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Developing supply chain strategies based on the survey of supply chain quality and technology management

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Abstract *A two-stage framework is developed on supply chain quality and technology management. This is based on a survey of the perceptions of practicing managers from Hong Kong's business corporations. The two-stage process involves empirical assessment of strategic supply chain quality and technology variables, and then using quality function deployment to deploy them to improve the competitiveness of the supply chain. This will help to achieve synergy among suppliers by focusing on the critical strategic variables to achieve sustainable competitiveness.*

Introduction

The traditional focus of supply chains was on transaction and delivery. In today's faster-paced markets, the focus has shifted to meet market demands correctly, rapidly, and profitably. With materials flowing downstream from suppliers, manufacturers, warehouses, stores to customers, and information flowing in both directions, supply chains must maintain and sustain technology-based and quality-driven capabilities in order to minimize systemwide costs, reduce lead time and transit time, and improve customer service levels. To this end, supply chains must be managed effectively.

Swaminathan *et al.* (1998) defined supply chain management as:

> . . . a network of autonomous or semiautonomous business entities collectively responsive for procurement, manufacturing and distribution activities associated with one or more families of related products.

In many situations, operating activities must be carried out across functions within organizations, across company boundaries, and across national borders (Lockamy *et al.*, 2000). Supply chain management, as a result, is a holistic and strategic approach to demand, operations, procurement, and logistics

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processes. Successful supply chain management depends on how well quality and technology are introduced and managed within the framework of the social and technical system of a supply chain. These social and technical systems are built on the interactions of many different variables in the areas of quality and technology management (Kuei *et al.*, 2001). Only when those variables are identified and managed by supply chain leaders and practicing managers would it be possible for organizations to develop effective plans for supply chain excellence. Supply chain quality management is not necessarily tool-based but also includes the customer-driven culture, which is the social base to facilitate the supply chain's workflow. Supply chain technology management, on the other hand, emphasizes the development of the technical base to facilitate the sharing of information on knowledge, markets, products, and processes among supply chain trading members. Integrated supply chain quality and technology management (SCQTM) helps to ensure successful supply chain management.

Although many practicing managers have recognized the importance of quality and technology in a broader supply chain context, critical dimensions of supply chain quality and technology management remain unclear. Few attempts have been made to empirically derive and strategically develop a plan to achieve supply chain excellence. Based on data collected from Hong Kong's high tech industries, a two-stage framework is developed on how to develop and deploy a strategic plan to build supply chain competitive advantage. This framework helps in the development and deployment of supply chain strategies not only to benefit individual supply chain members but also to benefit the entire supply chain.

Research background

Distribution process technology is one of Hong Kong's supply chain strengths (Magretta, 1998). This expertise is built on a well-developed banking and transportation infrastructure, and a host of information intensive service functions including product development, sourcing, financing, shipping handling, and logistics. Further, it is cultural in Hong Kong to be entrepreneurial. Wong *et al.* (1999) point out that Hong Kong's critical competitive advantage is access to the low cost production capabilities in China. As a result, Hong Kong companies are highly dependent on suppliers in China. Yam *et al.* (2000) reported that the adoption and implementation of ISO9000 systems in the early 1990s had a significant impact on igniting the quality management movement in Hong Kong.

Over the last two decades, the literature on quality management has been paying increasing attention to understanding the critical dimensions of quality. Ahire *et al.* (1996), for example, found that product quality is highly correlated with:

- customer focus;
- employee empowerment;

- supplier quality management;
- supplier performance; and
- internal quality information usage.

Based on the empirical evidence, they suggested that strategies for quality management must center on three critical factors: customer focus, superior supplier quality, and human resource management. Flynn *et al.* (1994) developed an instrument, which included the following critical dimensions: top management support, customer involvement, supplier involvement, workforce management, quality improvement rewards, product design, process management, and feedback. Saraph *et al.* (1989) collected surveys from 162 practicing managers in the USA and used the information to identify eight critical factors for quality management. These factors are: the role of top management leadership, the role of the quality department, training, product/service design, supplier quality management, process management, quality data and reporting, and employee relations.

Traditionally, information technology (IT) investments have focused mostly on productivity. Jurison (1998) noted that IT applications could be designed to improve both quality and productivity. Specifically, the use of IT in quality-oriented enterprises falls into three categories:

(1) process enabler;

(2) process integrator; and

(3) process performance monitoring and analysis.

Chow and Lui (2001) empirically assessed the association between the adoption level of total quality management concepts and the performance of information system function (ISF) in Hong Kong. They find that three factors need to be emphasized to improve ISF:

(1) user focus;

(2) IS top management support; and

(3) IS product/service design.

