.

The second conclusion is that technology development is a multi-faceted problem, which is affected by numerous important dimensions outside the traditional facets of technology. These facets not only extend beyond the company boundaries but also country boundaries.

## **9.6 What next?**



So far the intent has been to simply identify the factors of barriers, solutions and actions, although the number of occurrences of various factors gives some idea about their relative importances. In the next chapter a systematic approach to ranking the factors in order of importance is explained.




















## APPENDIX 9A

## APPENDIX 9A Complete list of actions found during exploratory interviews














Table 9A.1 provides complete list of all the actions found in the content analysis of the exploratory interviews. For completeness, this list also includes significant actions mentioned in table 9.2. The table also provides description of actions, the number of interviews in which various actions appeared, and identifies them to be in the control of the factory management or the government or neither of them.





**Table 9A.1:** Actions, and identification of their being in control of factory management or government. (N = Number of interviews in which this factor appeared,  = In control of factory management,  = In control of government, O = In control of neither the factory management nor the government)

	Action	Description of action	N	Control
<b>Technology and its acquisition</b>				
1.	Create team for technology improvement	Create teams in the company specifically for technology improvement.	1	
2.	Send people in existing plants for know-how	Send people in existing industries to gain know-how about various technologies.	1	
3.	Acquire complete knowledge about technologies to develop in the company	Acquire complete and in-depth knowledge about specific technologies to develop in the company.	3	
4.	Keep people aside for basic research	Keep some people aside in the company for basic research in technologies of interest.	1	
5.	Develop or acquire core	Develop or acquire the core	8	













	technologies, which are the mainstay or foundation technologies in your operations	technologies that form the foundation or are the mainstay for the business of the company.		
6.	Keep knowledge of the technology developments in your area	Keep knowledge of technological developments in the area of your business.	8	
7.	Consult published material about technologies in your company	Invest in and study published technical material, which may include books, journals, magazines etc.	6	
8.	Take help from consultants	Take help from consultants to improve technology.	5	
9.	Take help from the Internet	Search the Internet for technological information.	6	
10.	Copy and improve imported technology	Copy and improve upon technology imported earlier in the company.	3	
11.	Buy engineering and other software	Buy or develop engineering and other relevant software.	3	
12.	Visit and / or take part in industry exhibitions	Visit and / or take part in industry exhibitions.	3	
13.	Take membership of technical institutions	Take membership of technical institutions.	1	
14.	Visit machine tool manufacturers	Visit machine tool manufacturers.	1	
15.	Gradually obtain technology starting from assembly	Obtain technology gradually starting from assembly. Move on to manufacturing and design in the later stages.	2	
16.	Create awareness of technology	Create general awareness in the company about various technologies being applied in the company.	1	
17.	Acquire technology from renowned company	Acquire technology only from renowned companies.	1	
















18.	Create professional society in your area of work	Create professional society in the area of work of the company.	1	
19.	Keep abreast of developments in leading companies in your area	Keep abreast of developments in leading companies in the area of work of the company.	2	
20.	Get information from media	Get information about technology from media.	1	
21.	Scan the market for technology	Scan the market for technology to be developed or improved in the company.	1	
22.	Obtain information by meeting people	Obtain technological information by meeting knowledgeable people.	2	
23.	Acquire technology through projects	Acquire technology by taking up projects that require that technology.	1	
24.	Liaison with R&D companies in your area	Liaison with R&D companies in the area of work of the company.	1	
25.	Proliferate technology	Make efforts to proliferate newly acquired technologies to other companies so that more companies are working in your area.	1	
26.	Create technology development fund	Create technology development fund in the company.	1	
27.	Glamorize technology	Government should glamorize technology instead of glamorizing show business.	1	
<b>Products</b>				
28.	Diversify the products	Diversify the product range of products being made in the company.	10	
29.	Standardize products	Standardize products being made in the company.	1	
30.	Make product that lead technically in the national market	Make product that lead technically in the national market.	1	














31.	Change to better products	Change to better or improved products.	1	
32.	Make products that complement existing work	Make products that complement existing work already being done in the company.	1	
<b>Product development</b>				
33.	Government should make design institutes	Government should make design institutes that help industries in product development.	1	
34.	Reverse engineer products and production equipment	Companies should adopt reverse-engineering of products and production equipment.	11	
35.	Import product designs	Product designs should be imported.	1	
36.	Acquire complete capability of product design	Acquire or develop complete capability to design products in the company.	10	
37.	Modify products according to infrastructure available in the company	Make or modify products according to existing infrastructure in the company.	3	
38.	Develop passion of making new things	Develop passion of making new things in the company.	1	
39.	Make teams for new products	Make teams in the company for new product development.	1	
40.	Develop products according to national demands	Develop products according to demands and tastes of the national market.	2	
41.	Involve production people early in product development	Involve production people early in product development process.	1	
42.	Create ability to modify existing products	Create ability to modify existing products whose design was acquired from elsewhere.	1	
43.	Institutions for reverse-engineering should be	Institutions for reverse-engineering should be there either in public or	1	
















	there	private sector.		
44.	Teach product development in technical colleges	Product development should be taught in technical colleges.	1	
<b>Production Equipment</b>				
45.	Devise innovative solutions for lack of equipment	If equipment could not be acquired, try to find innovative alternate solutions.	1	
46.	Adopt automation	Adopt automation or low cost automation to replace manual activities.	7	
47.	Make production equipment inside your company	Make required production machines and equipment within the company.	4	
48.	Develop maintenance expertise	Develop expertise for maintenance of machines within the company.	2	
49.	Improve accuracy of machines	Modify equipment so that its accuracy is improved.	1	
50.	Change to better equipment	Obtain improved production equipment with aim to increase production and / or improve quality.	8	
51.	Get help from equipment suppliers in equipment selection	Get help in equipment selection from equipment suppliers.	1	
52.	Get guidance from other national users	Get guidance from other national companies on selection and purchase of equipment.	1	
53.	Standardize equipment in the factory	Standardise production equipment in the factory.	1	
54.	Modify equipment according to requirement	Make modifications in production equipment according to the requirement of production.	1	
55.	Make jigs and tools to improve production	Make proper jigs, fixtures and tools for improvement of production.	2	
<b>Methods and processes</b>				















56.	Gain experience of production processes being used in the company	People in the company should acquire experience of various processes so as to produce better products.	4	
57.	Emphasize and adopt quality control	Emphasize and adopt quality control in the company.	5	
58.	Plan production processes	Production processes should be properly planned.	1	
59.	Standardise production processes	Standardise various production processes in the company.	2	
60.	Issue exact quantities of materials for processes	Calculate and issue exact quantities of materials for various production processes so that material is not wasted.	1	
61.	Create systematic processes / production line concept	Generate sequence of processes so as to work according to production line concept.	2	
62.	Analyze processes to reduce cost	Analyze various production processes with aim to reduce cost of production.	2	
63.	Improve production processes	Adopt better production processes.	5	
64.	Government should create process design houses	Government should create centres that provide process design services.	1	
65.	Quality movement by the government	Government should start quality movement with aim to emphasize the importance of product quality.	1	
66.	There should be a quality award system	Government should introduce quality award system to encourage companies for better quality.	1	
<b>Input materials and components</b>				
67.	Create an office in an advanced country	Create office of the company in an advanced country to procure raw material and components for the company.	1	
68.	Get Government	If there are restrictions on import of raw	1	

















	permission for import of material	material, get permission from the government for import of materials.		
69.	Develop material testing facilities	Develop material testing facilities in the company.	2	
70.	Collaborate with foreign suppliers for components	Instead of buying through traders, work with the foreign suppliers for improved supply of components.	1	
71.	Source components from wherever suitable	Electronic components should be sourced from multiple sources and not from one or two sources.	2	
72.	Improve materials	Use better materials for production in the company.	1	
73.	Government should help in import of components	Government should help in import of electronic components	1	
74.	Correction of material policies by the government	Government should correct flaws in its policies related to material.	1	
75.	Minimal import duties on raw materials	Import duties on raw material should be minimal.	1	
<b>Management issues</b>				
76.	Convince people for change	In order to make technology and management changes successful, convince people for those changes.	3	
77.	Make people feel that they are important	Make people feel that they are important for the success of the company.	1	
78.	Give people chance to speak their mind	Give people chance to speak their mind before introducing changes in the company.	1	
79.	Give monetary benefits to people	Give monetary benefits to people for learning new skills.	2	
80.	Train people on new machinery	Train people on new machinery introduced in the company.	1	
81.	Change-management	In order to make changes successful, run change-management programs in the	1	

















	program	company.		
82.	Convince Board of Directors or senior management	In order to make technology and management changes, convince Board of Directors or senior management of the company.	2	
83.	Develop proper systems and procedures	Develop proper systems and procedures in the company.	5	
84.	Adopt teamwork	Teamwork should be followed in the company.	4	
85.	Develop commitment in management and employees with objectives of the company	Commitment with objectives of the company should be developed in people and management of the company.	8	
86.	Empower middle and junior management in day-to-day operations of the company	Senior or top management of the company should empower middle and junior management in day-to-day operations of the company.	4	
87.	Improve management procedures	Management tactics and procedures should be improved in the company.	1	
88.	Motivate workers	Motivate workers so they can perform better.	5	
89.	Install professional management	Professional management should be installed to run the company.	2	
90.	Make proper plans for development	The company should make proper plans of development.	5	
91.	Generate vision of the company	The company should generate its vision.	8	
92.	Development of management capability	The management of the company should generate capability to manage the company.	1	
93.	There should be correspondence between salary and skill	Salary of various workers in the company should be in accordance with their skill level.	1	
94.	Arrange training	Arrange training courses on	1	
















	courses on coordination	coordination so as to improve coordination in the company.		
95.	Arrange meetings and seminars	Arrange meetings and seminars so as to improve communication in the company.	1	
96.	Transport skilled people from elsewhere	If skilled manpower is not available in the vicinity of the company, transport skilled people from elsewhere	1	
97.	Encouragement of management	Management should encourage workers on work that they had never done before.	1	
98.	Proactive policy should be followed	Industries should follow proactive policy according to their vision and not reactive policy.	1	
99.	Remove unions	Remove unions in the company.	1	
100	Arrange meetings to discuss management issues	Arrange meetings to discuss management issues affecting the company.	2	
101	Remove communication gaps	Remove communication gaps in the company.	1	
102	Create competitive environment	Create competitive environment in the company so that people can work better.	1	
103	Work with dedication	Work with dedication.	7	
104	Narrow the gap of salaries	Narrow the gap of salaries between the top management and the workers.	1	
105	Don't be a 'Seth' oriented company	Don't be a 'Seth' oriented company in which the objective is only money and nothing else.	2	
106	Better human resource management	Company should follow better human resource management practices.	2	
107	Know everyone in the company	Top management of the company should know everybody in the company.	1	
108	Be results-oriented	Management of the company should be results-oriented.	1	














109	Management should take risks	Management of the company should take calculated risks for speedy success of the company.	1	
110	Decentralize the company	Management of the company should be decentralized.	1	
111	Continuity in management	There should be continuity in the management policies of the company.	1	
112	Make maximum of parts inside the company	Maximum of parts of the product being produced by the company should be made inside the company	1	
113	Senior managers in factory should work with workers	Senior managers in factory should work with common workers.	1	
114	Get ISO 9000 certification	Get ISO 9000 certification.	2	
115	CEO should obtain management training	CEO of the company should obtain management training.	1	
116	Hire returning qualified expatriate Pakistanis	Hire returning qualified and experienced expatriate Pakistanis.	1	
117	Give incentives for better productivity	Give incentives to people for better productivity.	2	
118	Recruit young people	Recruit young people in the company.	3	
119	Pay high salaries	Pay high salaries to employees of the company.	3	
120	Pay in time	Pay the salaries of the employees of the company in time.	1	
121	Make proper feasibilities	The company should make proper feasibility reports of projects they plan to take up.	1	
122	In a family-owned business, keep cohesion in the family	In family-owned businesses, there should be complete coherence in the family of owners.	1	
<b>Expertise in the company</b>				













123	Invest in human resource	Make investments so that skill level of human resource is increased.	2	
124	Train employees locally	Provide training to employees locally.	19	
125	Get knowledge yourself and transfer to workers	Get knowledge yourself and transfer that knowledge to workers.	2	
126	Send employees abroad for training	Send employees abroad for training.	9	
127	Make training institute in the company	Make training institute in the company.	1	
128	Train lower level staff	If there is lack of training of lower level staff, make efforts to train lower level staff	1	
129	Invest in R&D	Invest in research and development activities.	7	
130	Take help from international technical NGOs	Take help from international technical non-governmental organizations (NGOs).	1	
131	Take help from national agencies	Take help from national agencies that provide technical training to workers.	1	
132	Hire people to document for illiterate supervisors	If supervisors are skilful but illiterate, hire people to document technology for illiterate supervisors.	1	
133	Employ good human resource	Employ best available human resource.	5	
134	Maintain and retain human resource	Maintain and retain good human resource	2	
135	Plan careers of people	Make proper career plans for people.	1	
136	Provide education	If labour is illiterate, provide them basic education.	1	
137	Have targeted education and training	Make plans so that people in the company get targeted education and training.	1	
138	Make people computer	Make people computer literate.	1	












	literate			
139	Train people for R&D	Train people especially for research and development.	1	
140	Disseminate knowledge gained on courses	People who have gone on courses should disseminate the knowledge gained on courses.	2	
141	Develop local expertise of technologies imported from abroad	Develop local expertise of technologies acquired from abroad.	5	
142	People should adopt hands-on approach	People should adopt hands-on approach.	1	
143	Acquire skilled manpower from other companies	Acquire skilled manpower from other companies by luring them in the company.	1	
144	Workers should be rotated in jobs	Workers should be rotated in their jobs.	1	
<b>Data management and storage</b>				
145	Carry out computerization	Carry out computerization in the company.	2	
<b>Human factors</b>				
146	Provide opportunities to people	Provide opportunities to people in the company so that they can improve skills.	1	
147	Hire people in batches and then select	Hire people in batches and then select the best and fire the rest.	1	
148	Facilitate workers especially in the hour of need	Facilitate workers financially especially in the hour of need.	3	
149	Give sense of participation to workers	Give sense of participation in the matters of the company to the workers of the company.	1	
150	Respect the workers	Respect the workers of the company.	1	
151	Make the workers	Make efforts so that the workers of the	1	















	satisfied	company feel satisfied in their jobs.		
152	Forcefully stop brain drain	Forcefully stop brain drain (professional people going abroad for jobs) from the country.	1	
<b>Financial and tax issues</b>				
153	Depend upon available resources	Depend only upon financial resources available in the company.	1	
154	Look for cheaper alternate solutions	If the problem of funds or resources is faced, look for cheaper alternate solutions.	1	
155	Reverse-engineer electronic cards	Reverse-engineer electronic cards if those are too expensive.	1	
156	Pay complete taxes	Pay all the taxes completely.	3	
157	Invest profits, don't borrow from bank	Invest profits; don't borrow from bank, so that high interest should not be paid to the bank.	1	
158	State should provide capital to companies	State should itself provide capital to companies	1	
159	Taxes should be on retailer	Taxes should be on retailer and not on producers.	1	
160	Components should have less duty than products	Components should have less duty than products.	1	
161	There should be no duties on electronic components	There should be no duties on electronic components.	1	
162	Duty structure conducive to national development	Duty structure should be such that it is conducive to development of national industries and products.	2	
163	Finance should be available from the national banks	Finance should be made available to industries from the national banks.	3	
164	Input materials should be duty-free	Input materials should be made duty-free.	1	












165	There should be no taxes on technology imports	There should be no taxes on technology imports.	1	
166	Banks should have experts for evaluation of industry proposals	Banks should have experts for evaluation of proposals from industry so that they provide finances to right kind of industries only.	1	○
167	Banks should provide export finance	Banks should provide finance for exports.	1	○
<b>Educational issues</b>				
168	Get associated with universities	Industries should get associated with universities in order to obtain knowledge and technical help.	1	
169	Try to improve technology level in universities	Industries should try to improve technology level in universities in their area of interest.	1	
170	Universities should work for industry	Educational institutions should work for industry on its technical and managerial problems.	3	
171	University people should have industrial backgrounds	People teaching in the university should have industrial backgrounds.	1	
172	Create system of technical education	Universities should create a system of technical education.	1	
173	Start diploma in manufacturing engineering	Universities or polytechnic institutes should start diploma in manufacturing engineering.	1	
<b>Issues related to government</b>				
174	Pay no bribes to people	Bribes should not be paid to government functionaries.	5	
175	Give these people minimal bribes	Minimal amount of bribe should be paid to government functionaries.	1	
176	Try to avoid dealing with the government	Industrialist should try to avoid dealing directly with the government. Instead they should insist on third-party traders	2	














		in government procurements.		
177	Fight cases in courts	Instead of bowing to the demands and paying bribes to government functionaries, fight cases made by them in the courts.	1	
178	Be open to inspectors	Industries should be open to government inspectors coming to industry for inspection.	1	
179	Arrange infrastructure yourself	If the government doesn't provide infrastructure facilities, the industrialists should not wait for the government and should try to arrange infrastructure facilities themselves.	1	
180	Work with customs and get an SRO issued	If problems are faced in import / export, the industrialists should work with customs and get Special Revenue Order (SRO) issued.	1	
181	Government should import technologies and create technology incubators	Government should itself make efforts for import of important technologies and develop those in the country through technology incubators.	1	
182	Government should create centres of excellence	Government should create centres of excellence in various technologies that become source of guidance and knowledge in various technologies.	1	
183	Shoot negligent people	Negligent people in the government should be shot dead.	1	
184	Government should protect businessmen	Government should provide security and protection to businessmen.	1	
185	No frequent changes in government policies	Government should not frequently change its policies affecting industries and businesses.	3	
186	Eliminate procedures	Government should make its procedures short and easy, and should eliminate long and difficult procedures.	1	
187	Government should provide infrastructure	Government should provide good infrastructure facilities including	2	












	facilities	communication, transport and utilities in the country.		
188	Supportive government policies for development of industry	Government policies should be such that they help industries improve in technology and grow.	10	
189	Government functionaries should be engineers	Government functionaries should be engineers so that they understand problems of industries.	1	
190	Industry should be free from controls	Industry should be free from government regulations and controls.	2	
191	Involve stakeholders in policy making	Government should involve stakeholders including mainly the industrialists in policy making for industry.	1	
192	Government should set engineering standards	Government should set engineering standards in the country.	1	
193	Government should ensure compliance to standards	Government should ensure compliance to international and national standards.	1	
194	Government should benchmark industry	Government should benchmark industry so as to provide them financial and other incentives according to their output.	1	
195	Financial incentives of the government	Government should give financial incentives to industry.	5	
196	Government should send people for higher studies	Government should send people for higher studies in advanced countries.	1	
197	National objectives should be set	Government should set national objectives.	1	
198	Government should assign products to industry	Government should assign products to particular industries for development.	2	
199	Government should create demand for national products	Government should create demand for national products either through its own procurement or through restricting	2	
















		imports.		
200	Government should import products & give to industry for development	Government should import products & give to industry for indigenous development.	1	
201	Government should regulate industry	Government should regulate industry so that industry is not completely free but works under government regulations.	2	
202	Government should create industrial nuclei & industrial clusters	Government should create industrial nuclei so that industrial clusters are built around it.	2	
203	Government should make export-oriented policies	Government should make export-oriented policies.	2	
204	Government should attract expatriate Pakistanis	Government should attract qualified and experienced expatriate Pakistanis through financial incentives so that they can play their role in national industrial development.	2	
205	Interest of top level in the country helps	Interest of chief executive of the country in industrial development helps.	2	
206	Collaborate with research institutes	Industries should collaborate with research institutes created by the government.	2	
207	Government should give productivity targets	Government should give productivity targets to various industries.	1	
208	Government should give awards to industry people	Government should give awards to industry people on quality, indigenization and productivity.	1	
209	Appoint industry-related people in ministries	Government should appoint industry-related people in ministries dealing with industry and businesses.	2	
210	Investments made by the government in the industry	Government should itself invest in engineering companies.	3	









211	Lobbying by Chamber of Commerce and industry associations	Chamber of Commerce and industry associations should lobby in the government for policies and regulations helping industry and businesses.	3	
212	Government should provide subsidy for participation in trade shows	Government should provide subsidy for participation in foreign trade shows.	1	
213	EPB should take part in engineering trade shows	Export Promotion Bureau (EPB) should take part in engineering trade shows abroad.	1	
214	Government should have training institutes	Government should create training institutes that provide training to industry people.	2	
215	Government should provide finance for special equipment	Government should provide finance for special equipment in the factories.	1	
216	Government should create common facility centres & CAD/CAM centres	Government should create common facility centres & CAD/CAM centres to help industries develop technologies.	4	
217	Government should make industry development plans	Government should make plans for development of industry.	1	
218	Communication between government and business should be close	There should be close communication between government and businesses.	1	
219	Engineering Development Board is positive effort	Engineering Development Board created by the government is positive effort that is helping national industry.	2	
220	Choose some groups and provide them incentives	Government should choose some patriotic and capable industrial groups and provide them financial incentives for development of technology and industry in the country.	2	
221	Government / embassies can help in	Government, through its embassies abroad should help in selling	1	











	selling technology	technologies and products in export markets.		
222	Convince government for rational duty structure	Industrialists should convince government for duty and tariff structure conducive for development of national industry.	1	
223	Government's software technology park was of help	Software technology park created by the government was of help in national industrial development.	1	
224	Government should support high-tech research-based firms	Government should support high-tech research-based firms so as to help develop latest technologies in the country.	1	
225	Government should give preference to projects made by national industry	Government should give preference to those projects that are made by national industry.	1	
226	Government should finance projects made by national industry	Government should finance those projects that are made by national industry.	1	
227	Government should make feasibility reports	Government should make feasibility reports on viability of various industries so as to help entrepreneurs.	1	
228	Government should subsidize training	Government should subsidize training provided in the industries.	1	
229	Government organizations should be decentralized	Government organizations should be decentralized so that on-site management is completely empowered.	1	
230	Privatization should be carried out	Government should carry out privatization and should make private sector stronger.	1	
<b>Business environment factors</b>				
231	Follow standards	Industries should follow national and international standards.	2	
232	Switch to new technology standard	When world technology standards change, industries should switch to new	1	





		technology standards.		
233	Collaborate with other industries in your area	Industries should collaborate together and help each other in improving technologies.	3	
234	Create positive competition	Industries should create healthy and positive competition among them and should not use negative tactics.	1	
235	National standards body should be there	There should be standards body in the country developing and providing engineering standards for the industries.	2	
236	Government should develop basic metals and plastics industries	Basic industries for metals and plastics should be developed in the country by the government.	3	
<b>Market factors</b>				
237	Market products aggressively	Industries should aggressively market their products.	6	
238	Export products	Industries should export their products.	5	
239	Create national brand	Industrialists should develop their own national brand name.	1	
240	Government should give equal opportunities to national companies	Government should give equal opportunities to national companies as provided to foreign companies.	1	
241	Stop smuggling	Government should stop smuggling.	1	
242	Investments should be brought in the country	Government should make efforts to bring foreign investment in the country.	1	
243	There should be no protections	Government should not provide tariff protections to industry.	1	
244	Tariff barriers placed by the government for protection of industry	Government should protect industry through tariff barriers.	6	
245	Remove uncertainty in the market	Uncertainty in the market should be removed for better industrial development.	1	



246	WTO would finish monopolies	WTO would finish monopolies created by various companies. This would be useful for national industrial development.	1	○
<b>Foreign factors</b>				
247	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies so that they can guide in improving technology standards.	6	
248	Make joint ventures with foreign companies	Work in association with foreign companies in business arrangement that involves local production and thus transfer of know-how and expertise to the company.	13	
249	Import technology through licensing and other means	Import of know-how of various facets of technology from foreign companies through various means including licensing.	12	
250	Get foreign consultancy in technical matters	Get help from foreign consultants in technical matters related to design, manufacture, management and marketing	12	
251	Prove to your foreign joint venture partners that you were capable of working with them	Prove to your joint venture partners that you are capable of entering into joint venture with them.	4	
252	Make engineers work in foreign companies	Acquisition of knowledge and skills in arrangement where local people work in foreign companies for specified time.	1	
253	Establish overseas companies	Establish companies in advanced countries with an aim to acquire technical knowledge and to market products and services.	1	
254	Visit foreign countries or foreign companies	Visit foreign manufacturers or countries with an aim to obtain knowledge about their technology.	6	

255	Foreign affiliation in equipment selection and absorption	Get help in equipment selection and absorption from foreign affiliates.	1	
256	Government should give subsidies for technology import	Government should give subsidies for import of technology.	1	
257	Government should protect market to force foreign manufacturers for technology transfer	Government should protect market from foreign manufacturers so as to force them for tech transfer to national companies.	2	
258	Government controls on visits should be removed	Government should not place controls on foreign visits.	1	
259	Bring high-tech MNCs to the country	Government should make efforts and provide all sorts of incentives to bring high-tech multinational companies (MNCs) in the country	1	
<b>Entrepreneurship</b>				
260	No one-man-shows	Owners should not try to do everything themselves.	1	
261	Entrepreneur should do management courses	Entrepreneur should do management courses so as to do better management.	1	
262	Involvement of owners in technical matters	Owners should themselves get involved in technological matters of the company.	5	
263	Government should provide opportunities	Government should provide opportunities to people so that they could become entrepreneurs.	1	
<b>Vendors</b>				
264	Educate industrialists to hire qualified people	The company should educate and convince vendors to hire qualified people.	1	
265	Educate vendors on quality	The company should work with vendors and solve their technical problems so as to improve quality.	2	
266	Create a vendor	Create a vendor development cell in the	1	



	development cell in the company	company.		
267	Engineering graduates should be entrepreneurs	Engineering graduates should become entrepreneurs themselves.	1	○
268	Testing & inspection facilities should be at suppliers' factories	Vendors should have testing & inspection facilities at their factories.	1	○
<b>Ethical issues</b>				
269	There should be strong ethics	Ethical level of people in the company should be very high, so that they don't compromise on ethics.	1	
270	Be fair and honest in business	The company should be completely fair and honest in business.	6	
271	Allah's help	Allah's help should be there. The people in the company should pray for Allah's help.	1	
272	Keep good intentions	The people in the company should work with good intentions.	2	

## Chapter 10

# Ranking Survey, Stages and Model for Technology Development

### 10.1 Introduction

The factors extracted from the semi structured interviews (chapter 6) were presented in the last three chapters. This chapter will present the result of a survey conducted to rank the barriers and action factors in order of their importance. The most highly ranked factors are then used to develop two Action Plans - one for factory managers and one for government policy makers.

This chapter also presents the stages for catch-up with leading companies of the world, which emerged from the interviews.

The stages and the action plans combine together to make a model for technology development.

### 10.2 The Ranking Survey

The semi structured interviews resulted in lists of barriers, solutions and actions. Significant barriers and actions, which appeared in more than 5 % of the interviews, were separated. The next logical step was to organise these significant factors on the basis of their importance in some way. Although the number of interviews in which factors appeared gave some idea about their importance there were two problems:



- Because several interviews were conducted in each of the three case study factories, the results may be biased towards those factories.
- The exploratory nature and semi-structured style of interviews could have produced biased results.

### **10.3 Research method used in the ranking survey**

The significant barriers and significant actions identified previously were incorporated into a structured and quantified questionnaire-based survey. Each respondent was asked to rank the importance of each barrier or action to their company. The questionnaire is reproduced as Appendix 10A.

#### **10.3.1 The ranking questionnaire**

The questionnaire started with an initial section asking optional questions about the respondent and his company, plus mandatory questions asking the academic qualification and total work experience of the respondent.

There were two main sections. The first of these required the respondents to rate 52 significant barriers in order of their seriousness, according to their experience. The possible options for rating included 'no problem', 'minor problem', 'medium problem' and 'major problem' in technology development, which were given scores of 0, 1, 2, and 3 respectively. They were also given the options 'not applicable' and 'I don't know'.

The second main section listed 59 significant actions, and respondents were required to rate these in order of their benefit, again based upon their experience. The possible

options for rating included 'not beneficial', 'slightly beneficial', 'beneficial' and 'very beneficial', which were given scores of 0, 1, 2, and 3 respectively, in addition to 'not tried' and 'I don't know'.

The last section was optional and it asked the respondents to comment upon the barriers or actions or other aspects of technology development.

### **10.3.2 Pilot phase of ranking survey**

The questionnaire was devised in such a way that intentions had been made very clear, using shaded areas and bold letters. The meaning of the questions was made sure during discussions in the pilot phase. The respondents were asked to point out if they could not understand a question.

A pilot survey was conducted with three respondents filling in the questionnaire. After minor changes and verification that the data could be analysed for results, the revised questionnaire was again filled in by the same three respondents, who approved it this time.

### **10.3.3 Implementation of the ranking survey**

The target population for the main survey was the selected sub-sectors of the manufacturing sector as pointed out in Chapter 4. It was decided that only one questionnaire would be obtained from each company so that the results are not biased. It was also decided that questionnaires would be sent to companies in and around Islamabad, Lahore and Karachi, so that the sample would be representative of the whole country. The areas of activity also varied widely, including cars, air conditioners, electronics, home appliances, fabricated metal parts, motor cycles, industrial machinery and televisions etc.



Initially questionnaires were sent to the people who had taken part in the status survey (chapter 5), and to some other companies in the target population. Reminder telephone calls were made to all the people whose reply had not been received after two weeks. Out of thirty questionnaires sent initially, eight had been received after three weeks.

