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ABSTRACT

This paper investigates the structure of industrial and business network strategies in the global manufacturing environment based on empirical data from 87 manufacturing firms in the Pearl River Delta of Southern China. Relevant data was collected using a questionnaire approach and analyzed using appropriate statistical techniques. Hierarchical cluster analysis was employed to devise taxonomy for industrial network strategies. Three distinct clusters were identified: Network Integrators, Network Learners and Network Conformists. Results indicate that the former two clusters, though differing in the extent of scale, adopt a holistic approach in developing both intra- and inter-firm strategies and that the third cluster can be described as static in terms of the network strategies used.

INTRODUCTION

The Pearl River Delta in Southern China (PRD) is a collective name covering the triangular region around the confluence of the Pearl River system that stretches across Guangdong Province of Southern China. The relocation of manufacturing plants from Hong Kong to Guangdong Province began in the early 1980s (Information Service Department, 2002) and is now virtually complete, leaving Hong Kong with only the related manufacturing services. The PRD region had more than 53,000 of manufacturing establishments in 2001 (Federation of Hong Kong Industries, 2002), while the total export value for the region in the same year accounted for 4.7% of the world merchandise trade (Federation of Hong Kong Industries, 2002). The PRD has thus developed into a very important member of the global manufacturing establishment (Zhao, Lo, & Sculli, 2005).

The flow of manufactured items within a company and between companies has now become an important area of research, and at a macro level, these companies play their individual roles along the entire value chain. The structure and nature of the underlying industrial networking strategies has, to the authors' best knowledge, received limited attention from researchers, and a logically defined classification of industrial network strategies is needed in order to obtain a deeper insight into industrial networking. The results presented in this paper, are possibly a first attempt to devise a framework for the development of the associated industrial taxonomy using empirical evidence collected from manufacturing firms in Southern China. The two main industrial zones of Southern China are Hong Kong and PRD, and the taxonomy developed applies to the industrial networks of the manufacturing industries across both zones.

Classification in a very broad sense is the grouping of similar objects (Everitt, 1993). It is a rather primitive method for categorizing objects into groups that are characterized by similarities and differences that the other groups do or do not possess to the same extent. Gordon (1996) suggests that the classes are discovered through the process of classification and are unknown *a priori*. He defines classification as: "… the investigation of a set of objects in order to establish whether or not they fall naturally into groups (or classes, or clusters) of objects with the property that objects in the same group are similar to one another and different from objects in other groups; these groups are unknown at the start of the investigation, and need to be determined."

In recent years, cluster analysis has been the main technique used to reveal the underlying structure of various empirically based Operations Management (OM) topics, including advanced manufacturing technology (AMT), quality management system (QMS) and supply networks. Diaz, Machuca and Alvarez-Gil (2003) applied hierarchical cluster analysis to determine the appropriate number of groups for AMT investment patterns in the aeronautical industry. They identified 3 relatively distinct groups: traditionalists, designers, and investors who represent the underlying structure of the industry. Yeung, Chan and Lee (2003) adopted the hierarchical procedures to identify 4 specific groups of electronics manufacturing firms that are significantly different in their practice of QMS. Harland, Lamming, Zheng, and Johnsen (2001) employed cluster analysis to define 4 types of manufacturing firm that have distinct characteristics in supply networking strategies. Evidence of the growing popularity and acceptability of the use of cluster analysis in OM research can readily be found (Miller & Roth, 1994).

In order to address network classification in industrial networks, Rudberg and Olhager (2003) suggest two distinct research tracks: supply chain research and manufacturing networks. For the first research track, i.e. research on supply chain, Fisher (1997) proposed two distinct types of supply chain according to the demand nature of the products—functional or innovative products. He argued that functional products have a more predictable demand and that innovative products have a more rapidly changing demand. Functional and innovative products impose different requirements on the supply chain because the former requires an efficient supply process and the later a responsive one. Lamming, Johnson, Zheng and Harland (2000) further developed the initial classification of supply networks based on Fisher's (1997) functional/innovative concept by including other product characteristics such as product uniqueness and complexity. Harland et al. (2001) continued the line taken by Lamming *et al.* (2000) and proposed a classification based on the two dimensions of supply network dynamics and degree of focal firm influence. However, this research is only concerned with the supply chain, i.e., the link with external parties, and represents only one side of the entire picture.

The second track of research focuses on manufacturing networks. Shi and Gregory (1998) proposed a classification of manufacturing networks based on the structural characteristics of the manufacturing firms. Geographic dispersion is the key dimension that differentiates domestic manufacturing companies from the global ones. Both the structural (e.g. vertical integration, technology) and the infrastructural (e.g. workforce, quality) elements are used to identify the characteristics of the various types of manufacturing network. While the importance of manufacturing strategies has been widely recognized (Hayes & Wheelwright, 1984), a holistic network classification that covers both the supply chain and the manufacturing one has still remained substantially unexplored. Table 1 summarizes the two tracks of research, one focusing on the supply chain and the other on the manufacturing networks. Rudberg and Olhager (2003) seem to be an exception covering elements of both tracks.

Table 1: Two tracks of research on industrial network classifications

Table 1: Two tracks of research on industrial network classifications.

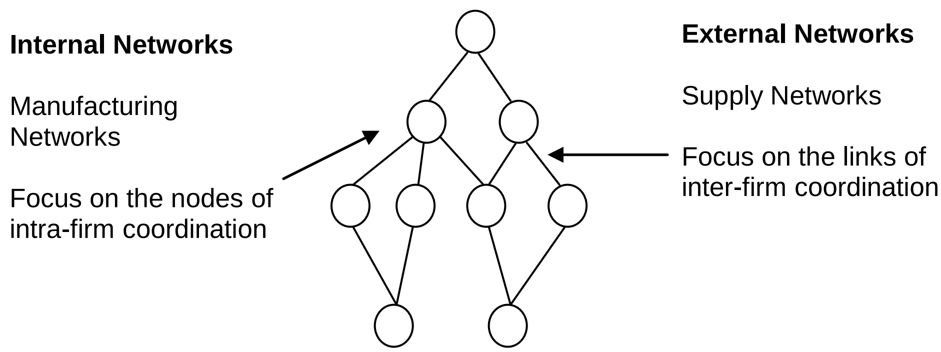
	Manufacturing Network	Supply Chain	Empirical Evidence	Driving Dimension(s)
Fisher (1997)		√		Demand nature of products
Lamming *et al.,* (2000)		√		Product complexity Innovative/ functional products
Harland *et al.,* (2001)		√	√	Environmental volatility Focal firm influence in the network
Shi and Gregory (1998)	√			Geographic dispersion Interdependent coordination
Rudberg and Olhager (2003)	√	√		Number of organizations in the network Number of sites per organization