Ayers (1993) contended that technology alone could not increase efficiency and effectiveness. Rather, the integration with total quality management concepts can help an organization realize the potential gains of IT. Dewhurst *et al.* (1999) presented a complete and comprehensive review of the literature concerning the relationship between IT and TQM. They suggest that IT has a key role to play in the process of applying TQM in an organization and can affect all the dimensions specified by Saraph *et al.* (1989), Flynn *et al.* (1994) and Ahire *et al.* (1996). According to a survey of 213 practicing managers, Karimi *et al.* (1996) found that the degree of IT integration within firms is a primary determinant of firms' willingness to use IT as part of their strategic response to globalization. Further, the degree of IT investment is found to be associated with a firm's size, competitive strategy, and IT maturity.

The focus of quality-based paradigm has also shifted from the traditional company-centered setting to complete supply chain systems. Levi (1998) called the phenomenon of total quality relationship in the supply chain a paradigm shift. In the traditional paradigm, enterprises tend to focus on issues such as price, product quality, and delivery time. Supplier-customer relationship has evolved from building quality into purchasing to co-making quality products. As a result, joint quality improvement strategies are normal and expected. Bessant *et al.* (1994) identified seven components of total quality relationships in the supply chain, namely, strategy, boundary definition, monitoring and measuring performance, developing and managing the culture within the relationship, people and structures, processes and coordination, and continuous improvement. These components need to be managed if supply chain quality is to be sustained. Handfield *et al.* (1998) further suggested that the focus of supply chain quality should be to develop a quality infrastructure. Quality infrastructure consists of leadership and human resource development. The focus on supply chain quality in turn may lead to improved financial results, and customer satisfaction.

A number of empirical works exist to provide insights on the critical elements of quality management in the supply chain context. Kannan *et al.* (1998) identified three factors for supply chain quality:

(1) supplier evaluation;

(2) supplier involvement; and

(3) the decentralization of purchasing.

Krause *et al.* (2000) reported that suppliers' performance would determine the long-term success of the purchasing firms. Many purchasing firms have also indicated that the critical supplier improvement areas include:

- quality, delivery;
- cost reduction;
- new technology adoption;
- financial health; and
- product design.

Mentzer *et al.* (2001) also presented empirical support for the following nine logistics service quality constructs:

(1) personal contact quality;

(2) order release quantities;

(3) information quality;

(4) ordering procedures;

(5) order accuracy;

(6) order condition;

(7) order quality;

(8) order discrepancy handling; and

(9) timeliness.

They suggested that organizations should customize their logistics services by customer segments. Two major findings are presented in their study:

(1) Personal contact quality had a positive effect on perceptions of timeliness.

(2) Perceptions of the effectiveness and ease of use for ordering procedures had the most consistent positive effect on satisfaction.

Based on data collected from Taiwan's computer and electronics industries, Kuei and Madu (2001) identified three critical success factors for supply chain excellence:

(1) supplier relationship;

(2) IT-driven change; and

(3) customer focus.

The objectives of this paper are significantly different from the previously mentioned work, and are as follows:

- To empirically identify if there is a divergence in the perceptions of practicing managers on factors that are associated with organizational performance and supply chain quality and technology management practices.
- To deploy those strategic variables and identify operating initiatives via quality function deployment process to achieve supply chain excellence.

The next two sections will elaborate how this can be achieved through our proposed methodology.

Empirical assessment

The following hypothesis is used:

H1. A firm's organizational performance can be discriminated by its supply chain quality and technology management (SCQTM) practices.

Questionnaires were mailed to managers of Hong Kong's business corporations based on the directory of Key Decision-Makers in Hong Kong Business 2000-2001. Organizations of all selected candidates were contacted by telephone calls and confirmed with the adoption of supply chain or logistics management. A total of 108 practicing managers responded after follow-up mailings and telephone calls. Kuei and Madu's (2001) instrument is used to measure organizational performance and dimensions of supply chain quality management. Five technology-related factors were introduced in the survey to measure the role of supply chain technology management:

(1) information technology infrastructure;
(2) database system;
(3) IT-enabled logistics and production;
(4) IT-enabled marketing and after-sales services; and
(5) IT-driven supply chain integration.

