"A Taxonomy of Highly Interdependent, Supply Chain Relationships: The Use of Cluster Analysis" *International Journal of Logistics Management* Vol. 18 No. 3, (2007) pp. 385-401

# A Taxonomy of Highly Interdependent, Supply Chain Relationships: The Use of Cluster Analysis

**Authors:**

***Dr Andrew S Humphries***
1 Castle Rose, Woughton Park, Milton Keynes, MK6 3BQ, UK
Tel: 01908-664119
E-mail: andrew_humphries@bigfoot.com

***Dr John Towriss***
Cranfield Centre for Logistics and Supply Management
Chain Management, Cranfield School of Management, Cranfield University, Cranfield, Bedfordshire, UK.
Tel: 01234-754123
E-mail: j.towriss@cranfield.ac.uk

***Prof Richard Wilding (correspondence)***
Cranfield Centre for Logistics and Supply Management
Chain Management, Cranfield School of Management, Cranfield University, Cranfield, Bedfordshire, UK.
Tel: 01234-751122
E-mail: richard.wilding@cranfield.ac.uk
Web: www.richardwilding.info

**Abstract**

# A Taxonomy of Highly Interdependent, Supply Chain Relationships: The Use of Cluster Analysis


## Structured Abstract

**Purpose**
Cluster analysis provides a statistical method whereby unknown groupings of similar attributes can be identified from a mass of data and is well know within marketing and a wide range of other disciplines. This paper describes the use of cluster analysis in an unusual setting to classify a large sample of dyadic, highly interdependent, supply chain relationships based upon the quality of their interactions. We show how careful attention to the detail of research design and, the use of combined methods led to results that were both useful to managers and make a contribution to knowledge.

**Design/ methodology / approach**
Data relating to 55 monopolistic relationships in the UK defence procurement sector were collected. Hierarchical Cluster Analysis using Wards Method was undertaken on scores from five dimensions measuring relationship satisfaction. The resulting clusters are described in terms of the scores on the dimensions and also in terms of their relationships with data, quantitative and qualitative, exogenous to the clusters.

**Findings**
The analysis reveals five distinct clusters of relationships. Statistically significant differences are evident in the scores on the five dimensions of satisfaction with respect to these clusters. These scores lead to the labels 'Poor 1' Moderate 2', 'Moderate 3' and 'Good 4' being assigned to the clusters. The clusters display statistically significant relationships with a number of the exogenous variables including the value of the contract and the age of the technology involved. Relationships with the exogenous qualitative data are indicative of the validity of the clusters.

**Originality / Value**
This paper takes a novel approach to gaining an understanding of relationships through the use of hierarchical cluster analysis. This provides an elegant way of exposing the influences on relationship satisfaction at a disaggregate level which are not possible by taking an aggregate approach. This will be of particular interest to researchers who are seeking patterns in large data sets and practitioners who can identify better practice guidelines when working within supply chain relationships. The disaggregate approach using Cluster Analysis provides extraordinarily detailed insights into relationship patterns.



**Paper type**
Research paper

**Keywords**

Collaboration, Interdependence, Supply Chain Relationships, Cluster Analysis

**Biographies**

Andrew Humphries PhD. has over 30 years of experience as a practicing, operational logistician. He works with companies in both the public and private sectors to improve understanding of the dynamics of collaborative supply chain relationships.

John Towriss, PhD, is Senior Lecturer at the Centre for Logistics and Supply Chain Management, Cranfield School of Management UK and specialises in quantitative aspects of management research.

Richard Wilding, PhD, is Professor of Supply Chain Risk Management at the Centre for Logistics and Supply Chain Management, Cranfield School of Management U.K. Richard works with European and International companies on logistics and supply chain projects in all sectors including pharmaceutical, retail, automotive, high technology, food drink and professional services to name a few. He has published widely in the area of supply chain management and is Editorial Advisor to a number of top journals in the area. www.richardwilding.info

# A Taxonomy of Highly Interdependent, Supply Chain Relationships: The Use of Cluster Analysis

**Introduction:**

Improving the performance of Defence Procurement relationships has been a government priority for some years in most European countries and the US. However; post Cold War defence industry concentration matched to declining government budgets has resulted in a restricted or monopolist market with attendant tensions that appear to block progress (Kovacic, 1999, Humphries & Wilding, 2004a, Serfati, 2001). The purpose of the research upon which this paper is based was to gain an understanding of the drivers of satisfaction that affect these high technology, strategically important relationships. To achieve this objective this paper takes a disaggregate approach through the derivation of a taxonomy of these satisfaction drivers in a way not possible through the use of a technique such as multiple regression analysis. The paper describes how patterns were sought using Cluster Analysis within a large volume of quantitative data which represented measurements of the strengths of managers' perceptions within 55 highly interdependent UK Defence Procurement dyadic relationships. More specifically the paper describes how the taxonomy was produced from

measurement of five dimensions of relationship satisfaction and the relationships of the resultant groupings with other variables in order to facilitate an understanding of the theoretical and policy implications of the taxonomy. This research follows the conceptual thrust provided by Lamming et al (2004) to disentangle the elements within a set of elements that make up both the activity and the nature of business relationships.