Most of the published research on the classification of industrial networks has been done on manufacturing companies in the developed Western Economies and Japan (Harland et al., 2001; Lamming et al., 1999). The PRD of Southern China has, over the past 15 years, become of one the principal manufacturing areas of the world, and Hong Kong is strategically located very near the mouth of the PRD. The manufacturing sector in Hong Kong and the PRD is dominated by small and medium-sized enterprises (SMEs), constituting up to 98.74% of the entire output of the manufacturing sector in 2002 (Information Service Department, 2002). The most representative of the manufacturing industries in terms of gross output are wearing apparel and textiles, electrical and electronic products, metal products and machinery, and plastic products (Census and Statistics Department, 2001). Hong Kong's manufacturing sector is closely linked to the PRD, with the PRD engaged in actual physical manufacture and Hong Kong providing support services such as accounting, purchasing, head office management and pre-production planning.

The Research Framework

At the generic level, a value network is defined as a network of facilities, possibly owned by different organizations, where time, place or shape utility is added to goods and services at various stages such that the value for the ultimate customer is increased (Rudberg & Olhager, 2003). The focus of this paper is on the industrial network strategies that are adopted as part of the value network. From an Industrial Engineering point of view, industrial networks can be seen as inter-connected links and stages for both internal and external product related strategies that firms carry out in order to add value for customers. The difference between internal and external networks is better illustrated in Figure 1. By “internal networks” we mean the management of self-owned manufacturing facilities that are wholly within a single manufacturing establishment. The management of internal manufacturing networks is principally concerned with efficiency and costs at the individual factory level, indicated by the nodes in the networks, see Figure 1. On the other hand, “external networks” refer to the coordination of facilities owned by different organizations or entities along the network (Hayes & Wheelwright, 1984). The link between the nodes is the primary concern, which from a supply chain perspective means that a more collaborative objective is shared amongst the entities involved in the network.

Figure 1: Industrial networks with intra- and inter-firm coordination.



By adopting the notion that an industrial network has internal and external focuses, the classification of industrial networks will encompasses the strategies of both types of network. Such an integrative view is indispensable as a primary foundation for a more complete taxonomization of industrial networks (Rudberg and Olhager, 2003). For a non-industrial network see Rosenthal, Seeman and Gibson (2005) and Leung, Wong and Sculli (2006) for a logistic network. The key notion of network perspective is the *coordination* displayed by the focal manufacturing company within its organization and between its partnering entities (Rudberg & Olhager, 2003). Industrial network practices are broadly categorized into two types: intra-firm strategies and inter-firm strategies. Intra-firm strategies refer to company wide strategic coordination that help the company build competitive advantages (Wu, Chu, Li, Han & Sculli, 2003) Inter-firm strategies, on the other hand, means integrative collaborations between a company and the external entities involved in the same industrial network. In this study, the variables are chosen primarily on their merit in terms of their *coordinating function*. The strategic practice selected therefore needs display significant coordinating functions, either in the internal or external level. Accordingly, intra-firms strategies selected include cross functional cooperation, engineering coordination and Just-in-time practice. On the external side, strategies include supplier relationship, customer relationship, organizational learning, and information exchange. An illustrative diagram of the research framework is shown in Figure 2. The definition and concepts behind each of the networking strategies will now be discussed individually.

Intra-firm Strategies

i) Cross functional cooperation

Cross functional cooperation is defined as the degree to which different departments and individuals within the plant coordinate their activities and efforts (Ketokivi & Schroeder, 2004). The possibilities of cross function combination within an organization can be vast. This study draws a focus on cooperation between manufacturing related functions and peripheral functions, but not among peripheral functions or manufacturing functions. Inter-functional harmony between manufacturing and marketing functions is a typical example of the positive influence of cross functional cooperation on business strategy formulation. Informal communication within a team and a mix of members' knowledge, skills and abilities also enhance the effectiveness of team cooperation. Through cooperating in a face to face communication, cross functional teams provide the opportunity for constituents to express concerns (Kuofteros, Vonderembse, & Doll, 2001). The item components used in this study to measure this cross functional cooperation include co-involvement, communication, team commitment, and involvement of engineers (Ketokivi and Schroeder, 2004). It is argued that cross functional cooperation is likely to be an internal network strategy that reflects the extent to which an organization adopts a network perspective for internal management.