Because of shortage of time, it was decided that personal visits to respondents should be made, so that results could be obtained quickly. The respondents whose answers had not been received by mail were thus asked for a personal visit. The researcher thus visited factories in Islamabad, Lahore and Karachi. These personal visits paid off and many more questionnaires were completed.

In order to increase the number of respondents, snowball sampling was resorted to. Respondents were requested to refer the researcher to prospective respondents who fulfilled the criteria set by the researcher. This technique was successful. The result of all these endeavours was thirty four completed questionnaires.

#### **10.4 Method of analysis of results of ranking survey**

The data was fed into the computer by the researcher himself and was randomly checked for accuracy twice.

The mean score  $\bar{X}$  and standard deviation of scores  $S$  of each barrier or action factor were calculated. Then standard deviations of the mean were calculated using the formula:

$$\sigma_v = \frac{S}{\sqrt{n}}$$

Where  $n$  is the sample size.

95 % confidence intervals of the population means were calculated using Student's t distribution, which is used to calculate confidence intervals when the population standard deviation is unknown and the sample standard deviation has to be used.

For sample size  $n$  of 34, the number of degrees of freedom was  $n - 1 = 33$ . Based upon the t distribution with 33 degrees of freedom, the 95 % confidence interval was  $\pm 2.0345 S / \sqrt{n}$ . This was used to indicate the probable accuracy range of the calculated means for each factor.



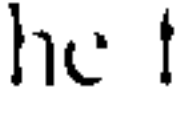
## 10.5 Survey results – Ranking of Barriers











The results showed that the average total experience of the respondents was 23.7 years. All the respondents had at least graduate level education. The majority had degrees in engineering or business administration.

Table 10.1 provides results for the barriers section of the questionnaire. The average of all the mean scores is 1.86. This value may seem a bit high. The possible range was 0 to 3, so an average of 1.5 might be expected. It could be argued that only significant barriers were included in the survey, so higher than average scores were easily possible.















The lowest score was 0.71, with a 95% confidence range of 0.37 to 1.05 (barrier 31). The Highest score was 2.67 with a 95% confidence range of 2.44 to 2.89 (barrier 47). Clearly the barriers are effectively ranked, but a difference of say 0.2 between two barriers would not be statistically significant.

15 barriers were found to be in the jurisdiction of management, 28 in the jurisdiction of government and 9 in control of neither.

**Table 10.1:** Ranking of barriers or problems in technology development  
(**Mean score:** Mean score of all the respondents,  = In control of factory managers,  = In control of government,  = In control of neither the factory managers nor the government)

	Significant barriers	Mean Score ( $\bar{X}$ )	Standard deviation of the mean (S)	95 % confidence interval for population mean	Control
<b>Technology and its acquisition</b>					
1.	Lack of information and knowledge about technology	1.76	0.19	1.38 2.14	
<b>Production Equipment</b>					
2.	Inadequacy of production equipment	1.88	0.18	1.52 2.25	
<b>Methods and processes</b>					
3.	Technical problems in production processes	1.38	0.15	1.08 1.68	
<b>Input materials and components</b>					
4.	Difficulties in import of raw materials	1.24	0.22	0.80 1.68	
5.	Non-availability of raw materials in Pakistan	2.12	0.17	1.76 2.47	
6.	Poor or inconsistent raw material quality available in Pakistan	2.31	0.16	1.99 2.64	
7.	Lack of availability of electronic components in Pakistan	1.94	0.18	1.57 2.30	
8.	Difficulty in import of electronic components	1.23	0.21	0.79 1.66	
<b>Management issues</b>					
9.	People resisting technology changes	1.35	0.19	0.96 1.75	
10.	Opposition of senior management for technology changes	0.91	0.20	0.51 1.31	



11.	Lack of teamwork	1.29	0.21	0.87 – 1.72	
12.	Lack of professional management	1.73	0.22	1.29 – 2.17	
<b>Expertise in the company</b>					
13.	Shortage of trained human resource	1.97	0.17	1.63 – 2.31	
14.	Lack of good human resource	2.03	0.14	1.74 – 2.32	
15.	Illiteracy of employees	1.55	0.21	1.12 – 1.97	
<b>Human factors</b>					
16.	Brain drain from Pakistan	1.60	0.20	1.19 – 2.01	○
17.	Large number of employees leaving the company	1.27	0.19	0.88 – 1.67	
<b>Financial and tax issues</b>					
18.	Shortage of funds and resources	1.48	0.24	1.00 – 1.97	
19.	Duties / sales tax high on national products than on imports	2.06	0.20	1.65 – 2.48	
20.	High prices of machinery	2.06	0.18	1.69 – 2.43	○
21.	Problems in getting finance from banks	1.30	0.20	0.90 – 1.70	
22.	High price of utilities (electricity, gas, telephone and water)	2.56	0.15	2.26 – 2.86	
<b>Educational issues</b>					
23.	University curricula not related to industry	2.26	0.15	1.95 – 2.58	
24.	R&D by government and other institutions unrelated to industry	2.52	0.14	2.24 – 2.79	
<b>Issues related to government</b>					
25.	Corrupt government functionaries	2.22	0.16	1.89 – 2.55	
26.	Incapable government functionaries	2.53	0.14	2.25 – 2.81	

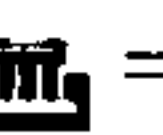

27.	Bad attitude of government inspectors	2.31	0.18	1.93	2.69	🏢
28.	Large number of government inspectors	2.46	0.16	2.13	2.80	🏢
29.	Frequent changes in government policies	2.24	0.17	1.88	2.59	🏢
30.	Bad government policies	2.22	0.16	1.89	2.55	🏢
31.	Long and difficult government procedures	2.67	0.11	2.44	2.89	🏢
32.	Hurdles by lower level staff in government procedures	2.48	0.16	2.17	2.80	🏢
33.	Problems at customs during imports or exports	1.97	0.19	1.59	2.35	🏢
34.	Lack of government support	2.15	0.17	1.80	2.49	🏢
35.	Announced government incentives not enforced	1.67	0.18	1.29	2.04	🏢
<b>Business environment factors</b>						
36.	Lack of standards in Pakistan	2.06	0.16	1.73	2.39	🏢
37.	Lack of technological infrastructure (knowledge base, know-how, basic industries, vendors, basic and applied research, etc) in Pakistan	2.36	0.14	2.08	2.65	🏢
<b>Market factors</b>						
38.	Small national market	2.21	0.15	1.91	2.51	○
39.	Smuggling	1.90	0.23	1.43	2.37	🏢
40.	Poor marketing of products	1.81	0.17	1.46	2.16	🏢
41.	Preference of foreign brands by people	1.88	0.21	1.44	2.31	○
42.	Competition of our products with cheap imports	1.91	0.20	1.50	2.31	🏢
43.	Conditionalities imposed on Pakistan on tariff, trade and industry issues by	1.58	0.21	1.14	2.01	○

















	IMF and World Bank				
44.	WTO regulations	1.23	0.21	0.80 – 1.66	○
<b>Foreign factors</b>					
45.	Bad perception about Pakistan in world market	2.00	0.18	1.63 – 2.37	○
46.	Restrictions on export of technology by some countries or companies	1.55	0.17	1.20 – 1.90	○
47.	Restriction on foreign visits or contacts by the government	0.71	0.17	0.37 – 1.05	🏛️
48.	Geopolitical situation or sanctions against Pakistan	1.26	0.17	0.91 – 1.61	○
<b>Entrepreneurship</b>					
49.	One-man-show (Owner or one person making every significant decision himself)	1.69	0.23	1.22 – 2.16	🏭
<b>Vendors</b>					
50.	Vendors ignorant about quality	2.03	0.17	1.67 – 2.39	🏭
51.	Vendors lack technical skills	2.06	0.18	1.70 – 2.42	🏭
52.	Illiterate vendors	2.00	0.18	1.63 – 2.37	🏛️






### 10.5.1 Medium barriers

It was decided to define as ‘medium barriers’ the smaller set that had a mean score of 2.00 or more. There were 24 of these and they are listed in table 10.2, together with the category that they come under.



**Table 10.2:** Medium barriers or problems in technology development  
**(Mean score:** Mean score of all the respondents,  = In control of factory managers,  = In control of government,  $\bigcirc$  = In control of neither the factory managers nor the government)

	Category	Medium barriers	Mean Score ( $\bar{X}$ )	Control
1.	Input materials and components	Non-availability of raw materials in Pakistan	2.12	
2.		Poor or inconsistent raw material quality available in Pakistan	2.31	
3.	Expertise in the company	Lack of good human resource	2.03	
4.	Financial and tax issues	Duties / sales tax high on national products than on imports	2.06	
5.		High prices of machinery	2.06	$\bigcirc$
6.		High price of utilities (electricity, gas, telephone and water)	2.56	
7.	Educational issues	University curricula not related to industry	2.26	
8.		R&D by government and other institutions unrelated to industry	2.52	
9.	Issues related to government	Corrupt government functionaries	2.22	
10.		Incapable government functionaries	2.53	
11.		Bad attitude of government inspectors	2.31	
12.		Large number of government inspectors	2.46	
13.		Frequent changes in government policies	2.24	
14.		Bad government policies	2.22	
15.		Long and difficult government procedures	2.67	
16.		Hurdles by lower level staff in government procedures	2.48	
17.		Lack of government support	2.15	

18.	Business environment factors	Lack of standards in Pakistan	2.06	
19.		Lack of technological infrastructure (knowledge base, know-how, basic industries, vendors, basic and applied research, etc) in Pakistan	2.36	
20.	Market factors	Small national market	2.21	○
21.	Foreign factors	Bad perception about Pakistan in world market	2.00	○
22.	Vendors	Vendors ignorant about quality	2.03	
23.		Vendors lack technical skills	2.06	
24.		Illiterate vendors	2.00	

### 10.5.2 Discussion of medium barriers

Comparing the significant barriers of table 10.1 and the medium barriers of table 10.2, we can see that:

- 18 of the 24 medium barriers are in the control of the government. This result is in line with the findings of Swierczek and Nourie (1992), who found that the majority of barriers companies face in developing technology in Thailand are government related.
- The biggest group of medium barriers were the 9 out of 24 classified as issues related to the government. This shows a clear negative perception of the government in Pakistan.
- Problems in technology acquisition, products, product development, equipment and processes are absent in the list of medium barriers. Only one factor, 'lack of good human resource', could marginally make it to the medium problem list from management issues, human factors and expertise in the company. This means that almost none of the medium barriers to technology development are directly related to facets of technology.
- Only one factor, 'small national market', was included in the medium problem list from market factors. Similarly, only one factor, 'bad perception about Pakistan in the

world market', could marginally make it to the medium problem list from foreign factors.

- Both of the educational issues present in the list of significant barriers are also in the list of medium barriers, which shows that education is not supporting manufacturing companies.
- All the three vendor related factors have made their way into the medium problems list, albeit marginally, which shows relatively poor support from the vendor industry.
- Poor availability and poor quality of raw materials are also medium barriers.
- Three finance related factors and both national business environment factors were rated as medium barriers, which shows general unsupportive environment for manufacturing companies.

### **10.5.3 Substantial barriers**

To refine the list still further, we define 'substantial barriers' as having a mean score of 2.5 or above. There were four of these, listed in table 10.3.

### **10.5.4 Discussion on 'substantial barriers'**







All the four are in control of the government. Prices of utilities are in control of the government because the government-owned companies provide these facilities and government sets their prices. The majority of the R&D institutions are also government financed and controlled.

Two other barriers, with scores very near the level of 'substantial barriers' have also been included in table 10.3, and both of these are related to the government.



This shows the negative role of the government in technology and hence industry development in Pakistan. This is in contrast to the literature on East Asian success where government role has been dominantly positive.

**Table 10.3: Substantial barriers in technology development**  
(Mean score: Mean score of all the respondents,  $\bar{x}$  = In control of government)

	Category	Substantial barriers	Mean Score ( $\bar{X}$ )	Control
1.	Financial and tax issues	High price of utilities (electricity, gas, telephone and water)	2.56	
2.	Educational issues	R&D by government and other institutions unrelated to industry	2.52	
3.	Issues related to government	Incapable government functionaries	2.53	
4.		Long and difficult government procedures	2.67	
5.		<i>Large number of government inspectors</i>	2.46	
6.		<i>Hurdles by lower level staff in government procedures</i>	2.48	

### **Incapable government functionaries**

The majority of the respondents consider government functionaries to be incapable of understanding and solving industry problems. One respondent wrote in his comments at the end of the ranking questionnaire: “High-tech and high value addition go together, and become source of wealth of the nations. Our government officer has not understood this aspect. Businesses and businessmen have been ruined in such a way that educated people have been made frightened from this.”

### **Make the procedures easier and minimise government involvement**



‘Long and difficult government procedures’ was the top scorer, with mean score of 2.67. Another nearly substantial problem ‘Hurdles by lower level staff in government procedures’ is also because of long and difficult procedures. The managers thus want to minimise involvement of government and its functionaries in their business. One respondent wrote in his comments: “Minimise government involvement in industry/commerce in the field of regulation. Facilitation yes, but not regulation.”












## **10.6 Survey results – Ranking of actions**

Table 10.4 shows the results of the ranking survey for the ‘actions’ section of the questionnaire. The average of the mean scores of all the significant actions was 2.45, rather higher than the 1.86 average of the barriers. This means that almost all the actions gained strong approval from the respondents. This unexpected result is explained in section 10.6.2.



















There are only four actions that have mean score less than 2.00. These are the following:

















- Take help from consultants (Mean score: 1.94)
- Make production equipment inside your company (Mean score: 1.39)
- Pay no bribes to people (Mean score: 1.85)
- Tariff barriers placed by the government for protection of industry (Mean score: 1.81)














**Table 10.4:** Ranking of actions helpful for technology development  
 (Mean score: Mean score of all the respondents,  = In control of factory managers,  = In control of government)

	Significant actions	Mean Score ( $\bar{X}$ )	Standard deviation of the mean (S)	95 % confidence interval for population mean	Control
<b>Technology and its acquisition</b>					
1.	Acquire complete knowledge about technologies to develop in the company	2.69	0.11	2.46 – 2.91	
2.	Keep knowledge of the technology developments in your area	2.69	0.08	2.52 – 2.85	
3.	Develop or acquire core technologies, which are the mainstay or foundation technologies in your operations	2.67	0.08	2.50 – 2.83	
4.	Consult published material about technologies in your company	2.52	0.10	2.32 – 2.71	
5.	Take help from consultants	1.94	0.13	1.67 – 2.21	
6.	Use Internet	2.47	0.12	2.22 – 2.72	
7.	Copy and improve imported technology	2.29	0.13	2.03 – 2.56	
8.	Buy engineering and other software	2.50	0.11	2.27 – 2.73	
9.	Visit or take part in industrial exhibitions	2.24	0.15	1.92 – 2.55	
<b>Products</b>					
10.	Diversify into new products	2.31	0.13	2.05 – 2.57	
<b>Product design</b>					
11.	Acquire complete capability of product design locally	2.23	0.15	1.93 – 2.53	




12.	Modify products according to infrastructure available in the company	2.23	0.17	1.89 - 2.57	
13.	Reverse engineer products and production equipment	2.25	0.16	1.92 - 2.58	
<b>Production Equipment</b>					
14.	Change to better production equipment	2.69	0.09	2.50 - 2.87	
15.	Adopt automation	2.43	0.13	2.16 - 2.70	
16.	Make production equipment inside your company	1.39	0.21	0.96 - 1.82	
<b>Methods and processes</b>					
17.	Improve production processes	2.70	0.09	2.51 - 2.88	
18.	Gain experience of production processes being used in the company	2.53	0.12	2.29 - 2.77	
19.	Adopt and emphasize quality control	2.91	0.05	2.81 - 3.00	
<b>Management issues</b>					
20.	Convince people for change	2.59	0.13	2.33 - 2.85	
21.	Develop proper systems and procedures	2.76	0.09	2.59 - 2.94	
22.	Adopt teamwork	2.85	0.07	2.70 - 3.00	
23.	Develop commitment in management and employees with objectives of the company	2.76	0.11	2.53 - 2.99	
24.	Motivate workers	2.79	0.07	2.64 - 2.93	
25.	Make proper plans for development	2.68	0.11	2.45 - 2.90	
26.	Work with dedication	2.91	0.05	2.81 - 3.00	
27.	Recruit young people	2.32	0.15	2.02 - 2.63	
28.	Generate vision of the company	2.55	0.12	2.30 - 2.79	
29.	Empower middle and junior management in day-to-day operations	2.52	0.10	2.32 - 2.71	

	of the company				
30.	Pay high salaries to employees	2.13	0.13	1.86 – 2.39	
<b>Expertise in the company</b>					
31.	Train employees locally	2.26	0.12	2.02 – 2.51	
32.	Send employees abroad for training	2.21	0.12	1.95 – 2.46	
33.	Invest in R&D	2.70	0.11	2.47 – 2.92	
34.	Employ good human resource	2.79	0.07	2.65 – 2.94	
35.	Develop local expertise of technologies imported from abroad	2.79	0.07	2.65 – 2.94	
<b>Human factors</b>					
36.	Facilitate workers financially especially in the hour of need.	2.69	0.09	2.50 – 2.87	
<b>Financial and tax issues</b>					
37.	Finance should be made available from the local banks	2.56	0.14	2.28 – 2.84	
38.	Pay taxes completely	2.28	0.17	1.93 – 2.63	
<b>Educational issues</b>					
39.	Universities should work for industry	2.65	0.11	2.42 – 2.87	
<b>Issues related to government</b>					
40.	Pay no bribes to people	1.85	0.22	1.40 – 2.30	
41.	No frequent changes in government policies	2.47	0.17	2.11 – 2.82	
42.	Supportive government policies for development of industry	2.82	0.07	2.68 – 2.96	
43.	Financial incentives of the government	2.58	0.12	2.33 – 2.83	
44.	Investments made by the government in the industry	2.13	0.19	1.74 – 2.52	
45.	Lobbying in the government by	2.22	0.15	1.91 – 2.53	

	Chambers of Commerce & Industry				
46.	Government Common Facility Centres or CAD / CAM centers	2.27	0.19	1.89 - 2.65	
<b>Business environment factors</b>					
47.	Government should develop basic metals and plastics industries	2.26	0.18	1.89 - 2.63	
48.	Collaborate with other industries in your area	2.25	0.15	1.94 - 2.56	
<b>Market factors</b>					
49.	Market products aggressively	2.36	0.14	2.08 - 2.65	
50.	Export products	2.72	0.08	2.56 - 2.88	
51.	Tariff barriers placed by the government for protection of industry	1.81	0.17	1.46 - 2.16	
<b>Foreign factors</b>					
52.	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies	2.77	0.07	2.62 - 2.92	
53.	Make joint ventures with foreign companies	2.58	0.11	2.36 - 2.80	
54.	Import technology through licensing and other means	2.41	0.14	2.13 - 2.69	
55.	Get foreign consultancy in technical matters	2.00	0.14	1.72 - 2.28	
56.	Prove to your foreign joint venture partners that you were capable of working with them	2.44	0.12	2.19 - 2.69	
57.	Visit foreign countries or foreign companies	2.55	0.11	2.33 - 2.76	
<b>Entrepreneurship</b>					
58.	Involvement of owners in technical matters	2.03	0.18	1.66 - 2.40	



Ethical Issues					
59.	Be fair and honest in business	2.82	0.11	2.60 – 3.00	

### 10.6.1 Tariff barriers

One important finding was that the managers did not consider tariff barriers for protection of the industry as beneficial. They only like the government to enforce supportive policies and give some financial incentives. One respondent wrote in his comments at the end of the questionnaire: “In an industry like ours, we want a level playing field when competing with foreign vendors”.

### 10.6.2 Researching the unexpected results

An average score as high as 2.45 was unexpected, and raised the problem that the scores for all of the factors were well within the 95% confidence limits of a large number of other factors, so that discrimination for ranking purposes was not at all strong.

There had been forewarning of the problem because when the results of the pilot phase had been analysed the average of the mean scores of all the actions was 2.50. This aspect was discussed in detail with the pilot phase respondents who replied that the result did represent their true feelings and they did not think that they would give lower scores to various factors.

As the researcher had been aware of this during the main survey, he discussed this aspect in detail with many respondents. It was found that around 30 per cent of the factors were rated 3 or ‘very beneficial’ by most of the respondents. These included factors such as ‘change to better production equipment’, ‘adopt and emphasize quality control’, ‘improve production processes’, ‘employ good human resource’, ‘Supportive

government policies' etc. Similarly, the management proverbs such as 'work with dedication', 'adopt teamwork', 'motivate workers', 'develop commitment' etc were also rated as 'very beneficial'.

Another important aspect was that all the respondents had ticked a few 0s and 1s and had ticked at least once on 'not tried' or 'I don't know'. This showed that they were alert to all the options and that they had rated most of the factors high deliberately.



Another aspect was that some respondents may not have experienced all the foreign factors and they may have been answering based upon their perceptions and not their experiences. In order to clarify this aspect, the researcher discussed it with three of the respondents and discussed brief case histories of their companies. It was revealed that all the three respondents had actually experienced all the foreign factors they had graded.

















Based upon these three cases and considering the fact that the average total experience of the respondents had been 23.7 years, the researcher concluded that the respondents were actually grading based upon their experiences and not their perceptions.

Overall the conclusion is that nearly all the actions are indeed highly beneficial.
















### **10.6.3 Concept of 'substantially beneficial'**

To reduce the number of actions the term 'substantially beneficial' was introduced to describe actions with mean scores of 2.5 or over, and these are listed in table 10.5 together with their classifications under categories.

**Table 10.5:** Substantially beneficial actions for technology development  
 (Mean score: Mean score of all the respondents,  = In control of factory managers,  = In control of government)

	Categories	Substantially beneficial actions	Mean Score ( $\bar{X}$ )	Control
1.	Technology and its acquisition	Acquire complete knowledge about technologies to develop in the company	2.69	
2.		Keep knowledge of the technology developments in your area	2.69	
3.		Develop or acquire core technologies, which are the mainstay or foundation technologies in your operations	2.67	
4.		Consult published material about technologies in your company	2.52	
5.		Buy engineering and other software	2.50	
6.	Production equipment	Change to better production equipment	2.69	
7.	Methods and processes	Improve production processes	2.70	
8.		Gain experience of production processes being used in the company	2.53	
9.		Adopt and emphasize quality control	2.91	
10.	Management issues	Convince people for change	2.59	
11.		Develop proper systems and procedures	2.76	
12.		Adopt teamwork	2.85	
13.		Develop commitment in management and employees with objectives of the company	2.76	
14.		Motivate workers	2.79	
15.		Make proper plans for development	2.68	
16.		Work with dedication	2.91	



17.		Generate vision of the company	2.55	
18.		Empower middle and junior management in day-to-day operations of the company	2.52	
19.	Expertise in the company	Invest in R&D	2.70	
20.		Employ good human resource	2.79	
21.		Develop local expertise of technologies imported from abroad	2.79	
22.	Human factors	Facilitate workers financially especially in the hour of need.	2.69	
23.	Market factors	Export products	2.72	
24.	Foreign factors	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies	2.77	
25.		Make joint ventures with foreign companies	2.58	
26.		Visit foreign countries or foreign companies	2.55	
27.	Ethical issues	Be fair and honest in business	2.82	
28.	Financial and tax issues	Finance should be made available from the local banks	2.56	
29.	Educational issues	Universities should work for industry	2.65	
30.	Issues related to government	Supportive government policies for development of industry	2.82	
31.		Financial incentives of the government	2.58	

#### 10.6.4 Discussion of 'substantially beneficial' actions

Nine out of 31 substantially beneficial actions belong to the management category, five are in the technology acquisition category, and three actions each are related to foreign factors, expertise in the company and processes in the company.

The most important point is that 27 out of 31 of the actions are in the control of the factory managers themselves. Only four are in the control of the government. The factor 'Universities should work for industry' is in government control because the majority of the major universities are run and financed by the government.

The second important point is that technology development is a multi-dimensional problem. Factory managers who intend to carry out technology development activities in their company should work in numerous directions.

### **10.7 Action plans for factory managers and for the government**

The solutions to substantial barriers or problems and the substantially beneficial actions can be represented diagrammatically to form action plans for the factory managers and the government policy makers. These plans are depicted in figure 10.2 and figure 10.1 respectively.

The action plan for the factory managers asks the managers to work in following technology related dimensions:

- Acquire knowledge about technologies to be applied in the company.
- Obtain better production equipment.
- Improve production processes and product quality.
- Improve management techniques
- Invest in R&D and acquire expertise

In addition, specific advices in dimensions beyond technology facets are:

- Export products
- Work as OEM, enter into foreign collaboration and visit foreign countries or companies.

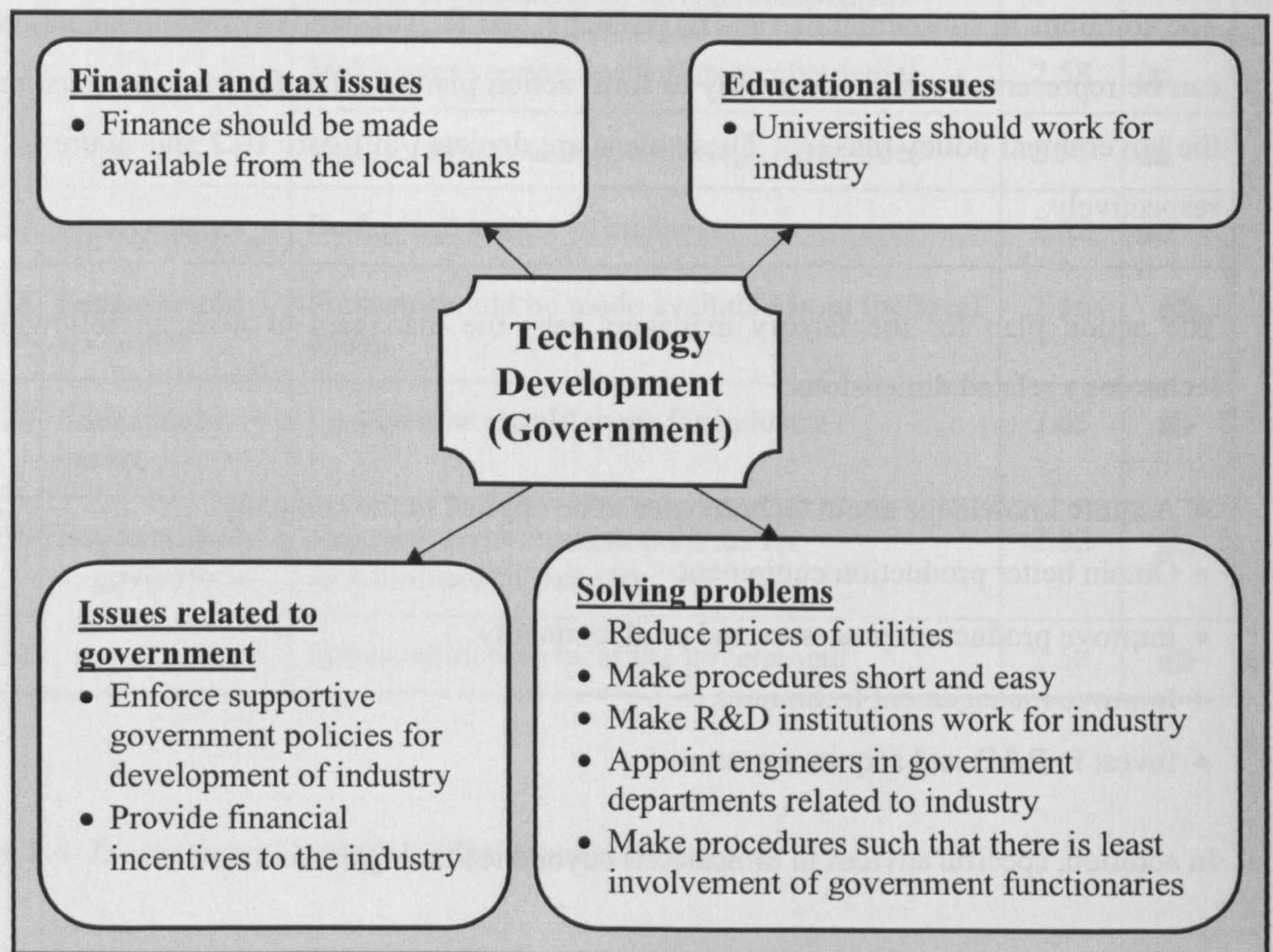


Similarly specific advice to government policy makers is:

- Enforce supportive policies.
- Provide financial incentives.
- Reduce utility prices.
- Make procedures short and easy, and with minimum involvement of government functionaries.

