Asian Academy of Management Journal, Vol. 11, No. 1, 19–47, January 2006

SUPPLIER SELECTION STRATEGY AND MANUFACTURING FLEXIBILITY: IMPACT OF QUALITY AND TECHNOLOGY ROADMAPS

Muhamad Jantan[1]*, Nelson Oly Ndubisi*[2] *and Loo Cha Hing*[3]
[1]Center for Policy Research, [3]School of Management,
Universiti Sains Malaysia, 11800 USM Pulau Pinang, Malaysia
[2]Labuan School of International Business and Finance, Universiti Malaysia Sabah,
P.O. Box 80594, 87015 F.T. Labuan, Malaysia
e-mail: [1]mjantan@usm.my, [2]nels@ums.edu.my

ABSTRACT

The study evaluates the relationship between technology, quality, cost and delivery performance-based, supplier selection strategies, and manufacturing flexibilities namely, product flexibility, launch flexibility, and volume flexibility. Moreover, the moderating impact of supplier management strategies, namely quality roadmap and technology roadmap on the above relationships were also explored. The data for the study was drawn from a sample of companies listed in the factory directory published by the Penang Development Corporation (PDC). A postal survey of 120 manufacturers provided a return of 92 usable responses. The results reveal that the selection of suppliers based on technological and quality performance positively affects all the three dimensions of manufacturing flexibility, with complementary effects of good technology and quality roadmaps. Technology and quality roadmaps act as predictors for product and volume flexibilities. However, when launch flexibility is the focus, both technology and quality roadmaps moderate the impact of supplier selection strategies. Details of the findings, theoretical and practical implications, and the research limitation are discussed.

Keywords: manufacturing flexibility, supplier selection strategy, supplier management strategy, technology roadmap, quality roadmap, Malaysia

INTRODUCTION

With the shorter product life cycle, increasing trend of outsourcing and divesting of non-core activities, the manufacturer needs to closely collaborate with its suppliers to ensure that the upstream activities are managed properly to meet operational needs. Therefore, the supplier selection and supplier management strategies are viewed as important strategic decisions especially in this highly demanding, uncertain, and competitive market. Proper selection and management of the right suppliers would allow the manufacturer to leverage on their best-in-class technical capabilities and expertise to further improve its supply chain

flexibility. The volatility and variability of demand requires more focus on manufacturing flexibility for the manufacturer to continuously stay competitive. Firms are using effective supply chain management (SCM) to support their multiple manufacturing goals such as flexibility, cost, quality, and delivery (Wacker, 1996).

Manufacturers have utilized suppliers' strengths and technologies to support new product development efforts (Morgan & Monczka, 1995) and have drastically reduced supply bases to a handful of certified suppliers (Inman & Hubler, 1992). Most of the recent literatures on SCM focus on manufacturers' attempts to integrate processes and form alliances with suppliers to more efficiently and effectively manage the purchasing and supply function. Carter, Monczka, Slaight, and Swan (2000) forecast that supplier selection will increasingly be based on strategic contribution to the supply chain and will extend beyond the first-tier suppliers. Supplier involvement in product and process design, and continuous improvement activities for instance, has been shown to have a positive impact on competitive advantage and performance (Vonderembse & Tracey, 1999). In general, SCM seeks to improve the performance through elimination of waste and better leveraging of internal and external supplier capabilities, and technologies (Morgan & Monczka, 1996).

The intense global competition over the past decade has promoted SCM as a corporate strategy and a popular topic for academic research. Manufacturers have used SCM to describe the integration and partnership efforts with first- and second-tier suppliers to improve the business performance. The objectives of these partnerships are to offer the lowest total cost, high-quality products and services with greater flexibility. Prior empirical studies on achieving manufacturing flexibility goals have centered on the uses and advantages of advanced technology. Few studies have examined other alternative ways of attaining flexibility objectives (Narasimhan & Das, 1999). One of the possibilities is to study the emphasis of the manufacturer's supplier selection and management strategy and their contribution towards its flexibility. Thus, this study investigates the relationship between manufacturer's supplier selection strategy and the level of manufacturing flexibility achieved; as well as the moderation effect of technology and quality roadmaps (two important supplier management strategies) on the relationship.