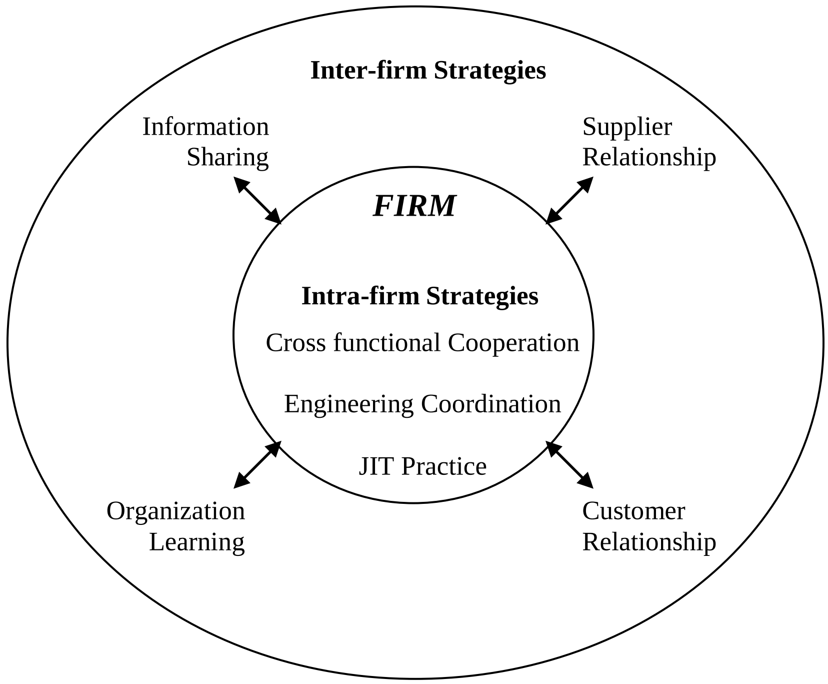
ii) Engineering Coordination

Engineering coordination is a subset of concurrent engineering. Concurrent engineering comprises three basic elements: early involvement of constituents, team approach and concurrent work flow (Kuofteros et al., 2001). Concurrent work flow is defined as simultaneous planning of product, process and manufacturing that allows issues of manufacturability to be evaluated and incorporated in the final product design. Engineering coordination encompasses not only concurrent work flow, but the use of platform strategy, which is the planning of multiple generations of products by having a core design that can be modified to create derivative or enhanced variants (Kuofterous, Vonderembse, & Doll, 2002). Engineering coordination is therefore the concurrent planning of the manufacturability of final product design based on a common platform. The simultaneous practices of using standardized components, product modules, and the strategy of reducing components to achieve design for manufacturability are measures representing the extent to which engineering coordination is being done.

iii) Just-in-time (JIT) practice

JIT practice is defined as the degree to which the manufacturing plant seeks to eliminate waste and minimize inventories through measures such as set-up time reduction, frequent re-supply and delivery, and plant layout (Ketokivi & Schroeder, 2004). The central idea of JIT practice is to develop company wide continuous improvement and problem-solving efforts by workers, engineers, and management for the long-term survival and evolution of the organization (Sakakibara, Flynn, & Schroeder, 1993). The coordination, cooperation and integration of functions within an organization are one of the keys to the continuous realization of JIT practice (Sakakibara et al., 1993). In this study, the measure of JIT practice reflects the extent to which functions are integrated and coordinated at the node level in a network; measures used are from Ketokivi and Schroeder (2004).

Figure 2: A Framework for development of industrial network patterns.



Inter-firm Strategies

i) Supplier and Customer Relationship

The practice of Supply Chain Management (SCM) refers to the undertaking of a set of strategies in an organization to promote effective management of the links between network entities. Strategic supplier partnership and customer relationship are identified as two major aspects that cover both upstream and downstream of supply chains (Li, Ragu-Nathan, Ragu-Nathan, & Rao, 2004). The novel practice of strategic supplier relationship covers areas such as long-term relationship, communication, supplier involvement and supplier quality (Chen & Paulraj, 2004; Ketokivi & Schroeder, 2004), representing the measures adopted in this study. On the downstream side, customer relationship comprises the set of practices that are employed for the purpose of managing customer complaints, building long-term relationships with customers, and improving customer satisfaction (Li et al., 2004). Customer focus is a key strategy for company survival in competitions and has always been the core purpose of business (Chen & Paulraj, 2004). Hence, stratifying customer relationship plays an important role in inter-firm networks. In this study, customer relationship covers areas of customer involvement, communication, quality initiatives and responsiveness (Ketokivi & Schroeder, 2004; Chen & Paulraj, 2004).

ii) Organizational Learning

One of the greatest challenges that organizations face in the dynamic market is to create a learning climate that is integral in the development of inter-firm partnership (Slater & Narver, 1995; Johnson & Sohi, 2003). At the most generic level, organizational learning is the development of new knowledge or insights that have the potential to influence behavior (Slater

& Narver, 1995). Organizational learning comprises a three stage process which includes information dissemination, information acquisition and shared interpretation (Slater & Narver, 1995). In our study the process is incorporated in the process of cross functional cooperation stated as a separate scale construct. In order to confine the scope of organizational learning to the building of inter-firm partnership, we adopt information acquisition and shared interpretation as the basis of measurement. Information acquisition is a measure of the immediate outcome of organizational learning. Information may be acquired through direct experience, experiences of others or organizational memory (Slater & Narver, 1995). In an organization that leverages a shared interpretation of information, consensus is built on the meaning of the information, which in turns helps managers to make sense of the information that is acquired (Johnson & Sohi, 2003). In the context of an industrial network, it is expected that a firm's learning strategies will result in a positive influence on inter-firm relationships.

iii) Information Sharing

Information sharing involves two levels: quantity and quality (Li et al., 2004). We define information sharing as the extent to which critical and proprietary information is communicated between two adjacent entities in the industrial network. Information sharing is an important inter-firm strategy that indicates the use of SCM (Hill & Scudder, 2002). Network entities that are highly integrated in terms of information are better synchronized especially in collaborative forecasting, planning and replenishment (Mentzer, Min, & Zacharia, 2000). Information sharing is differentiated into two types according to the level of communication. A single contact transaction of information between parties is considered as an operational partnership, whereas a multilevel communication refers to a strategic partnership (Mentzer et al., 2000). In this study, information sharing refers to a strategic partnership whereby the extent of information sharing is measured by the degree of strategic information sharing, the degree of information intensity (Kearns & Lederer, 2004) and the degree of synchronization with network partners.

DATA COLLECTION AND STATISTICAL ANALYSES

Instrument development and data collection

Company data for the pilot study and main was extracted from the list of members of the Chinese Manufacturers' Association of Hong Kong (CMA). We adopted the use of traditional printed mail survey rather than other forms of survey such as fax, email and electronic or email surveys because these methods have the potential disadvantage of addressing a sub-population, which may be caused by the inaccessibility of the particular technology used by the survey.

In the very early stages of this study, a set of intuitive items were identified based on an extensive literature review. Suggestions were then collected from industrial experts and practitioners through interviews. This helped to identify relevant and possibly useful to include in the preliminary questionnaire (Hensley, 1999). While the original questionnaire was developed using English, it had to be translated into Chinese because many of the potential respondents would not have been able to read the original. Accuracy in translation was, as far as possible, ensured by using multiple translators and by reviewers who were proficient in both languages.