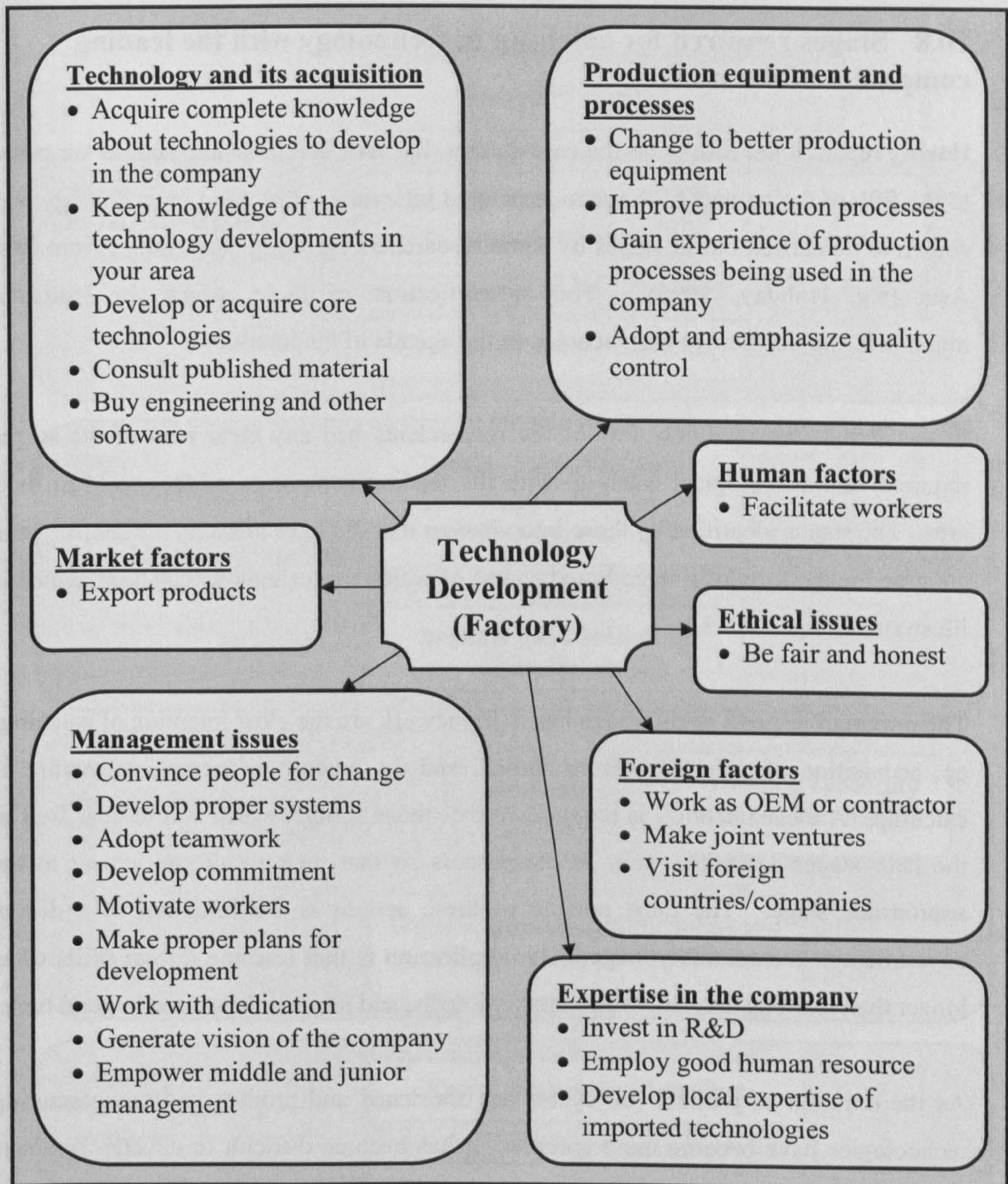
Additionally, universities and R&D institutions should work for industry and finance should be made available from banks.

**Figure 10.1:** Action plan for government policy makers





**Figure 10.2:** Action plan for factory managers





## **10.8 Stages required for catch-up in technology with the leading companies of the world**

Having reported the results on the case studies, barriers, solutions and actions we come to the fifth of the outputs of the semi structured interviews. Catch-up in technology was shown to be carried out in stages by some researchers narrating case studies from East Asia (e.g. Hobday, 1995). Thus identification of these stages for Pakistani manufacturing companies was included in the agenda of the interviews.

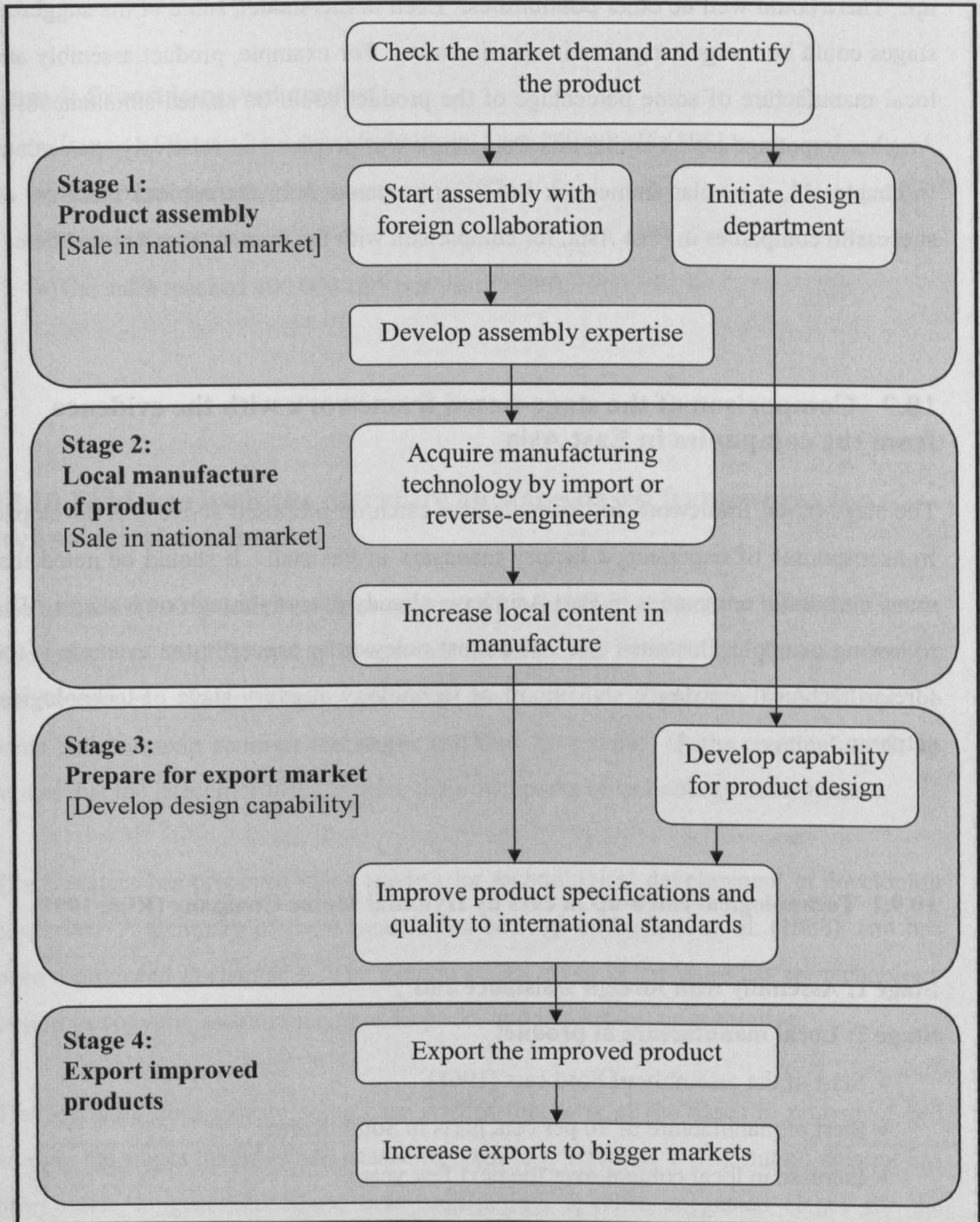
It was found that relatively few of the respondents had any clear idea of the stages required for technological catch-up with the leading companies of the world in their area. The stages identified by those interviewees that did have ideas on the subject were compiled in the form of a stage-based course of action for technology catch-up, which is illustrated in figure 10.3.

The important aspects of this stage-based framework are the clear intention of catching-up, acquisition of technology from abroad, and the gradual or incremental nature of catch-up. A clear intention is required so that those actions which would bear fruit at the later stages are taken early in the process so that their result can appear at the appropriate stage. The most notable of these actions is the initiation of a design department at the assembly stage. The implication is that learning design skills takes longer than learning assembly or production skills, and needs to be started in good time.

As the duration of product life cycles has shortened and product and manufacturing technologies have become more complex, it has become difficult to develop products and processes only on the basis of reverse-engineering. Foreign collaboration and import of technology have become more or less mandatory to ensure catch-up in technology.



**Figure 10.3:** Proposed scheme of stages required for technological catch-up





It must be noted that it is not claimed that this is the only route to technological catch-up. There could well be other possibilities. Even in this model, some of the suggested stages could be merged together in certain cases. For example, product assembly and local manufacture of some percentage of the product could be started simultaneously. Another important aspect is that this framework was prepared on relatively sparse data. In chapter 11, a similar framework has been prepared from the copious literature on successful companies in East Asia, for comparison with the framework presented here.

## **10.9 Comparison of the stage-based framework with the evidence from the companies in East Asia**

The stage-based framework for technological catch-up proposed above was developed from responses of experienced factory managers in Pakistan. It should be noted that many successful companies in East Asia have already passed through such stages. The following example illustrates this. The most noteworthy aspect in the example is the foreign technical assistance and import of technology at every stage of technological catch-up.

### **10.9.1 Technological catch-up in cars by Hyundai Motor Company (Kim, 1997)**

#### **Stage 1: Assembly with foreign assistance and**

#### **Stage 2: Local manufacture of product**

- Start of the assembly of Ford cars (1968).
- Start of manufacture of 20 per cent parts in South Korea.
- Increase in local content over the next few years.

#### **Stage 3: Develop design capability and prepare for export**

- Import of car designs from Mitsubishi Motor Company (1973).
- Designed the new car through foreign technical assistance (1973 to 1975).



- Start of manufacture of own designed car with Mitsubishi engine (1975).
- Start of export efforts (1976).

#### **Stage 4: Export improved product**

- Import of front wheel drive technology from Mitsubishi (1981).
- Start of production of improved car (1982).
- Rise in exports.
- Car sales reached 400,000 cars per year (1986).

### **10.10 Evidence from the literature on stage-based frameworks for technological catch-up**

Lee and Lim (2001) described three patterns of technological catch up, as mentioned in Appendix 1A: ‘Path following’ means that the latecomer firms follow the same steps as the forerunner. ‘Stage-skipping’ catch-up means that the latecomer firms follow the same path but skip some of the stages and thus save time. ‘Paths creating’ catch-up means that the latecomer firms explore their own paths of technology development.

The literature has proposed many models for technological development in developing countries. A summary of these models has been given by Lee et. al. (1988), and has been reproduced in chapter 3. The general stages given in these models are technology import or copying, assimilation or absorption, and innovation or generation.

The literature does narrate some case studies that look at the cases in retrospect and analyse the stages that they had passed through (e.g. Hobday, 1995), but no attempt has been made to generalise these case studies into specific suggested stages for the technological catch-up of firms. For example, Hobday (1995) pointed out the following stages in case of Anam Industrial, a chip packaging company from South Korea:

- Phase 1: Learning the art of assembly.

- Phase 2: Learning process engineering skills.
- Phase 3: The switch to locally initiated learning.
- Phase 4: Towards product innovation capabilities.

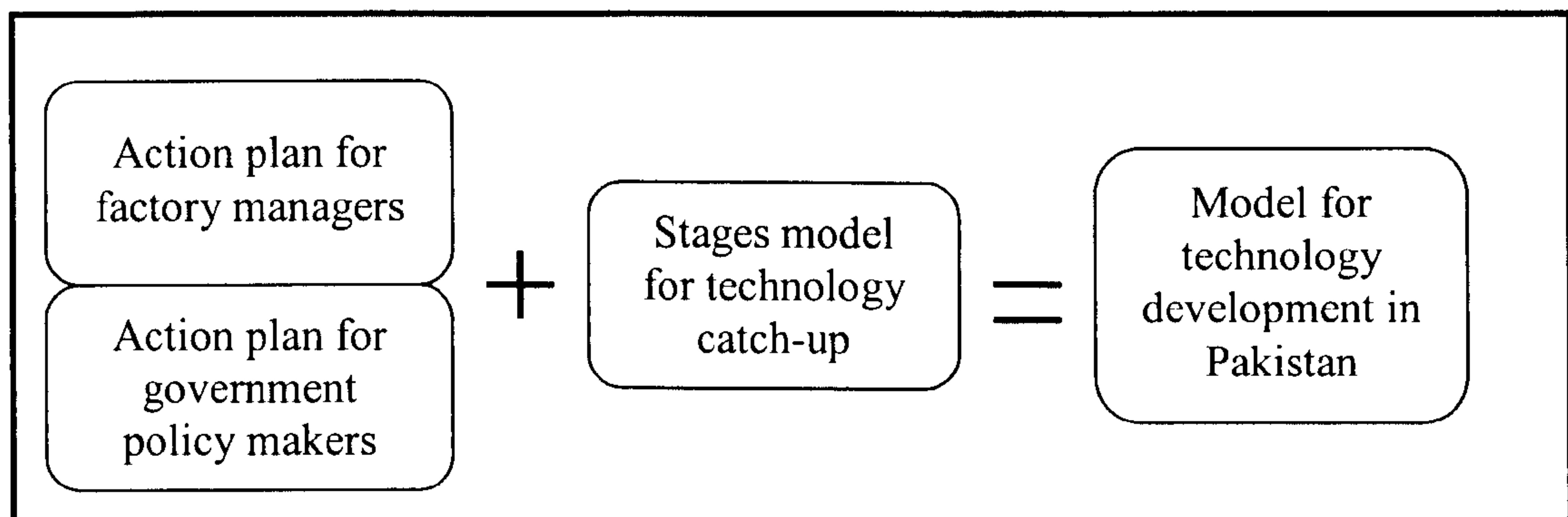
This research has developed a stage based model intended to be a guideline for individual companies aspiring to catch-up in technology.

Two particular aspects are important. Firstly, this research has advised that companies aspiring to catch-up should start to acquire design capabilities early in their life, and strengthen them with time. Secondly, these aspiring companies must get into export.

### 10.11 Conclusion – a Model for Technology Development

Bringing together figures 10.1, 10.2 and 10.3, we can now summarise all the findings from the interviews and the ranking survey in a single model:

**Figure 10.4:** Model for Technology Development in Pakistan



The next chapter produces a comparative model from case studies of manufacturing companies given in the literature on East Asia



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## APPENDIX 10A

## APPENDIX 10A

## Questionnaire for Ranking Survey

**Research project:** Technology options for the manufacturing sector of Pakistan in the catch-up process

**Researcher:** Numan Iqbal, TROSS scholar

**Research supervision:** R&D Management Centre, Cranfield University, UK

Survey QuestionnaireYour Experiences about Barriers and Actions in Technology Development

A2: Date: \_\_\_\_\_ A1: Survey No.: \_\_\_\_\_

A3: City: \_\_\_\_\_

B1: Name (**optional**) \_\_\_\_\_

B2: Job title (manager, general manager etc) (**optional**) \_\_\_\_\_

B3: Name of company (**optional**) \_\_\_\_\_

B4: Academic Qualification (BSc, MBA etc) \_\_\_\_\_

B5: Total work experience (years) \_\_\_\_\_

Section 1: Barriers or problems in technology development

This section concerns problems encountered by some companies in developing their technology. It asks how serious these problems have been for development of technology in your company.

• **Please answer questions based upon your EXPERIENCES ONLY and NOT your OPINIONS.**

• There are 52 questions in this section, and **one tick is required for each.**

• If the meaning of a question is not clear, please circle the question number.

## Definitions of options:

Not Applicable NA <input type="checkbox"/>	<i>Seriousness of problems in development of technology encountered in our company</i>				<i>I Don't Know</i> DN <input type="checkbox"/>
	<i>No problem in technology development</i> 0 <input type="checkbox"/>	<i>Minor problem in technology development</i> 1 <input type="checkbox"/>	<i>Medium problem in technology development</i> 2 <input type="checkbox"/>	<i>Major problem in technology development</i> 3 <input type="checkbox"/>	
This barrier has not been experienced by us	The barrier was experienced but did not cause significant problem in technology development	It was minor problem for us in technology development	It was problem of medium level for us in technology development	It was major problem for us in technology development	I do not know about this issue



Barriers in technology development	Not Applicable	Seriousness of problems in development of technology encountered in our company				I Don't Know
		No problem in technology development	Minor problem in technology development	Medium problem in technology development	Major problem in technology development	
<b>Technology and its acquisition</b>						
1. Lack of information and knowledge about technology	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Production equipment</b>						
2. Inadequacy of production equipment	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Methods and processes</b>						
3. Technical problems in production processes	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Input materials</b>						
4. Difficulties in import of raw materials	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
5. Non-availability of raw materials in Pakistan	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
6. Poor or inconsistent raw material quality available in Pakistan	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
7. Lack of availability of electronic components in Pakistan	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
8. Difficulty in import of electronic components	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Management issues</b>						
9. People resisting technology changes	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
10. Opposition of senior management for technology changes	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>



Barriers in technology development	Not Applicable	Seriousness of problems in development of technology encountered in our company				I Don't Know
		No problem in technology development	Minor problem in technology development	Medium problem in technology development	Major problem in technology development	
11. Lack of teamwork	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
12. Lack of professional management	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Expertise in the company</b>						
13. Shortage of trained human resource	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
14. Lack of good human resource	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
15. Illiteracy of employees	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Human factors</b>						
16. Brain drain from Pakistan	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
17. Large number of employees leaving the company	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Financial and tax issues</b>						
18. Shortage of funds and resources	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
19. Duties / sales tax high on national products than on imports	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
20. High prices of machinery	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
21. Problem in getting finance from banks	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
22. High price of utilities (electricity, gas, telephone and water)	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Educational factors</b>						
23. University curricula not related to industry	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>



Barriers in technology development	Not Applicable	Seriousness of problems in development of technology encountered in our company				I Don't Know
		No problem in technology development	Minor problem in technology development	Medium problem in technology development	Major problem in technology development	
24. R&D by government and other institutions unrelated to industry	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Issues related to government</b>						
25. Corrupt government functionaries	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
26. Incapable government functionaries	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
27. Bad attitude of government inspectors	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
28. Large number of government inspectors	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
29. Frequent changes in government policies	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
30. Bad government policies	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
31. Long and difficult government procedures	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
32. Hurdles by lower level staff in government procedures	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
33. Problems at customs during imports or exports	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
34. Lack of government support	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
35. Announced government incentives not enforced	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Business environment factors</b>						



Barriers in technology development	Not Applicable	Seriousness of problems in development of technology encountered in our company				I Don't Know
		No problem in technology development	Minor problem in technology development	Medium problem in technology development	Major problem in technology development	
36. Lack of standards in Pakistan	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
37. Lack of technological infrastructure (knowledge base, know-how, basic industries, vendors, basic and applied research, etc) in Pakistan	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Market factors</b>						
38. Small national market	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
39. Smuggling	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
40. Poor marketing of products	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
41. Preference of foreign brands by people	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
42. Competition of our products with cheap imports	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
43. Conditionalities imposed on Pakistan on tariff, trade and industry issues by IMF and World Bank	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
44. WTO regulations	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Foreign factors</b>						
45. Bad perception about Pakistan in the world market	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
46. Restrictions on export of technology by some countries or companies	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>



Barriers in technology development	Not Applicable	Seriousness of problems in development of technology encountered in our company				I Don't Know
		No problem in technology development	Minor problem in technology development	Medium problem in technology development	Major problem in technology development	
47. Restriction on foreign visits or contacts by the government	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
48. Geopolitical situation or sanctions against Pakistan	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Entrepreneurship</b>						
49. One-man-show (Owner or one person making every significant decision himself)	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Vendors</b>						
50. Vendors ignorant about quality	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
51. Vendors lack technical skills	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
52. Illiterate vendors	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>



**Section 2: Actions for technology development**

This section concerns actions some companies have used to try to develop their technology. It asks how beneficial these actions have been for development of technology in your company.

- **Please answer questions based upon your EXPERIENCES ONLY and NOT your OPINIONS.**
- There are 59 questions in this section, and **one tick is required for each.**
- If the meaning of a question is not clear, please circle the question number.

**Definitions of options:**

<i>Not tried</i> NA <input type="checkbox"/>	<i>Benefit of actions for development of technology tried in our company</i>				<i>I Don't Know</i> DN <input type="checkbox"/>
	<i>Not beneficial for technology development</i> 0 <input type="checkbox"/>	<i>Slightly beneficial for technology development</i> 1 <input type="checkbox"/>	<i>Beneficial for technology development</i> 2 <input type="checkbox"/>	<i>Very beneficial for technology development</i> 3 <input type="checkbox"/>	
This idea would not apply to us, or we have not tried it	Applicable and tried but not beneficial for technology development of our company	It was slightly beneficial for technology development of our company	It was beneficial for technology development of our company	It was very beneficial for technology development of our company	I don't know about this issue

<b>Actions for technology development</b>	Not tried	<b>Benefit of actions for development of technology tried in our company</b>				<b>I Don't Know</b>
		Not beneficial for technology development	Slightly beneficial for technology development	Beneficial for technology development	Very beneficial for technology development	
<b>Technology acquisition</b>						
1. Acquire complete knowledge about technologies to develop in the company	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
2. Keep knowledge of the technology developments in your area	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>



Actions for technology development	Not tried	Benefit of actions for development of technology tried in our company				I Don't Know
		Not beneficial for technology development	Slightly beneficial for technology development	Beneficial for technology development	Very beneficial for technology development	
3. Develop or acquire core technologies, which are the mainstay or foundation technologies in your operations	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
4. Consult published material about technologies in your company	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
5. Take help from consultants	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
6. Use Internet	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
7. Copy and improve imported technology	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
8. Buy engineering and other software	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
9. Visit or take part in industrial exhibitions	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Products</b>						
10. Diversify into new products	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Product design</b>						
11. Acquire complete capability of product design locally	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
12. Modify products according to infrastructure available in the company	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
13. Reverse engineer products and production equipment	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Production equipment</b>						
14. Change to better production equipment	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>



Actions for technology development	Not tried	Benefit of actions for development of technology tried in our company				I Don't Know
		Not beneficial for technology development	Slightly beneficial for technology development	Beneficial for technology development	Very beneficial for technology development	
15. Adopt automation	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
16. Make production equipment inside your company	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Production processes</b>						
17. Improve production processes	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
18. Gain experience of production processes being used in the company	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
19. Adopt and emphasize quality control	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Management issues</b>						
20. Convince people for change	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
21. Develop proper systems and procedures	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
22. Adopt teamwork	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
23. Develop commitment in management and employees with objectives of the company	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
24. Motivate workers	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
25. Make proper plans for development	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
26. Work with dedication	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
27. Recruit young people	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
28. Generate vision of the company	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>



Actions for technology development	Not tried	Benefit of actions for development of technology tried in our company				I Don't Know
		Not beneficial for technology development	Slightly beneficial for technology development	Beneficial for technology development	Very beneficial for technology development	
29. Empower middle and junior management in day-to-day operations of the company	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
30. Pay high salaries to employees	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Expertise in the company</b>						
31. Train employees locally	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
32. Send employees abroad for training	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
33. Invest in R&D	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
34. Employ good human resource	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
35. Develop local expertise of technologies imported from abroad	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Human issues</b>						
36. Facilitate workers financially especially in the hour of need.	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Finance and tax issues</b>						
37. Finance should be made available from the local banks	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
38. Pay taxes completely	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Educational issues</b>						
39. Universities should work for industry	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Issues related to the government</b>						
40. Pay no bribes to people	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>



Actions for technology development	Not tried	Benefit of actions for development of technology tried in our company				I Don't Know
		Not beneficial for technology development	Slightly beneficial for technology development	Beneficial for technology development	Very beneficial for technology development	
41. No frequent changes in government policies	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
42. Supportive government policies for development of industry	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
43. Financial incentives of the government	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
44. Investments made by the government in the industry	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
45. Lobbying in the government by Chambers of Commerce & Industry	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
46. Government Common Facility Centres or CAD / CAM centers	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Business Environment Factors</b>						
47. Government should develop basic metals and plastics industries	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
48. Collaborate with other industries in your area	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Market Factors</b>						
49. Market products aggressively	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
50. Export products	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
51. Tariff barriers placed by the government for protection of industry	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Foreign factors</b>						
52. Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>



Actions for technology development	Not tried	Benefit of actions for development of technology tried in our company				I Don't Know
		Not beneficial for technology development	Slightly beneficial for technology development	Beneficial for technology development	Very beneficial for technology development	
53. Make joint ventures with foreign companies	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
54. Import technology through licensing and other means	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
55. Get foreign consultancy in technical matters	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
56. Prove to your foreign joint venture partners that you were capable of working with them	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
57. Visit foreign countries or foreign companies	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Entrepreneurship</b>						
58. Involvement of owners in technical matters	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>
<b>Miscellaneous</b>						
59. Be fair and honest in business	NA <input type="checkbox"/>	0 <input type="checkbox"/>	1 <input type="checkbox"/>	2 <input type="checkbox"/>	3 <input type="checkbox"/>	DN <input type="checkbox"/>

Please write any *comments* that you would like to make about various barriers and problems or about actions or about the questionnaire or about technology development in general.

*Thank you* for your cooperation in filling in this questionnaire.

**Please put the questionnaire in the attached stamped and self-addressed envelope and post it.**



## APPENDIX 10B

### APPENDIX 10B                      Cover letter for Ranking Survey

#### R&D Management Centre

School of Engineering  
Cranfield University  
Cranfield  
Bedford MK43 0AL, UK

Email: [rdman@cranfield.ac.uk](mailto:rdman@cranfield.ac.uk)  
[www.cranfield.ac.uk/sme/rdman](http://www.cranfield.ac.uk/sme/rdman)

#### Numan Iqbal

House No. 1, Street No. 2,  
A – 3/4, Islamabad.

Tel : (051)-1234567  
Email: [n.iqbal.2001@cranfield.ac.uk](mailto:n.iqbal.2001@cranfield.ac.uk)

5 March, 2004

Mr. ABC  
XYZ Company  
Technology Development City

Dear Sir,

This letter is an invitation to participate in my PhD research to find out how Pakistani manufacturing companies can best set about catching up with world standards. This research is funded by the Ministry of Science and Technology, Pakistan, and is being supervised by Cranfield University, UK.

During the course of this research, I interviewed numerous experienced managers in manufacturing industries of Pakistan to find out what their problems were, and what approaches had been used to develop technology in their industries. This resulted in lists of problems and actions for technology development in manufacturing companies of Pakistan. As the next logical step, I have prepared this questionnaire, whose purpose is to discover how important different problems and actions are, according to the experience of senior managers such as yourself.

I am sure you will find this questionnaire useful and interesting as it is based upon experiences of other senior managers. I would greatly appreciate if you could take time out of your busy schedule to fill it in. The average time for doing this is about 27 minutes. I have attached a stamped self-addressed envelop for its return.

With best regards,

Sincerely yours,

Numan Iqbal.



**Research project – Statement and definitions**

**Managing technology in manufacturing companies of Pakistan**

Numan Iqbal. March 2004.

**Research title:**

Technology options for the manufacturing sector of Pakistan in the catch-up process.

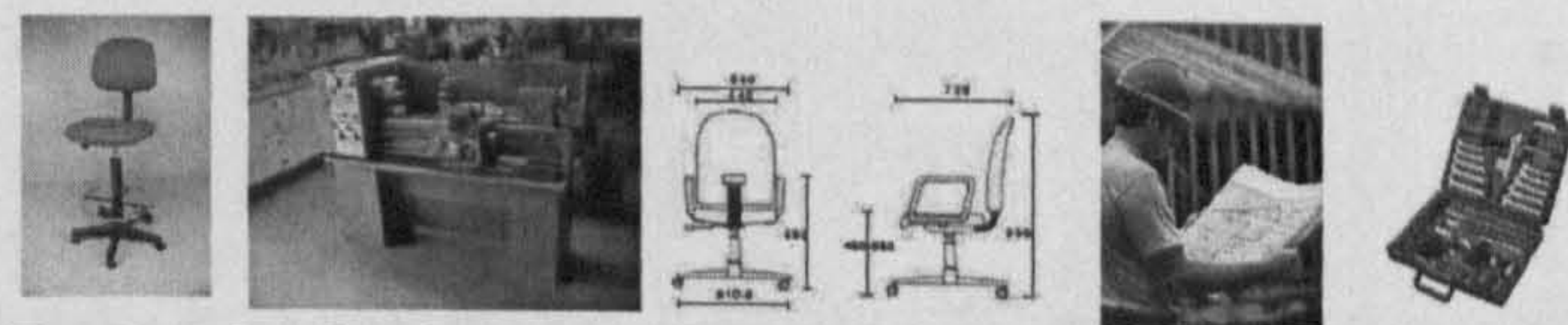
**Research statement:**

The manufacturing sector has proved to be vitally important in countries that have developed at a fast pace. Their thriving manufacturing sectors have been based upon rapid technology acquisition and absorption.

This research explores the steps that manufacturing companies in Pakistan should follow, and the help that the commercial environment of the company (government, banks, other industries, research institutes, universities etc) should provide, so that they can acquire improved technologies and ultimately become competitive with the leading companies of the world.

**Definitions:**

**Technology:** Technology is the means of transfer of an idea into reality. This includes products; equipment, machinery and tools; processes; materials; drawings, process sheets and specifications; human expertise; and the system that combines the other forms of technology to produce products.



Facets of technology – Product, equipment, tools, drawings, expertise, processes, management etc.

**Technology acquisition:** The process of purchasing or otherwise obtaining different facets of technology.

**Technology absorption:** The process of incorporation of different facets of technology in the company.

**Catch-up in technology:** The process through which the companies can get closer to the companies leading the world in their business in various facets of technology.



## Chapter 11

# **Development of an East Asian Model of Technology Development from the Literature**

### **11.1 Introduction – the need for generation of an East Asian Model**

This chapter describes the generation of the basis for a systematic comparison of the results obtained from research in Pakistan with the literature on East Asian success stories.