Manufacturing Flexibility

A key dimension in supply chain performance is flexibility. Flexibility is one of the important objectives in Operation Strategy Model (Schroeder, 2000) and is often seen as a reaction to environmental uncertainty (Suarey, Cusumano, & Fine, 1991; Gerwin, 1993). The increasingly uncertain environment resulting

from accelerating changes in customer expectations, global competition and technology faced by manufacturers (Germain, Droge, & Christensen, 2001) has made flexibility a strategic imperative that enables firms to cope with uncertainty (Sethi & Sethi, 1990). Flexibility is described as the ability of a manufacturing system to cope with environmental uncertainties (Barad & Sipper, 1988). Although there are numerous ways to characterize supply chain flexibility, for example, manufacturing flexibility and marketing flexibility (Vickery, Calantone, & Droge, 1999), this research focuses on manufacturing flexibility. In general, flexibility reflects an organization's ability to effectively adapt or respond to changes that add value in the customer's eyes (Upton, 1995). Today, as time to market continues to compress due to customers changing demands, manufacturers are responding with a complementary reduction in product life cycle. In order to meet this variability in demand, the manufacturer needs to incorporate flexible supply chain in their operations that are scalable and adaptable to achieve shorter order fulfillment lead-time. Hahn, Watts, and Kim (1990) emphasize that an organization's ability to produce a quality product at a reasonable cost and in a timely manner, are heavily influenced by its suppliers' capabilities.

Manufacturing flexibility refers to the quickness and the ease with which plants can respond to changes in market conditions. Thus, the concept of flexibility is essentially a measure of the efficiency of the process of change. It derives from the efficiency of the production system not in making products, but in changing either the number or types of product made. Manufacturing flexibility is affected by uncertainties in "upstream" as well as "downstream" activities. Events such as supplier defaults on delivery and performance, machine breakdowns, rejects, variable task times, changes in demand volume, product mix, price, and competitors' action have the potential to further exacerbate the level of uncertainty that a manufacturer faced (Zelenovic, 1982; Gupta & Goyal, 1989). Anand and Ward (2004) viewed flexibility as the level of slack in response to deal with this uncertainty. A dominant feature of the extant literature is the various terminologies used to described manufacturing flexibilities, and the attempt to provide useful taxonomies to better understand this concept of flexibility (e.g. Narasimhan & Das, 1999; Zhang, Vonderembse, & Lim, 2003). Narasimhan and Das (1999) has categorized the various flexibilities by operational flexibility (equipment, material, routing, material handling, and program), tactical (mix, volume, and expansion), and strategic (new product and market); whilst Zhang et al. (2003) considered the dichotomy of competence flexibility (machine, labour, material handling, and routing) versus capability flexibility (volume and mix). Flexibility by nature is multidimensional (Koste & Malhotra, 1999) and to avoid the confusion arising from the various terminologies and classifications, Anand and Ward (2004) use the underlying elements of range and mobility to capture the essence of flexibility. Further,

Upton (1994) argued that the taxonomies do not capture local nuances of flexibility. This research uses the perspective of internal versus external flexibility in the sense that is similar to that advocated by Zhang et al. (2003); where internal flexibility is the flexibility that customers do not see, whereas external are those that are visible to the firm's customers. From this perspective, tactical and operational flexibilities as referred to in the literature would be classified as internal competencies; whereas volume and product flexibility are external capabilities. The focus of this study is on external flexibility, which can be argued to be of primary concern in competition. However, from the external perspective, product flexibility focuses on the variety and range of features, while ignoring the time dimension. Informal interviews with managers in manufacturing firms argued that their customers are also concern with the timing of the introduction of new products; where the capability to introduce or launch new products at opportune times is also important to maintain competitiveness in this era of time-based competition. For this reason this study will also consider launch flexibility; which we describe as the capacity to incorporate changing lead time to introduce new products. Thus, the three dimensions of focal interest in this study are volume, product, and launch flexibility.