**Research Background**

From an interdisciplinary perspective Humphries & Wilding (2003) proposed that Supply Chain Management, Relationship Marketing and Transaction Cost Economics (TCE) offered reasonably consistent views of the underlying drivers and development of collaborative business relationships. Over the last 30 years in the face of increasing pace of change, globalisation and customer sophistication business-to-business relationships have migrated from transactional/adversarial roots (Lambert et al, 1996) epitomised by the Automotive Industry in the 1970s and 80s (Sako et al, 1994) to more relational practices (Perks & Easton, 2000). Moreover, these trends are evident in both the public and private sectors (Christopher, 1997, Harland et al, 2000). The supply chain has evolved from logistics through process improvements towards high value, complex supply chains requiring increasingly sophisticated linkages between customers and fewer suppliers (Lamming et al, 2001). Relationship Marketing describes developments from managerial marketing via networked structures through to Marriage analogies, Key Account Management and virtual organisations (Sheth & Sharma, 1997). The International Marketing and Purchasing Group's dyadic interaction approach identifies context, parties, interaction and behavioural dimensions (Kern and Willcocks, 2002). More specifically, Brennan et al (2003) explore the relationship-specific adaptations in which firms alter their business practices uniquely for individual partners. Relational variables included trust, commitment and $C^3$ behaviour (co-

operation, collaboration and co-ordination) (Wilding & Humphries, 2006, Spekman et al, 1998). Finally, TCE's more technical level of analysis of the underlying relational factors in contractual relationships described a trend to explain contractual relationships in other than market forces terms (Macneil, 1980). The concept of the hybrid mode as an intermediate state between market and hierarchy to support various forms of long-term contracting (Williamson, 1996) acknowledged the need to explain the governance arrangements required for more relational business dealings. However, within these bodies of knowledge there appeared to be limited integration of such ideas (Rindfleisch & Heide, 1997), or empirical research on long-term dyadic relationships (Rousseau et al, 1998) or, substantive research into the attitudinal behaviours which generate adversarial practices such as power abuse, lack of transparency, poor communications and opportunism (Braithwaite, 1998).

In addressing these important theoretical issues it is possible to provide a clear contribution to knowledge about the dynamics of collaborative business relationships. Within the UK defence procurement sector we chose the UK Defence Logistics Organisation as our research environment for a number of key reasons. Firstly it manages a large number of long-term, strategically important, highly collaborative supply chain relationships with major industries and thus offers an ideal environment for the research. Secondly, the relative lack of competition in UK Defence Procurement provides an opportunity to focus on close-coupled relationships without the distraction of market influences. Lastly, as already mentioned in the Introduction, the Defence Logistics Organisation has long suffered from poor external relationship performance and this research could potentially provide managers with useful ideas for improvement.

The selected theoretical lens was Oliver Williamson's (1975) Organisations Failure Framework because of its emphasis on behaviours within transaction cost economising

situations (including governance arrangements to guard against opportunism and information impactedness). Also, because this framework presupposes that highly interdependent relationships within a limited or monopoly market situation will tend towards the adversarial (Williamson, 1996) it seemed to be particularly suited to the UK Defence Procurement situation. The 5 dimensions used in the research were thus based on Williamson's (1975) Organisations Failure Framework:

1. Creativity – the degree of innovation and dynamism (Bounded Rationality).
2. Stability – the extent of relationship specific investments (Uncertainty/Complexity).
3. Communication – the quality of relationship communication (Information Impactedness).
4. Reliability – the effectiveness and efficiency of joint operations (Opportunism).
5. Value – the degree of share of joint relationship outputs (Small Numbers)

As well as using the TCE literature, the scale items used to measure the dimensions were derived from the Supply Chain Management literature (for its operational efficiency variables) and, Relationship Marketing (bringing specialised business relationship variables such as trust and commitment) thus allowing 3 disciplines together to produce *'transcendent insights'* that would not be perceived by the individual disciplines working alone (Starkey & Madan, 2001).

**The Empirical Basis of the Research**

A key informant data-capture approach was designed using both quantitative (questionnaire) and qualitative (semi-structured interview) methods, which aimed to measure perceptions from both sides of each relationship (Ganesan, 1994; Jick,1979). Operationalization of the research instrument concentrated on the five dimensions derived from Williamson's (1975)

framework the relationships; namely ‘Creativity’, ‘Stability’, ‘Communication’, ‘Reliability’ and Value’ using 5-point Likert scale items grounded in the relevant literature. The end points of the scales were ‘Very Satisfied’; ‘Very Unsatisfied. The Cronbach Alpha scores based on the averaged item scores for each dimension are shown in Table 1. A score of at least 0.80 is indicative of a high level of internal consistency and reliability (Bowman & Ambrosini, 1997) for the instrument.

| **Dimension** | |
|---|---|
| Creativity | 0.80 |
| Stability | 0.77 |
| Communication | 0.76 |
| Reliability | 0.77 |
| Value | 0.88 |

Table 1. Research Instrument Cronbach Alpha Scores.

The semi-structured interview design involved following-up the quantitative results by capturing ‘why’ information from senior managers for each dimension of the relationship in question i.e. what were the key factors that resulted in success or failure? By this additional means it was intended to obtain the richness of perceptions needed to gain insight into the subtleties and depth of the business problem. Under self-selected census arrangements data were collected from 55 relationship dyads representing £575.8m annual spend (approximately one quarter of the total) within the sea, land and air business units of the UK Defence Logistics Organization. , Qualitative data relating to issues and their significant were recorded usingsemi-structured interviews.

As discussed earlier this paper employs on a disaggregate approach to gain an understanding of the drivers that affect high technology, strategically important relationships To this end cluster analysis was employed and the next sections discuss the rationale for this decision, describe the process we followed and the results obtained. Finally we conclude by reviewing the implications for theory, practice and research.

**Cluster Analysis - An Overview of the Technique**

Cluster analysis has been variously defined as: a family of techniques used to partition a set of objects into two or more groups based on the similarity of the objects for a set of specified characteristics (Everitt et al, 2001, Hair et al, 1984, Kaufman & Rousseeuw,1990); a technique that sorts observations into similar sets or groups; groupings where the statistical variance among elements grouped together is minimised while between-group variance is maximised (Borland et al, 2001, Ketchen & Shook, 1996) and also; a means of developing empirical groupings of persons, products or occasions which may serve as the basis for further analysis (Punj & Stewart, 1983). Methods of cluster analysis fall into two main groups: hierarchical and non hierarchical. Since hierarchical methods are the most commonly used they will be the focus of the following discussion.