A lot of literature has been published about those countries in East Asia that have developed in a relatively short time. The literature provides success stories of some companies in these countries but it does not provide much insight into the barriers and problems in technology development that were met, or their solutions. Although many actions helpful in technology development can be found dispersed in this literature, there is no systematic compilation of these actions.

It was decided that such compilation should be carried out so that a direct comparison with research in Pakistan could be made. This resulted in a model of technology development from East Asia, similar to that developed in Pakistan. Chapter 12 compares and contrasts the two compilations of factors (models) from Pakistan and from the literature on East Asia.



## **11.2 Method of compilation of factors**

### **11.2.1 What part of literature was included in the compilation of factors**

The literature on technology development issues was reviewed in chapter 3. The majority of the literature on technology development in developing countries discusses policy issues and actions required for technology development at the government level. Some parts of the literature also describe policies followed and actions taken at the firm level, giving case studies of technology development at the firm level.

As this research is related to technology development issues at the firm level, those papers that presented case studies of technology development at the firm level were selected for a compilation of factors. These papers quoted case studies of companies from four East Asian countries – South Korea, Taiwan, Singapore and Malaysia. Only those case studies were considered which were from the same sub-sectors of the manufacturing sector that had been selected in the research boundaries of this research (chapter 4).

Content analysis (explained in next two sections) of these selected papers provided the required barrier, solution and action factors. But a review of this compilation revealed that very few government related factors were counted.

As the role of the government has been considered dominant in East Asia by numerous researchers (e.g. Lee and Yang, 2000, and Hsu and Chiang, 2001), it was decided that literature indicating specific actions taken by the governments in East Asia should also be included in the compilation, so that a complete picture could be obtained.

As the literature on these four countries did not cite many barriers to technology development, a paper on companies of Thailand was also included as it indicated some barriers.

Table 11.1 lists all the research papers and book chapters included in the analysis. Some papers additional to those that were reviewed in chapters 2 and 3 are included.

**Table 11.1:** The research papers and book chapters included in the compilation of factors to develop the East Asian model

	<b>Reference</b>	<b>Company/Companies/ Government</b>	<b>Co. code</b>	<b>Product</b>
1.	Magaziner & Patinkin (1989), and Hobday (1995)	Samsung	e1	Microwave Oven
2.	Lee & Lim (2001)	Hyundai	e2	Semiconductors / DRAM
3.	Kim (1997b), and Lee & Lim (2001)	Samsung	e3	Semiconductors / DRAM
4.	Lee & Lim (2001)	Samsung, LG, ETRI	e4	CDMA Cellular phones
5.	Lee & Lim (2001)	Sambo / Quenix	e5	PC, Audio / Video equipment
6.	Hyun (1999), and Lee & Lim (2001)	Hyundai Motor Company	e6	Cars and car engine
7.	Bae & Lee (1986)	Firm P	e7	Staple machinery
8.	Bae & Lee (1986)	Firm W	e8	Machine tools
9.	Bae & Lee (1986)	Firm K	e9	Knitting machinery
10.	Bae & Lee (1986)	Firm H	e10	Shot blast machinery
11.	Bae & Lee (1986)	Firm D	e11	Machinery
12.	Bae & Lee (1986)	Firm S	e12	Machinery
13.	Hobday (1995)	ACER	e13	Computers
14.	Hobday (1995)	ANAM international	e14	Packaging of ICs
15.	Hobday (1995)	RJP	e15	Consumer electronics
16.	Hobday (1995)	Wearnes Hollingsworth Group	e16	Computers



17.	Hobday (1995)	MTI	e17	Integrated circuits
18.	Bowonder & Miyake (1994)	Hitachi	e18	Various products
19.	Chu (1997)	Bicycle companies in Taiwan	e19	Bicycle
20.	Hobday (1995)	Samsung	e20	Radio, TV, Electronics
21.	Rabushka (1987)	Government actions in Taiwan	e21	
22.	Chang et.al. (1999)	Government Research Institute (GRI) in Taiwan	e22	Computers
23.	Mathews (1997)	GRI and companies in Taiwan	e23	Semiconductors
24.	Lee & Yang (2000)	Science park in Taiwan	e24	
25.	Sikka (1998)	Government actions in South Korea	e25	
26.	Tidd & Brocklehurst (1999)	Government and companies in Malaysia	e26	
27.	Tidd & Brocklehurst (1999)	Globetronics Bhd.	e27	Electronics
28.	Lee (2000)	Medison Co. Ltd.	e28	Electronic medical equipment
29.	Lee (2000)	Doojin Electronics Co. Ltd.	e29	MPEG, DVD boards
30.	Lee (2000)	Turbo Tek Co. Ltd.	e30	CNC controllers
31.	Lee (2000)	Companies in South Korea	e31	
32.	Hsu & Chiang (2001)	Government actions in Taiwan	e32	
33.	Choi (1989)	Government and companies in South Korea	e33	

34.	Yoshimatsu (2000)	Government and Proton in Malaysia	e34	Car
35.	Choi (1988)	Government and companies in South Korea	e35	
36.	Swee (1996)	Government and companies in Singapore and Malaysia	e36	
37.	Chang & Hsu (1998)	GRI and companies in Taiwan	e37	Semiconductors
38.	Choi (1981)	Government and companies in South Korea	e38	
39.	Kim & Lee (2002)	Subtronix	e39	Power supply, CRT
40.	Kim & Lee (2002)	Manutronix	e40	Coil and transformer
41.	Kim & Lee (2002)	Marketronix	e41	TV parts and computer accessories
42.	Kim & Lee (2002)	Innotronix	e42	Buzzer and coil
43.	Kim & Lee (2002)	Ventronix	e43	Plastic magnet and other electronic components
44.	Kim (1997a)	Korea Steel Pipe Company	e44	Steel pipes and its machinery
45.	Kim (1997a)	Wonil Machinery Works	e45	Hot and cold rolling machinery
46.	Swierczek & Nourie (1992)	Various companies in Thailand	e46	Various products

### 11.2.2 Preparation and rules for coding in content analysis

The compilation of factors was carried out through content analysis of the papers in the literature, in the similar way as had been done for the interviews. The concepts looked



for during content analysis process included barriers to technology development, their suggested solutions, if any, and actions supporting technology development.

It was decided that only the existence of a factor would be counted in a particular case study and not its number of mentions in that case study. On the other hand, the number of mentions would be counted across case studies. It was decided that concepts would be coded the same even if they appeared in different forms or different wording.

If any company was described in more than one reference, the factors from all those accounts were combined together so as to avoid repetition and biasing of results. An example is the development of a microwave oven by Samsung, which was described in two papers. If a research paper described more than one case study, those case studies were considered separately.

Some papers were included in the analysis which did not describe individual case studies but did mention examples of actions taken by various companies for development of a certain product. As the product was the same and individual companies could not be considered individually in this case as it would have resulted in only one or two factors, such accounts were considered as one case study.

Each of the papers describing specific government actions for technology development was considered as one case study.

Twenty three research papers and two book chapters thus generated forty six case studies.

### **11.2.3 Conduct of the content analysis**

All explicit or directly affecting and implicit or indirectly affecting barriers and actions to various facets of technology were coded, and were organised according to the categories of the same framework of issues for technology development as was developed in chapter 6.

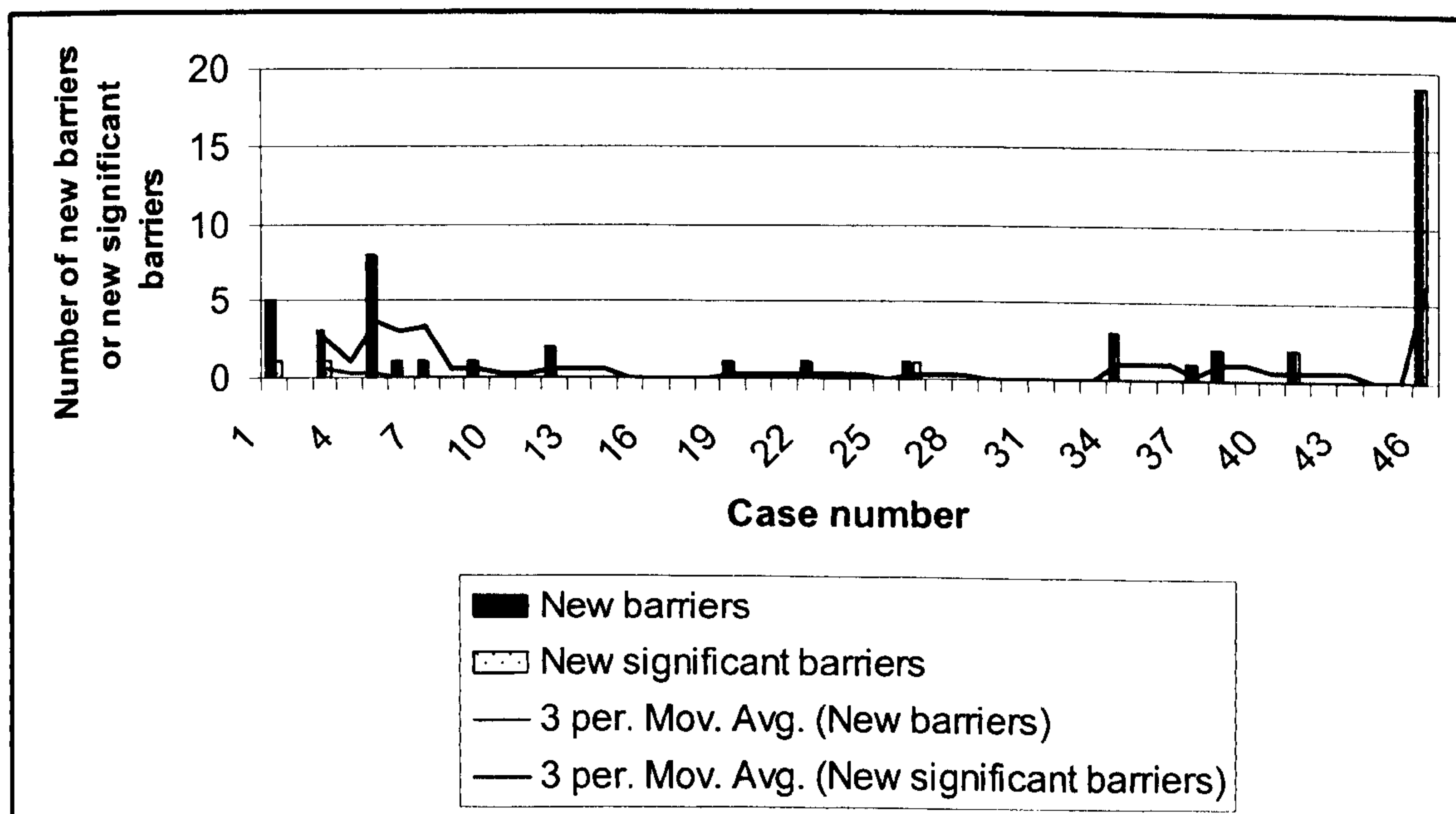
The factors obtained were compared against the descriptions of factors generated during the content analysis of the interviews in Pakistan. Descriptions were developed for those barrier and actions which had not arisen in Pakistan. These descriptions helped to ensure that all factors were clear and unique.

Once the content analysis process had been completed, the factors were identified on the basis of their being in control of the factory management or the government or neither of them.

### 11.3 Results – Compilation of barriers


Figure 11.1 shows how new significant barriers appeared as the analysis of the cases proceeded. There was a surge in barrier count in the last case simply because this was the paper about Thailand that had been included especially because it was rich in barriers.


**Figure 11.1:** Frequency of appearance of new barriers and new significant barriers during content analysis of various cases in development of the East Asian model.





Appendix 11A lists of the barriers obtained during the content analysis process. Only three barriers were mentioned in three or more case studies (i.e. 5%) and could be termed 'significant barriers' by the criteria used in the previous chapter. Table 11.2 lists these.

**Table 11.2:** Significant barriers in the East Asian model of technology development, their descriptions, and identification of their being in control of factory management or government or neither of them. (N: Number of case studies in which this factor appeared,  = In control of government, O = In control of neither the factory managers nor the government)

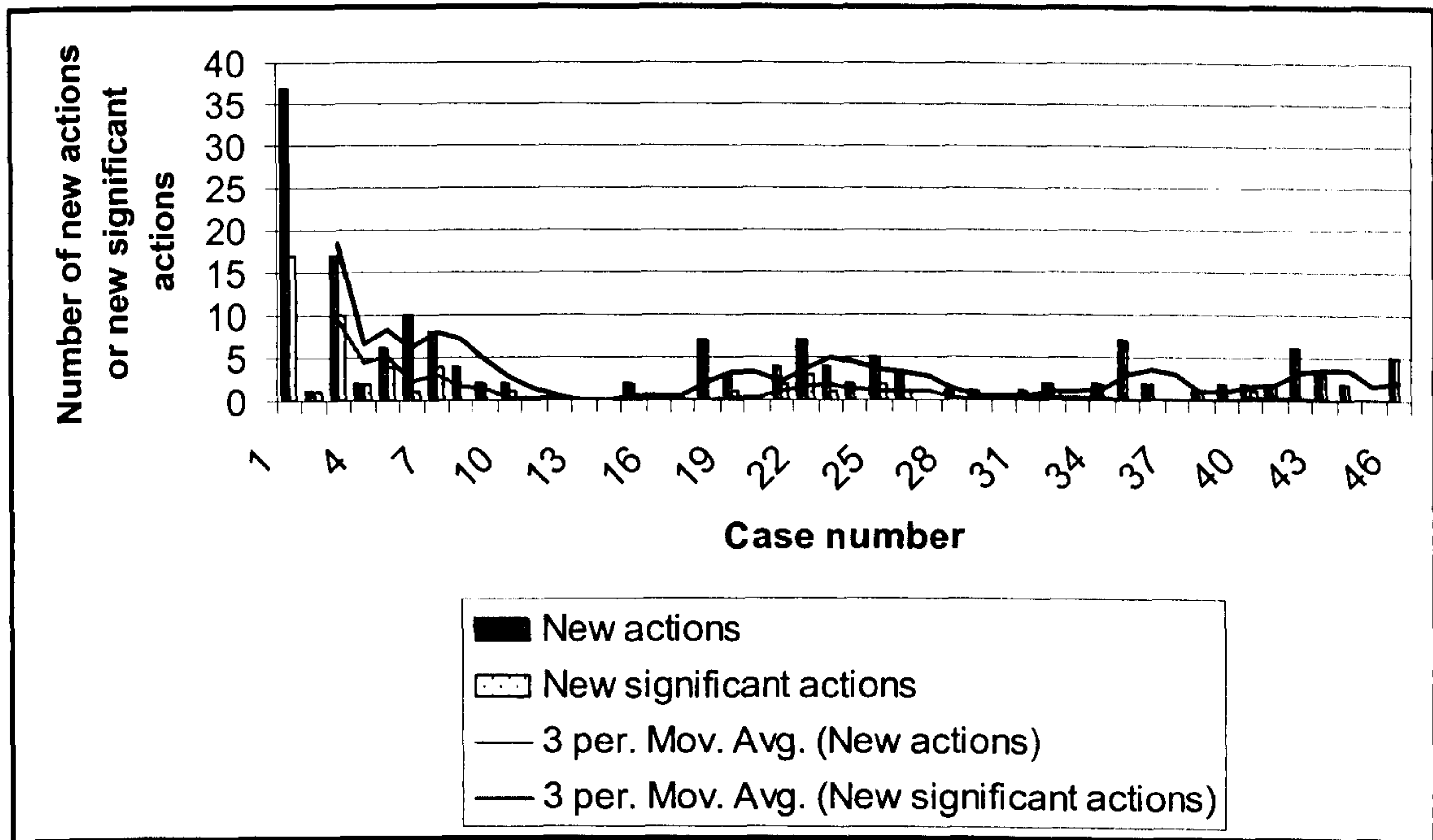
	Significant Barriers	Description of barriers	N	Control
<b>Expertise in the company</b>				
1.	Shortage of trained human resource	There is shortage of trained people in the country.	4	
<b>Market factors</b>				
2.	Small national market	The market for products within the country is small.	3	O
<b>Foreign factors</b>				
3.	Restrictions on export of technology by some countries or companies	Some countries or companies put restrictions on export of technology that hampers technology development in the country.	3	O



#### 11.4 Results – Compilation of actions


Figure 11.2 show the rate of appearance of new actions and significant actions as the analysis of cases proceeded. Significant actions were the ones mentioned in three or

more (5% or more) case studies. 40 out of 52 significant actions had been obtained in the first ten cases. The last significant action was obtained in case number 40. 161 actions were identified in the case studies and these are listed in appendix 11B. Table 11.3 lists the 53 significant actions.

**Figure 11.2:** Frequency of appearance of new actions and new significant actions during content analysis of the cases in development of the East Asian model




**Table 11.3:** Significant actions in the East Asian model of technology development, their descriptions, and identification of their being in control of the factory management or the government or neither of them. (N: Number of case studies in which this factor appeared,  = In control of factory managers,  = In control of government)




	<b>Actions</b>	<b>Description of actions</b>	<b>N</b>	<b>Control</b>
<b>Technology and its acquisition</b>				
1.	Copy and improve imported technology	Copy and improve upon technology imported earlier in the company.	4	













2.	Gradually obtain technology starting from assembly	Obtain technology gradually starting from assembly. Move on to manufacturing and design in the later stages.	5	
<b>Products</b>				
3.	Diversify the products	Diversify the product range of products being made in the company.	8	
4.	Develop state-of-the-art products and not proven products	Develop state-of-the-art products and not proven products, so that technology gap with leading companies can be reduced.	6	
<b>Product development</b>				
5.	Reverse engineer products and production equipment	Companies should adopt reverse-engineering of products and production equipment.	5	
6.	Acquire complete capability of product design	Acquire or develop complete capability to design products in the company.	18	
<b>Production Equipment</b>				
7.	Adopt automation	Adopt automation or low cost automation to replace manual activities.	3	
8.	Make production equipment inside your company	Make required production machines and equipment within the company.	4	
9.	Change to better equipment	Obtain improved production equipment with aim to increase production and/or improve quality.	7	
<b>Methods and processes</b>				
10.	Improve production processes	Adopt better production processes.	5	
<b>Management issues</b>				
11.	Develop commitment in management and employees with objectives of the company	Commitment with objectives of the company should be developed in people and management of the company.	3	









12.	Generate vision of the company	The company should generate its vision.	6	
13.	Hire returning qualified expatriate nationals	Hire returning qualified and experienced expatriate nationals.	3	
<b>Expertise in the company</b>				
14.	Invest in human resource	Make investments so that skill level of human resource is increased.	4	
15.	Train employees locally	Provide training to employees locally.	4	
16.	Send people abroad for training	Send people abroad for training.	9	
17.	Invest in R&D	Invest in research and development activities.	16	
<b>Educational issues</b>				
18.	Get associated with universities	Industries should get associated with universities in order to obtain knowledge and technical help.	8	
<b>Issues related to government</b>				
19.	Government should provide infrastructure facilities	Government should provide good infrastructure facilities including communication, transport and utilities in the country.	6	
20.	Financial incentives of the government	Government should give financial incentives to industry.	8	
21.	National objectives should be set	Government should set national objectives.	7	
22.	Government should create demand for national products	Government should create demand for national products either through its own procurement or through restricting imports.	3	
23.	Collaborate with research institutes	Industries should collaborate with research institutes created by the government.	7	
24.	Investments made by	Government should itself invest in	3	



	the government in the industry	engineering companies.		
25.	Government should have training institutes	Government should create training institutes that provide training to industry people.	5	
26.	Government should create common facility centres & CAD/CAM centres	Government should create common facility centres & CAD/CAM centres to help industries develop technologies.	5	
27.	Government should make industry development plans	Government should make plans for development of industry.	9	
28.	Government built industrial parks	Government built industrial parks.	8	
29.	Government provided low cost loans for selected new products	Government provided low cost loans for selected new products to be developed in various private companies.	5	
30.	Technology development in public-private partnership	Technology development was carried out in public-private partnership	5	
31.	Government provided information on state-of-the-art technology trends	Government provided information to the industry on state-of-the-art technology trends.	3	
32.	Government encouraged local production of parts	Government encouraged local production of parts by providing incentives.	3	
33.	Government R&D institute acquired technology and disseminated it to industry	Government R&D institute acquired technology and disseminated it to industry.	5	
34.	Government shared R&D cost incurred by companies	Government shared R&D cost incurred by companies.	8	
35.	Government created Industrial Technology	Government created Industrial Technology Research Institutes	7	

	Research Institutes			
36.	Government enacted laws for promotion of science and technology	Government enacted laws for promotion of science and technology.	4	
37.	Government provided finance for commercializing R&D	Government provided finance for commercializing R&D.	4	
38.	Government expanded education in science and technology	Government expanded education in science and technology.	3	
39.	Government created fund for R&D or subsidized R&D	Government created fund for R&D or subsidized R&D.	4	
<b>Business environment factors</b>				
40.	Collaborate with other industries in your area	Industries should collaborate together and help each other in improving technologies.	3	
<b>Market factors</b>				
41.	Market products aggressively	Industries should aggressively market their products.	3	
42.	Export products	Industries should export their products.	15	
43.	Tariff barriers placed by the government for protection of industry	Government should protect industry through tariff barriers.	6	
<b>Foreign factors</b>				
44.	Bring high-tech MNCs to the country	Government should make efforts and provide all sorts of incentives to bring high-tech multinational companies (MNCs) in the country	3	
45.	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies so that they can guide in improving technology standards.	16	



46.	Make joint ventures with foreign companies	Work in association with foreign companies in business arrangement that involves local production and thus transfer of know-how and expertise to the company.	15	
47.	Import technology through licensing and other means	Import of know-how of various facets of technology from foreign companies through various means including licensing.	17	
48.	Get foreign consultancy in technical matters	Get help from foreign consultants in technical matters related to design, manufacture, management and marketing	10	
49.	Establish overseas companies	Establish companies in advanced countries with an aim to acquire technical knowledge and to market products and services.	10	
50.	Visit foreign countries or foreign companies	Visit foreign manufacturers or countries with an aim to obtain knowledge about their technology.	4	
51.	Make strategic alliances with other companies	Make strategic alliances with other foreign companies.	6	
52.	Acquire small high-tech companies in foreign countries	Acquire small high-tech companies in foreign countries.	4	
<b>Entrepreneurship</b>				
53.	Involvement of owners in technical matters	Owners should themselves get involved in technological matters of the company.	6	



### 11.5 Beneficial actions and substantially beneficial actions











If it is assumed that the number of occurrences of various actions is directly proportional to their degree of benefit, two higher stages of benefit can be considered, to create a similarity with the Pakistani Technology Development Model.

- Beneficial actions, with number of occurrences of 5 or more (10 % cases or more)
- Substantially beneficial actions, with number of occurrences of 7 or more (15 % cases or more)






Similar stages might be defined for barriers also, but none of the barriers had a number of occurrences of more than 4.

Table 11.4 lists the 19 substantially beneficial actions in the East Asian technology development literature.

**Table 11.4:** Substantially beneficial actions, which have frequency of occurrence of 7 or more (15 % or more) in the East Asian technology development model, and identification of their being in control of the factory management or the government. (N: Number of case studies in which this factor appeared,  = In control of factory managers,  = In control of government)

	Categories	Substantially beneficial actions	N	Control
1.	Products	Diversify the products	8	
2.	Product development	Acquire complete capability of product design	18	
3.	Production Equipment	Change to better equipment	7	
4.	Expertise in the company	Send people abroad for training	9	
5.		Invest in R&D	16	
6.	Educational issues	Get associated with universities	8	
7.	Issues related to government	Financial incentives of the government	8	
8.		National objectives should be set	7	
9.		Collaborate with research institutes	7	
10.		Government built industrial parks	8	



11.		Government should make industry development plans	9	
12.		Government shared R&D cost incurred by companies	8	
13.		Government created Industrial Technology Research Institutes	7	
14.	Market factors	Export products	15	
15.	Foreign factors	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies	16	
16.		Make joint ventures with foreign companies	15	
17.		Import technology through licensing and other means	17	
18.		Get foreign consultancy in technical matters	10	
19.		Establish overseas companies	10	

### 11.5.1 Discussion on substantially beneficial actions

The following points are important in the list of substantially beneficial actions presented in table 11.4.

- All the actions except those related to the government are in the control of the factory managers.
- Acquiring complete capability of product design has been the top scorer, followed by importing technology, investment in R&D, working as OEM or contractor, making joint ventures with foreign companies, and exporting products.
- Government also has very significant contribution in the list of action factors, as 7 out of 19 factors relate to the government. This shows the positive role of the government in technology development in manufacturing companies of successful East Asian countries.

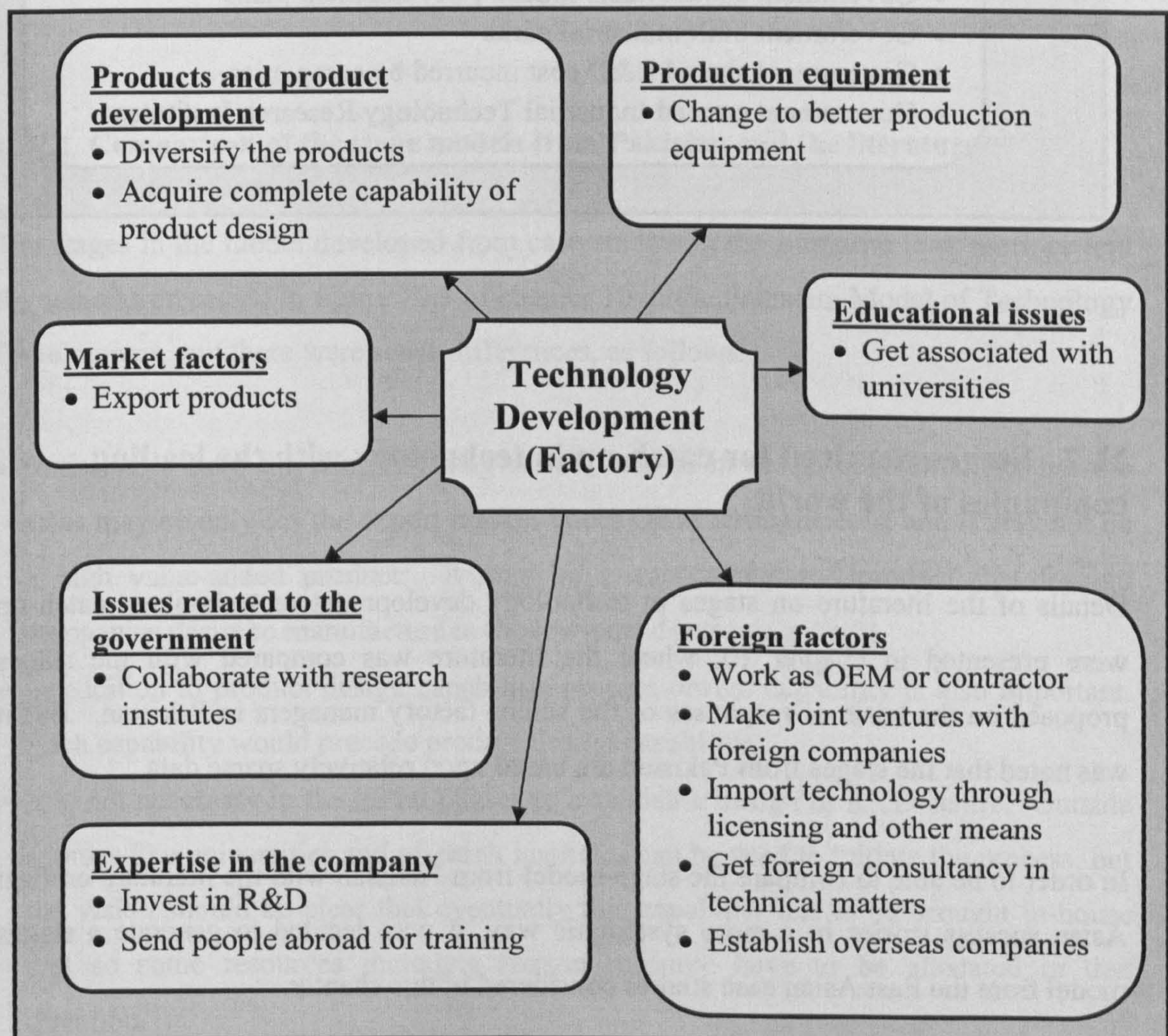


- The foreign factors comprise 5 out of 8 highest scoring factors. This shows the importance of foreign technology acquisition in the case studies.