Product flexibility is becoming increasingly important in today's competitive environment. Product flexibility is a value-adding attribute that is immediately visible to the customer. It requires the effective collaboration of the internal and external functional players, including marketing, product design and development, engineering, and suppliers. Vickery et al. (1999) found product flexibility to be significantly related to financial and marketing performance. Prior researches have not explored the direct impact of supplier selection and management on product flexibility, and it is one of the intentions of this research to fill the gap.

Volume flexibility directly impacts customers' perceptions by preventing out-of-stock conditions for products that are suddenly in high demand. Hayes and Wheelwright (1984) describe the importance of this capability in a highly cyclical industry such as furniture, emphasizing the necessity of being able to accelerate or decelerate production very quickly and juggle orders so as to meet demands for unusually rapid delivery. Volume flexibility requires close coordination between a manufacturer and its suppliers, especially in the face of increasing demand. Empirical study has indicated that volume flexibility and launch flexibility are key responses to marketing practice uncertainty and product uncertainty, respectively (Vickery et al., 1999).

Furthermore, as the product life cycle dramatically decreases, increasing strategic emphasis is being placed on bringing many new products to market as quickly as possible since it provides companies a real competitive advantage. Launch

flexibility offers the following advantages: (1) pioneering performance advantage, where early market entry is related to higher market share or profitability (Robinson, Fornel, & Sullivan, 1992; Maidique & Zirger, 1984); (2) quality image perception advantage, where the early entrant has the first opportunity to build and nurture a long-term relationship with the buyer and search costs would induce the buyer to remain with the early entrant (Hauser & Wernerfelt, 1990; McMath & Forbes, 1998, pp. 22–24; Maidique & Zirger, 1984); (3) innovation leadership advantage, where technology superiority is perceived by customer; scale and experience economy advantages, where early entrant can gain production efficiencies from early buildups of experience and size advantages (Lieberman & Montgomery, 1988; McMath & Forbes, 1998, pp. 129–30).

Supplier Selection Strategy

Supplier selection strategy is the strategy adopted by the manufacturer to evaluate and select the suppliers, who fulfill the requirements of the manufacturer. To develop a more effective relationship with suppliers, organizations are using specific criteria to strengthen the selection process. Over time, these criteria change in the wake of new challenges faced in selecting suppliers who can add long-term value to the manufacturer (Lemke, Goffin, & Szwejczewski, 2000).

Hahn et al. (1990) identified quality, cost and delivery performance history, and technical capabilities as important criteria in supplier selection. Weber and Current (1991) reviewed 74 articles discussing supplier selection criteria, and found quality was perceived to be the most important, followed by delivery performance and cost. The selection of suppliers is critical for several reasons. First, the trend towards "just-in-time" manufacturing practices has resulted in a supply base reduction (Pearson & Ellram, 1995). Second, owing to resource scarcity, there is a need for greater interaction between the buyer and the supplier. Third, many firms involve their suppliers early in the planning process so that they are able to deliver superior value to their customers (Trent & Monczka, 1998).

Supplier selection strategy in terms of technology, quality, cost, and delivery performance are important strategies in reducing "upstream" uncertainties, such as supplier defaults on delivery and performance, and quality rejects; as well as "downstream" uncertainties due to demand volatility and changes in product mix, price, and competitors' action. However, the impact of each of these strategy on the various dimensions of flexibility differ; we believe that the impact may be direct as well as moderated by the strategies used to manage the selected suppliers, particularly the technology roadmap and quality roadmap used to encourage suppliers' performance.

Technology and Quality Roadmaps

Technology and quality roadmaps are essential elements of supplier management strategy. Beyond selecting the right suppliers, managing them is an activity that can ensure that the expectations of the manufacturer are met. Suppliers are now seen as important resource to manufacturers, as they have a large and direct impact on the cost, quality, technology, and time-to-market of new products (Handfield, Ragarz, Petersen, & Monczka, 1999). The management of the supplier relationship is a vital, as supplies shape both the competitiveness and profitability of a company (Lemke et al., 2000). As highlighted by Christopher and Martin (1997), effective supplier management can take costs out of the supply chain.