Hierarchical procedures involve the construction of a hierarchy of a treelike structure. There are basically two types of hierarchical clustering procedures agglomerative and divisive. In the agglomerative methods, which is the method used in this research every relationship starts out as its own cluster. In this research each relationship was quantified on the basis of the mean satisfaction scores on the Likert scales for each of the five dimensions detailed in the previous section. In the cluster analysis, the two closest clusters (or relationships) are combined into a new aggregate cluster, thus reducing the number of clusters by one in each step. In some cases, a third relationship joins the first two in a cluster. In others, two groups of relationships formed at an earlier stage may join together in a new cluster. Eventually, all relationships are grouped into one large cluster; for this reason, agglomerative procedures are sometimes referred to as build-up methods (Hair et al, 1984). Hierarchical clustering methods do not require preset knowledge of the number of groups which suits our large research data set. The method of computation used in this

method of cluster analysis is to first create a matrix of relative similarities (known as the similarity matrix) between all objects (for this research using the relationship satisfaction scores table) and then use this matrix as the basis for combining the relationships into groups, or clusters (Hair et al, 1984). The elements of the matrix are measures of similarity or differences between the observations with a commonly used measure being the Squared Euclidean Distance.

Within agglomerative hierarchical procedures there are different calculation methods available for combining the observations into clusters. These include Single Linkage, Complete Linkage, Average Linkage the Centroid Method and Ward's Method (Hair et al, 1984). Ward's Method links the pair of clusters that produce the smallest variance in the merged cluster. It uses an analysis of variance approach to evaluate the distances between clusters. In short, this method attempts to minimize the Sum of Squares of any two clusters that can be formed at each step. Of the alternatives Ward's method has the fewest inherent biases Everitt et al, 2001, Ketchen & Shook, 1996, Punj & Stewart, 1983) and as a consequence is used for the cluster analysis described in this paper. (. In consequence it was used for the Cluster Analysis described in this paper and we utilised the statistical software package SPSS to carry out the calculations.

**Issues Relating to the Use of Cluster Analysis**

The use of Cluster Analysis is not without its problems and this section details how, within the context of this research, these were addressed.

**The Selection of Variables**: Attention to initial variable selection is crucial because even one or two irrelevant variables may distort an otherwise useful cluster solution. There should be a clear rationale for the selection of the variables (Everitt et al, 2001, Punj & Stewart, 1983) and thus the first key part of the cluster analysis process is the selection of variables

underpinned by a rigorously designed research. This problem was addressed by having a firm theoretical base for research, namely Williamson's (1975) Organisations Failure Framework which yielded the five dimensions and by subsequently adopting a rigorous approach to the selection of scale items which involved firstly them being identified in the literature and then verified and subsequently expanded based upon in-depth interviews with managers from the target industry (Faes et al, 2001, Olszewski et al, 1987, Sharma & Lambert, 1990).

**The Validity of the Cluster Solution**: Cluster analysis has been criticised because several aspects of the process require extensive reliance on researcher judgement. Lack of care especially in the detailed research design phase, or the absence of a clear theoretical basis for variable selection, means that the technique may generate clusters even when no meaningful groups are embedded in the sample (Ketchen & Shook, 1996, Sutton, 2003). It is sometimes possible to split the sample, carry out cluster analysis on both sub samples and then compare the results but this was not possible in the case of this research because of the size and characteristics of the sample. There is no standard tool for assessing the degree of consistency and therefore the validity of cluster analysis solutions. An assessment based upon comparison of results obtained from using different clustering methods (e.g. single linkage, centroid method, etc) was rejected on the grounds that because the methods differ computationally so widely very different results are to be expected. Instead in this research emphasis was placed on the face validity of the cluster solution and its relationship related to variables other than those used to generate the solution (i.e. criterion-related validity (Kerlinger,(1973) together with a clear demonstration that the classification has broader implications (Faes et al, 2001, Punj & Stewart, 1983, Sharma & Lambert, 1990).

**Determining the Number of Clusters**: Several methods can be used to determine the number of clusters arising from cluster analysis One approach is to visually inspect the dendrogram for natural clusters of dense 'branches'. This is a somewhat subjective approach and so the following method was adopted for this paper. Wards method as previously discussed effectively produces minimum variance clusters. The merger of every possible cluster pair is considered and the two clusters whose fusion results in minimum increase in 'information loss' are combined. Information loss is defined in terms of 'Error Sum-of-Squares'. For each stage in the clustering process the Error Sum of Squares can be plotted against the number of clusters with a marked discontinuity in the resultant 'agglomeration' curve indicating the point in the fusion process where dissimilar clusters are being merged. (Everitt et al, 2001, Kaufman & Rousseeuw, 1990). Figure 1 shows the gradient of the agglomeration curve at each stage in the fusion process. It clearly shows a marked increase subsequent to the production of four clusters, indicating the fusion of relatively dissimilar clusters after this point in the fusion process. Thus a four cluster solution was taken forward for further analysis.

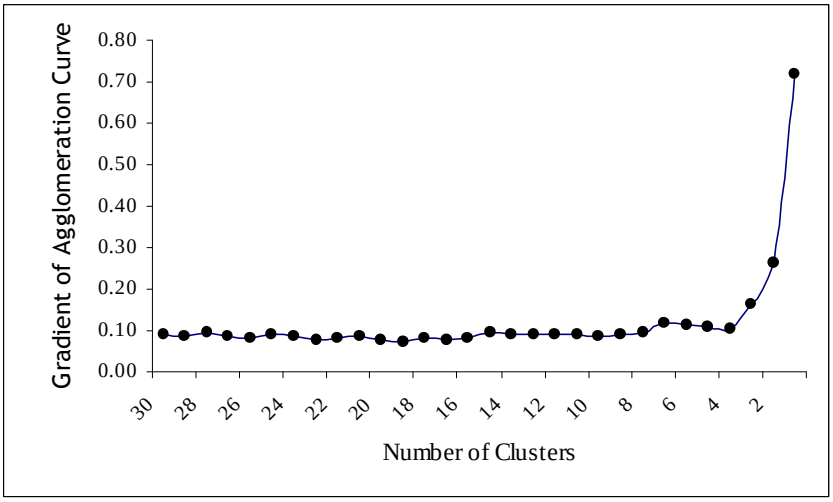


Figure 1. Agglomeration Graph.