## 11.6 Action plan for the factory managers and the government

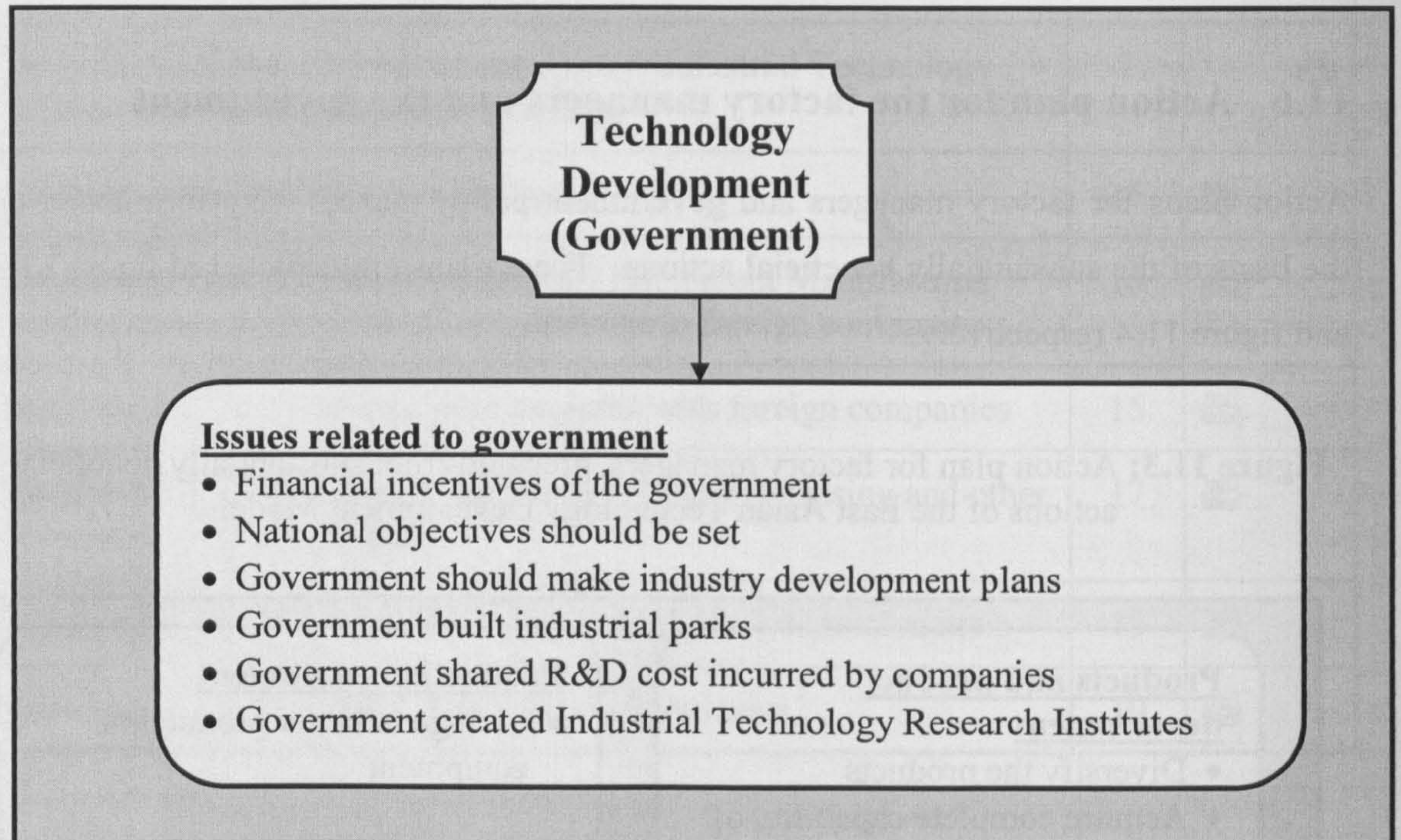
Action plans for factory managers and government policy makers were formulated on the basis of the substantially beneficial actions. These plans are depicted in figure 11.3 and figure 11.4 respectively.

**Figure 11.3:** Action plan for factory managers, prepared from substantially beneficial actions of the East Asian Technology Development Model





**Figure 11.4:** Action plan for government policy makers, prepared from substantially beneficial actions of the East Asian Technology Development Model



### **11.7 Stages required for catch-up in technology with the leading companies of the world**

Details of the literature on stages in technology development or technology catch-up were presented in chapter 10, where the literature was compared with the stages proposed on the basis of responses of the senior factory managers in Pakistan. But it was noted that the stages from Pakistan are based upon relatively sparse data.

In order to be able to compare the stage-model from Pakistan with the literature on East Asian success stories in a more systematic way, it was decided to generate a stages model from the East Asian case studies considered in this chapter.



This model, given in figure 11.5, was generated by carefully studying the accounts of the successful companies in the cases and noting their commonalities. Some cases did specifically refer to stages (e.g. Hobday, 1995).

The important aspects in the case studies were acquisition of technology from foreign sources through various means during all the stages, acquisition of design capability and export.

According to the literature, all those firms that have caught up with the world leading companies in their area have acquired design technology in addition to assembly and manufacturing technologies. Export is an obvious factor as no company in the developing world can dream to catch-up with the advanced world unless it is exposed to fierce global competition.

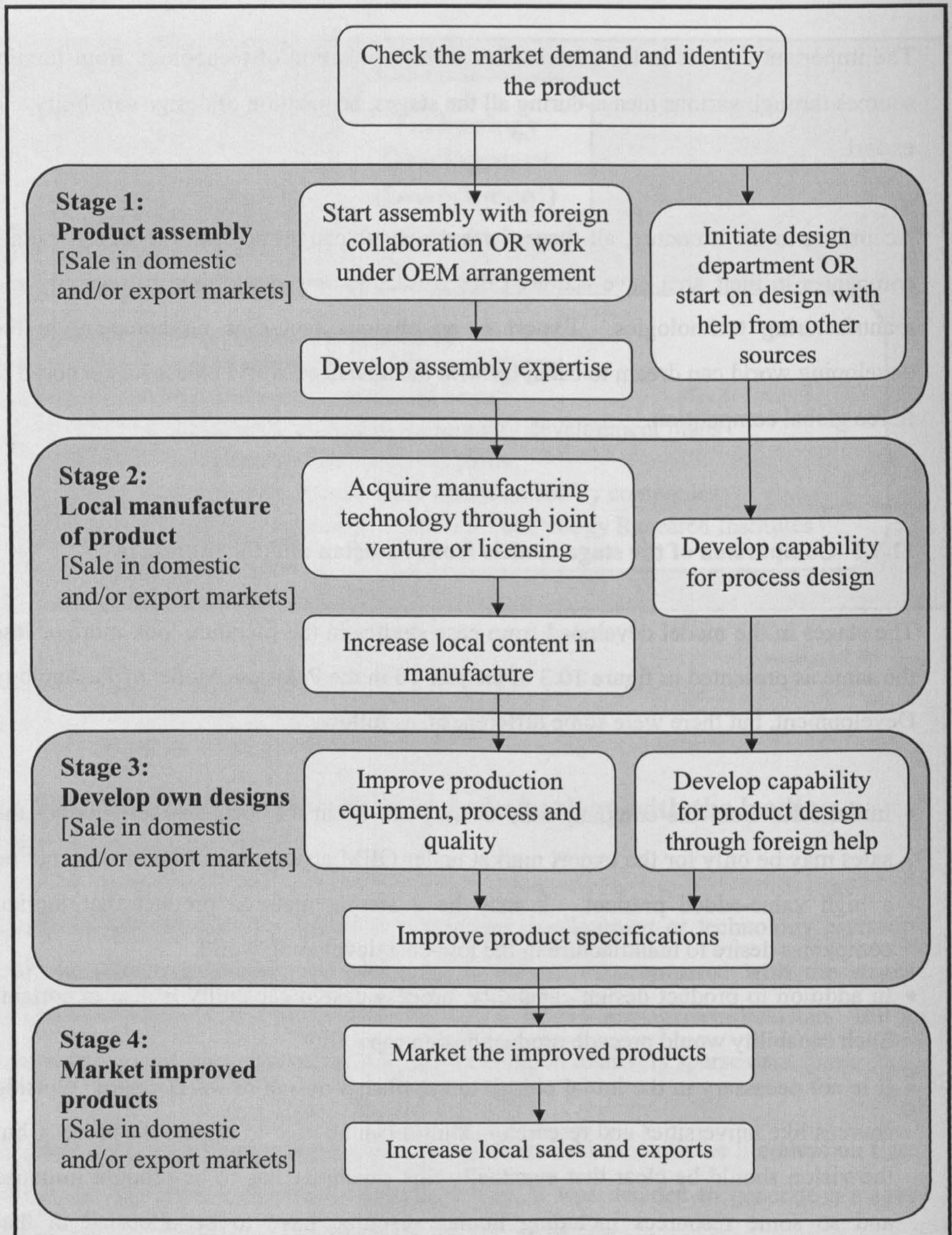
### **11.7.1 Comparison of the stage models from Pakistan and the literature**

The stages in the model developed from case studies in the literature look more or less the same as presented in figure 10.3 of chapter 10 in the Pakistani Model of Technology Development, but there were some differences, as follows.

- Initial sales from the company may or may not be in the local market. Rather the sales may be only for the export market under OEM arrangements, and it may not be a high value-added product. It may be a simple matured product that foreign companies desire to manufacture in the low-cost developing world.
- In addition to product design capability, process design capability is also important. Such capability would precede product design capability.
- It is not necessary in the initial phases to establish a design or R&D centre. Outside sources like universities and research institutes can be used to initiate the process, but the vision should be clear that eventually this capability has to be brought in-house and so some resources including human resource have to be allocated in that direction.



**Figure 11.5:** Stages required for technological catch-up, as extracted from case studies in the literature on East Asia





## **11.8 Discussion – confirmation of the findings of this research**

The East Asian case studies were based on hindsight on the technology development process in companies. The fact that these case studies did not mention many barriers could be because the difficulties had been obscured by the passage of time.

A general comparison of the findings of this research and the literature showed that there were lot of commonalities in the actions, which was evident from comparison of the lists of significant actions in the two models. It can be seen that the Pakistani model is broader in coverage of issues, but the East Asian model presents the positive role of the government which is non-existent in the Pakistani case.

The findings of this research were thus confirmed from the systematic analysis of the literature.

A detailed comparison of the two models will be presented in chapter 12, where a case has been made that if the two models are combined, the positive role of the government would be added to the empirical model from Pakistan, making it a comprehensive model for technology development for both factory managers and government policy makers.



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## APPENDIX 11A












### APPENDIX 11A Barriers, their description, and identification of their being in control of factory management or government







**Table 11A.1:** Barriers in the East Asian model of technology development, their descriptions, and identification of their being in control of factory management or government or neither of them. (N: Number of case studies in which this factor appeared,  = In control of factory managers,  = In control of government, O = In control of neither the factory managers nor the government)

	Barriers	Description of barriers	N	Control
<b>Technology and its acquisition</b>				
1.	Lack of information and knowledge about technology	There is general lack of knowledge and information in the company about technology and its development.	2	
2.	Lack of technical support in the country	Sources that can provide technical support to industries are generally not available in the country.	2	
3.	Lack of information systems	There is lack of technical information sources in the country.	1	
4.	Inaccessibility of available information systems	Those information sources that do exist are generally inaccessible.	1	
<b>Product development</b>				
5.	Technical problems in product development	Technical problems of various types hinder product development process.	1	
6.	Lack of product design capabilities	The company lacks capability to design new products.	2	
<b>Production Equipment</b>				
7.	Problems in operation of machines	The people in the company faced problems in operation of machines	1	
<b>Methods and processes</b>				

8.	Lack of quality culture	Culture of quality control is lacking in the company.	1	
<b>Input materials and components</b>				
9.	Non-availability of raw materials in the country	Availability of input materials is poor in the country.	1	
10.	Poor or inconsistent raw material quality available in the country	Quality of raw material available nationally is poor and/or inconsistent.	1	
<b>Management issues</b>				
11.	Managerial mistakes	Management mistakes result in poor management of technology.	1	
12.	Administrative problems	Problems exist in administration of the company.	1	
<b>Expertise in the company</b>				
13.	Shortage of trained human resource	There is shortage of trained people in the country.	4	
14.	Lack of encouragement for R&D	Management of the company does not encourage research and development work.	1	
15.	Lack of expertise	People lack expertise to do required technical work.	1	
16.	Lack of qualified technicians	Shortage of qualified technicians exists in the company.	1	
17.	Lack of skilled labour	Skilled labour is in shortage in the company.	1	
<b>Human factors</b>				
18.	Large number of employees leaving the company	Large number of employees leaving the company creates problem in development of technology.	1	
<b>Financial and tax issues</b>				
19.	Shortage of funds and resources	Lack of resources or funds doesn't allow technology improvement.	1	



20.	Problem in taxes	There are inconsistencies in tax structure that creates problems.	1	
21.	Companies cannot afford R&D	It is difficult for the manufacturing companies to pay for high cost of research and development.	2	
22.	Limited private financial support	Few private sources exist for providing funds to manufacturing companies.	1	
23.	High cost of transfer of technology or technology licensing	Cost associated with import of technology through licensing or otherwise is high	1	○
<b>Educational issues</b>				
24.	University curricula not related to industry	University curricula are not relevant to industry, so graduates produced are not useful for industry.	1	
25.	R&D by educational institutions is unrelated to industry	Research and development carried out in universities and other educational institutions is not of applied nature, and is unrelated to industry.	1	
<b>Issues related to government</b>				
26.	Lack of infrastructure facilities	Infrastructure facilities are poor in the country.	1	
27.	Lack of government support	Government does not provide help and support to industry.	1	
28.	Bureaucratic controls on industry.	Government has placed lot of bureaucratic limitations and controls on the working of the industries.	1	
29.	Unrelated R&D in government institutions	Government research institutions are doing R&D that is unrelated to industry.	1	
30.	Bad government policies	Government policies are bad for technology development in manufacturing industries.	1	
31.	Lack of institutional framework for development	No institutional framework existed in the government for development of manufacturing industry.	1	



32.	Lack of legal basis for government incentives	The incentives announced by the government lacked legal basis.	1	
33.	Inadequate funding by the government on public sector R&D	Funding by the government on public sector R&D was inadequate.	1	
34.	Lack of specialized technical research centres	There was lack of specialized technical research centres in the country.	1	
35.	Government promoted 'bumiputera' industries which were not capable	Government promoted incapable 'bumiputera' industries in Malaysia, which created dissatisfaction in other racial minorities.	1	
36.	Lack of intellectual property protection	The government did not ensure protection of intellectual property rights.	1	
<b>Business environment factors</b>				
37.	Changing world technology standards	Technology standards change in the world making it mandatory for national manufacturers to shift to them at heavy expense.	1	○
<b>Market factors</b>				
38.	Small national market	The market for products within the country is small.	3	○
39.	Competition of our products with cheap imports	Nationally manufactured products have to compete with cheap imports.	1	
40.	Preference of foreign brands by people	People generally patronize imported brand names instead of nationally produced products.	1	○
41.	Low-quality producers filling market with cheap products	Low quality producers take some market share away by filling the market with cheap products.	1	○
<b>Foreign factors</b>				
42.	Restrictions on export of technology by some countries or companies	Some countries or companies put restrictions on export of technology that hampers technology development in the	3	○











		country.		
43.	Insistence of foreign companies to gain managerial control	Foreign companies insisted on getting managerial control in joint ventures.	1	○
44.	Foreign firms reluctant to supply key components	In joint ventures or technology transfer agreements, foreign firms were reluctant to supply key components to domestic companies.	1	○
45.	Charges of infringement in patents	Foreign companies made charges of infringement in patents against domestic companies involved in reverse engineering.	1	○
46.	Foreign companies were repulsed because of strict government regulations	Foreign companies were reluctant to make joint ventures in the country because of strict government regulations regarding ownership and technology transfer.	1	⚙️
47.	Difficulty in accessing foreign knowledge bases	Knowledge bases available in the foreign countries are difficult to access from this country.	1	⚙️
<b>Entrepreneurship</b>				
48.	Lack of technological vision of CEO	The CEO of the company lacked technological vision.	1	⚙️
<b>Vendors</b>				
49.	Vendors ignorant about quality	Majority of the vendor industries in the country are ignorant of quality.	1	⚙️
50.	Vendors lack technical skills	Vendor industry lacks technical skills required to do quality work.	1	⚙️
51.	Shortage of vendor industries	There is shortage of vendor industries in the country.	1	⚙️












## APPENDIX 11B













### APPENDIX 11B                      Actions, their description, and identification of their being in control of factory management or government

**Table 11B.1:** Actions in the East Asian model of technology development, their descriptions, and identification of their being in control of factory management or government or neither of them. (N: Number of case studies in which this factor appeared,  = In control of factory managers,  = In control of government, O = In control of neither the factory managers nor the government)














	Actions	Description of actions	N	Control
<b>Technology and its acquisition</b>				
1.	Create team for technology improvement	Create teams in the company specifically for technology improvement.	1	
2.	Send people in existing plants for know-how	Send people in existing industries to gain know-how about various technologies.	2	
3.	Develop or acquire core technologies, which are the mainstay or foundation technologies in your operations	Develop or acquire the core technologies that form the foundation or are the mainstay for the business of the company.	1	
4.	Consult published material about technologies in your company	Invest in and study published technical material, which may include books, journals, magazines etc.	2	
5.	Take help from consultants	Take help from consultants to improve technology.	1	
6.	Copy and improve imported technology	Copy and improve upon technology imported earlier in the company.	4	
7.	Visit and/or take part in industry exhibitions	Visit and/or take part in industry exhibitions.	1	
8.	Gradually obtain technology starting from	Obtain technology gradually starting from assembly. Move on to	5	
















	assembly	manufacturing and design in the later stages.		
9.	Scan the market for technology	Scan the market for technology to be developed or improved in the company.	1	
10.	Carry out long-range technology forecasting	Carry out long-range technology forecasting in the company.	1	
11.	Get technical assistance from customer firm	In an OEM arrangement or while working as contractor, get technical assistance from the customer firm	2	
12.	Acquire knowledge from equipment suppliers	Acquire technical knowledge about various facets of technology from the equipment suppliers	2	
<b>Products</b>				
13.	Diversify the products	Diversify the product range of products being made in the company.	8	
14.	Make products that lead technically in the national market	Make products that lead technically in the national market.	2	
15.	Change to better products	Change to better or improved products.	1	
16.	Develop state-of-the-art products and not proven products	Develop state-of-the-art products and not proven products, so that technology gap with leading companies can be reduced.	6	
17.	Make unique products for unique markets	Make unique products for unique markets and not the same product for all the markets.	2	
<b>Product development</b>				
18.	Reverse engineer products and production equipment	Companies should adopt reverse-engineering of products and production equipment.	5	
19.	Acquire complete capability of product design	Acquire or develop complete capability to design products in the company.	18	

20.	Modify products according to infrastructure available in the company	Make or modify products according to existing infrastructure in the company.	1	
21.	Make teams for new products	Make teams in the company for new product development.	1	
22.	Involve production people early in product development	Involve production people early in product development process.	2	
23.	Create R&D centre for new product development	Create R&D centre for new product development in the company.	2	
24.	Create two teams: one in home country and one in advanced country	For development of a technically advanced product, create two teams: one in the home country and one in an advanced country	1	
<b>Production Equipment</b>				
25.	Adopt automation	Adopt automation or low cost automation to replace manual activities.	3	
26.	Make production equipment inside your company	Make required production machines and equipment within the company.	4	
27.	Change to better equipment	Obtain improved production equipment with aim to increase production and/or improve quality.	7	
28.	Get machines reverse-engineered from a local company	Get machines reverse-engineered from a local company that can provide such services.	1	
<b>Methods and processes</b>				
29.	Gain experience of production processes being used in the company	People in the company should acquire experience of various processes so as to produce better products.	1	
30.	Emphasize and adopt quality control	Emphasize and adopt quality control in the company.	2	
31.	Quality movement by the government	Government should start quality movement with aim to emphasize the	1	














		importance of product quality.		
32.	Analyze processes to reduce cost	Analyze various production processes with aim to reduce cost of production.	1	
33.	Improve production processes	Adopt better production processes.	5	
<b>Input materials and components</b>				
34.	Import parts for which material is not available	Import parts for which material is not available in the country.	1	
35.	Improve materials	Use better materials for production in the company.	1	
<b>Management issues</b>				
36.	Adopt teamwork	Teamwork should be followed in the company.	1	
37.	Develop commitment in management and employees with objectives of the company	Commitment with objectives of the company should be developed in people and management of the company.	3	
38.	Empower middle and junior management in day-to-day operations of the company	Senior or top management of the company should empower middle and junior management in day-to-day operations of the company.	1	
39.	Motivate workers	Motivate workers so they can perform better.	1	
40.	Make proper plans for development	The company should make proper plans of development.	2	
41.	Generate vision of the company	The company should generate its vision.	6	
42.	Work with dedication	Work with dedication.	2	
43.	Senior managers in factory should work with workers	Senior managers in factory should work with common workers.	1	
44.	Hire returning qualified expatriate nationals	Hire returning qualified and experienced expatriate nationals.	3	













45.	Build company culture upon local cultural rules	Build company culture upon local cultural rules	1	
46.	Priority not high profits but high production	Give priority to high production and not to high profits.	1	
47.	Start production line in spite of no orders	Start production line in anticipation of orders so that the required order can be supplied when it is placed.	1	
48.	Always make deliveries on time	Always make deliveries on time	1	
49.	Create crisis situation to assimilate technology	Create crisis situation in the company to assimilate technology in short time	1	
50.	Aggressive approach to achieve self-reliance	Adopt aggressive approach to achieve self-reliance in design and production of processes.	1	
51.	Acquire technology in 'unpackaged' form	Acquire technology in 'unpackaged' form, and not in 'packaged' form, as it makes the recipient learn quickly and independent of single source.	1	
52.	Strong support from top management of the company	Top management of the company should provide strong support for accomplishment of the desired objectives.	1	
53.	Create horizontal information flow structures	Create horizontal information flow structures in addition to vertical information flow structures in the company.	1	
54.	Create corporate IT network for better coordination	Create corporate IT network for better coordination in the company.	1	
55.	Create company slogan	Create company slogan.	1	
56.	Introduce employee ownership program	Introduce employee ownership program in the company so that employees get strongly associated with the company.	1	
57.	Develop global supply	If the inputs are to be acquired from many foreign sources, develop global	1	
















	chain management system	supply chain management system.		
58.	Share profits with employees	Share company profits with employees of the company so that they have better sense of association with the company.	1	
59.	Install merit based reward system	Install merit based reward system in the company.	1	
60.	Develop close relationship with major customers	Develop close relationship with major customers.	1	
<b>Expertise in the company</b>				
61.	Invest in human resource	Make investments so that skill level of human resource is increased.	4	
62.	Train employees locally	Provide training to employees locally.	4	
63.	Send people abroad for training	Send people abroad for training.	9	
64.	Invest in R&D	Invest in research and development activities.	16	
65.	Employ good human resource	Employ best available human resource.	2	
66.	Acquire skilled manpower from other companies	Acquire skilled manpower from other companies by luring them in the company.	1	
67.	Hire people with prior experience of technology to develop	Hire people with prior experience of technology to develop in the company.	1	
68.	Hire foreign workers at low wages	Hire foreign workers at low wages.	1	
69.	Get training from customer	In an OEM or contractor arrangement, get training from customer.	1	
<b>Human factors</b>				
70.	Facilitate workers especially in hour of need	Facilitate workers financially especially in hour of need.	1	













<b>Financial and tax issues</b>				
71.	State should provide capital to companies	State should itself provide capital to companies	2	
72.	Willingness to wait for payback of investment	The management of the company should be willing to wait for payback of investment.	1	
73.	Government should provide tax rebates for exports	Government should provide tax rebates for exports.	1	
74.	In a conglomerate, compensate financial losses through other companies	In a conglomerate, compensate for financial losses in one company through other companies.	1	
75.	Government should give financial incentives for R&D	Government should give financial incentives for R&D	1	
<b>Educational issues</b>				
76.	Universities should work for industry	Educational institutions should work for industry on its technical and managerial problems.	1	
77.	Get associated with universities	Industries should get associated with universities in order to obtain knowledge and technical help.	8	
78.	Government placed emphasis on technical education	Government placed emphasis on technical education so that support for manufacturing industry could be created.	1	
<b>Issues related to government</b>				
79.	Government should create centres of excellence	Government should create centres of excellence in various technologies that become source of guidance and knowledge for industry.	1	
80.	Government should provide infrastructure facilities	Government should provide good infrastructure facilities including communication, transport and utilities in the country.	6	
81.	Supportive government	Government policies should be such	1	



	policies for development of industry	that they help industries improve in technology and grow.		
82.	Financial incentives of the government	Government should give financial incentives to industry.	8	
83.	National objectives should be set	Government should set national objectives.	7	
84.	Government should create demand for national products	Government should create demand for national products either through its own procurement or through restricting imports.	3	
85.	Collaborate with research institutes	Industries should collaborate with research institutes created by the government.	7	
86.	Investments made by the government in the industry	Government should itself invest in engineering companies.	3	
87.	Lobbying by Chamber of Commerce and industry associations	Chamber of Commerce and industry associations should lobby in the government for policies and regulations helping industry and businesses.	2	
88.	Government should have training institutes	Government should create training institutes that provide training to industry people.	5	
89.	Government should create common facility centres & CAD/CAM centres	Government should create common facility centres & CAD/CAM centres to help industries develop technologies.	5	
90.	Government should make industry development plans	Government should make plans for development of industry.	9	
91.	Communication between government and business should be close	There should be close communication between government and businesses.	1	
92.	Engineering Development Board is positive effort	Engineering Development Board created by the government is positive effort that is helping national industry.	1	
93.	Government should	Government should subsidize training	2	











	subsidize training	provided in the industries.		
94.	Government built industrial parks	Government built industrial parks.	8	
95.	Government provided low cost loans for selected new products	Government provided low cost loans for selected new products to be developed in various private companies.	5	
96.	Government subsidised utilities	Government subsidised utilities for manufacturing industry.	1	
97.	Technology development in public-private partnership	Technology development was carried out in public-private partnership	5	
98.	Government provided information on state-of-the-art technology trends	Government provided information to the industry on state-of-the-art technology trends.	3	
99.	Government encouraged local production of parts	Government encouraged local production of parts by providing incentives.	3	
100.	Government inspected exports to prevent sub-standard exports	Government inspected exports to prevent sub-standard exports giving bad reputation to the country.	1	
101.	Government created export processing zones	Government created export processing zones for boosting exports.	1	
102.	Government R&D institute acquired technology and disseminated it to industry	Government R&D institute acquired technology and disseminated it to industry.	5	
103.	Government arranged national science and technology conference	Government arranged national science and technology conference so that national needs and objectives could be discussed.	2	
104.	Government shared R&D cost incurred by companies	Government shared R&D cost incurred by companies.	8	
105.	Government R&D institute invested in joint company	Government R&D institute invested in joint company with another domestic company	2	
106.	Government created	Government created Industrial	7	















	Industrial Technology Research Institutes	Technology Research Institutes		
107.	Government research institute (GRI) created venture capital fund	Government research institute (GRI) created venture capital fund.	1	
108.	Government provided automated customs service in science parks	Government provided automated customs service in science parks.	1	
109.	Government provided R&D and training facilities in science parks	Government provided R&D and training facilities in science parks.	1	
110.	Government developed high quality manpower	Government developed high quality manpower through various means including financing higher education.	2	
111.	Government enacted laws for promotion of science and technology	Government enacted laws for promotion of science and technology.	4	
112.	Government protected intellectual property rights	Government protected intellectual property rights.	2	
113.	Government created fund for quality and productivity improvement in SMEs	Government created fund for quality and productivity improvement in small and medium enterprises (SMEs)	1	
114.	Government provided finance for commercializing R&D	Government provided finance for commercializing R&D.	4	
115.	Government expanded education in science and technology	Government expanded education in science and technology.	3	
116.	Government facilitated import of technology	Government facilitated import of technology in various ways including providing guarantees for loans.	1	
117.	Government facilitated establishment of research institutes in private industries	Government facilitated establishment of research institutes in private industries	1	
118.	Government helped in	Government helped in recruitment	2	









	recruitment from abroad	from abroad.		
119.	Government initiated research projects	Government itself initiated research projects important for national development.	1	
120.	Government promoted facilities that can be leased on short-term basis	Government promoted facilities that can be leased on short-term basis.	1	
121.	Government reduced tariff rates for import of R&D equipment	Government reduced tariff rates for import of R&D equipment.	1	
<b>Business environment factors</b>				
122.	National standards body should be there	There should be standards body in the country developing engineering standards for the industries.	2	
123.	Collaborate with other industries in your area	Industries should collaborate together and help each other in improving technologies.	3	
<b>Market factors</b>				
124.	Market products aggressively	Industries should aggressively market their products.	3	
125.	Export products	Industries should export their products.	15	
126.	Tariff barriers placed by the government for protection of industry	Government should protect industry through tariff barriers.	6	
127.	Create national brand	Industrialists should develop their own national brand name.	2	
128.	Government enforced import licensing	Government enforced import licensing for saving national industry.	1	
129.	Government reduced excise duty on parts	Government reduced excise duty on parts so that products could be assembled locally.	1	
130.	Export old equipment to other countries	Export old equipment that has become redundant due to modernisation to	2	



		other countries		
<b>Foreign factors</b>				
131.	Buy technology from small firms needing money for survival	Buy technology from small firms needing money for survival.	1	
132.	Negotiate technology from multiple sources	Negotiate technology agreements from multiple sources so that a competition could be created.	1	
133.	Acquire technology from multiple sources	If possible, acquire technology from multiple sources so that better product could be developed locally.	1	
134.	Don't share management control with joint venture partners	Don't share management control with joint venture partners.	1	
135.	Develop key components indigenously	Develop key components of the product indigenously so that dependence on foreign sources could be finished.	1	
136.	Bring high-tech MNCs to the country	Government should make efforts and provide all sorts of incentives to bring high-tech multinational companies (MNCs) in the country	3	
137.	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies so that they can guide in improving technology standards.	16	
138.	Make joint ventures with foreign companies	Work in association with foreign companies in business arrangement that involves local production and thus transfer of know-how and expertise to the company.	15	
139.	Import technology through licensing and other means	Import of know-how of various facets of technology from foreign companies through various means including licensing.	17	
140.	Get foreign consultancy in	Get help from foreign consultants in	10	

	technical matters	technical matters related to design, manufacture, management and marketing		
141.	Establish overseas companies	Establish companies in advanced countries with an aim to acquire technical knowledge and to market products and services.	10	
142.	Visit foreign countries or foreign companies	Visit foreign manufacturers or countries with an aim to obtain knowledge about their technology.	4	
143.	Buy equipment from foreign companies going bankrupt	Buy equipment from foreign companies going bankrupt.	2	
144.	Plan to be a world-player	Plan to be a world-level company as early as possible.	1	
145.	Send engineers in foreign markets in addition to sales people	Send engineers in foreign markets in addition to sales people so that they could have first hand knowledge of preferences of people.	1	
146.	Get approvals for sales in foreign markets	Get approvals from foreign governments for sales in foreign markets.	1	
147.	Make strategic alliances with other companies	Make strategic alliances with other foreign companies.	6	
148.	Govt should place export requirements on foreign joint venture companies	Govt should place export requirements on foreign joint venture companies.	1	
149.	Hire experienced foreign technologists	Hire experienced foreign technologists.	2	
150.	Move production facilities to low-cost countries	Move production facilities to low-cost countries.	1	
151.	Acquire small high-tech companies in foreign countries	Acquire small high-tech companies in foreign countries.	4	
152.	Government R&D institute and MNC jointly developed	Government R&D institute and multinational companies (MNC)	1	



	research institute	jointly developed research institute.		
153.	Government R&D institute conducted joint research with foreign scholars	Government R&D institute conducted joint research with foreign scholars.	1	
154.	Company entered into joint research program with foreign R&D institute	Company entered into joint research program with foreign R&D institute.	1	
155.	MNCs developed skills development centres	Multinational companies (MNCs) developed skills development centres.	1	○
<b>Entrepreneurship</b>				
156.	Involvement of owners in technical matters	Owners should themselves get involved in technological matters of the company.	6	
157.	High-tech company established by returning nationals	High-tech company established by returning nationals.	1	
158.	Entrepreneur having prior experience	Prior experience of entrepreneur could be very helpful in technology development.	2	
<b>Vendors</b>				
159.	Educate vendors on quality	The company should work with vendors and solve their technical problems so as to improve quality.	2	
160.	Government provided finance to develop vendor industry	Government provided finance to develop vendor industry in the country.	1	
<b>Ethical issues</b>				
161.	Keep good intentions	The people in the company should work with good intentions.	1	

## Chapter 12

# Comparison with Literature – the Combined Model

### 12.1 Introduction – Comparison of the two models

Two technology development models have been presented in the previous chapters. One has been developed empirically from responses of experienced factory managers in Pakistan and the second has been developed from case studies of East Asian companies in the literature.