A pilot study was then conducted in order to collect some initial feedback and to identify suspicious items and potential problems that may require additional reconsideration (Mangione, 1995). The target sample included the main industries: apparel, electrical and electronic products, metal products and machinery, and plastics products and toys. The pilot study provided usable data for the preliminary testing of the reliability and validity of the item scales, and also showed that the 5-point Likert scale is adequate in allowing respondents to express their perceived answers to sufficient degree of accuracy. The indications for all 5 scale points were: point “1” indicates a definite conformity to that practice; point “2” indicates conformity; point “3” indicates neutrality; point “4” indicates disagreement and point “5” indicates a definite disagreement

The final survey instrument was made up of several sections, which included the demographics information of the company and specific questions on network strategies. The questionnaires were sent out by post together with a covering letter and a stamped return envelope. Respondents were advised to return the completed questionnaire either by post or by fax. Companies that did not respond within a month were sent a reminder with another copy of the questionnaire. Out of 734 companies involved, 89 responses were received, which is a response rate of approximately 12%. This low rate was, however, validated against non-response bias; this is discussed in the appropriate section below. After removing responses with missing information and partly completed questions, a net 87 were available for further analysis. A summary of the responses is given in Table 2.

Table 2: Profile of respondents.

Industry Mix		
Apparel	21	24.1%
Electrical and Electronics	21	24.1%
Metal and Machinery	21	24.1%
Plastic and Toys	23	26.4%
Other	1	1.1%
Total	87	100.0%
Company Scale		
1-100	23	26.4%
101-500	23	26.4%
501-1000	10	11.5%
1001-2000	11	12.6%
2001-5000	11	12.6%
Over 5000	9	10.3%
Total	87	100.0%
Company Ownership		
100% Local	75	86.2%
100% Foreign	6	6.9%
Joint Venture	5	5.7%
Not indicated	1	1.1%
Total	87	100.0%
Respondent Position		
Top/ Divisional Management	60	69.0%
Engineer/ Operationalist/ Executive	16	18.4%
Administrative/ Clerical Staff	5	5.7%
Not Indicated	6	6.9%
Total	87	100.0%
Locations of plants		
Include Pearl River Delta	81	93.1%
Hong Kong only	3	3.4%
Other parts of Southern China	3	3.4%
Total	87	100.0%

Construct validity and reliability

Factor analysis is commonly used for accessing construct validity (Hensley, 1999). Construct validity is defined as a measure of the degree to which the scale measures the abstract or theoretical construct it intended to measure (Hensley, 1999). Two criteria, which include (1) ascertaining the correlation of the measure with other measures designed to compute the same construct, and (2) ensuring whether the measure behaves as intended, must be fulfilled to establish construct validity (Churchill, 1979).

In order to maintain the ratio of observations to variables at 5:1 (Hair, Anderson, Tatham, & Black, 1998), the data is split into 2 sets, one on internal strategies and the other on external. All items examined in this study generate individual factor loadings ranging from 0.550 to 0.890, which are above the practical acceptable level at ±0.5 (Hair et al., 1998). All constructs are supported by an average factor loading of at least 0.678, indicating a satisfactory statistical representation of indicators for our sample size (Hair et al., 1998). The results of CPA are further confirmed by the KMO measure of sampling adequacy (Hensley, 1999; Hair et al., 1998). Table 3 shows the corresponding results for the measures obtained by PCA. Satisfactory factor loading and KMO measures are both signs of evidence of construct validity.

The Cronbach's α is one of the most commonly used methods for assessing internal consistency reliability (O'Leary-Kelly & Vokurka, 1998). The value of Cronbach's α for the seven constructs on network strategy range from 0.589 to 0.861, see Table 3. Apart from the α for JIT Practice, all other constructs have an α larger than 0.7 and are above the generally suggested acceptance level. However, a cut-off level of 0.5 or 0.6 is acceptable for a relatively newly developed scale (Nunnally, 1967). According to interviews with experts and industrialists who currently work in Chinese owned manufacturing companies in the PRD, JIT practice is still a relatively new concept among industrialists. Their perception of JIT has still not reached agreement on a mutually and generally accepted conception. Hence, a less consolidated ground of common understanding on the items related to JIT is observed and the item scale of JIT is accepted as a developing scale, which needs to be improved in future studies.

Table 3: Validity and reliability of item scale.

Construct	Item Scale		Factor Loading
Intra-firm Network Strategy *(KMO = 0.716)*			
Cross funcation Cooperation	Co-involvement		0.803
(Cronbach's α = 0.811)	Cross funcational communication		0.717
	Shared commitment		0.867
	Involvement of engineer		0.708
		Mean	0.774
Engineering Coordination	DFM/ DFA		0.839
(Cronbach's α = 0.836)	Component reduction		0.890
	Component standardization		0.797
		Mean	0.842
Just-in-time Practice	JIT delivery		0.606
(Cronbach's α = 0.583)	Small lot-size productions		0.720
	Inventory reduction		0.836
		Mean	0.721
Inter-firm Network Strategy *(KMO = 0.849)*			
Supplier Relationship	Close communication		0.550
(Cronbach's α = 0.782)	Supplier involvement		0.691
	Supplier quality		0.651
	Long-term relationship		0.819
		Mean	0.678
Customer Relationship	Close communication		0.791
(Cronbach's α = 0.747)	Customer Involvement		0.759
	Quality Feedback		0.820
	Response to customer		0.675
		Mean	0.761
Organization Learning	In-house Information acquisition		0.724
(Cronbach's α = 0.861)	External Information acquisition		0.788
	Constant review		0.673
	Shared interpretation of success		0.676
	Shared interpretation of mistake		0.736
		Mean	0.719
Information Sharing	Information intensity		0.658
(Cronbach's α = 0.717)	Synchronization with supplier		0.712
	Synchronization with customer		0.815
		Mean	0.728

Non-response bias refers to the differences between the answers of non-respondents and respondents. Late respondents have been defined as processing similar characteristics of the non-respondents because they are "less readily" to respond to the questionnaire than early respondents (Armstrong & Overton, 1977). Chi-square analysis is commonly used for comparing the demographics of respondents and non-respondents. A Chi-square analysis on the two sets of respondents in terms of the number of employee and the type of ownership showed no significant difference in the profiles of early and late respondents, and it seems reasonable to conclude that the results of this study will not be significantly affected by non-response bias.