**Standardisation of Variables**: The computation of the similarity coefficients in Cluster Analysis means variables with large values are given more weight than those with small ones.

The remedy is standardisation of variables for example so that they have a mean of zero and a standard deviation of one. Moreover, unusual or 'outlier' observations may also be present which might skew the cluster analysis validity (Kaufman & Rousseeuw, 1990, Ketchen & Shook, 1996). In this research however, the data were from similar scales with no outliers and therefore standardisation was not necessary.

**Cluster Topology**

This section describes the results of the high level cluster analysis. The resulting taxonomy of relationships is characterised in the following section. As previously mentioned, Ward's Method was used to identify four groups of similar relationships within the sample population of UK Defence Logistics Organisation businesses as shown in Figure 1. The next step was to describe their characteristics using the quantitative and qualitative data and, to relate the results to some additional, exogenous variables as recommended by Punj & Stewart (1983). In this section we describe the clusters from a quantitative perspective and then relationships with the exogenous variables and finally, provide findings relating to how the qualitative data help characterise each cluster.

**Statistical Testing:** The quantitative data was partitioned according to the five dimensions of the theoretical framework (Wilding & Humphries, 2006) and the mean relationship satisfaction scores for each cluster are shown in Table 2. As explained previously these values are the mean scores from the five point Likert scales.

| **Cluster Label** | **Poor 1** | **Mod 2** | **Mod 3** | **Good 4** |
|---|---|---|---|---|
| Mean Cluster Satisfaction Score: | 40.80 | 57.13 | 67.84 | 89.16 |
| Number of Relationships in Cluster: | 10 | 12 | 23 | 10 |
| **Cluster Dimensions** | **Mean Satisfaction Levels** | | | |
| **Creativity** - promoting quality, innovation and a long-term approach by encouraging high performance | 35.30 | 56.66 | 73.36 | 91.60 |
| **Stability** - synchronisation of objectives and confidence building | 32.60 | 48.16 | 63.09 | 88.10 |
| **Communication** - shared data environment, openness, | 54.40 | 66.33 | 63.31 | 83.40 |

| | | | | |
|---|---|---|---|---|
| common performance measures, frequent interaction | | | | |
| **Reliability** - concentrating on service and product delivery, lowering joint costs and risks, building up trust | 28.90 | 45.58 | 62.63 | 90.20 |
| **Value**- creating a win-win relationship in which each side is delighted to be a part | 52.80 | 68.91 | 76.81 | 92.50 |

Table 2. Quantitative Data by Cluster and Dimension.

Analysis of Variance (ANOVA) on the Mean Cluster Satisfaction Score shows a significant difference ($p<0.001$) across the clusters. Given that a Levene test indicated homogeneity of variances across the clusters post-hoc testing was undertaken using both the Least Squares Difference method (LSD). Results indicated significant differences ($p<0.001$) between all pairing of mean satisfaction scores shown in Table 2.

The same procedures were used to test for differences in each of mean dimension scores across the clusters and the subsequently across individual pairs. Given positive results for tests of homogeneity of variances Table 3 shows the results of the ANOVA tests and clearly

| Dimension | F | Sig |
|---|---|---|
| Creativity | 85.28 | <0.001 |
| Stability | 48.56 | <0.001 |
| Communication | 09.11 | <0.001 |
| Reliability | 21.73 | <0.001 |
| Value | 29.40 | <0.001 |

Table 3. ANOVA – Dimensions by Cluster

indicates significant differences for across all clusters for all dimensions. Post hoc testing using the LSD method showed that only in the case of one dimension, 'Communications', were pairwise comparisons across clusters found to be insignificant ($p<0.05$). This result is detailed in Table 4. All other comparison were found to be significant ($p<0.05$). These results indicating the existence of clear well defined groupings.

| | (I)Cluster | (J) Cluster | Mean Difference (I-J) | Sig. |
|---|---|---|---|---|
| Communications | Poor 1 | Mod 2 | -8.8 | 0.078 |
| | | Mod 3 | -3.0 | 0.516 |

Table 4. Post Hoc Testing Results

From the interpretation of these results at face value, the four clusters of relationships, when measured in terms of satisfaction, appeared to fall into three main categories: Poor - Cluster 1, Moderate Clusters 2 & 3, Good – Cluster 4. The differences between the Clusters can be clearly seen in Table 2 and for example, managers' concern over the Reliability of service delivery arrangements in Clusters 1, 2 and 3 is clearly evident.

**Relationships with External Variables.** In order to seek richer patterns within the quantitative data and to provide a measure of criterion-related validity, a number of external variables were selected that could be used for linking with the clusters. The variables listed were sourced from an internal UK Defence document on Improving Supplier Management. The previously cited qualitative research suggesting that these variables might be related to relationship satisfactionStatistical testing on the relationship between the clusters and these variables was undertaken with significant results reported at the level $p<0.05$. The results of these tests are discussed below and summarized in Table 5.

| # | **Variable** | **Values** | **Relationship to Clusters ($p<0.05$)** |
|---|---|---|---|
| 1 | Value of Contract in Year | £ - Higher spend<br>£ - Lower spend | Yes |
| 2 | Relationship Duration | Long: >20 yrs<br>Medium: 10-19 yrs<br>Short: 1-9 yrs | No |
| 3 | Team Size | Number in Team | No |
| 4 | Technology Age | Old: >2 Upgrades<br>Medium: 1-2 Upgrades<br>New: 0 Upgrades | Yes |
| 5 | Technological Complexity | System<br>Component | No |
| 6 | Ministry of Defence Contractors League - Annual Spend per Supplier (DASA, 2001) | 1: >£250m<br>2: £100m-£250m<br>3: £50m-£100m<br>4: £25m-£50m<br>5: £10m-£25m<br>6: £5m-£10m | Yes |