This chapter will highlight the commonalities of the two models and elaborate on their differences with possible explanations. A combined comprehensive model of technology development is then developed by combining the two models.

### 12.2 Comparison of factor count in Pakistani and East Asian models

Tables 12.1 and 12.2 show the number of barriers and action factors in the two models. The tables also give the numbers for

- the significant factors, which appeared in more than 5 % interviews (in the Pakistani model) or more than 5 % of case studies (in the East Asian model).
- the medium barriers or beneficial actions. In the Pakistani model these scored more than 2.00 in the ranking survey. In the East Asian model, these have a number of occurrences of 5 or more (10 % of case studies or more)



- the substantial barriers or substantially beneficial actions. In the Pakistani model these scored more than 2.50 in the ranking survey, and in the East Asian model, these appeared in 7 or more case studies (15 % of case studies or more).

### 12.2.1 Comparison of barrier count in Pakistani and East Asian models

It can be seen from table 12.1 that the model empirically developed in Pakistan is overwhelmingly more comprehensive than its East Asian counterpart.

Out of 19 factors in the East Asian model that are not in the Pakistani model, six were related to the government and five were related to foreign factors. There were only three significant barriers in the East Asian model, and all of them had been present in the Pakistani model. The last column of the table gives the number of barriers if two models are combined.

**Table 12.1:** Comparison of barriers count in Pakistani and East Asian models  
(PM = Pakistani Model, EAM = East Asian Model)

	Count of barriers					
	Total in PM	In PM but not in EAM	In both PM and EAM	In EAM but not in PM	Total in EAM	In a combined model
Total number of barriers	226	194	32	19	51	245
Significant barriers	52	49	3	0	3	52
Medium barriers	24	24	0	0	0	24
Substantial barriers	4	4	0	0	0	4

### 12.2.2 Comparison of action count in Pakistani and East Asian models

It can be seen from table 12.2 that again the Pakistani Model is broader than the East Asian Model.

Out of 94 new factors from East Asia, 28 were related to the government, 20 were foreign factors, and 15 were management factors. This shows that governments in East Asia had played a much bigger role than what has been done by the Pakistani government. It also shows that companies in East Asia were doing more business with foreign companies than their Pakistani counterparts.

**Table 12.2:** Comparison of actions count in Pakistani and East Asian models  
(PM = Pakistani Model, EAM = East Asian Model)

	Count of actions					
	Total in PM	In PM but not in EAM	In both PM and EAM	In EAM but not in PM	Total in EAM	In a combined model
Total number of actions	272	205	67	94	161	366
Significant actions	59	33	26	27	53	86
Medium actions	55	38	17	16	33	71
Substantial actions	31	25	6	13	19	44

### 12.3 Comparison of significant factor count in Pakistani and East Asian models in the categories of issues for technology development

Tables 12.3 and 12.4 show the numbers of significant factors, allocated to their categories, and again divide the significant factors into those significant in each of the



two models, or in both of them. This highlights the differences of emphasis in the two models.

### 12.3.1 Comparison of significant barriers count in categories of the issues in the Pakistani and East Asian models

It can be seen in table 12.3 that all the 52 significant barriers are from the Pakistani model. Only three of these are also significant in the East Asian model, and 12 others are present in the East Asian model but are not significant.

There are 37 significant barriers that are present in the Pakistani model but are absent in its counterpart. The most notable aspect is the absence of 10 out of 11 significant barriers related to the government, and 4 out of 5 significant barriers related to finance and tax issues in the East Asian model. This shows the negative contribution of the government in Pakistan, which is clearly absent in East Asia.

**Table 12.3:** Comparison of significant barriers count in various categories in the Pakistani and the East Asian Models, and the total number of significant barriers in Combined Model. (PM = Pakistani Model, EAM = East Asian Model)

Categories of issues for technology development	Factors significant in both PM and EAM	Factors significant in PM but not in EAM		Factors significant in EAM but not significant in PM		Total significant factors in Combined Model
		Factors present in EAM but not significant	Factors not in EAM	Factors present in PM but not significant	Factors not in PM	
Technology acquisition		1				1
Products						0

Product development						0
Production equipment			1			1
Production processes			1			1
Input materials		2	3			5
Management issues			4			4
Data management						0
Expertise in company	1		2			3
Human factors		1	1			2
Finance and tax issues		1	4			5
Educational issues		2				2
Issues related to govt.		1	10			11
Business environment			2			2
Market factors	1	2	4			7
Foreign factors	1		3			4
Entrepreneurship			1			1
Vendor issues		2	1			3
Ethical issues						0
<b>Total</b>	<b>3</b>	<b>12</b>	<b>37</b>	<b>0</b>	<b>0</b>	<b>52</b>
<b>Cumulative total</b>	<b>52</b>			<b>0</b>		<b>52</b>

### 12.3.2 Comparison of significant actions count in categories of the issues in the Pakistani and East Asian models

Table 12.4 shows that 26 (30 % of 86) actions are significant in both the models, while 53 (62 % of 86) of the significant factors may or may not be significant in both, but are common in both the models. The following aspects are worth noting in the table:



- Out of 27 significant actions contributed by the East Asian model, 17 are related to the government, and 11 of these 17 are not present in the Pakistani Model.
- Out of 24 significant actions related to the government in the combined model, 20 are significant in East Asian model, as compared to only 7 in the Pakistani model. This again shows the positive role of the governments in East Asia.
- The East Asian model has 9 out of 10 of the foreign factors, while the Pakistani model has only 6. This gives an idea about the role of foreign technology in the technological development of East Asia.
- The Pakistani model has a wider coverage. There are many more technology acquisition issues, management issues, human factors, finance and tax issues and educational issues in the Pakistani model.
- Commonalities exist in the two models in products, production equipment and processes, expertise in the company, market factors, entrepreneurship and foreign factors.

**Table 12.4:** Comparison of significant actions count in various categories in the Pakistani and the East Asian models, and the total number of significant actions in a Combined Model. (PM = Pakistani Model, EAM = East Asian Model)

Categories of issues for technology development	Factors significant in both PM and EAM	Factors significant in PM but not in EAM		Factors significant in EAM but not significant in PM		Total significant factors in Combined Model
		Factors present in EAM but not significant	Factors not in EAM	Factors present in PM but not significant	Factors not in PM	
Technology acquisition	1	4	4	1		10
Products	1				1	2

Product development	2	1				3
Production equipment	3					3
Production processes	1	2				3
Input materials						0
Management issues	2	5	4	1		12
Data management						0
Expertise in company	3	1	1	1		6
Human factors			1			1
Finance and tax issues			2			2
Educational issues			1	1		2
Issues related to govt.	3	1	3	6	11	24
Business environment	1		1	1		3
Market factors	3					3
Foreign factors	5		1	2	2	10
Entrepreneurship	1					1
Vendor issues						0
Ethical issues			1			1
<b>Total</b>	<b>26</b>	<b>14</b>	<b>19</b>	<b>13</b>	<b>14</b>	<b>86</b>
<b>Cumulative total</b>		<b>59</b>		<b>27</b>		<b>86</b>

### 12.3.3 The case for the combination of Pakistani and East Asian models

It can be said that the two models are in agreement in the categories that relate various facets of technology, and the market factors category. The differences are in issues related to the government, and various other aspects that affect technology but are not



facets of technology. The Pakistani model has wider coverage of technology aspects but the East Asian model provides better accounts of government actions and foreign factors.

It is therefore appropriate to add the extra factors arising from the East Asian Model to those in the Pakistani model, so that a more comprehensive model is developed.

It would be hoped that this Combined Model would be generic and would be useful for factory managers and government policy makers in all the developing countries of the world.



#### **12.4 Building a Combined Model from the Pakistani and East Asian models**













All the significant action factors in the Combined Model are listed in table 12.5. (The significant barrier factors in the combined model are the same as those in the Pakistani model given in chapter 10).

For actions in the East Asian model (EAM), the number of cases in which any factor appeared is shown. For significant actions in the Pakistani model (PM), the score in the ranking survey is shown and not the number of interviews in which an action occurred. For other actions, the number of exploratory interviews in which this factor appeared is shown. The significant factors from the EAM that are not significant in the PM have been italicised and underlined.



















Appendices 12B and 12C provide comprehensive lists of the 245 barriers and the 366 actions in the Combined Model.








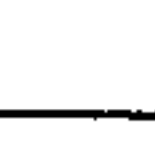

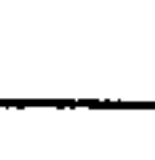

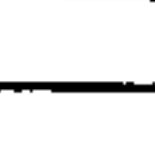
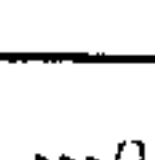
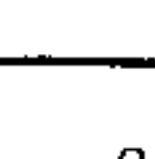
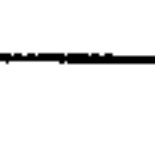




**Table 12.5:** Significant actions in the Combined Model, along with their score in the ranking survey or the number of appearances in the interviews or case studies.

(The significant factors from the EAM that are not significant in PM have been italicised and underlined, **PM** = Pakistani Model, **EAM** = East Asian Model, **Score** = Score in the ranking survey, for significant barriers, **No. of Int.** = number of interviews in the exploratory phase in which this factor appeared,  = In control of the factory managers,  = In control of the government)

	Significant Actions	Presence in PM		No. of cases in the EAM	Control
		Score	No. of Int.		
<b>Technology and its acquisition</b>					
1.	<i>Gradually obtain technology starting from assembly</i>		2	<u>5</u>	
2.	Development of complete knowledge about technologies being used in the company	2.69			
3.	Keep knowledge of the technology developments in your area	2.69			
4.	Develop your core technologies, which are the mainstay or foundation technologies in your operations, within your company	2.67		<u>1</u>	
5.	Consult published material about technologies in your company	2.52		<u>2</u>	
6.	Buy engineering and other software	2.50			
7.	Use Internet	2.47			
8.	Copy and improve imported technology	2.29		<u>4</u>	
9.	Visit or take part in industrial exhibitions	2.24		<u>1</u>	
10.	Take help from consultants	1.94		<u>1</u>	
<b>Products</b>					
11.	Diversify into new products	2.31		<u>8</u>	
12.	<i>Develop state-of-the-art products and not proven</i>			<u>6</u>	




















	<i>products</i>				
<b>Product development</b>					
13.	Acquire complete capability of product design locally	2.23		<u>18</u>	
14.	Reverse engineer products and production equipment	2.25		<u>5</u>	
15.	Modify products according to infrastructure available in the company	2.23		<u>1</u>	
<b>Production equipment</b>					
16.	Change to better production equipment	2.69		<u>7</u>	
17.	Adopt automation	2.43		<u>3</u>	
18.	Make production equipment inside your company	1.39		<u>4</u>	
<b>Production processes</b>					
19.	Improve production process	2.70		<u>5</u>	
20.	Adopt and emphasize quality control	2.91		<u>2</u>	
21.	Gain experience of production processes being used in the company	2.53		<u>1</u>	
<b>Management issues</b>					
22.	Generate vision of the company	2.55		<u>6</u>	
23.	Work with dedication	2.91		<u>2</u>	
24.	Adopt teamwork	2.85		<u>1</u>	
25.	Motivate workers	2.79		<u>1</u>	
26.	Develop proper systems and procedures	2.76			
27.	Develop commitment in management and employees with the objectives of the company	2.76		<u>3</u>	
28.	Make proper plans of development	2.68		<u>2</u>	
29.	Convince people for change	2.59			
30.	Empower middle and junior management in day-to-day operations of the company	2.52		<u>1</u>	

31.	Recruit young people	2.32			
32.	Pay high salaries to employees	2.13			
33.	<i>Hire returning qualified expatriate nationals</i>		1	<u>3</u>	
<b>Expertise in the company</b>					
34.	Invest in R&D	2.70		<u>16</u>	
35.	Send employees abroad for training	2.21		<u>9</u>	
36.	Employ good human resource	2.79		<u>2</u>	
37.	Develop local expertise of technologies imported from abroad	2.79			
38.	Train employees locally	2.26		<u>4</u>	
39.	<i>Invest in human resource</i>		2	<u>4</u>	
<b>Human factors</b>					
40.	Facilitate workers especially in the hour of need	2.69			
<b>Finance and tax issues</b>					
41.	Finance should be made available from the local banks	2.56			
42.	Pay taxes completely	2.28			
<b>Educational issues</b>					
43.	<i>Get associated with universities</i>		1	<u>8</u>	
44.	Universities should work for industry	2.65		<u>1</u>	
<b>Issues related to the government</b>					
45.	Supportive government policies for development of industry	2.82			
46.	Financial incentives of the government	2.58		<u>8</u>	
47.	No frequent changes in government policies	2.47			
48.	<i>Government making industry development plans</i>		1	<u>9</u>	
49.	<i>Government built industrial parks</i>			<u>8</u>	



50.	<u>Government shared R&amp;D cost incurred by companies</u>			<u>8</u>	
51.	<u>Government created Industrial Technology Research Institutes</u>			<u>7</u>	
52.	<u>National objectives / targets should be set</u>		1	<u>7</u>	
53.	<u>Collaborate with government research institutes</u>		2	<u>7</u>	
54.	<u>Government should provide infrastructure facilities</u>		2	<u>6</u>	
55.	<u>Government should have training institutes</u>		2	<u>5</u>	
56.	<u>Government provided low cost loans for selected new products</u>			<u>5</u>	
57.	<u>Technology development in public-private partnership</u>			<u>5</u>	
58.	<u>Government R&amp;D institute acquired technology and disseminated it to industry</u>			<u>5</u>	
59.	<u>Government enacted laws for promotion of science and technology</u>			<u>4</u>	
60.	<u>Government provided finance for commercializing R&amp;D or spinning off companies from GRI</u>			<u>4</u>	
61.	<u>Government provided information on state-of-the-art technology trends</u>			<u>3</u>	
62.	<u>Government should create demand for local products</u>		2	<u>3</u>	
63.	<u>Government encouraged for local production of parts</u>			<u>3</u>	
64.	<u>Government expanded education in science and technology</u>			<u>3</u>	
65.	Government Common Facility Centres or CAD / CAM centres	2.27		<u>5</u>	
66.	Lobbying in the government by Chambers of Commerce and Industry	2.22		<u>2</u>	
67.	Investments made by the government in the industry	2.13		<u>3</u>	
68.	Pay no bribes to people	1.85			
<b>Business environment factors</b>					

69.	<i>There should be national standards body</i>		2	<u>3</u>	
70.	Collaborate with other industries in your area	2.25		<u>3</u>	
71.	Government should develop basic metals and plastics industries	2.26			
<b>Market factors</b>					
72.	Export products	2.72		<u>15</u>	
73.	Tariff barriers placed by the government for protection of industry	1.81		<u>6</u>	
74.	Market products aggressively	2.36		<u>3</u>	
<b>Foreign factors</b>					
75.	Import technology through licensing and other means	2.41		<u>17</u>	
76.	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies	2.77		<u>16</u>	
77.	Make joint ventures with foreign companies	2.58		<u>15</u>	
78.	Get foreign consultancy in technical matters	2.00		<u>10</u>	
79.	<i>Establish overseas companies or overseas R&amp;D companies</i>		1	<u>10</u>	
80.	<i>Make strategic alliances with other companies</i>			<u>6</u>	
81.	<i>Acquire small high-tech companies in foreign countries</i>			<u>4</u>	
82.	Visit foreign countries or foreign companies	2.55		<u>4</u>	
83.	<i>Bring high-tech MNCs to the country</i>		1	<u>3</u>	
84.	Prove to your foreign joint venture partners that you were capable of working with them	2.44			
<b>Entrepreneurship</b>					
85.	Involvement of owners in technical matters	2.03		<u>6</u>	
<b>Ethical issues</b>					
86.	Be fair and honest in business	2.82			



#### **12.4.1 Discussion of the significant actions in the combined model**

The following points can be noted from table 12.5.



1. The East Asian model emphasises some aspects which were either not thought of by the Pakistani factory managers or are not presently applicable in Pakistan. These represent the determination for catch-up in the East Asian companies. Examples are:
  - Develop state-of-the-art products and not proven products
  - Acquire small high-tech companies in foreign countries
  - Make strategic alliances with other companies
  
2. The role of the government is very positive and significant in East Asia. Notable actions by the government include:
  - Governments set national targets or objectives and formulated industry development plans to achieve these objectives.
  - Government created industrial parks and Industrial Technology Research Institutes.
  - Government R&D institute acquired technology and disseminated it to industry.
  - Government enacted laws for promotion of science and technology.
  - Government provided low cost loans for selected new products.










#### **12.4.2 Substantially beneficial actions in the combined model**

Table 12.6 shows the substantially beneficial actions in the combined model. Actions which were substantially beneficial in the East Asian model, and not in the Pakistani model, are given in italics and underlined for differentiation. These are 13 of the 44 substantially beneficial actions. Six of these are related to government issues, three are




















related to foreign factors, two are related to products and product development, and one each is related to educational factors and expertise in the company.

















These 13 factors add important dimensions to the Pakistani action model given in chapter 10. These dimensions include the role of the government, emphasis on acquisition of product development capability, and addition of foreign technology acquisition modes.

**Table 12.6:** Substantially beneficial actions in the Combined Model  
( = In control of the factory managers,  = In control of the government)

	Substantially beneficial actions	Control
<b>Technology and its acquisition</b>		
1.	Development of complete knowledge about technologies being used in the company	
2.	Keep knowledge of the technology developments in your area	
3.	Develop your core technologies, which are the mainstay or foundation technologies in your operations, within your company	
4.	Consult published material about technologies in your company	
5.	Buy engineering and other software	
<b>Products</b>		
6.	<i>Diversify into new products</i>	
<b>Product development</b>		
7.	<i>Acquire complete capability of product design locally</i>	
<b>Production equipment</b>		
8.	Change to better production equipment	
<b>Production processes</b>		
9.	Improve production process	



10.	Adopt and emphasize quality control	
11.	Gain experience of production processes being used in the company	
<b>Management issues</b>		
12.	Generate vision of the company	
13.	Work with dedication	
14.	Adopt teamwork	
15.	Motivate workers	
16.	Develop proper systems and procedures	
17.	Develop commitment in management and employees with the objectives of the company	
18.	Make proper plans of development	
19.	Convince people for change	
20.	Empower middle and junior management in day-to-day operations of the company	
<b>Expertise in the company</b>		
21.	Invest in R&D	
22.	<i>Send employees abroad for training</i>	
23.	Employ good human resource	
24.	Develop local expertise of technologies imported from abroad	
<b>Human factors</b>		
25.	Facilitate workers especially in the hour of need	
<b>Finance and tax issues</b>		
26.	Finance should be made available from the local banks	
<b>Educational issues</b>		
27.	<i>Get associated with universities</i>	
28.	Universities should work for industry	

<b>Issues related to the government</b>		
29.	Supportive government policies for development of industry	
30.	Financial incentives of the government	
31.	<u>Government making industry development plans</u>	
32.	<u>Government built industrial parks</u>	
33.	<u>Government shared R&amp;D cost incurred by companies</u>	
34.	<u>Government created Industrial Technology Research Institutes</u>	
35.	<u>National objectives / targets should be set</u>	
36.	<u>Collaborate with government research institutes</u>	
<b>Market factors</b>		
37.	Export products	
<b>Foreign factors</b>		
38.	<u>Import technology through licensing and other means</u>	
39.	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies	
40.	Make joint ventures with foreign companies	
41.	<u>Get foreign consultancy in technical matters</u>	
42.	<u>Establish overseas companies or overseas R&amp;D companies</u>	
43.	Visit foreign countries or foreign companies	
<b>Ethical issues</b>		
44.	Be fair and honest in business	



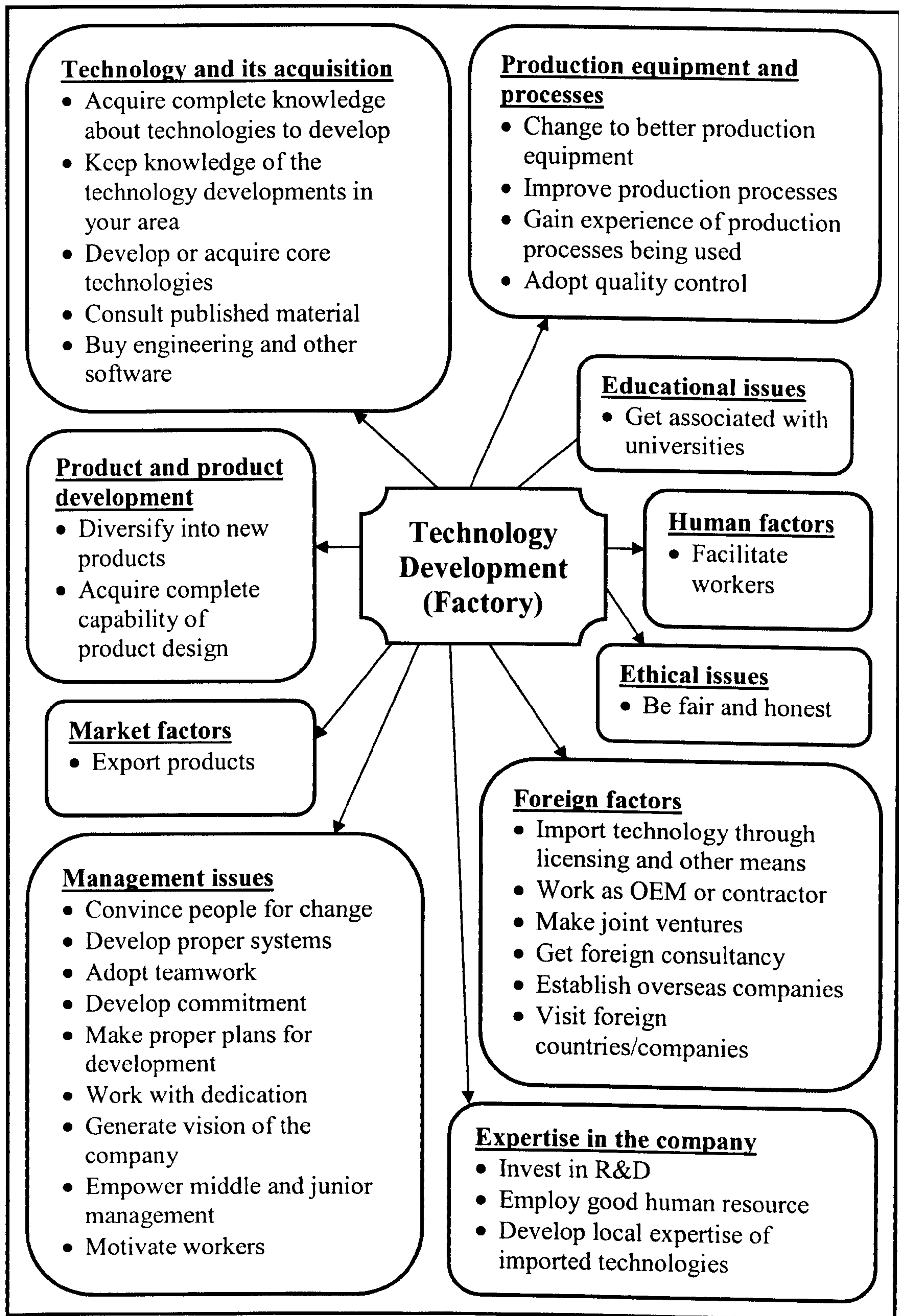
## **12.5 Action plans for factory managers and government policy makers and stages for catch-up in the Combined Model**

Action plans for factory managers and for government policy makers were next made from the substantially beneficial actions given above by separating the actions according to whether they were in the control of the factory managers or the government.

### **12.5.1 Action plan for factory managers**

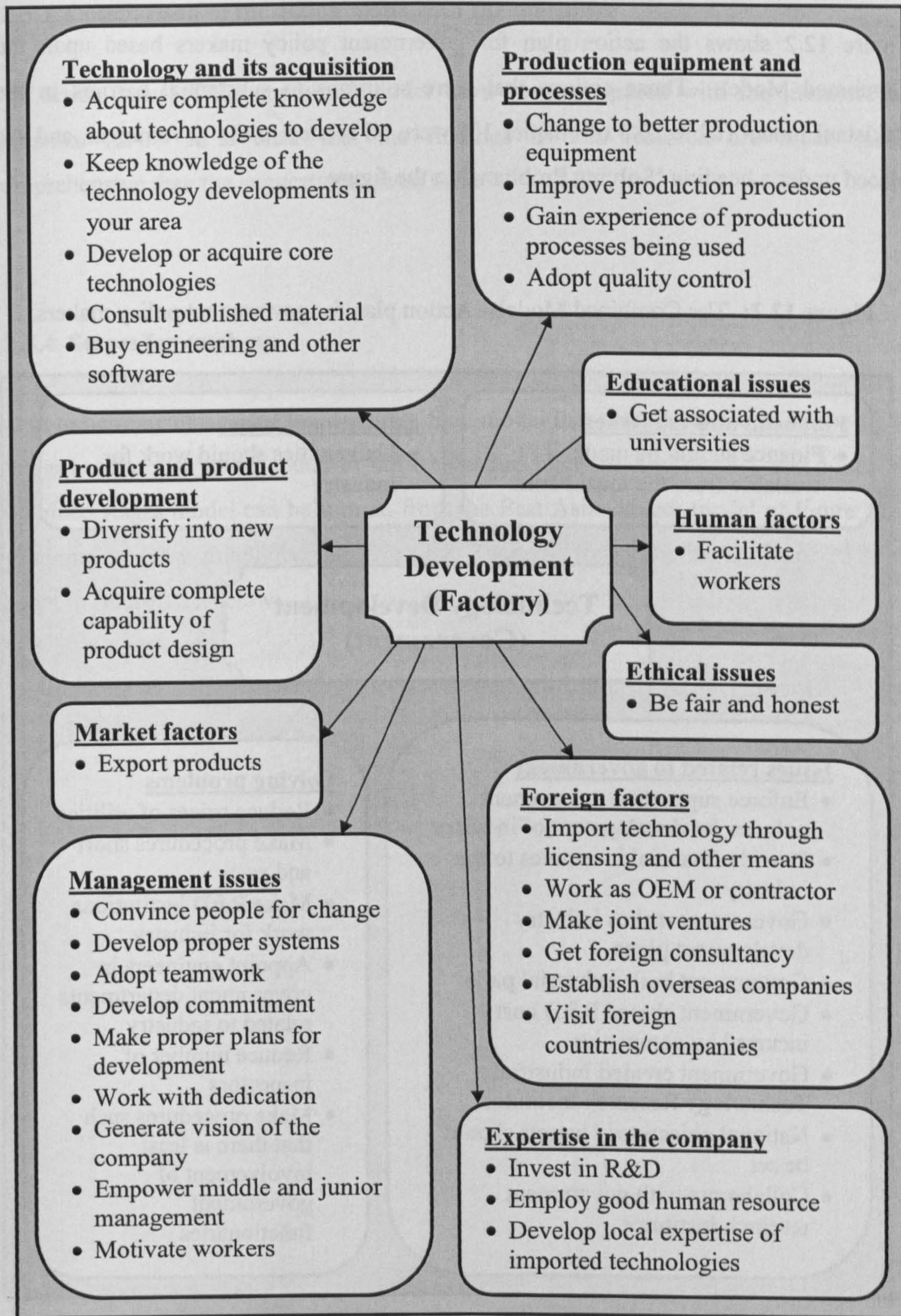
Figure 12.1 shows action plan for factory managers. The plan makes apparent that actions have to be taken in multiple directions. In addition to asking for improvement in the technology facets, the action plan emphasises acquisition of technology especially from abroad, product diversification, product development capability, and export of products.