Forker, Ruch, and Hershauer (1999) states that "for suppliers to reduce defects and production costs, cross organizational cooperation between the supplier's quality department and the buyer procurement department is essential." The supplier's quality department is chosen because it is the one that will most likely work with the buyer's procurement department in a supplier development program (Watts & Hahn, 1993). Pender (1993) promotes a supplier development process that recognizes and develops suppliers to the highest standards of quality. This supplier development process is based on a clear quality policy with the sole objective of exceeding customer expectations. They stressed that although it is important to have a well-designed supplier development programme, it is more important that the programme is well communicated and understood by the supplier.

In order to release products quickly, supplier selection occurs at the front end of the program, long before the specifications are laid out. Sun System involves supplier by reviewing their technology roadmaps to determine what technology is emerging that Sun may be able to use in future products (Teague, 1997). By bringing the leading edge technologies into the design process at an early stage, suppliers can help the manufacturer to reduce lead-time and improve product performance. Suppliers also generate greater awareness and understanding of new technologies amongst manufacturers to encourage them to adopt new technologies that can improve their manufacturing flexibility.

Technology and quality roadmaps are part of supplier management strategy used by the manufacturer to improve its supplier's performance and capabilities to meet the manufacturer's short-term and long-term supply needs. Supplier management is concerned with organizing the optimal flow of high-quality, value-for-money materials or components to manufacturing company from a suitable set of innovative suppliers (Goffin, Szwejczewski, & Colin, 1997). It is impossible to find the supplier who matches 100% the needs of the manufacturer

in the initial selection process. This strategy allows the manufacturer to bridge the gaps, after the supplier selection process, between its suppliers' capabilities and its own expectation.

Establishment of technology and quality roadmap is believed to be one of the important activities in supplier management. BMW published a Supplier Partnership Manual and held seminars for suppliers to present their "Roadmap to Quality", which helped BMW to be 20% above the industry average in several quality-performance categories. This manual clearly delineates supplier responsibilities and expectations and is geared toward improving alignment between the corporate cultures (Handfield, Krause, Scannel, & Monczka, 2000). Such roadmaps are becoming increasingly common to spur manufacturer and supplier organizational alignment. They attempt to show companies where they are today and project where they should be in the short, medium and long term. By having clear quality and technology roadmap, the manufacturer is more ready to combat the war of uncertainty in its supply chain.

MODEL AND METHODS

Figure 1 shows the schema of the research constructs. It posits that different strategies will have differential impacts on manufacturing flexibilities. It also argues that selection strategy alone is not sufficient to ensure the achievement of flexibility; technology and quality roadmaps are necessary to manage the selected suppliers.

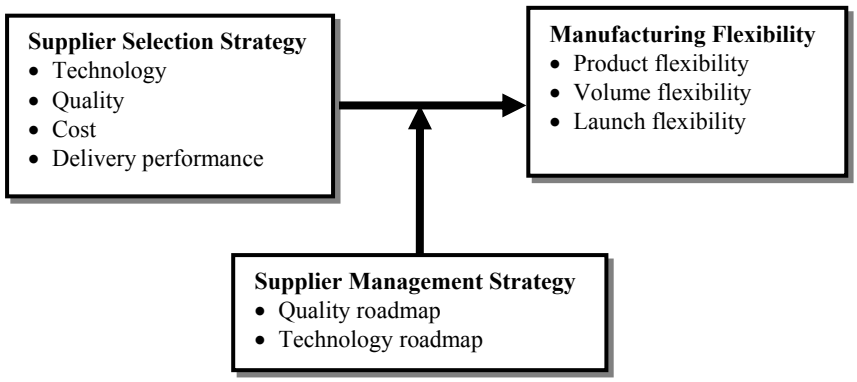

Figure 1. Research schema

The population for this study consists of the manufacturing firms located in northern Malaysia, state of Penang. The manufacturers are from different countries of origin (namely, United States [US], Germany, Japan, Malaysia,

Taiwan, and United Kingdom [UK]), and they are involved in the manufacture of semiconductors, computer and computer peripherals, telecommunications, electrical products and instruments. The sampling frame is drawn from companies listed in the Factory Directory published by Penang Development Corporation (PDC). Purposive sampling was used, because there is a significant proportion of companies in the sampling frame did not focus on achieving flexibility or practice SCM. The respondents who were target are the purchasing director or manager, as they are in the best position to provide the desired information for this study.