Table 5 Cluster Relationships with External Variables

**1 Value of Contract in a Year**: Analysis of Variance (ANOVA) on mean scores for the average value of the contract per year showed a significant relationship ($p<0.048$) with the clusters. Post hoc testing revealed significant differences between Cluster 'Mod 2' with a mean value of £22.6m and Clusters 'Mod 3' and 'Good 4' with mean values of £5.2m and £4.25m respectively. Reference to Table 2 shows an interesting relationship with the mean satisfaction scores associated with these clusters and provides criterion-related validity to the clusters. It is indicative that smaller value and hence less complex relationships are linked to higher levels of satisfaction because they are easier to manage.

**2 Relationship Duration**: At an overall level a link could be established between the duration of the relationship and 'Satisfaction' as shown in Table 6. No link was established between relationship duration and the clusters.

| | **Relationship Duration** | | |
|---|---|---|---|
| | Long | Medium | Short |
| Mean Satisfaction Score | 60.3 | 64.1 | 77.7 |
| n | 26 | 19 | 9 |

Table 6 Satisfaction and Relationship Duration

**3 Team Size**: No relationship was detected with satisfaction scores and the clusters. This coincides with the pattern found at an aggregate level. This was unexpected because one might surmise that smaller teams would find it easier to establish and maintain better supply chain relationships because of the need to maintain fewer personal relationships. However at the aggregate level a significant relationship ($r = 0.65$: $p <0.01$) was found with the value of the contract. This is what one might expect with higher value contracts requiring larger management teams and is indicative of the validity of the underlying data.

**4 Technology Age**: A relationship was detected between the age of the technology and the relationship clusters with a Chi Square test revealing an association between the two variables at $p < 0.05$. Clusters 'Good 4' and 'Mod 3' displaying relatively high proportions of relationships (30% and 36% respectively) involving 'New Technology' It will be recalled that these are the two clusters with the highest mean satisfaction scores. This supports the hypothesis that newer technology would be easier to support and therefore potentially places less strain on the relationship. However, statements in the qualitative data also suggested that good relationships involving older technology could still exist because they had been established over many years. This may well explain the lack of relationship between relationship satisfaction and the age of the technology that was found at an aggregate level and adds support to the disaggregate approach adopted in this paper.

**5 Technology Complexity**: No link was found between the complexity/size of the product and the relationship clusters. It might have been expected that the larger, more complex product relationships such as aircraft and tanks might, due to the size and difficulty of the management task, be less successful that relationships dealing with components such as hydraulic motors. This issue requires further research to understand.

**6 Contractors' League**: An association was found between the clusters and the UK Ministry of Defence's spend banding (League Table) of suppliers. The cluster 'Mod 3' had a relatively low proportion (9%) of suppliers in the highest band of greater than £250 million spend per year. The cluster 'Mod 2' on the other hand had a relatively high proportion (58%) of relationship with suppliers who fell into this category. This supports the findings on the value of contract in a year. This is understandable because it was found that the higher banded Suppliers tended to be awarded the bigger contracts. It should be noted that no

relationship could be detected at an aggregate level between the position of a relationship within the UK Ministry of Defence's spend banding of suppliers and relationship satisfaction.

This analysis offered a number of useful insights that assisted with characterizing the relationship clusters and also adds considerably to validation of the clusters in term of criterion validity.

**Cluster Characterisation**

In this section qualitative data obtained from the semi-structured interviews is linked to the clusters to help understanding of the characteristics of each. The chart in Figure 2 shows the relative size of each cluster and its position within the spectrum of quantitative results. Following the example of Olszewski et al (1987) we chose to give the clusters descriptive titles to typify their character.

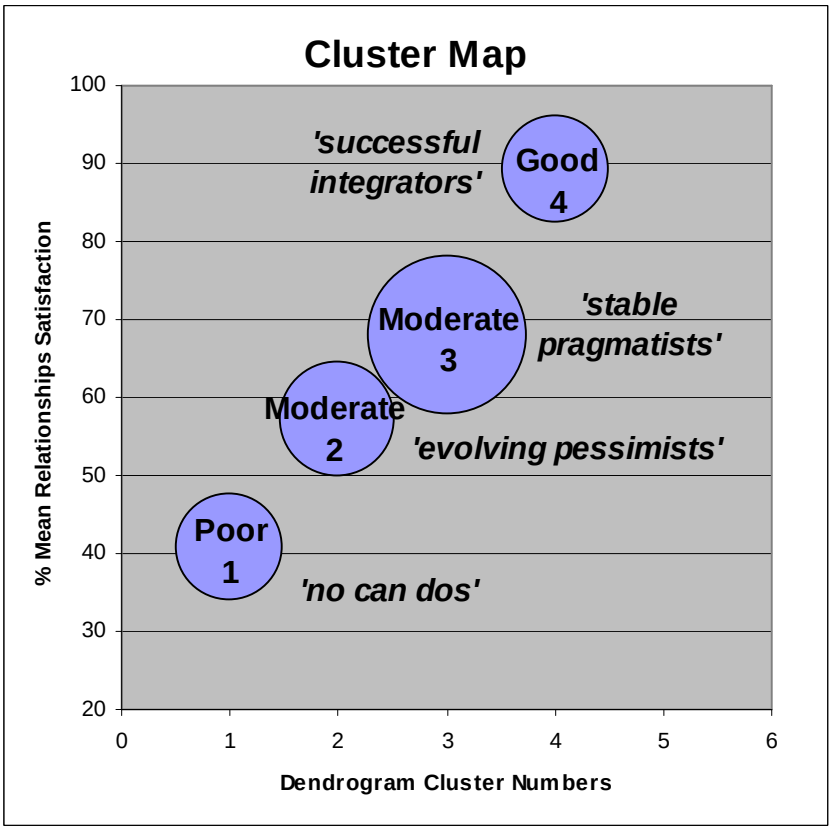


Figure 2. Clusters Showing Mean Satisfaction % and Size.