Figure 12.1: The Combined Model – Action plan for factory managers.





**Figure 12.1:** The Combined Model – Action plan for factory managers.

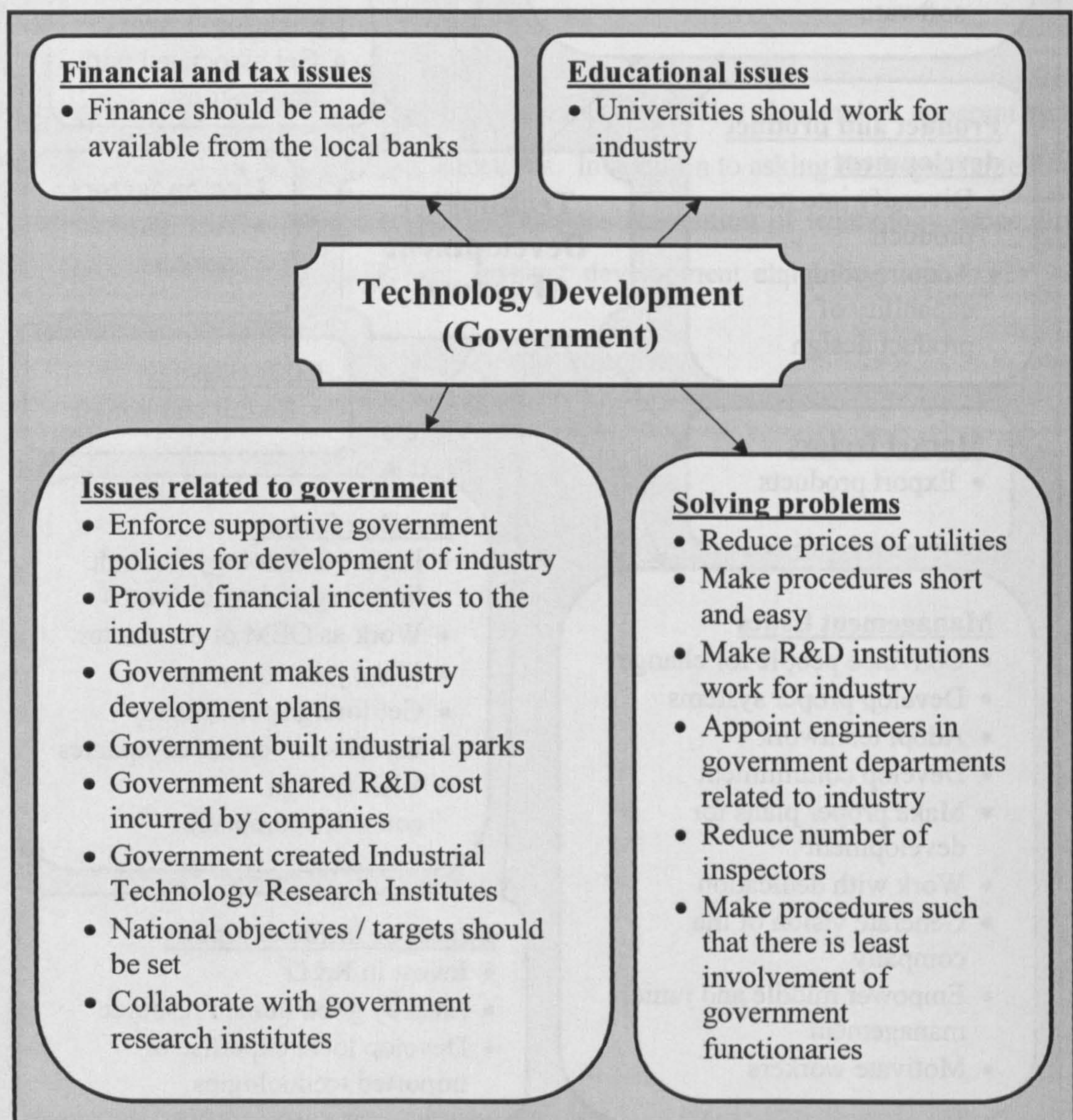




### 12.5.2 Action plan for government policy makers

Figure 12.2 shows the action plan for government policy makers based upon the Combined Model. Those actions that were solutions to substantial barriers in the Pakistani model (table 10.3 of chapter 10) were all related to the government, and are placed under a heading ‘Solving Problems’ in the figure.

**Figure 12.2:** The Combined Model – Action plan for government policy makers.





### **12.5.3 Comparison of the action plans with the literature**

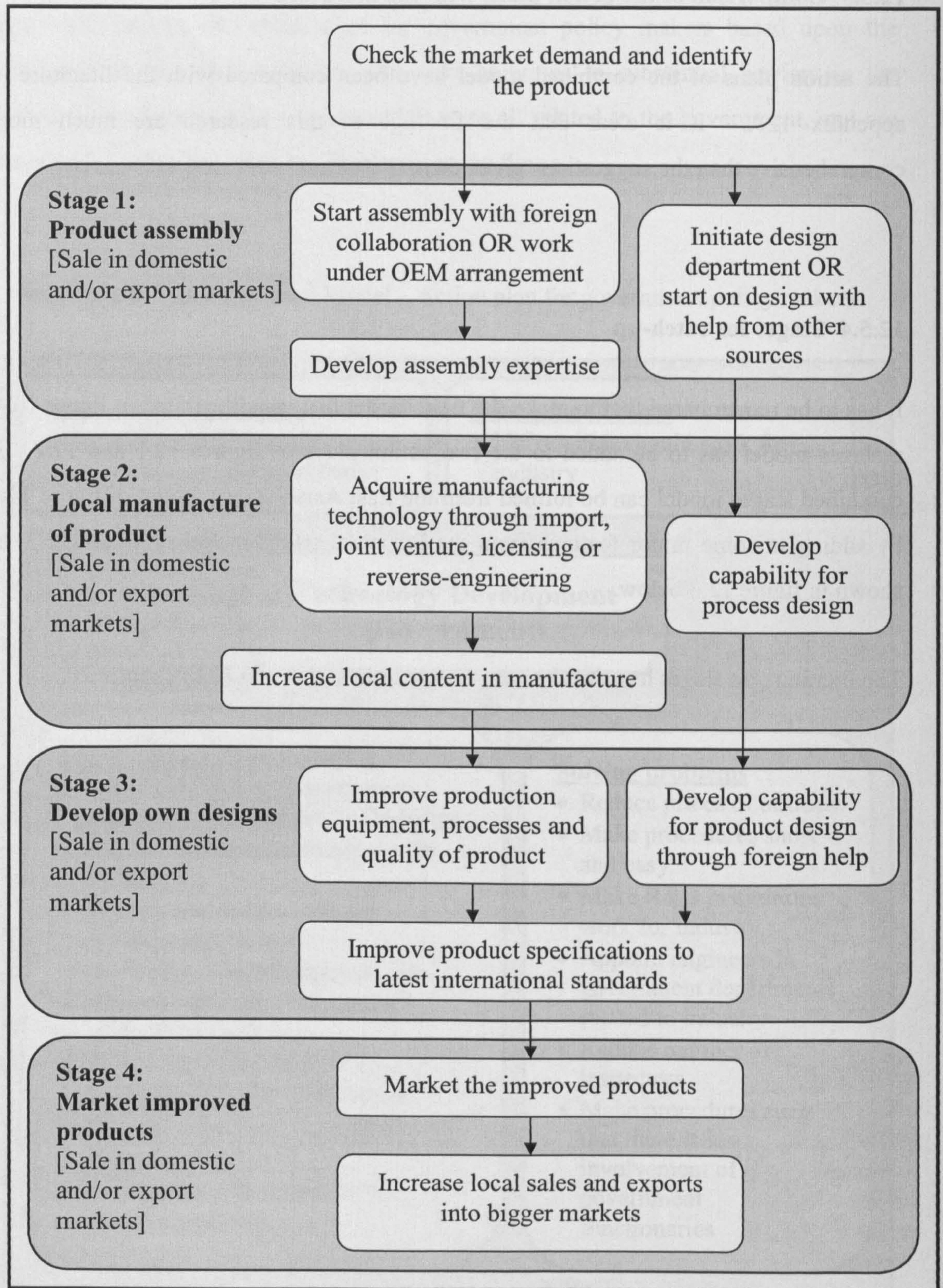
The action plans of the combined model have been compared with the literature in appendix 12A. It is clear that the findings of this research are much more comprehensive than the suggestions given there.

### **12.5.4 Stages for catch-up**

It has to be remembered that to make the final model that was illustrated in figure 10.4, a stages model has to be added to the two action plans of figures 12.1 and 12.2. A combined stages model can be formed from the East Asian stages model of figure 11.5 by adding in some minor features from the Pakistani stages model of figure 10.3, as shown in figure 12.3 below.

The literature on stages has already been reviewed in section 10.10 of chapter 10.



**Figure 12.3:** The Combined Model –Stages for technological catch-up



## 12.6 Super-summary

Figures 12.1, 12.2 and 12.3 summarise the findings of this research. We can condense the finding still further, as follows.

1. Technology development is a multi-dimensional problem.
2. Technology development in manufacturing companies could be carried out by factory managers without explicit support from the government, but if all-out government support exists, the process could be accelerated.
3. The action plan for the factory managers asks for actions for improvement of technology facets, acquisition of technology especially from the foreign sources, acquisition of design capability, and export of products.
4. The action plan for government policy makers asks for reduction in utility prices, making the procedures simple, making industry development plans, developing industrial parks, creating Industrial Technology Research Institutes, giving financial incentives and making supportive policies for the industry.
5. The stages for catch-up require that a capability of design be generated in parallel with the capability of assembly and manufacture. Acquisition of technology from foreign sources and export should be the hallmarks of the strategy.

## Reference

- Kim, L. (1998) Technology policies and strategies for developing countries: lessons from the Korean experience. *Technology Analysis & Strategic Management* **10(3)**, 311-323.



## APPENDIX 12A

### APPENDIX 12A Comparison of the action plans with the literature

Kim (1998) provided suggestions for public policy and corporate strategy based upon South Korean experience. His suggestions for public policy for less developing countries are:

- Expand investment in education before launching industrialisation programme.
- Buy turnkey plants and capital goods instead of licensing and foreign direct investment (FDI).
- Adopt export promotion policy.
- Invest in creating science and technology infrastructure, such as research institutes.
- Adopt a liberal policy on brain drain.
- Establish a separate ministry of science and technology.
- Foster entrepreneurs.

His suggestions for the corporate strategy are:


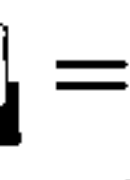

- The small and medium sized enterprises (SMEs) should adopt imitative approach.
- Large firms should enter collaborative agreements with foreign suppliers.
- Adopt informal mechanisms instead of formal ones in acquiring foreign technology.
- Acquire in-house technological capabilities to assimilate imported technologies.
- Adopt crisis construction to expedite technological learning.






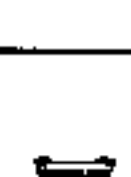
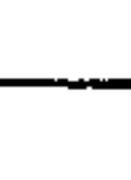
There are some commonalities in these recommendations with the findings of this research. For example, in case of public policy: creation of science & technology infrastructure, such as research institutes, and in case of corporate strategy: foreign collaboration and acquisition of in-house technological capabilities.

## APPENDIX 12B

### APPENDIX 12B Comprehensive list of the barriers in the Combined Model and comparison of the Pakistani and East Asian models



















Table 12.B1 provides complete list of the barriers in the combined model. The score of the factors in the ranking survey or the number of interviews in the exploratory phase in which various factors were found is given for factors from the Pakistani Model (PM). For comparison purposes, the number of cases in which various factors were found is given for factors from East Asian Model (EAM).

**Table 12.B1:** Comprehensive list of all the barrier factors in the Combined Model (The factors from the EAM absent in the PM have been italicised and underlined, **PM** = Pakistani Model, **EAM** = East Asian Model, **Score** = Score in the ranking survey, for significant barriers, **No. of Int.** = number of interviews in the exploratory phase in which this factor appeared,  = In control of the factory managers,  = In control of the government,  = In control of neither factory management nor the government)















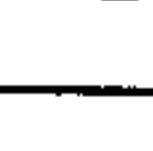

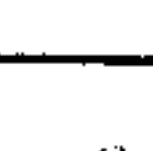
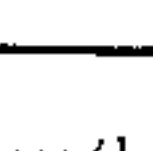
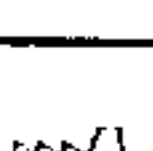
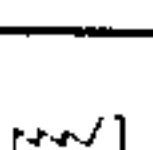




	Actions	Presence in PM		No. of cases in the EAM	Control
		Score	No. of Int.		
<b>Technology and its acquisition</b>					
1.	Lack of information and knowledge about technology	1.76		<u>2</u>	
2.	Technology improvement is neglected		2		
3.	Lack of interest in basic research		1		
4.	Lack of engineering libraries		1		
5.	Unavailability of technical books		1		
6.	Lack of technical support in the country		1	<u>2</u>	
7.	Limited internet access from Pakistan		1		



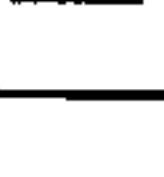







8.	External experts not familiar with business processes		1		○
9.	<i>Lack of information systems</i>			<u>1</u>	🏭
10.	<i>Inaccessibility of available information systems</i>			<u>1</u>	🏭
<b>Products</b>					
11.	Lack of product diversification		1		🏭
<b>Product development</b>					
12.	Technical problems in product development		2		🏭
13.	Shortage of design engineers		1		🏭
14.	Lack of design houses		1		🏭
15.	Lack of awareness of design		1		🏭
16.	Regulations prohibit reverse-engineering		1		○
17.	<i>Lack of product design capabilities</i>			<u>2</u>	🏭
<b>Production equipment</b>					
18.	Inadequacy of production equipment	1.88			🏭
19.	Lack of automation		2		🏭
20.	Problems in maintenance of imported machines		1		🏭
21.	Problems in maintenance of old equipment		2		🏭
22.	Low accuracy machinery		1		🏭
23.	Problems of transition to new machines		1		🏭
24.	Lack of knowledge to maintain equipment		1		🏭
25.	Non-availability of equipment in Pakistan		1		🏭
26.	Lack of tool and die making sources		1		🏭
27.	Long time required in import of equipment		1		○
28.	<i>Problems in operation of machines</i>			<u>1</u>	🏭
<b>Production processes</b>					




















29.	Technical problems in production processes	1.38			
30.	Shortage of process design engineers		1		
31.	Lack of experience		2		
32.	Lack of quality culture		2	<u>1</u>	
33.	Shortage of heat treatment service companies		1		
<b>Input materials</b>					
34.	Small volume requirement of components		1		
35.	Lack of availability of electronic components in Pakistan	1.94			
36.	Difficulties in import of raw materials	1.24			
37.	Non-availability of raw materials in Pakistan	2.12		<u>1</u>	
38.	Difficulty in import of electronic components	1.23			
39.	Poor or inconsistent raw material quality available in Pakistan	2.31		<u>1</u>	
40.	Government requirement to procure poor nationally-produced materials		2		
41.	Electronic components available in the country are unreliable		1		
42.	Components with fake markings sold locally		1		
43.	Raw material supply in national market is intermittent		1		
44.	Restriction on import of raw materials		1		
45.	Single source of steel in Pakistan		1		
46.	High price and large minimum order quantity in national market		1		○
47.	Long lead time in imports		2		○
<b>Management issues</b>					
48.	People resisting technology changes	1.35			







49.	Opposition of senior management for technology changes	0.91			
50.	Lack of teamwork	1.29			
51.	Lack of professional management	1.73			
52.	Lack of system		1		
53.	People lack commitment		2		
54.	On-site management not empowered		1		
55.	Poor management procedures		2		
56.	Lack of motivation		1		
57.	Lack of planning		1		
58.	Lack of vision		1		
59.	Lack of managerial capabilities		2		
60.	Lack of correspondence between salaries and skill		1		
61.	Lack of coordination		1		
62.	Lack of communication		1		
63.	Lack of technically skilled manpower in the vicinity		1		
64.	Lack of confidence for work never done before		1		
65.	Reactive style of work		1		
66.	Unions don't consider company's advantages		1		
67.	Negative attitude of colleagues		1		
68.	High management away from plant		1		
69.	Hiring people without requirement		1		
70.	Hiring incompetent people		1		
71.	Nepotism		2		
72.	Managerial mistakes		1	<u>1</u>	























73.	Trying to make everything yourself		1		
74.	Not giving due importance to lower staff		1		
75.	Lack of people for quality management		1		
76.	Lack of stability in the company		1		
77.	Administrative problems		2	<u>1</u>	
78.	Negative attitude of expert people		1		
79.	Stress on short-term benefits		1		
80.	Lack of engineering approach		1		
81.	No realisation of importance of human resource		1		
82.	High labour cost in public sector		1		
83.	Restriction on hiring		1		
84.	Restriction on salary structure		1		
<b>Expertise in the company</b>					
85.	Shortage of trained human resource	1.97			
86.	Lack of good human resource	2.03			
87.	Illiteracy of employees	1.55			
88.	Lack of training of lower level staff		1		
89.	Lack of encouragement for R&D		1		
90.	Lack of expertise		1		
91.	Illiterate supervisors cannot document technology		1		
92.	Lack of familiarity of people with new technology		1		
93.	Experts have been placed in wrong fields		1		
94.	Management is reluctant about training		1		
95.	Lack of manufacturing engineers		1		
96.	Lack of qualified technicians		2	<u>1</u>	





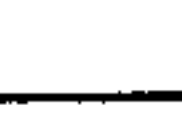














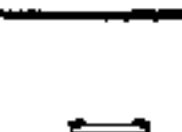

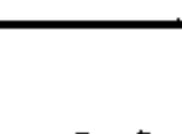


97.	Engineers shy of working with their hands		1		
98.	Engineers reluctant to work under illiterate supervisors		1		
99.	Lack of skilled labour		1	<u>1</u>	
100.	No system of training		1		
101.	Engineers not given right kind of jobs		1		
<b>Human factors</b>					
102.	Large number of employees leaving the company	1.27		<u>1</u>	
103.	People lack opportunities		1		
104.	People are content at existing position		1		
105.	People lack initiative		1		
106.	Dissatisfied workers		1		
107.	Hot temperament of top management		1		
108.	Ego problems widespread		2		
109.	People moving to secure government jobs		1		○
110.	Brain drain from Pakistan	1.60			○
<b>Finance and tax issues</b>					
111.	Duties / sales tax high on national products than on imports	2.06			
112.	Problems in getting finance from banks	1.30			
113.	Shortage of funds and resources	1.48		<u>1</u>	
114.	High price of utilities (electricity, gas, telephone and water)	2.56			
115.	State financing is not available		1		
116.	More duty on components, less on finished goods		2		
117.	Electronics components are expensive		1		













118.	Bad tariff structure making things expensive		1		
119.	Problem in taxes		1	<u>1</u>	
120.	Funding agencies don't fund software projects		1		
121.	High raw material price		1		
122.	Companies cannot afford R&D		2	<u>2</u>	
123.	Banks not lending to engineering industry		1		
124.	People are not interested in investing in engineering industry		1		
125.	High prices of machinery	2.06			○
126.	Expensive software		2		○
127.	High cost of transfer of technology or technology licensing		2	<u>1</u>	○
128.	<i>Limited private financial support</i>			<u>1</u>	
<b>Educational issues</b>					
129.	University curricula not related to industry	2.26		<u>1</u>	
130.	R&D by government and other institutions unrelated to industry	2.52		<u>1</u>	
131.	No system of producing technicians		1		
132.	Polytechnics not producing manufacturing people		2		
133.	University teachers ignorant of industry practices		1		
134.	Engineering graduates lack industry knowledge.		2		
135.	Lack of motivation in universities		1		
<b>Issues related to the government</b>					
136.	Corrupt government functionaries	2.22			
137.	Government policies change frequently	2.24			
138.	Long and difficult government procedures	2.67			



139.	Bad attitude of government inspectors or functionaries	2.31			
140.	Lack of government support	2.15		<u>1</u>	
141.	Incapable government functionaries	2.53			
142.	Problems at customs during imports or exports	1.97			
143.	Hurdles by lower level staff in government procedures	2.48			
144.	Large number of government inspectors	2.46			
145.	Government incentives are not enforced	1.67			
146.	Bad government policies	2.22		<u>1</u>	
147.	Inactivity of government research institutes		2		
148.	Lack of infrastructure facilities		1	<u>1</u>	
149.	Bureaucratic controls on industry.		1	<u>1</u>	
150.	No role of stake-holders in policy making		1		
151.	Government not implementing standards		1		
152.	Government powers used against businessmen		1		
153.	Wrong methods of technology development in the Government		1		
154.	Lack of continuity in government research institutions		1		
155.	Unrelated R&D in government institutions		1	<u>1</u>	
156.	Old regulations on electronics create problems		1		
157.	Government not permitting national products to sell in Pakistan		1		
158.	Government not paying outstanding bills		1		
159.	Government demand is intermittent		1		
160.	Government not promoting national products		1		

161.	Non-technical people in government		1		
162.	Government-businessman corrupt partnership		1		
163.	Lack of trust of bureaucracy on industrialists		2		
164.	Government does not allow offering credit to foreign customers		1		
165.	Long time required for court cases		1		
166.	Changing SRO numbers in every budget		1		
167.	Government officials do a lot of lip service but fail to act		1		
168.	Lack of dynamic industrial package from government		1		
169.	Lack of effective forums in government		1		
170.	<i><u>Lack of institutional framework for development</u></i>			<u>1</u>	
171.	<i><u>Lack of legal basis for government incentives</u></i>			<u>1</u>	
172.	<i><u>Inadequate funding by the government on public sector R&amp;D</u></i>			<u>1</u>	
173.	<i><u>Lack of specialized technical research centres</u></i>			<u>1</u>	
174.	<i><u>Government promoted 'bumiputera' industries which were not capable</u></i>			<u>1</u>	
175.	<i><u>Lack of intellectual property protection</u></i>			<u>1</u>	
<b>Business environment factors</b>					
176.	Lack of technological infrastructure in the country	2.36			
177.	Lack of standards in Pakistan	2.06			
178.	Transportation is expensive		1		
179.	Bonded carrier is very expensive		1		
180.	Problem of law and order		2		
181.	No collaboration among each other		2		
182.	Lack of copyright concept		1		



183.	No forum for OEM suppliers		1		
184.	Lack of metallurgy based industry		2		
185.	Weak basic engineering technology		1		
186.	Lack of plastics base		1		
187.	Shortage of utilities		2		
188.	Changing world technology standards		1	<u>1</u>	○
189.	Cost of certifications is very high		1		○
190.	Certification from Pakistan is not acceptable		1		○
191.	Investment frauds		1		○
192.	Aid agencies not funding private sector		1		○
193.	Shortage of other companies in the same business		1		○
<b>Market factors</b>					
194.	Poor marketing of products	1.81			
195.	Smuggling	1.90			
196.	Competition of our products with cheap imports	1.91		<u>1</u>	
197.	Conditionalities imposed on Pakistan on tariff, trade and industry issues by IMF and World Bank	1.58			
198.	Lobbies of foreign companies work against national companies		2		
199.	Afghan transit trade has damaged industry		2		
200.	High import tariffs		1		
201.	Preference of foreign brands by people	1.88		<u>1</u>	○
202.	Small national market	2.21		<u>3</u>	○
203.	WTO regulations	1.23			○
204.	Reduction in investment in the country		1		○
205.	Restriction on exporting to Pakistan		2		○

206.	9-11 scenario affected badly		1		○
207.	Dumping policy of foreign countries		1		○
208.	Competitors discouraging clients		1		○
209.	Lack of continuous flow of products / cyclic demand		2		○
210.	Foreign customers discriminate against defence related companies		1		○
211.	Problems in exports		1		○
212.	Uncertainty in the market		1		○
213.	<i><u>Low-quality producers filling market with cheap products</u></i>			<u>1</u>	⊠
<b>Foreign factors</b>					
214.	Lack of interaction with developed countries		1		⊠
215.	Restriction on foreign visits or contacts by the government	0.71			⊠
216.	Restrictions on collaboration		1		⊠
217.	Changing foreign exchange rates		1		⊠
218.	Foreign investment in projects		1		⊠
219.	No collaboration with neighbouring countries		1		⊠
220.	Bad perceptions about Pakistan in world market	2.00			○
221.	Restrictions on export of technology by some countries or companies	1.55			○
222.	Geopolitical situation or sanctions against Pakistan	1.26			○
223.	Foreign pressures for unfair duties		1		○
224.	Vicinity to Afghanistan		1		○
225.	<i><u>Insistence of foreign companies to gain managerial control</u></i>			<u>1</u>	○
226.	<i><u>Foreign firms reluctant to supply key components</u></i>			<u>1</u>	○

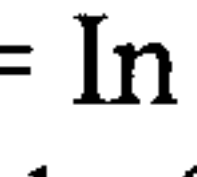
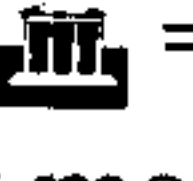








227.	<i>Charges of infringement in patents</i>			<u>1</u>	○
228.	<i>Foreign companies were repulsed because of strict government regulations</i>			<u>1</u>	⚙️
229.	<i>Difficulty in accessing foreign knowledge bases</i>			<u>1</u>	⚙️
<b>Entrepreneurship</b>					
230.	One-man-show (Owner or one person making every significant decision himself)	1.69			⚙️
231.	Industrialist not interested in R&D		1		⚙️
232.	Industrialist having no trust in national technology		1		⚙️
233.	Lack of opportunities of entrepreneurship		1		⚙️
234.	Culture of entrepreneurship does not exist		1		⚙️
235.	Job mentality of people		1		⚙️
236.	Lack of experience of running a public limited company		1		⚙️
237.	<i>Lack of technological vision of CEO</i>			<u>1</u>	⚙️
<b>Vendors</b>					
238.	Vendors ignorant about quality	2.03		<u>1</u>	⚙️
239.	Vendors lack technical skills	2.06		<u>1</u>	⚙️
240.	Illiterate vendors	2.00			⚙️
241.	Lack of qualified people in vendor industry		1		○
242.	Inconsistency in quality of suppliers		1		○
243.	Low reliability of supplies from suppliers		1		○
244.	<i>Shortage of vendor industries</i>			<u>1</u>	○
<b>Ethical issues</b>					
245.	Lack of ethics		1		⚙️

## APPENDIX 12C

























### APPENDIX 12C Comprehensive list of the actions in the Combined Model and comparison of the Pakistani and East Asian models






















Table 12.C1 provides complete list of action factors in the Combined Model. The score of the factors in the ranking survey or the number of interviews in the exploratory phase in which various factors were found is given for factors from the Pakistani Model (PM). For comparison purposes, the number of cases in which various factors were found is given for factors from East Asian Model (EAM).