Agglomerative hierarchical clustering is a technique that proceeds by a series of step-wise successive fusions of n individuals into a final group of n members. Agglomerative clustering is a widely used hierarchical method which attempts to find the optimal step in some defined sense at each stage of the agglomeration process. Ward's method generally gives the most satisfactory performance, especially when cluster sizes are similar (Everitt, Landau, & Leese, 2001). Ward's method was used to cluster our 87 responses using seven network strategy constructs with 26 scale items. There are two approaches to determine the appropriate number of clusters (Yeung et al., 2003). First, a large percentage change in the agglomeration coefficient at each stage of the hierarchical process is an indication of a fusion of two non-homogenous groups (Hair, et al., 1998; Yeung et al., 2003), and investigating the percentage change of the agglomeration coefficient is an effective way to determine the number of clusters. Another way to determine the number of clusters is to make use of the dendrogram (Yeung et al., 2003). This is done by interpreting the visual tree diagram displayed by the dendrogram through the hierarchical steps of the agglomeration process. The more obvious groups can thus be visually identified on the dendrogram. With the use of both methods, three clusters were identified from our 87 responses from the manufacturing companies. Figure 3 shows the patterns for the three clusters of the various network strategies that were identified using Ward's method, and Table 4 shows the cluster compositions.

Figure 3: A plot of network patterns of 3 clusters.

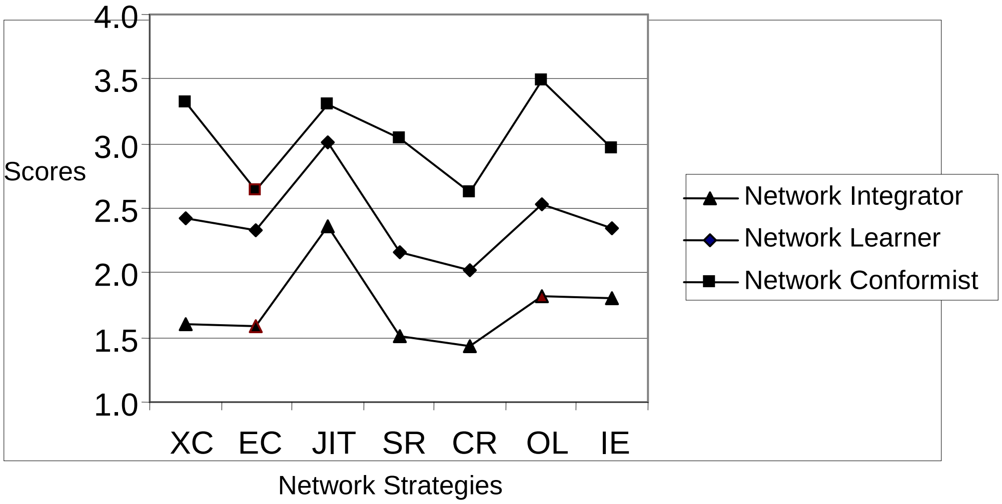


Table 4: Table of cluster compositions.

	Network Integrator		Network Learner		Network Conformist	
	n=24		n=42		n=21	
Apparel	2	8%	12	29%	6	29%
Electrical and Electronics	10	42%	10	24%	1	5%
Metal and Machinery	6	25%	8	19%	6	29%
Plastic and Toys	6	25%	11	26%	7	33%
Other	0	0%	1	2%	1	5%
Total	24	100%	42	100%	21	100%
1-100	6	25%	9	21%	7	33%
101-500	6	25%	11	26%	6	29%
501-1000	3	13%	5	12%	2	10%
1001-2000	2	8%	5	12%	4	19%
2001-5000	3	13%	7	17%	1	5%
Over 5000	4	17%	5	12%	1	5%
Total	24	100%	42	100%	21	100%
100% Local	20	83%	35	83%	20	95%
100% Foreign	2	8%	4	10%	0	0%
Joint Venture	1	4%	3	7%	1	5%
Not indicated	1	4%	0	0%	0	0%
Total	24	100%	42	100%	21	100%

Validation of clusters

A one-way Analysis of Variance (ANOVA) was conducted (Diaz et al., 2003) on the three identified clusters to determine the significance of the difference between the group means for each of the item scales. The ANOVA test shows that differences in group means for all the 26 item scales are well beyond the significance level, $p<.05$. Almost all the items show significant evidence, with many even at the $p<.005$ level. To further test for evidence on the differences between groups, a more conservative post-hoc test, the Scheffe test, was done (Cramer, 2003). While the Scheffe test is more sensitive against type I error (Yeung et al., 2003), results show that 74 out of 87 pairs of cross comparisons are significant at $p<.05$ and/or $p<.005$ levels. Both tests reinforce the evidence that the cluster classification identified by using Ward's hierarchical clustering method is acceptably strong; see Table 5 for the results of both tests.

Table 5: Results by ANOVA and Scheffe method.