('Bubble' size equates to the number of relationships contained in the cluster – Poor 1: 10, Moderate 2: 12, Moderate 3: 23, Good 4: 10)

**Poor 1 'No can dos' (Poor Relationships):** Cluster 'Poor 1' contains 10 relationships that represent the lowest quality group as shown in Figure 2. The satisfaction scores in Table 2 present levels well below the other clusters with only the Quality (52%) and Communication (54%) dimensions offering positive ratings. Analysis shows that these relationships were likely to be higher spending and longer duration (>20 years) and, less likely to contain Suppliers from the top banding of UK Ministry of Defence Suppliers. Potentially one would thus expect adversarial conditions to apply with perceptions that efforts to improve or gain better equity were unrequited. It is also likely that in this cluster a high number of negative features as typified by the theoretical framework might be found. The linked qualitative data revealed that although there were some beliefs about poor supply chain practices and processes e.g. *'they provide no information so we cannot plan ahead'*, there was also evidence of adversarial behaviour resulting from the lack of competition in these relationships. Feelings of '*imprisonment*' and '*impotence*' exacerbated by long term lack of co-operation seemed to have resulted in an ongoing situation of entrenched opposition to any form of innovation e.g. *'take it or leave it' is their attitude'* and *'we are under great pressure to reduce our costs but they takes advantage of its sole supplier position by over-charging for proprietary items'*. As one might expect, the qualitative data did indicate efforts were being made to seek improvements e.g. *'we both realise that the only way forward is to partner but the supplier has had its own way for so long that it is very reluctant to change'*, The lack of reciprocation was clear and this was often attributed to a 'take it or leave it', 'no can do' attitude. In conclusion, Cluster 1 appears to provide a fairly close fit to the negative behavioural predictions of the theoretical framework which dwelt on issues such as opportunism and lack of trust.

**Mod 2 'Evolving pessimists' (Moderate Low Performance Relationships):** Cluster 'Mod 2' represents a smaller group of 12 relationships, of 'moderate' satisfaction. Reference to Tables 2 and 4 shows satisfaction levels to be 'moderate on the five dimensions with the exception of a low level on the Reliability dimension. It is likely that operating problems such as supply chain complexity, inherent difficulties in predicting customer requirements and either cultural or financial obstacles to process/facility improvements are apparent and generally reducing the overall relationship satisfaction level. The qualitative data from both sides support this proposition .There were statements about poor supply chain practices e.g. *'they don't seem to have the resources to chase their sub-contractors who let them down'* and *'their spares ordering point just seems to add more delay'*. However there were also statements that link back to the type of adversarial attitudes found in Cluster 1 such as perception and cultural differences and, a lack of will to be co-operative e.g. *'without a common understanding of how we are doing and what we must achieve we cannot move forward'* and *'they don't seem to realize we have production schedules and cannot stop everything to satisfy their instant requirement'*. It is thus possible to hypothesise that Cluster 'Mod 2' as a development phase between Poor and Moderate quality relationships where although the will to co-operate is growing , 'evolving pessimists', the ability to translate this into reliable, supply chain services has yet to develop.

**Mod 3 'Stable pragmatists' (Moderate Relationships):** Cluster 'Mod 3' contains 22 relationships and represents the larger of two Moderate 'Satisfaction' groupingss. Table 2 indicates a level of satisfaction just above the mean of the other clusters with only the Communication dimension just below this level. Table 5 shows that these relationships were likely to be in the middle of the spending bracket, less likely to be in the top banding of MoD Suppliers and of more medium and short (1-19 yrs) durations. Potentially one would expect greater incidence of '$C^{3'}$ Behaviour ('Cooperation', 'Coordination', 'Collaboration') and

reciprocity in these relationships with a more even balance of small numbers and normal supply chain operating difficulties. As expected there was a range of views from respondents but the expressions of positive pragmatism predominated e.g. *'because our organisations are quite small it's important to be realistic with our relationship improvement expectations'*. The small numbers (restricted market) situation is openly acknowledged as a limitation on management freedom eg. *'although they know full well we can't source their products elsewhere, the relationship is still amicable'* but, does not seem to deadlock the relationship as occurred in come cases in Cluster 'Poor 1'. Culture-matching appears to have taken place which has engendered a sense of 'being in the same boat' and 'stable pragmatism' eg. *'they are a bit like us; evolutionary, quality-oriented, resource-capped and not full of management-speak. They are almost fun to deal with!'*. Moreover, many of the problems mentioned appeared to be those normally associated with the effective implementation of supply chain management.

**Good 4 'Successful integrators' (Good Relationships)**: Cluster 'Good 4' represents the grouping of 10 relationships with high overall satisfaction scores as shown in Figure 2. Table 2 indicates a level of satisfaction well above the other clusters. Further analysis shows that these relationships were likely to be lower spending, in the top banding of MoD Suppliers. These relationships are likely to contain high levels of interdependence, $C^3$ Behaviour, information sharing and innovation resulting in efficient, effective supply chains focused on customer requirements. The qualitative data showed clear evidence of the open acknowledgement of the small numbers situation within the Good Cluster e.g. *'although we have no choice in this relationship, by building trust and working hard to secure joint benefits, it is a pleasure to operate'* however, any opportunistic behaviours appeared to be negated by joint concentration on the supply chain processes – 'successful integrators' - that ensure optimal service deliver and mutual benefits e.g. '*we don't have a contract monitoring*

*team because it creates distrust and adds cost, instead we all concentrate on customer-service*'. A noticeable feature of this cluster was the importance of social interaction eg. '*our partnering arrangement is effective because of the excellent mix of individuals who really work well together'.*