**Table 12.C1:** Comprehensive list of all the action factors in the Combined Model (The factors from the EAM absent in the PM and the factors significant in EAM but not in PM have been italicised and underlined, **PM** = Pakistani Model, **EAM** = East Asian Model, **Score** = Score in the ranking survey, for significant barriers, **No. of Int.** = number of interviews in the exploratory phase in which this factor appeared,  = In control of the factory managers,  = In control of the government,  = In control of neither factory management nor the government)















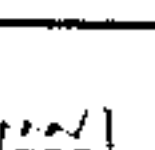
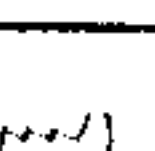
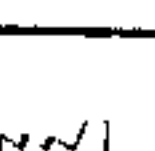


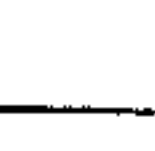
	Actions	Presence in PM		No. of cases in the EAM	Control
		Score	No. of Int.		
<b>Technology and its acquisition</b>					
1.	Development of complete knowledge about technologies being used in the company	2.69			
2.	Keep knowledge of the technology developments in your area	2.69			
3.	Develop your core technologies, which are the mainstay or foundation technologies in the operations, within your company	2.67		<u>1</u>	
4.	Consult published material about technologies in your company	2.52		<u>2</u>	
5.	Take help from consultants	1.94		<u>1</u>	



6.	Use Internet	2.47			
7.	Copy and improve imported technology	2.29		<u>4</u>	
8.	Buy engineering and other software	2.50			
9.	Visit or take part in industrial exhibitions	2.24		<u>1</u>	
10.	<i>Gradually obtain technology starting from assembly</i>		2	<u>5</u>	
11.	Create team for technology improvement		1	<u>1</u>	
12.	Send people in existing plants for know-how		1	<u>2</u>	
13.	Keep people aside for basic research		1		
14.	Take membership of technical institutes		1		
15.	Visit machine tool manufacturers		1		
16.	Create awareness of technology		1		
17.	Acquire technology from renowned company		1		
18.	Create professional society in your area of work		1		
19.	Keep abreast of developments in leading companies in your area		2		
20.	Get information from media		1		
21.	Scan the market for technology		1	<u>1</u>	
22.	Obtain information by meeting people		2		
23.	Acquiring technology through projects		1		
24.	Liaison with R&D companies in your area		1		
25.	Proliferate technology		1		
26.	Glamorize technology		1		
27.	Copy & absorb old technology		2		
28.	Create technology development fund		1		
29.	<i>Carry out long-range technology forecasting</i>			<u>1</u>	














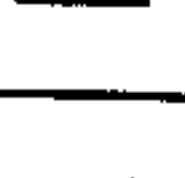
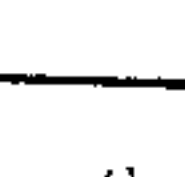
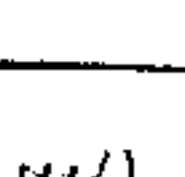








30.	<i>Get technical assistance from customer firm</i>			<u>2</u>	
31.	<i>Acquire knowledge from equipment suppliers</i>			<u>2</u>	
<b>Products</b>					
32.	Diversify into new products	2.31		<u>8</u>	
33.	<i>Develop state-of-the-art products and not proven products</i>			<u>6</u>	
34.	Standardise products		1		
35.	Make product that lead technically in the local market		1	<u>2</u>	
36.	Change to better products		1	<u>1</u>	
37.	Make product that complement existing work		1		
38.	<i>Make unique products for unique markets</i>			<u>2</u>	
<b>Product development</b>					
39.	Acquire complete capability of product design locally	2.23		<u>18</u>	
40.	Modify products according to infrastructure available in the company	2.23		<u>1</u>	
41.	Reverse engineer products and production equipment	2.25		<u>5</u>	
42.	Government should make design institutes		1		
43.	Institutions for reverse-engineering should be there		1		
44.	Import product designs		1		
45.	Import products samples to develop locally		2		
46.	Teach product development in technical colleges		1		
47.	Develop passion of making new things		1		
48.	Make teams for new products		1	<u>1</u>	
49.	Develop products according to local demands		2		
50.	Involve production people early in product development		1	<u>2</u>	








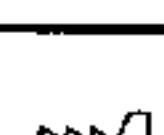

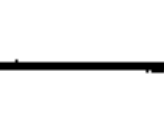

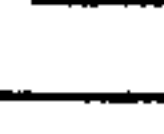





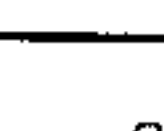
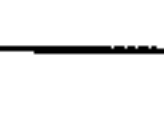
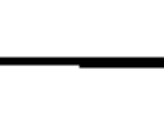



51.	Get product ideas from other companies		1		
52.	Create ability to modify existing products		1		
53.	<i>Create R&amp;D centre for new product development</i>			<u>2</u>	
54.	<i>Create two teams: one in home country and one in advanced country</i>			<u>1</u>	
<b>Production equipment</b>					
55.	Change to better production equipment	2.69		<u>7</u>	
56.	Adopt automation	2.43		<u>3</u>	
57.	Make production equipment inside your company	1.39		<u>4</u>	
58.	Devise innovative solutions for lack of equipment		1		
59.	Develop maintenance expertise		2		
60.	Help from equipment suppliers in equipment selection		1		
61.	Get guidance from other local users		1		
62.	Standardize equipment in the factory		1		
63.	Foreign affiliation in equipment selection and absorption		1		
64.	Modify equipment according to requirement		1		
65.	Make jigs and tools to improve production		2		
66.	Improve accuracy of machines		1		
67.	<i>Get machines reverse-engineered from a local company</i>			<u>1</u>	
<b>Production processes</b>					
68.	Improve production process	2.70		<u>5</u>	
69.	Gain experience of production processes being used in the company	2.53		<u>1</u>	
70.	Adopt and emphasize quality control	2.91		<u>2</u>	

























71.	Government should create process design houses		1		
72.	There should be a quality award system		1		
73.	Plan production processes		1		
74.	Standardise production processes		2		
75.	Issue exact quantities of materials for processes		1		
76.	Create systematic processes / production line concept		2		
77.	Analyze processes to reduce cost		2	<u>1</u>	
<b>Input materials</b>					
78.	<i>Import parts for which material is not available</i>			<u>1</u>	
79.	Government should help in import of components		1		
80.	Create an office in an advanced country		1		
81.	Get government permission for import of material		1		
82.	Correction of material policies by the government		1		
83.	Develop material testing facilities		2		
84.	Collaborate with foreign suppliers for components		1		
85.	Source components from wherever suitable		2		
86.	Improve materials		1	<u>1</u>	
87.	Minimal import duties on raw materials		1		
<b>Management issues</b>					
88.	Convince people for change	2.59			
89.	Develop proper systems and procedures	2.76			
90.	Adopt teamwork	2.85		<u>1</u>	
91.	Develop commitment in management and employees with the objectives of the company	2.76		<u>3</u>	
92.	Motivate workers	2.79		<u>1</u>	





















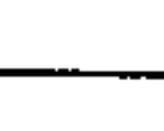


93.	Make proper plans of development	2.68		<u>2</u>	
94.	Work with dedication	2.91		<u>2</u>	
95.	Recruit young people	2.32			
96.	Generate vision of the company	2.55		<u>6</u>	
97.	Empower middle and junior management	2.52		<u>1</u>	
98.	Pay high salaries to employees	2.13			
99.	<i>Hire returning qualified expatriate nationals</i>		1	<u>3</u>	
100.	Make people feel that they are important		1		
101.	Give people chance to speak their mind		1		
102.	Give monetary benefits to people		2		
103.	Train people on new machinery		1		
104.	Change-management program		1		
105.	Convince Board of Directors or senior management		2		
106.	Improve management procedures		1		
107.	Install professional management		2		
108.	Development of management capability		1		
109.	There should be correspondence between salary and skill		1		
110.	Arrange training courses on coordination		1		
111.	Arrange meetings and seminars		1		
112.	Transport skilled people from elsewhere		1		
113.	Encouragement of management		1		
114.	Proactive policy should be followed		1		
115.	Remove unions		1		
116.	Arrange meetings to discuss management issues		2		
























117.	Remove communication gaps		1		
118.	Create competitive environment		1		
119.	Narrow the gap of salaries		1		
120.	Don't be a 'Seth' oriented company		2		
121.	Better human resource management		2		
122.	Know everyone in the company		1		
123.	Be results-oriented		1		
124.	Management should take risks		1		
125.	Decentralize the company		1		
126.	Continuity in management		1		
127.	Make maximum of parts inside the company		1		
128.	Senior managers in factory working with workers		1	<u>1</u>	
129.	Get ISO 9000 certification		2		
130.	CEO should obtain management training		1		
131.	Give incentives for better productivity		2		
132.	Pay in time		1		
133.	Make proper feasibilities		1		
134.	In a family-owned business, keep cohesion in the family		1		
135.	<u>Company was built upon local cultural rules</u>			<u>1</u>	
136.	<u>Priority not high profits but high production</u>			<u>1</u>	
137.	<u>Start production line in spite of no orders</u>			<u>1</u>	
138.	<u>Always make deliveries on time</u>			<u>1</u>	
139.	<u>Create crisis situation to assimilate technology in short time</u>			<u>1</u>	
140.	<u>Aggressive approach to achieve self-reliance</u>			<u>1</u>	























141.	<u>Acquire technology in 'unpacked' form</u>			<u>1</u>	
142.	<u>Strong support from top management of the company</u>			<u>1</u>	
143.	<u>Create horizontal information flow structures</u>			<u>1</u>	
144.	<u>Create corporate IT network for better coordination</u>			<u>1</u>	
145.	<u>Create company slogan</u>			<u>1</u>	
146.	<u>Introduce employee ownership program</u>			<u>1</u>	
147.	<u>Develop global supply chain management system</u>			<u>1</u>	
148.	<u>Share profits with employees</u>			<u>1</u>	
149.	<u>Install merit based reward system</u>			<u>1</u>	
150.	<u>Develop close relationship with major customers</u>			<u>1</u>	
<b>Expertise in the company</b>					
151.	<u>Invest in human resource</u>		2	<u>4</u>	
152.	Train employees locally	2.26		<u>4</u>	
153.	Send employees abroad for training	2.21		<u>9</u>	
154.	Invest in R&D	2.70		<u>16</u>	
155.	Employ good human resource	2.79		<u>2</u>	
156.	Develop local expertise of imported technologies	2.79			
157.	Get knowledge yourself and transfer to workers		2		
158.	Make training institute in the company		1		
159.	Train lower level staff		1		
160.	Take help from international technical NGOs		1		
161.	Take help from local agencies		1		
162.	Hire people to document for illiterate supervisors		1		
163.	Maintain and retain human resource		2		
164.	Plan careers of people		1		




















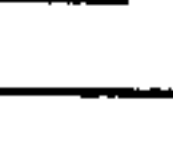


165.	Provide education		1		
166.	Have targeted education and training		1		
167.	Make people computer literate		1		
168.	Train people for R&D		1		
169.	Disseminate knowledge gained on courses		2		
170.	People should adopt hands-on approach		1		
171.	Acquiring skilled manpower from other companies		1	<u>1</u>	
172.	Workers should be rotated in jobs		1		
173.	<u>Hire people with prior experience of technology to develop</u>			<u>1</u>	
174.	<u>Hire foreign workers at low wages</u>			<u>1</u>	
175.	<u>Get training from customer</u>			<u>1</u>	
<b>Data management and storage</b>					
176.	Carry out computerization		2		
<b>Human factors</b>					
177.	Facilitate workers especially in the hour of need	2.69			
178.	Forcefully stop brain drain		1		
179.	Provide opportunities to people		1		
180.	Hire people in batches and then select		1		
181.	Give sense of participation to workers		1		
182.	Respect the workers		1		
183.	Make the workers satisfied		1		
<b>Finance and tax issues</b>					
184.	Finance should be made available from the local banks	2.56			
185.	Pay taxes completely	2.28			





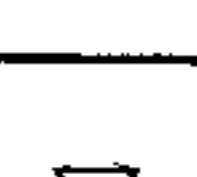









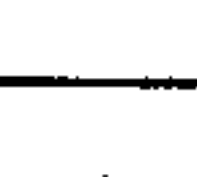






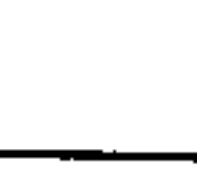


186.	State should provide capital for companies		1	<u>2</u>	
187.	Taxes should be on retailer		1		
188.	Components should have less duty than products		1		
189.	There should be no duties on electronic components		1		
190.	Duty structure conducive to local development		2		
191.	Depend upon available resources		1		
192.	Look for cheaper alternate solutions		1		
193.	Manufacture the required machinery yourself		2		
194.	Reverse-engineer electronic cards		1		
195.	Banks should provide export finance		1		
196.	Input materials should be duty-free		1		
197.	Invest profits, don't borrow from bank		1		
198.	There should be no taxes on technology imports		1		
199.	<i>Willingness to wait for payback of investment</i>			<u>1</u>	
200.	<i>Government should provide tax rebates for exports</i>			<u>1</u>	
201.	<i>In a conglomerate, compensate financial losses through other companies</i>			<u>1</u>	
202.	<i>Government should give financial incentives for R&amp;D</i>			<u>1</u>	
<b>Educational issues</b>					
203.	Universities should work for industry	2.65		<u>1</u>	
204.	<i>Get associated with universities</i>		1	<u>8</u>	
205.	University people should have industrial backgrounds		1		
206.	Create system of technical education		1		
207.	Start diploma in manufacturing engineering		1		
208.	Try to improve technology level in universities		1		





















209.	<i>Government placed emphasis on technical education</i>			<u>1</u>	
<b>Issues related to the government</b>					
210.	Pay no bribes to people	1.85			
211.	No frequent changes in government policies	2.47			
212.	<i>Government should provide infrastructure facilities</i>		2	<u>6</u>	
213.	Supportive government policies for development of industry	2.82			
214.	Financial incentives of the government	2.58		<u>8</u>	
215.	<i>National objectives / targets should be set</i>		1	<u>7</u>	
216.	<i>Government should create demand for local products</i>		2	<u>3</u>	
217.	<i>Collaborate with government research institutes</i>		2	<u>7</u>	
218.	Investments made by the government in the industry	2.13		<u>3</u>	
219.	Lobbying in the government by Chambers of Commerce and Industry	2.22		<u>2</u>	
220.	<i>Government should have training institutes</i>		2	<u>5</u>	
221.	Government Common Facility Centres or CAD / CAM centres	2.27		<u>5</u>	
222.	<i>Government making industry development plans</i>		1	<u>9</u>	
223.	<i>Government built industrial parks</i>			<u>8</u>	
224.	<i>Government provided low cost loans for selected new products</i>			<u>5</u>	
225.	<i>Technology development in public-private partnership</i>			<u>5</u>	
226.	<i>Government provided information on state-of-the-art technology trends</i>			<u>3</u>	
227.	<i>Government encouraged local production of parts</i>			<u>3</u>	
228.	<i>Government R&amp;D institute acquired technology and disseminated it to industry</i>			<u>5</u>	




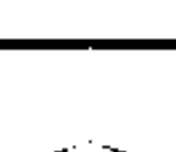













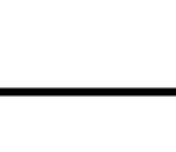
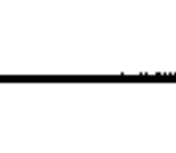


229.	<u>Government shared R&amp;D cost incurred by companies</u>			<u>8</u>	
230.	<u>Government created Industrial Technology Research Institutes</u>			<u>7</u>	
231.	<u>Government enacted laws for promotion of science and technology</u>			<u>4</u>	
232.	<u>Government provided finance for commercializing R&amp;D or spinning off companies from GRI</u>			<u>4</u>	
233.	<u>Government expanded education in science and technology</u>			<u>3</u>	
234.	Government should import technologies and create technology incubators		1		
235.	Government should create centres of excellence		1	<u>1</u>	
236.	Shoot negligent people		1		
237.	Give these people minimal bribes		1		
238.	Try to avoid dealing with the government		2		
239.	Fight cases in courts		1		
240.	Government should protect businessmen		1		
241.	Eliminate procedures		1		
242.	Be open to inspectors		1		
243.	Arrange infrastructure yourself		1		
244.	Government functionaries should be engineers		1		
245.	Industry should be free from controls		2		
246.	Involve stakeholders in policy making		1		
247.	Involve industry associations in policy making		1		
248.	Government should set engineering standards		1		
249.	Government should ensure compliance to standards		1		
250.	Work with customs and get an SRO issued		1		





















251.	Quality movement by the government		1	<u>1</u>	
252.	Government should benchmark industry		1		
253.	Government should send people for higher studies		1		
254.	Government should assign products to industry		1		
255.	Government should import products & give to industry for development		1		
256.	Government should regulate industry		2		
257.	Government should create industrial nuclei & industrial clusters		2		
258.	Government should make export-oriented policies		2		
259.	Government should attract expatriate Pakistanis		2		
260.	Interest of top level in the country helps		2		
261.	Government should give productivity targets		1		
262.	Government should give awards to industry people		1		
263.	Appoint industry-related people in ministries		2		
264.	Government should provide subsidy for participation in trade show		1		
265.	EPB should take part in engineering trade shows		1		
266.	Government should provide finance for special equipment		1		
267.	Communication between government and business should be close		1	<u>1</u>	
268.	Engineering Development Board is positive effort		2	<u>1</u>	
269.	Choose some groups and provide them incentives		2		
270.	Government / embassies can help in selling technology		1		
271.	Convince government for rational duty structure		1		
272.	Government's software technology park was of help		1		





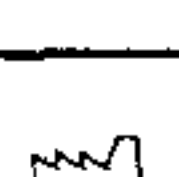








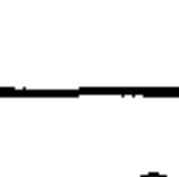





273.	Government should support high-tech research-based firms		1		
274.	Government giving preference to projects made by local industry		1		
275.	Government financing projects made by local industry		1		
276.	Government should make feasibility reports		1		
277.	Government should subsidize training		1		
278.	Government organizations should be decentralized		1		
279.	Privatization should be carried out		1		
280.	<i>Government subsidised utilities</i>			<u>1</u>	
281.	<i>Government inspected exports to prevent sub-standard exports</i>			<u>1</u>	
282.	<i>Government created export processing zones</i>			<u>1</u>	
283.	<i>Government arranged national science and technology conference</i>			<u>2</u>	
284.	<i>Government R&amp;D institute invested in joint company with another domestic company</i>			<u>2</u>	
285.	<i>Government research institute (GRI) created venture capital fund</i>			<u>1</u>	
286.	<i>Government provided automated customs service in science parks</i>			<u>1</u>	
287.	<i>Government provided R&amp;D and training facilities in science parks</i>			<u>1</u>	
288.	<i>Government developed high quality manpower</i>			<u>2</u>	
289.	<i>Government protected intellectual property rights</i>			<u>2</u>	
290.	<i>Government created fund for quality and productivity improvement in SMEs</i>			<u>1</u>	
291.	<i>Government facilitated import of technology</i>			<u>1</u>	
292.	<i>Government facilitated establishment of research</i>			<u>1</u>	













	<i>institutes in private industries</i>				
293.	<i>Government helped in recruitment from abroad</i>			<u>2</u>	
294.	<i>Government initiated research projects</i>			<u>1</u>	
295.	<i>Government promoted facilities that can be leased on short-term basis</i>			<u>1</u>	
296.	<i>Government reduced tariff rates for import of R&amp;D equipment</i>			<u>1</u>	
<b>Business environment factors</b>					
297.	<i>There should be national standards body</i>		2	<u>3</u>	
298.	Government should develop basic metals and plastics industries	2.26			
299.	Collaborate with other industries in your area	2.25		<u>3</u>	
300.	Follow standards		1		
301.	Switch to new technology standard		1		
302.	Establish industries in areas conducive for investment		1		
303.	Comply to international standards		1		
304.	Create positive competition		1		
305.	Private sector should be made stronger		1		
<b>Market factors</b>					
306.	Market products aggressively	2.36		<u>3</u>	
307.	Export products	2.72		<u>15</u>	
308.	Tariff barriers placed by the government for protection of industry	1.81		<u>6</u>	
309.	Government should give equal opportunities to local companies		1		
310.	Stoppage of smuggling		1		
311.	Investments should be brought in the country		1		



312.	There should be no protections		1		
313.	WTO should finish monopolies		1		○
314.	Create local brand		1	<u>2</u>	
315.	Remove uncertainty in the market		1		
316.	<i>Government enforced import licensing</i>			<u>1</u>	
317.	<i>Government reduced excise duty on parts</i>			<u>1</u>	
318.	<i>Export old equipment to other countries</i>			<u>2</u>	
<b>Foreign factors</b>					
319.	<i>Bring high-tech MNCs to the country</i>		1	<u>3</u>	
320.	Work as Original Equipment Manufacturer (OEM) or contractor to foreign companies	2.77		<u>16</u>	
321.	Make joint ventures with foreign companies	2.58		<u>15</u>	
322.	Import technology through licensing and other means	2.41		<u>17</u>	
323.	Get foreign consultancy in technical matters	2.00		<u>10</u>	
324.	Prove to your foreign joint venture partners that you were capable of working with them	2.44			
325.	<i>Establish overseas companies or overseas R&amp;D companies</i>		1	<u>10</u>	
326.	Visit foreign countries or foreign companies	2.55		<u>4</u>	
327.	<i>Make strategic alliances with other companies</i>			<u>6</u>	
328.	<i>Acquire small high-tech companies in foreign countries</i>			<u>4</u>	
329.	Engineering companies should go into export		1		
330.	Government should give subsidies for technology imports		1		
331.	Government should protect market to force foreign companies for tech transfer		2		
332.	<i>Buy technology from small firms needing money for</i>			<u>1</u>	

	<i>survival</i>				
333.	<i>Negotiate technology from multiple sources</i>			<u>1</u>	
334.	<i>Acquire technology from multiple sources</i>			<u>1</u>	
335.	Government controls on visits should be removed		1		
336.	<i>Don't share management control with joint venture partners</i>			<u>1</u>	
337.	<i>Develop key components indigenously</i>			<u>1</u>	
338.	Give all types of incentives to MNCs		1		
339.	Make engineers work in foreign companies		1		
340.	<i>Buy equipment from foreign companies going bankrupt</i>			<u>2</u>	
341.	<i>Plan to be a world-player</i>			<u>1</u>	
342.	<i>Send engineers in foreign markets in addition to sales people</i>			<u>1</u>	
343.	<i>Get approvals for sales in foreign markets</i>			<u>1</u>	
344.	<i>Government should place export requirements on foreign joint venture companies</i>			<u>1</u>	
345.	<i>Hire experienced foreign technologists for technology development</i>			<u>2</u>	
346.	<i>Move production facilities to low-cost countries</i>			<u>1</u>	
347.	<i>Government R&amp;D institute and MNC jointly developed research institute</i>			<u>1</u>	○
348.	<i>Government R&amp;D institute conducted joint research with foreign scholars</i>			<u>1</u>	
349.	<i>Company entered into joint research program with foreign R&amp;D institute</i>			<u>1</u>	
350.	<i>MNCs developed skills development centres</i>			<u>1</u>	○
<b>Entrepreneurship</b>					
351.	Involvement of owners in technical matters	2.03		<u>6</u>	



352.	No one-man-shows		1		
353.	Government should provide entrepreneurship opportunities		1		
354.	Entrepreneur should do management courses		1		
355.	<i>High-tech company established by returning nationals</i>			<u>1</u>	
356.	<i>Entrepreneur having prior experience</i>			<u>2</u>	
<b>Vendors</b>					
357.	Educate industrialists to hire qualified people		1		
358.	Educate vendors on quality and technical matters		2	<u>2</u>	
359.	Engineering graduates should be entrepreneurs		1		○
360.	Testing & inspection facilities should be at suppliers' factories		1		○
361.	Crave a vendor development cell in the company		1		
362.	<i>Government provided finance to develop vendor industry</i>			<u>1</u>	
<b>Ethical issues</b>					
363.	Be fair and honest in business	2.82			
364.	There should be strong ethics		1		
365.	Allah's help		1		○
366.	Keep good intentions		2	<u>1</u>	

## Chapter 13

# Conclusion

### 13.1 Introduction

This chapter has four main objectives: To provide a summary of the findings of this research; to compare these findings with the literature; to present the main conclusions; and to propose directions for future research.

### 13.2 Questions posed at the start of this research

This research set out to find the answers of the following questions:

1. What is the level of technology in the manufacturing companies of Pakistan in comparison to the leading companies of the world? (Status of technology)
2. Why are these companies at their present state of technology? What is holding them back from catching up with the leading companies of the world? (Barriers to technology development)
3. How could these barriers be removed? (Solutions to barriers)
4. What steps should be taken so that these companies can catch up with the leading companies of the world? (Actions required for technology development)
5. What are the stages that these companies should follow in this catch-up process? (Stages for technology development)



### **13.3 Summary of the findings of this research**

#### **13.3.1 Technology status measurement in manufacturing companies**

1. Technology was divided into eight facets.
2. A simple but practical method of estimating the status of technology in each facet was developed and was successfully tested in companies in Pakistan.
3. Results from individual companies were aggregated to yield the result that the technology level in the manufacturing companies in Pakistan was roughly 60 % of the world level.
4. The method also determined that the companies in Pakistan were slowly catching up in technology.

#### **13.3.2 Framework of issues for technology development**

The research started by defining technology to be comprised of eight facets. It was later found that technology development involved issues much beyond these eight technology facets.

A framework of technology development issues thus emerged, which was found to be applicable to both barriers and actions. This framework had 19 dimensions or categories, which spanned not only beyond company boundaries but also beyond national boundaries.

#### **13.3.3 Barriers, solutions and actions**

##### **Barriers**

1. This research found 226 barriers to technology development. Fifty two significant barriers among these were ranked for their seriousness.
2. The vast majority of the important barriers were related to the government. Very few of the important barriers were related to the facets of technology.
3. All the substantial barriers were government related.

### **Solutions**

4. Solutions to almost all of the significant barriers were cited.
5. The majority of these solutions could be acted upon by factory managers themselves without specific support from the government.

### **Actions**

6. The research found 272 actions helpful in technology development. Fifty nine of the significant ones were ranked for their benefit.
7. The vast majority of the cited actions were in the control of the factory managers themselves.
8. Technology development requires actions not only in the facets of technology but also in the broader framework of issues.

#### **13.3.4 Model for technology development – Action plans and stages**

1. Action plans for factory managers and government policy makers were prepared based upon the substantially beneficial actions and solutions of substantial barriers.
2. The action plan for factory managers called for exports and acquisition of technology from foreign sources in addition to improvement in the facets of technology.
3. The action plan for government policy makers asked for reductions in the price of utilities, supportive policies, and financial incentives. It emphasised short and easy



procedures and a reduction in the interaction of the government functionaries with the factories.

4. A four stage catch-up model was proposed, which recommended the start of the acquisition of design capabilities at an early stage, which were to be strengthened with time. Exporting was also an important component of this catch-up plan.

### **13.3.5 Technology Development Model from East Asia**

1. The content analysis of the case studies in the literature on East Asia resulted in 51 barriers and 161 actions, which were segregated into various categories of the framework of issues, and ranked according to their importance. Action plans for factory managers and government were formulated from most important of the factors.
2. The positive role of the government was evident in the list of actions. This was lacking in Pakistan.
3. The action plan for factory managers emphasised acquisition of foreign technology, export and capability to design.
4. The action plan for the government included preparation of industry development plans after setting national objectives, giving financial incentives to industries, and establishment of research institutes for improvement in industrial technology.
5. The stages required for catch-up were similar to those developed in Pakistan, but there was emphasis on process design capability in addition to product design, and technology acquisition from foreign sources at all stages.

### **13.3.6 Development of Combined Technology Development Model**

Comparison of the empirical results from Pakistan and those from the East Asian literature prompted a combination of the two models to develop a comprehensive technology development model. This combined model was generated, and combined

actions plans for factory managers and government policy makers were formulated based upon this model. These action plans contained actions proposed in both the models.

### **13.4 Comparison of the findings of this research with existing literature**

Details of the comparison between the findings of the different components of this research and the available literature relevant to each component have already been discussed in chapters 5 through 12. This section will briefly summarise the results of this comparison.

#### **13.4.1 Technology Status Measurement**

It was argued that method proposed by this research is direct, simple, convenient, and tested. It provides much more information than the previously proposed methods.

#### **13.4.2 Framework of issues for technology development**

The literature does not contain any specific framework of issues for technology development. The framework of issues obtained through this research was compared to a 'technology complex' given in the literature. It was argued that this framework is much more practical than the 'complex'.



### **13.4.3 Barriers, solutions and actions**

A systematic comparison of barriers and actions found in the on-ground research in Pakistan with the literature was carried out through content analysis of the case studies of the East Asian companies.

- The comparison showed that the literature does not detail many barriers to technology development and it does not specify any solutions to those which have been mentioned.
- The empirical research in Pakistan had much wider coverage of issues than the literature.
- There were many commonalities in the two and some differences.
- The literature had many additional factors related to the government and technology acquisition from foreign countries.

### **13.4.4 Action plans for technology development**

The literature does not provide any compiled action plans for factory managers or government policy makers for technology catch-up in manufacturing companies. The advices given by certain authors are their own judgements based upon their experiences and not based upon compilation from empirical and literature sources.

### **13.4.5 Stages required for catch-up with world leading companies**

The literature does not provide specific stages required for catch-up in technology by manufacturing companies of developing countries. The stages proposed by this research are based not only upon the experience of senior factory managers but also upon the case studies given in the literature.

### **13.5 Conclusions of this research**

The following major conclusions could be derived from this research:

1. Catching up with the leading companies of the world is possible through technology development in manufacturing companies.
2. Division of technology into eight facets is a practical and useful approach.
3. Technology development in manufacturing companies is a multi-dimensional problem, the boundaries of which not only span beyond the company boundaries but also country boundaries. So steps in multiple directions have to be taken to achieve the objective.
4. The majority of the factors helping technology development are in the control of factory managers themselves. A positive role by the government could act as a catalyst in the catch-up process.
5. The most important aspects for factory managers in the technology catch-up process are acquisition of technology, especially from foreign sources, acquisition of capability to design products, export of products, and factory management.
6. The government should aim to reduce utility prices, make the procedures simple, and reduce the interaction of government functionaries with industries.
7. Stages for catch-up ask for building capability to design in parallel with acquiring assembly and production capabilities. The culmination of these stages should be export to bigger markets of the world.

### **13.6 Proposed future directions of research**

This research is a pioneering effort to build a practical framework of actions required for catch-up in technology. The following directions of further research could be proposed:



1. This research had targeted high value-added manufacturing companies. More research would be required to find out whether it is applicable in other manufacturing companies or not.
2. This research found that technology acquisition from advanced countries, exports and acquisition of design capability were important in catch-up in technology. Quantitative research would be required in this direction to determine the correlation between these factors and the pace of catch-up in technology.
3. Although this research has divided technology into facets and has considered them separately, more pointed research would be required to look into the quantified contribution of each of the facets in the catch-up process.
4. Being a long process, the catch-up process ought to be evaluated periodically. Techniques have to be found to quantifiably monitor and evaluate the progress of catch-up process. This would be difficult but interesting, as the object to chase is not static but dynamic.
5. As the requirements of each stage in the catch-up process could be different, research to formulate specific action plans for each stage could be carried out.
6. This research was conducted in Pakistan, and has taken the literature on East Asian companies into consideration. It remains to be determined whether the results of this research would be applicable in other parts of the world.
7. This research has proposed numerous actions for technology development in manufacturing companies. Further research would be required to determine how those actions could be best carried out. For example, a suggested action is 'convince people for change'. Further research would be required to find out how people could be best convinced for change.
8. The social, cultural and political influences on the progress of manufacturing sector were not studied in this research, as mentioned in section 1.3. Further research in this direction is required.