		ANOVA		Sheffee Method		
		F	Sig.		Sig.	
				Clusters	2	3
Cross funcation Cooperation (XF)	Co-involvement	20.129	.000**	1	.003**	.002**
				2		.000**
	Cross funcational communication	20.284	.000**	1	.067	.000**
				2		.000**
	Shared commitment	43.198	.000**	1	.000**	.000**
				2		.000**
	Involvement of engineer	44.538	.000**	1	.000**	.000**
				2		.000**
Engineering Coordination (EC)	DFM/ DFA	9.411	.000**	1	.298	.007*
				2		.000**
	Component reduction	9.912	.000**	1	.995	.000**
				2		.002**
	Component standardization	9.875	.000**	1	.067	.029*
				2		.000**
Just-in-time Practice (JIT)	JIT delivery	7.649	.001**	1	.758	.005*
				2		.003**
	Small lot-size productions	6.700	.002**	1	.112	.126
				2		.002**
	Inventory reduction	5.033	.009*	1	.804	.032*
				2		.019*
Supplier Relationship (SR)	Close communication	27.009	.000**	1	.000**	.001**
				2		.000**
	Supplier involvement	29.424	.000**	1	.000**	.016*
				2		.000**
	Supplier quality	18.284	.000**	1	.002**	.008*
				2		.000**
	Long-term relationship	12.243	.000**	1	.016*	.030*
				2		.000**
Customer Relationship (CR)	Close communication	14.646	.000**	1	.002**	.051
				2		.000**
	Customer Involvement	23.054	.000**	1	.000**	.003**
				2		.000**
	Quality Feedback	13.896	.000**	1	.013*	.015*
				2		.000**
	Response to customer	13.190	.000**	1	.305	.001**
				2		.000**
Organization Learning (OL)	In-house Information acquisition	32.870	.000**	1	.000**	.004**
				2		.000**
	External Information acquisition	19.800	.000**	1	.003**	.002**
				2		.000**
	Constant review	23.783	.000**	1	.004**	.000**
				2		.000**
	Shared interpretation of success	35.650	.000**	1	.000**	.007*
				2		.000**
	Shared interpretation of mistake	20.799	.000**	1	.000**	.029*
				2		.000**
Information Sharing (IS)	Information intensity	8.290	.001**	1	.060	.089
				2		.001**
	Synchronization with supplier	17.179	.000**	1	.008*	.003**
				2		.000**
	Synchronization with customer	13.937	.000**	1	.003**	.059
				2		.000**

* The mean difference is significant at $p < .05$

** The mean difference is significant at $p < .005$

FINDINGS AND DISCUSSION

The hierarchical clustering analysis identified three clear groups, see Figure 3 for the graphical representation. We can refer to these three groups of manufacturing companies as "Network Integrators", "Network Learners" and "Network Conformists" respectively. The shape of the distribution of the three groups takes the form of a traditional normal distribution, where the two tails are represented by 24 and 21 companies and the middle by 42. The general patterns of Network Integrators and Network Learners are similar, but mainly differ by average scale values. However, Network Conformists do not display a similar structure in their networking pattern. Network Conformists show more distinct characteristics in several strategy items, see Table 6 for item scale details, and mean values and standard deviations.

Table 6: Mean values and standard deviations of item scales.

		Network Integrator		Network Learner		Network Conformist	
Intra-firm Network Strategy		n=24		n=42		n=21	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Cross function Cooperation (XF)	Co-involvement	1.75	0.608	2.52	0.773	3.29	1.056
	Cross functional communication	1.75	0.532	2.57	0.703	3.00	0.775
	Shared commitment	1.50	0.511	2.26	0.665	3.33	0.796
	Involvement of engineer	1.42	0.584	2.33	0.816	3.67	0.966
Engineering Coordination (EC)	DFM/ DFA	1.29	0.464	1.95	0.825	2.29	1.007
	Component reduction	1.71	0.690	2.69	0.950	2.71	1.102
	Component standardization	1.75	0.676	2.36	0.759	2.90	1.221
Just-in-time Practice (JIT)	JIT delivery	2.17	0.761	2.88	0.889	3.05	0.805
	Small lot-size productions	2.08	0.974	2.57	0.887	3.10	0.944
	Inventory reduction	2.83	1.239	3.57	0.966	3.76	1.091
Inter-firm Network Strategy							
Supplier Relationship (SR)	Close communication	1.42	0.504	2.17	0.537	3.00	1.140
	Supplier involvement	2.04	0.751	2.71	0.918	4.05	0.973
	Supplier quality	1.38	0.495	2.07	0.808	2.90	1.179
	Long-term relationship	1.21	0.415	1.69	0.604	2.24	1.044
Customer Relationship (CR)	Close communication	1.38	0.495	1.81	0.634	2.48	0.928
	Customer Involvement	1.54	0.509	2.31	0.869	3.24	1.044
	Quality Feedback	1.46	0.509	1.93	0.513	2.43	0.870
	Response to customer	1.33	0.482	2.05	0.697	2.33	0.856
Organization Learning (OL)	In-house Information acquisition	1.96	0.550	2.57	0.737	3.62	0.740
	External Information acquisition	1.83	0.830	2.71	0.909	3.43	0.978
	Constant review	1.75	0.637	2.36	0.742	3.57	0.870
	Shared interpretation of success	1.50	0.737	2.05	0.656	3.00	1.000
	Shared interpretation of mistake	2.08	0.590	2.95	0.764	3.81	1.030

Information Sharing (IS)	Information intensity	1.83	1.007	2.38	0.764	3.00	1.225
	Synchronization with supplier	1.87	0.612	2.50	0.741	3.10	0.700
	Synchronization with customer	1.71	0.624	2.14	0.608	2.81	0.928

Network Integrator

The cluster of "Network Integrator" consists of 24 manufacturing companies, and accounts for 27 % of the data sample. As the chosen name suggests, this group of companies adopt an integrative approach to manage internal and external network strategies. Network Integrators appear to excel in all the network strategies when compared to the other two clusters, both in terms of the intra-firm and inter-firm contexts. The questionnaire items are positively phrased, and therefore a lower score indicates a higher degree of agreement and that the company has adopted an integrative network approach. Figure 3 shows network integrators as having scores from 1 to 2 for all items except JIT, see Table 6 for the numerical values of all item scales. Among the practices on inter-firm related strategies, the Network Integrators show the highest conformity for Supplier and Customer Relationship (SCR). Network Integrators appear to be devoted to developing close communications with suppliers on a long-term basis. They also seem keen to develop close relationships with customers through several means, including the involvement of customers at the product design stage, encouraging customers to provide feedback on product quality, and maintaining a responsive attitude to customers needs. The conformity shown on the approaches taken to SCR is relatively homogenous across this cluster of companies, a fact indicated by the low standard deviations, which range from 0.42 to 0.51. It is worth noting here, however, that supplier involvement only has a mean of 2.04, which is the least affirmed aspect amongst all items on Supplier Relationship. Network Integrators have average values around 1.80 to 1.82 on organizational learning and information sharing. This suggests that on the road to becoming a learning organization, Network Integrators place high value on a shared interpretation of success, leading to a practice involving constant review and constant acquisition of in-house data and customer information. The priority for mistake evaluation is comparatively low when compared to the various other items on organizational learning. Information sharing is also a highly important strategy that Network Integrators practice in the PRD manufacturing establishments, and frequent exchange of information with suppliers and customers is common practice. Network Integrators generally agree that the practice of information sharing can successfully synchronize their operations with suppliers and customers.