The design of the questionnaire is derived from the issues and questions raised in the literature. The questions were taken directly from the past questionnaires with few modifications made to the model requirements (Narasimhan & Dass, 1999). Few academicians with expertise in this area were consulted for advice before developing the questionnaire, in addition to personal interviews conducted with practitioners who have vast experiences in supplier selection and management field as well as SCM. Their suggestions were incorporated in the questionnaire and pretested.

The pretest was performed on three purchasing managers to ensure that issues of concern are correctly addressed and also to ensure the clarity and validity of the questions. Changes were made based on their feedback to produce the final version. The final version has 46 items spread over four major sections. The first section contains 11 questions pertaining to the individual and organization profile. Questions in the other three sections use a 6-point Likert scale anchored at 1 (Strongly Disagree) and 6 (Strongly Agree). Section B has 13 questions to measure the organization supplier selection strategy (e.g., my unit selects suppliers whose technology meets my company's needs; my unit carries out total quality assessment on the suppliers during the selection process) and section C has 6 questions pertaining to technology and quality roadmaps (e.g., my business unit layout the future technology requirements to the suppliers; my business unit spells out clearly the required acceptable quality level to suppliers; there is a periodic quality review between my unit and the suppliers). The last section, section D contains 10 questions on manufacturing flexibility (for instance, my unit can increase product range with ease; my unit is able to introduce new products to market earlier than competition; my unit can support any sudden need for volume ramp around 20%).

A copy of the questionnaire was sent to each of the 120 companies listed in the sampling frame, out of which 100 were collected back. However, only 92 were usable, which indicates a response rate of approximately 77%. The flawed eight copies were either incomplete or filled up by nontarget respondents, who may not have the related experience.

RESULTS

Organizational Profile

Table 1 provides the summary of the organizational background namely, country of origin, size of the company in terms of number of employees, supplier base and material cost structure.

TABLE 1
PROFILE OF FIRMS IN THE SAMPLE

Profile	Description	No. of respondents	%
Country of origin	US based	38	41.3
	Japanese	25	27.2
	Malaysian	17	18.5
	Taiwan based	5	5.4
	Others (Germany, UK, & etc.)	7	7.6
No. of employees	50–100	3	3.3
	101–500	17	18.5
	>500	72	78.3
No. of suppliers	<50	8	8.7
	50–200	38	19.6
	201–500	36	39.1
	>501	30	32.6
Material cost over revenue	<50%	22	23.9
	51–60%	18	19.6
	61–70%	25	27.2
	>70%	25	27.2

A majority (41%) of the surveyed organizations are US based, followed by Japanese firms (27.2%), and the local companies make up 18.5% of the sample. The companies are generally large with 78.3% having more than 500 employees; thus, it is not surprising that a large majority (72%) of them have a supplier base exceeding 200 suppliers. It is also noted that for about 55% of them, material dominates the cost-revenue structure.

Goodness of Measurement

In order to ensure the validity and reliability of the measures, the multiple statements dealing with supplier selection, technology roadmap, quality roadmap, and manufacturing flexibility variables are assessed using factor and reliability analyses. Table 2a summarized the results of these analyses for manufacturing flexibility. The KMO and MSA values indicate sufficient number of significant

intercorrelations for factor analysis. One item for volume flexibility had to be removed to ensure valid and reliable measure of the three hypothesized dimensions. The three clean factors that emerged provide evidence of convergent validity, whilst the Cronbach α values of 0.65 or more provide evidence of internal consistency in the measures. Similarly, the summary provided in Tables 2b and 2c for the independent variables (supplier selection strategy) and moderators (technology and quality roadmaps) respectively, are sufficient to indicate that the measures are both valid and reliable. However, note that in the case of the supplier selection, the dimensions of emphasis on technology and quality converge into one factor, which is then named as technology-quality emphasis. Composite scores are then obtained using simple averaging.