A seven-point interval rating scale system is used in the survey, with 7 equaling the highest extent or degree. Reliability and validity test is used to examine these predetermined factors. Specifically, Cronbach's alpha reliability estimate test (Nunnally, 1967) and within-scale factor analysis (Flynn *et al.*, 1995) were applied. This reliability and validity test approach has been applied in other studies (Kuei *et al.*, 1997; Kuei and Madu, 2001). Further, factor analyses indicate that three factors can be drawn from organizational performance scale, namely, customer satisfaction, productivity, and financial results. Since this classification can clearly distinguish organizational performance, we therefore adopt this tri-factorial system. The multivariate scales for supply chain quality and technology management used in this study are shown in Table I. A *K*-means cluster analysis is conducted subsequently to classify three distinct groups of firms. The means and standard deviations of each factor grouped into three clusters are reported in Table II. Three clusters are labeled as low performance, medium performance, and high performance firms, respectively.

A stepwise discriminant analysis is undertaken to see if three different performance groups could be differentiated by SCQTM factors. From Table III, we note that two factors are singled out regardless of the comparison:

(1) IT-enabled logistics and production; and
(2) IT-enabled marketing and after-sales services.

The implication of this result is that practicing managers do perceive information systems as one of the major enablers in achieving customer satisfaction, productivity, and financial results. This finding is consistent with Magretta's (1998) report. Other critical variables that might contribute to the supply chain excellence were also identified. For example, from Table III, it is also observed that the high performance group tends to be different from the medium performance group on product design. This result suggests that practicing managers in Hong Kong perceive a focus on their internal core activities relating to product design and development as an important factor in managing the supply chain. This perception tends to be prevalent in small and medium business operations in Hong Kong. While this finding provides some insightful information, we can only speculate that these perceptual differences may be as a result of the different exposure and experiences of smaller firms with supply chain quality and technology management activities.

H1 is therefore confirmed by these results since our empirical evidences show that organizations can be differentiated by the different SCQTM factors. These SCQTM factors cover the use of IT and the essence of quality.

	Alpha	Factor analysis loading range	Dimension's description	Code used
Top Management leadership	0.66	0.56-0.78	Top management provides the necessary leadership in enabling conditions for TQ	TOP
Overall training	0.77	0.62-0.84	Job related skills and TQC concepts are emphasized	TRN1
Training on statistical methods	0.87	0.96	Workers are trained to use statistical techniques	TRN2
Company-oriented product design	0.79	0.83-0.90	Consider major elements of the product cycle. Emphasis is on company's internal operations	PROD1
Customer-oriented product design	0.66	0.72-0.80	Emphasis is on customers' needs and wants	PROD2
Statistics-based process management	0.99	0.99	Statistical methods are used to ensure stable and capable processes	PM1
Activities-based process management	0.93	0.65-0.94	Activities are monitored to ensure stable and capable processes	PM2
Quality data reporting	0.83	0.55-0.93	Records about cost of quality, and other indicators are kept for analysis	QI
Employee relations	0.91	0.69-0.95	Empower employees. Reliance on awareness and efforts of all employees	ER
Customer relations	0.92	0.54-0.95	Best-in-class customer satisfaction is emphasized	CR
Benchmarking learning	0.96	0.95-0.97	Benchmarking is used to improve the enterprise's performance	BL
Supplier quality capability	0.74	0.64-0.84	Emphasis is on quality, not on price. Use joint problem solving approach	SQC
Supplier quality development	0.87	0.77-0.94	Use fewer dependable and reliable suppliers. Develop relationship	SQD
Quality-oriented supplier selection	0.93	0.80-0.98	Suppliers are selected based on their capacity to meet the needs of the enterprise	SS1
Cost-oriented supplier selection[a]			Suppliers are selected based on the cost components	SS2
Supplier participation	0.99	0.99	Suppliers communicate and work with the enterprise	SP
IT infrastructure	0.97	0.89-0.93	IT infrastructure is set to support multiple levels of decision-making	IT
Database system	0.92	0.87-0.96	Database is used effectively to support multiple levels of decision-making	DS
IT-enabled operations: logistics and production	0.94	0.93-0.96	Maintain an information-base system that provides critical logistics and production information to operations employees and managers. Thus, better decisions can be expected	OP1
IT-enabled operations: marketing and after-sales	0.90	0.96	Maintain an information-base system that provides critical marketing and after-sales information to operations employees and managers	OP2
IT-driven supply chain integration	0.81	0.50-0.86	Computer systems are linked in the supply chain so that real-time responses to customer requirements are possible	ORG

Note: [a] one-item construct

Table I. Multivariate scales of supply chain quality management

For any pair of the performance group, critical factors are identified for further analysis through stepwise discriminant analysis. For example, when identifying discriminating items that separate high and medium performance groups, only the following three critical factors are used in the analysis:

(1) IT-enabled logistics and production;
(2) IT-enabled marketing and after-sales services; and
(3) company-oriented product design.