In terms of intra-firm networking, concurrent engineering seems to be widely practiced by the Network Integrators, with Design for Manufacturability (DFM) and Design for Assembly (DFA) being the most affirmed items. Component reduction and part standardization are also important means for maintaining internal engineering coordination. Furthermore, Network Integrators seem to make great efforts to thoroughly involve engineers in new product development, and regard team work, cross functional communications and co-involvement as normal essential in attaining a high degree of inter-functional cooperation. A particular concern for intra-firm networking, however, is the practice of JIT. The mean score of JIT practice, 2.36, is particularly weak when compared to other network strategies. The greatest challenge to Network Integrators seems to be the application and implementation of JIT concepts, which involves maintaining very low levels of inventory, ensuring that suppliers' deliveries are just-in-time and producing in small lot-sizes. In summary, Network Integrators, which comprise 28 % of the companies surveyed, are the leaders in truly practicing and sharing the views that effective networks must be developed for both internal and external control.

Network Learners

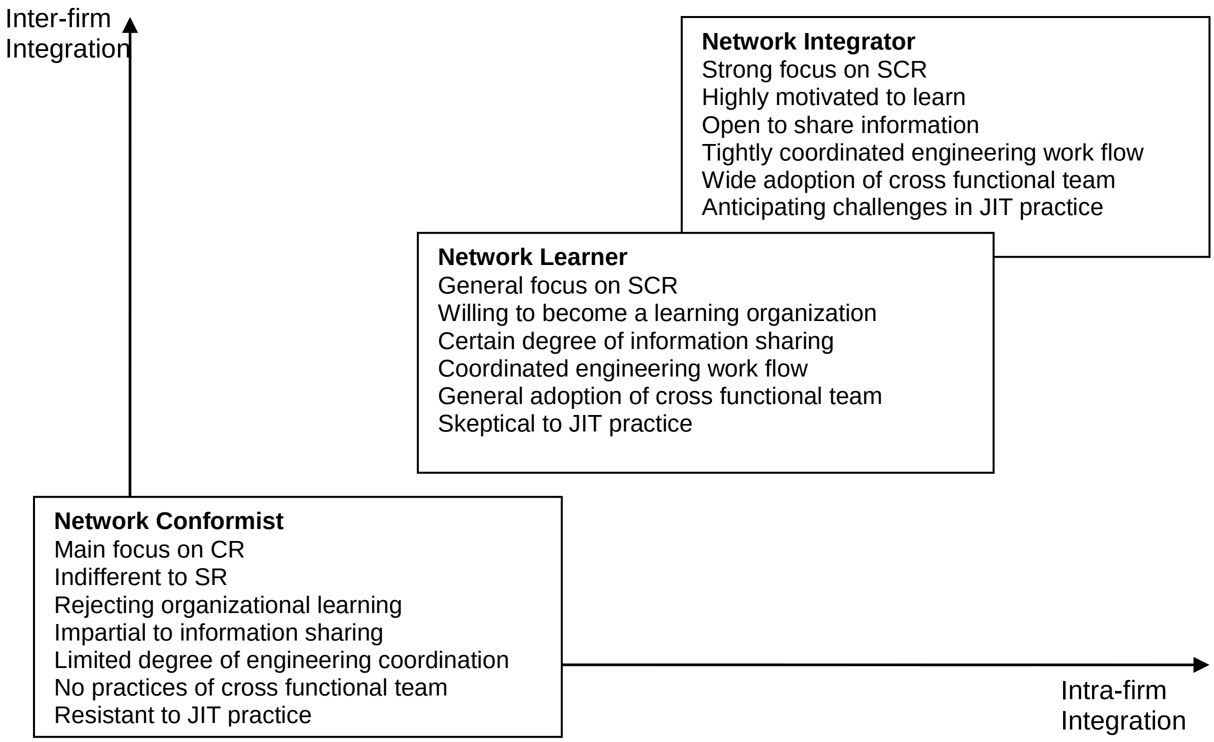
We use the term "Network Learner" to represent the middle-ground manufacturing companies that are not yet able to fully take advantage of the an integrative networking approach. This cluster accounts for 48% of the sample data and is the largest group. The Network Learners are, as the chosen name suggests, in the initial stages of becoming truly integrative and holistically networked manufacturing companies. The general pattern of Network Learners resembles that of Network Integrators, with the main difference being that this cluster has scores around 0.7 to 0.8 higher than those of Network Integrators. This difference implies that the strategies stated in the questionnaire context are not yet fully confirmable and accepted in the perspectives of the respondents. Nonetheless, they show only a lesser definite level of agreement by selecting a point of "2" instead of "1" on the various networking items. This observation can probably be explained by the fact that this cluster of companies are still *learning* and are on the way to becoming Network Integrators and will eventually be able to manage both intra- and inter-firm networks skillfully and easily. However, they will most likely face management and/or technical problems while moving towards holistic industrial networks.

Network Conformist

"Network Conformist" is the smallest cluster identified, accounting for 24% of the sample data. As the chosen name suggests, this cluster shows a more or less indifferent attitude towards engaging in networking strategies because they neither agree nor disagree with the network strategies outlined in the questionnaire, i.e. they just simply keep internal and external coordination at a minimum. This cluster of manufacturing companies has the highest mean values for all item scales, with scores both above and below the neutral point of 3. Although the differences in mean values between Network Conformists and Network Learners range from 0.3 to 0.9, the standard deviations of the individual mean item scores of Network Conformists are constantly higher than those of the other two clusters; 20 out of 26 item scales indicates a maximum value of 5, which means that the divergence in Network Conformists' networking practices is considerably wide. Results give no clear indication as to whether Network Conformists show a higher degree of conformity on intra- or inter-firm networking. However, engineering coordination and customer relationship are the two most consistent network strategies that Network Conformists practice; all the other 5 network strategies have values from 3 to 3.5.