**Conclusions: The Empirical Research**

In this paper Ward's Method of Cluster Analysis has been used to identify in a disaggregated way patterns within a large body of data representing a spectrum of dyadic business relationship satisfaction scores... This allowed a taxonomy to be identified as shown in Figure 2. Relationships between the clusters, and a number of exogenous variables gave a measure of criterion related validity to the clusters. It should be noted that some expected relationships, for example with 'Technology Complexity' failed to materialize. This is not seen as being indicative of a weakness in the analysis but simply that the values of these particular exogenous variables do not vary across the taxonomy. However this is clearly an area which would warrant further research. The clusters were further characterised using the qualitative data provided by managers as shown in the descriptive 'bubble chart' at Figure 2. From these analyses cluster groupings were recognisable as sub-divisions of Good, Moderate and Poor relationships, as measured in terms of satisfaction. A sub-group of the Moderate category (Cluster Mod 2) appeared to be a transition stage between the Poor and the Moderate clusters where although managers had realised the need to 'break away' from adversarial behaviours, they had not yet translated their intentions into improved business processes and Customer benefits. Cluster analysis thus allowed us to reveal a taxonomy of relationship types linked to exogenous variables and also qualitative data. This generated very clear descriptions of the relationship dynamics within the data and which importantly displayed both criterion-related and face validity. .

**Conclusions: Implications for Theory**

From a theoretical perspective we are able to integrate Williamson's (1975) Organisation Failure Framework factors within a large empirical study. The disaggregate approach using Cluster Analysis provides extraordinarily detailed insights into relationship patterns. The framework suggests that highly collaborative relationships within a limited market will tend to be adversarial because calculative trust (a focus on cost-effective contractual safeguards where failure to perform/reciprocate are not forgiven (Hill, 1990, Williamson, 1996)) is unlikely to sustain high productivity when subjected to strong internal and external pressures (Faulkner & De Rond, 2000, Humphries & Wilding, 2003). However, that over 75% of the relationships surveyed considered themselves to be successful (satisfaction rate 50% or greater) undermines this general assumption. The use of Cluster Analysis enabled deeper analysis of this high level view with four relatively homogenous groupings of relationships with respect to 'Satisfaction' being identified. This approach, which subsequently mapped qualitative and exogenous data onto the clusters, then facilitated the identification of the salient theoretical points. Importantly these points can be substantiated by reference to the relevant literature. Thus a number of instances were found where dyads realised they were locked into unsatisfactory relationships (Cluster 'Poor 1') and accused each other of opportunistically and cynically taking advantage of the situation to pursue their own objectives. Other reasons for lower relationship performance were more prevalent. The research results indicate that normal supply chain business relationship issues existed within all the clusters as the customers and suppliers struggled to improve process efficiency (Harland et al, 2000, Peck et al, 2000). It was also apparent that managers in each cluster were aware of their limited market/limited choices environment and the inherent power-

balance challenges (Cox & Lamming, 1997, Kovacic, 1999). However, it was especially where adverse conditions applied, such as poor relationship management and lack of investment in process improvement, that those small numbers dynamics (frustration at limited management options and, adversarial behaviours) generated adversarial conditions (Serfati, 2001, Sheth & Sharma, 1997). On the other hand, where the relationships were able to concentrate co-operatively on service delivery and long-term, equitable benefits sharing and, where efforts were made to match corporate cultures and build trusting personal relationships (McDonald et al, 1997, Rousseau et al, 1998), the potential limitations inherent within the highly interdependent dyads were minimised (Christopher, 1997, Humphries & Wilding, 2004b).

Although this research project took place within a limited business situation, it nevertheless allowed an integrated and interdisciplinarity approach to confirmed the general conclusions of many TCE, Supply Chain Management and Relationship Marketing writers and, to go much further by revealing a number of deeper dynamics in play within a substantial sample of long-term, collaborative relationship dyads. Further research is needed to test the approach in other business sectors and to examine in greater detail a number of more complex influences such as team and industry factors.

**Conclusions: Implications for Practice**

The UK Defence Logistics Organisation in question has long suffered from poor external relationship performance which regularly receives press criticism. This situation is mirrored in other western countries. The findings from this research confirms Parker & Hartley (1997) and Serfati's (2001) views that a mindset that accept and face the challenge from reduced management choices is an essential prerequisite to dealing effectively with the inherent pressures of long-term collaborative relationships. Knowledge of where you are in the

spectrum of relationship types (e.g. Figure 2) can also help managers to decide what targets need to be set and the remedial action necessary to achieve them. Moreover, the creation of an inventory of industry-specific endemic problems (in this case old, unreliable products, obsolescence, staff and organisational upheavals, poor end-customer visibility and lack of investment in modern procedures and systems) and finding joint, innovative ways to tackle them is likely to provide the best opportunity to appears to be a very effective way of resisting the negative pressures implied by Williamson's (1975) Organisations Failure Framework. This research has identified a number of salient patterns from which better practice guidelines can be derived for practitioners operating in the UK Defence Procurement environment. Given the parallels with similar situations in other countries, there appear to be valuable pointers for a wider 'population'. It is suggested that this is an important area for further research should be undertaken to validate these possibilities.

**References**


Borland, J., Hirschberg, J. and Lye, J. (2001) Data reduction of discrete responses: an application of cluster analysis. *Applied Economics Letters* **8,** pp. 149-153.

Bowman, C. and Ambrosini, V. (1997) Using Single Respondents in Strategy Research. *British Journal of Management* **8,** pp. 119-131.

Braithwaite, A. (1998) The Nine Maxims of Supply Chain Management. *Proceedings of the Logistics Research Network Conference 10/11 Sep 98*, pp. 456-471.

Brennan, D.R., Turnbull, P.W. and Wilson, D.T. (2003). 'Dyadic adaptation in business-to-business markets'. *European Journal of Marketing,* **37**, 1636-1665.