The final results are shown in Table IV. Knowledge of these detailed discriminating items could help supply chain managers to refocus their supply chain strategy.

Using QFD for strategic deployment

The empirical assessment above helps to identify strategic variables needed to achieve supply chain excellence. Once this is done, other critical questions on how to deploy those strategic variables must be answered. We conducted interviews with four supply chain experts to address these concerns. The participants have the following basic qualities that qualified them for this study:

- they are enthusiastic about participating;
- they had prior exposure to supply chain development decisions; and
- they know the supply chain practices in Asia.

Table II. Performance-based clusters' means and standard deviations

	Low performance cluster	Medium performance cluster	High performance cluster
Satisfaction	4.33 (0.94)	4.94 (0.26)	6.06 (0.25)
Productivity	2.00 (0.71)	5.02 (0.43)	5.62 (0.52)
Financial results	4.80 (0.76)	5.07 (0.58)	5.60 (0.55)

Table III. Critical factors separating low, medium, and high performance clusters (Wilks' lambda)

High vs. low	High vs medium	Medium vs low
OP2 (0.174)	OP1 (0.178)	OP2 (0.244)
OP1 (0.095)	OP2 (0.164)	OP1 (0.227)
SP (0.072)	PROD1 (0.151)	PM2 (0.204)
PM1 (0.064)		ORG (0.190)
PM2 (0.057)		TRN2 (0.182)
SS1 (0.052)		
SS2 (0.048)		
CR (0.044)		
TRN2 (0.039)		

Note: Probability < lambda: 0.0001

Table IV. Critical items separating low, medium, and high performance clusters

Clusters	Critical iems	Category
High vs low	Advanced computer system is used for inbound logistics	IT-enabled operations: logistics and production
	Advanced computer system is used for outbound logistics	IT-enabled operations: logistics and production
	Advanced computer system is used for after-sales services	IT-enabled operations: marketing and after-sales
	Auditing methods are used to ensure process quality	Activities-based process management
	Advanced computer system is used for production	IT-enabled operations: logistics and production
	Suppliers are able to deliver their promised services	Quality-oriented supplier selection
	Advanced statistical methods such as experimental design are incorporated in the training program	Training on statistical methods
	Statistical methods are used to ensure process quality	Statistics-based process management
High vs medium	Advanced computer system is used for inbound logistics	IT-enabled operations: logistics and production
	Advanced computer system is used for outbound logistics	IT-enabled operations: logistics and production
	Advanced computer system is used for after-sales services	IT-enabled operations: marketing and after-sales
	Product design is in line of company's strategic objectives	Company-oriented product design
	Advanced computer system is used for production	IT-enabled operations: logistics and production
Medium vs low	Advanced computer system is used for inbound logistics	IT-enabled operations: logistics and production
	Advanced computer system is used for outbound logistics	IT-enabled operations: logistics and production
	Advanced computer system is used for after-sales services	IT-enabled operations: marketing and after-sales
	Auditing methods are used to ensure process quality	Activities-based process management
	Employees are willing to participate in job-related education and training	IT-driven integration
	Advanced statistical methods such as experimental design are incorporated in the training program	Training on statistical methods
	Advanced computer system is used for production	IT-enabled operations: logistics and production

Given our findings, participants were asked to prioritize strategic dimensions of supply chain quality and technology, and to brainstorm potential operating initiatives for better level of supply chain excellence. The goal is to help a supply chain "x" in the high-tech industry set up supply chain policies on managing its supply chain to achieve the next level of excellence. Quality function deployment (see Figures 1 and 2) is used subsequently to correlate critical perspectives of supply chain quality and technology management and the potential operating initiatives. As noted by Madu (2000), quality function deployment (QFD) is an effective tool to deal with questions like: "what to do" and "how to do it." In the QFD development process, the "what to do" section is known as voices of customers, while the "how to do it" section deals with voices of organizations. The "what to do" section, in our example, is derived empirically from our survey on supply chain quality and technology management, while the "how to do it" section contains potential operating initiatives that could help to achieve the "what to do." Ratings of importance on strategic dimensions in the "what to do" section are determined by our experts after examining our empirical reports drawn from the previous step. Expert judgment is also applied here when evaluating the association between strategic variables and the operating initiatives. QFD exercises, as a result, help to identify the priorities on "what to do" and develop strategies to satisfy them.