Particularly interesting is organizational learning. Here Network Conformists score an average of only 3.5. Most of them appear to be indifferent and some even disagree with the practices of constant review, in-house data collection, and evaluation of mistakes. They also show similarly neutral responses for cross functional cooperation, indicating that engineers are seldom involved in new product development and that co-involvement of cross departmental parties is rarely practiced. Such observations not only indicate that these manufacturing companies have a low degree of conformity on integrative and holistic networking practices, but also that they share fundamentally different conceptions on industrial networking. They do not perceive the use of cross functional teams and the practice of formal learning in an organization as necessary. In summary, Network Conformists appear unenthusiastic in both the inside and outside the company context. Figure 4 shows a taxonomy characterizing these three types of clusters.

Figure 4: An illustration of 3 types of industrial networking patterns.



CONCLUSIONS

Several implications can be drawn from the findings. Firstly, results show that 76% of the sample population is moving towards an integrative and holistic approach for networking. Among the major network strategies, manufacturing companies place the maximum effort on maintaining an integrative SCR. Communication with customers, product quality feedback, customer involvement and responsiveness are shared across manufacturing companies are the core strategies in strengthening the downstream supply chain. Long-term supplier relationship, communication with suppliers, selection and use of quality suppliers and supplier involvement are also part of the competitive strategies adopted to manage the upstream part of their supply chain. Although organizational learning and information sharing are less prominent in terms of points scored, these two elements are also adopted as important strategies in developing external networks.

The involvement of engineers is also regarded as an important way to improve internal work flow. With the exception of the low values for JIT, all network strategy items for these two clusters show similar patterns, suggesting that the major population is moving towards the development of industrial networks with both internal and external features. While there is a gap in the extent of problem recognition, the views of manufacturing companies on the development of industrial networking appear to be pointing in the some direction.

A significant portion, 21%, of manufacturing companies show indifference and disagreement on the fundamental rationale for building industrial networks that encompass both the internal and external features. The companies, which we have labeled as “Network Conformists”, do not appear to have the motivation necessary to develop inter-functional teams and to achieve cross-functional cooperation. Departments tend to use the more traditional “over-the-wall” communication to manage projects and daily manufacturing operations. The involvement of engineers is very limited, even at the new product design stage. However, these companies will, to some extent, admit that early consideration of manufacturability and assembly is necessary. This apparent contradiction between of views and actions indicates that these companies do consider ease of manufacturability and assembly in their design process, but only at a late stage, when the cost of changes is probably too high. It also seems that component reduction and part standardization are not widely practiced. These companies adopt a rather one-directional product and engineering design process, whereby functional groups work separately and with minimal considerations for concurrent engineering and cross functional cooperation. These manufacturing companies have, in overall terms, underdeveloped intra-firm manufacturing network systems, and as far as we can ascertain from this study, internal communications - which most companies regard as essential in developing their core business - remain at an individual level.

Network Conformists also seems to have an indifferent view of external network practices. As the external business environment is rapidly moving towards information-based logistics management, it seems somewhat incredible that these manufacturing companies still cling to their traditional practices. The main reasons behind this observation is possibly a reluctance/resistance to change and lack management far sightedness. Results also indicate that both top management and divisional management tend to ignore organizational learning, suggesting a reluctance to change. Minimal efforts were also seen for in-house research and for constant reviews. The scores also indicate that management is doing very little in terms of evaluating employee performance. A culture of this nature will possibly limit the potential growth of such companies, especially in the current rapidly changing business environment. The lack of enthusiasm and reluctance to encompass an integrative perspective in coordinating their industrial networks will perhaps limit the long term development potential of this group of companies.

Results show that JIT Practices receive the least attention amongst all the companies surveyed. Even those companies that score high in terms of developing and maintaining networking strategies tend to score low on JIT related activities. The concept of keeping very small amounts of inventory via JIT seems the most disagreeable, perhaps due to the outdated traditional view that high inventories are a positive sign of factory size and complexity of operations. Initial interviews conducted with industrialists also revealed the same attitude: in the eyes of an interviewed manufacturer, producing on a "just-in-time" basis is pushing them into a status of "just-in-trouble". Our findings show that a policy of near zero inventories is still considered too vigorous and risky. While the companies surveyed do not themselves show a very high level of acceptance of JIT practices, they, however, seem to expect their suppliers to deliver on a JIT basis.

Amongst the four industrial sectors, the electrical and electronic sector has the largest percentages in the two clusters of Network Integrators and Network Learners, contributing 42% and 24% respectively, see Table 5. On the other hand, the wearing apparel sector has the lowest percentage in Network Integrators and a level of 28% for both Network Learners and Network Conformists. This result indicates that the electrical and electronic sector has a higher degree of initiative in taking an integrative approach towards network development. Industry related factors such as constantly changing demand, high technological obsolescence and cost fluctuations are possibly the driving forces that push this sector into taking a more aggressive and integrative approach in managing their industrial networks. The wearing apparel sector has always been the traditional and the biggest manufacturing sector in Hong Kong and the PRD, and lacks the incentive and determination required to make changes to existing networking practices. The ending of the Multi-fiber agreement may well prove to be the stimulus necessary for change.

Manufacturing in the PRD is now starting to enter the next stage of maturity. Over the past 20 or more years it has had the main advantage of cheap labour. This cheap labour advantage is expected to gradually disappear in the next the next several years. China is already under pressure to revalue its currency, the Yuan, and many of the labour intensive industries have already started looking for cheaper labour in less developed areas. Such areas can include Vietnam, India, Bangladesh, and a number of African countries. The ending of the multi-fiber agreement is also expected to considerably alter the dynamics of the garment and textiles industries. Manufacturers in the PRD are starting to become aware of the possible shifts that may take place, and studies such as this one will take on an ever increasing importance in helping them retain their competitive advantage.

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