Christopher, M. (2005) Logistics and Supply Chain Management. Harlow UK: FT Prentice Hall.

Cortina, J.M. (1993) What is Coefficient Alpha? An Examination of Theory and Applications. *Journal of Applied Psychology* **78** (1), pp. 98-104.

Everitt, B, Landau, S and Leese M (2001) 'Cluster analysis' 4th ed. London:Arnold.

Faes, W., Knight, L. and Matthyssens, P. (2001) Buyer profiles: an empirical investigation of changing organisational requirements. *European Journal of Purchasing & Supply Management* **7,** pp. 197-208.

Hair, J.F. Anderson, R.E. and Tatum, Ronald L. (1984) Multivariate data analysis with readings. Collier Macmillan, London.

Harland, C. and Gibbs, J. (2000) Supply Strategy for the Public Sector: Framing the Issues. *The 9th International Annual IPSERA Conference, University of Western Ontario, Proceedings, 24-27 May 2000.*

Humphries, A.S. and Wilding, R. (2003) Sustained Monopolistic Business Relationships: An Interdisciplinarity Case. *British Journal of Management* **14** (4), pp. 323-338.

Humphries, A.S. and Wilding, R. (2004a) Sustained Monopolistic Business relationships: A UK Defence Procurement Case. *European Journal of Marketing* **37** (1/2), pp. 99-120.

Humphries, A.S. and Wilding, R. (2004b) UK Defence Supply Chain relationships: A Study of Sustained Monopoly. *Management Decision* **42** (2), pp. 259-276.

Kerlinger, F. N. (1973). Foundations of behavioral research. New York: Holt, Rinehart, & Winston.

Lambert, D.M., Emmelhainz, M.A. and Gardner, J.T. (1996) Developing and Implementing Supply Chain Partnerships. *The International Journal of Logistics Management* **7** (2), pp. 1-17.

Lamming, R.C., Caldwell, N.D., Harrison, D.A. (2004) Developing the Concept of Transparency for Use in Supply Relationships. *British Journal of Management Management* **15** (4), pp. 291-320.

Lamming, R.C., Caldwell, N.D., Harrison, D.A. and Phillips, W. (2001) Transparency in Supply Relationships: Concept and Practice. *Journal of Supply Chain Management* Fall, pp. 4-10.

Kaufman, L and Rousseeuw, P.J. (1990) Finding groups in data: introduction to cluster analysis. New York, Wiley.

Kern, T. and Willcocks, L. (2002). 'Exploring relationships in information technology outsourcing: the interaction approach'. *European Journal of Information Systems*, **11**, 3-19.

Ketchen, D. and Shook, C. (1996) The Application of Cluster Analysis in Strategic management Research: An Analysis and Critique. *Strategic Management Journal* **17,** pp. 441-458.

Kovacic, W.E. (1999) Competition policy in the postconsolidation defense industry, *Antitrust Bulletin*, **44**(2 Summer), pp. 421-487.

McDonald, M., Millman, A. and Rogers, B. (1997) Key Account Management: Theory, Practice and Challenges. *Journal of Marketing Management* **13,** pp. 737-757.

Macneil, I.R. (1980) The New Social Contract: An Inquiry into Modern Contractual Relations. pp. 5-75. New Haven & London: Yale University Press.

Olszewski, A., Hennessey, H., Monchar, P. and Boudin, A. (1987) Corporate Culture: A Strategy to Enter Entrenched Markets. *Journal of Business & Industrial Marketing* **2** (3 Summer), pp. 5-15.

Perks, H. and Easton, G. (2000) Strategic Alliances: Partners as Customers. *Industrial Marketing Management* **29** pp. 327-338.

Punj, G. and Stewart, D. (1983) Cluster Analysis in Marketing Research: Review and Suggestions for Application. *Journal of Marketing Research* **20** (May):pp. 134-148.

Rindfleisch, A. and Heide, J.B. (1997) Transaction Cost Analysis: Past, Present, and Future Applications. *Journal of Marketing* **61** (Oct):pp. 30-54.

Rousseau, D.M., Sitkin, S.B., Burt, R.S. and Camerer, C. (1998) Not so different after all: A Cross-Discipline View of Trust. *Academy of Management Review* **23** (3), pp. 393-404.

Sako, M., Lamming, R. and Helper, S.R. (1994) Supplier relations in the UK car industry: good news - bad news. *European Journal of Purchasing & Supply Management* **1**, 237-248.

Sapsford, R. (1999) Survey Research. pp. 163-7, London: SAGE.

Serfati, C. (2001) The Adaptability of the French Armaments Industry in an era of Globalization. *Industry and Innovation*, **8**(Aug 2), pp. 221-240.

Sharma, A. and Lambert, D. (1990) Segmentation of Markets Based on Customer Service. *International Journal of Physical Distribution & Logistics Management* **20** (7), pp. 19-27.

Sheth, J.N. and Sharma, A. (1997) Supplier Relationships: Emerging Issues & Challenges. *Industrial Marketing Management* **26,** pp. 91-100.

Spekman, R.E., Kamauff, J.W. Jr and Myhr, N. (1998) An Empirical Investigation into Supply Chain Management: A Perspective on Partnerships. *Supply Chain Management* **3** (2), pp. 53-67.

Sutton, D. (2003) Book Review: Cluster Analysis by Brian S. Everitt, Sabine Landau and Morven Leese, London: Edwin Arnold Ltd, 2001. *International Journal of Market Research* **45** (Q4), pp. 515-516.

Wilding R and Humphries, A.S. (2006) Understanding collaborative supply chain relationships through the application of the Williamson organisational failure framework. *International Journal of Physical Distribution & Logistics Management.* **36**(4), pp 309-329.

Williamson, O.E. (1975) Markets & Hierarchies: Analysis & Anti-trust Implications. pp. 39-40. New York, The Free Press.

Williamson, O.E. (1996) The Mechanisms of Governance. Oxford, Oxford University Press.