'WHAT' Customer Requirements / 'HOW' Design Requirements	Importance to customer	Adopting the ERP System	Training TQ Leaders	Redesigning Fulfillment Process	Making Use of OR Models	Adopting the APS System	Sharing the Best Practices
IT-enabled Operations	5	⊙	⊙	⊙	⊙	⊙	⊙
Process Management	4	⊙	⊙	⊙	⊙	⊙	⊙
IT-Driven Integration	3	⊙	⊙	⊙	○	○	⊙
Supplier Selection	3	⊙	○	⊙	○	○	○
Training	3	⊙	⊙	⊙	⊙	⊙	⊙
Total		162	144	162	126	126	144

Rate of Importance: 5=most Important; 1=least Important

Relationships: ⊙ Strong = 9
○ Medium = 3
△ Weak = 1

Figure 1.
QFD

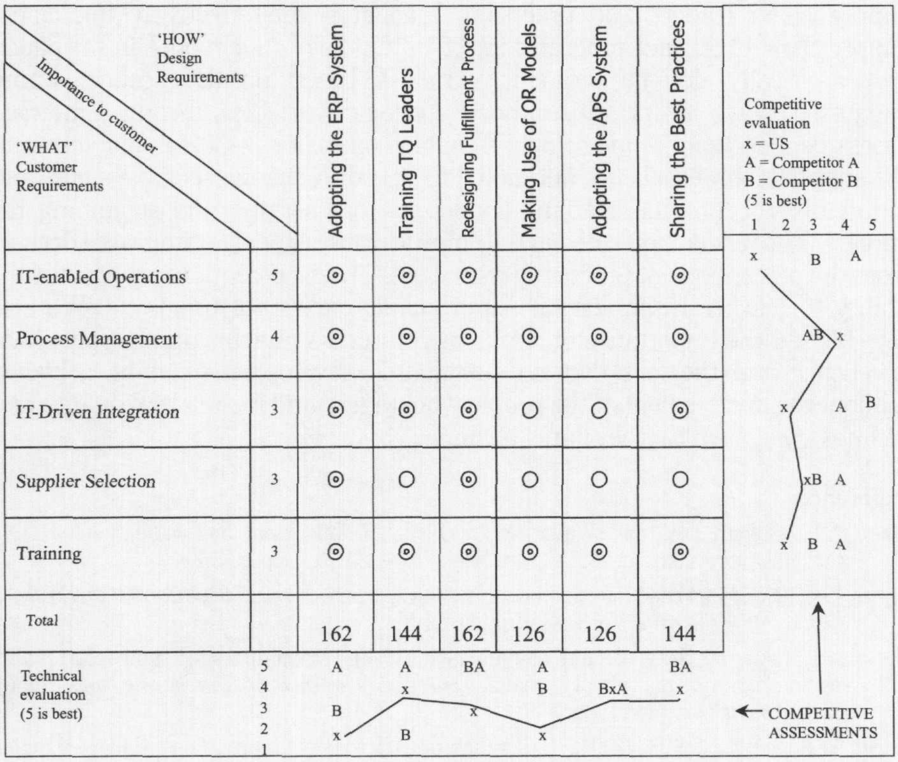

Figure 2. Benchmarking

Further, a benchmarking process could be used to compare with potential competitors from other supply chains. This is referred to as competitive benchmarking (Madu, 2000). Using this approach helps supply chain leaders and practicing managers to focus their strategy and resource allocation effort. Figure 2 shows how the process of benchmarking can be achieved by focusing on both the competitive evaluation that may focus on supply chain-based strategies and technical evaluations that may focus on organization-specific operating initiatives or what we may call "enablers" to achieving supply chain excellence. The supply chain "x", for example, positions itself against its competitors, especially those it is imitating to identify strategic issues that separate them and have been supportive to the supply chain future performance. On the other hand, in the competitive benchmarking, the supply chain leaders may also look at how some of identified requirements have influenced the competitiveness of other supply chains. Through this exercise, it is possible to select the operating initiatives to work on and implement the plan effectively.

Conclusions

We have described a two-stage strategic framework that will assist in the development of supply chain excellence programs. Government agencies, supply chain leaders and practicing managers can effectively implement supply chain excellence programs based on this two-stage model. In the paper, we empirically derived strategic variables based on data collected and suggested ways to prioritize those strategic variables. In the empirical assessment section, we identified IT-enabled operations as the major source of the supply chain excellence and noted the need to change social systems and foundations to provide enabling conditions for ensuring and sustaining the success. The results presented in the empirical assessment section were derived from the perceptions of practicing managers. These perceptions may affect the ability to effectively implement supply chain excellence programs. We also emphasized the importance of deployment process in achieving supply chain excellence and the fact that no sustainable development can be achieved without the involvement of the people who understand the internal quality and technology systems in the supply chain.

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