TABLE 2a
FACTOR ANALYSIS OF MANUFACTURING FLEXIBILITY
(DEPENDENT VARIABLE)

Items	Components		
	1	2	3
Product flexibility (broad range of product)	**0.838**		
Product flexibility (ease in increasing product range)	**0.773**		
Product flexibility (customizing to customers' needs)	**0.703**		
Product flexibility (delayed customization)	**0.579**		0.554
Launch flexibility (earlier introduction compared to competitor)		**0.732**	
Launch flexibility (product releases according to schedule)		**0.840**	
Launch flexibility (no delay in new product introduction due to suppliers)		**0.845**	
Volume flexibility (no excess inventory in demand reduction situations)			**0.828**
Volume flexibility (no stock out problem)		0.344	**0.751**
Percent variance explained	39.953	16.576	11.634
KMO		0.766	
MSA values		0.742–0.819	
Reliability (Cronbach α)	0.7479	0.8098	0.6468

Note. All loadings < 0.3 are suppressed.

TABLE 2b
FACTOR ANALYSIS OF SUPPLIER SELECTION STRATEGY
(INDEPENDENT VARIABLES)

Items	Component		
	1	2	3
Technology (best-in-class)	**0.6098**	–0.3029	0.3812
Technology (meeting company needs)	**0.6216**		
Technology (invest in technology)	**0.8149**		
Quality (quality performance records)	**0.6431**	0.3894	
Quality (quality assessment)	**0.6877**		
Quality (future quality goals)	**0.7143**		
Cost (unit cost)			**0.7807**
Cost (lowest quotes)			**0.7563**
Cost (annual cost reduction)			**0.6064**
Delivery (delivery performance records)		**0.7698**	
Delivery (monitoring delivery performance)		**0.7696**	0.3219
Delivery (lead time reduction program)		**0.7208**	
Percent variance explained	32.8570	17.6650	9.8830
KMO		0.7720	
MSA range		0.555–0.850	
Reliability (Cronbach α)	0.8145	0.6487	0.7894

Note. All loadings < 0.3 are suppressed.

TABLE 2c
FACTOR ANALYSIS OF TECHNOLOGY AND
QUALITY ROADMAPS (MODERATORS)

Items	Components	
	1	2
Quality roadmap (quality acceptance level)	**0.8204**	
Quality roadmap (periodic quality review)	**0.7776**	0.3096
Quality roadmap (consistent quality assurance)	**0.8753**	
Technology roadmap (future technology requirements)		**0.8180**
Technology roadmap (periodic technological review)	0.4865	**0.7045**
Technology roadmap (investment in technology R&D)		**0.8991**
Percent variance explained	57.0530	17.8820
KMO	0.7870	
MSA values	0.684–0.861	
Reliability (Cronbach α)	0.8157	0.8172

Note. All loadings < 0.3 are suppressed.

Table 3 summarizes the mean, standard deviation and the correlation between the major variables of the study. Taking into consideration that the scale used for flexibility is 1 to 6, the mean for volume flexibility is low compared to other variables, indicating some difficulties in coping with demand fluctuations. The other variables have mean values of at least 4. The supplier selection variables have mean values between 4.7 and 5.1 indicating that the variables are important in supplier selection. Among them, emphasis on delivery has the highest mean value (5.13), which shows the salience of delivery measure as compared to the other variables. Quality roadmap has a higher mean value (4.83) as compared to technology roadmap (4.18), albeit both are important strategies. The product and launch flexibility are highly rated as well, having mean value around 4.15. This indicates that product and launch flexibility are less problematic as compared to volume flexibility with a mean value of 3.24. This could probably be because the latter is more volatile.

Though the correlations are statistically significant, the values are at moderate levels. The correlations between the three dimensions of flexibility range from 0.27 to 0.44, indicating some degree of independence between them. Similarly the correlations between the supplier selection strategies range from a low of 0.07 to a high of 0.42, whereas the correlation between the moderators is highest at 0.54.

TABLE 3
MEAN, STANDARD DEVIATION, AND PEARSON CORRELATIONS

Variables	Mean (m)	Std. dev. (SD)	Correlation						
			1	2	3	4	5	6	7
Product flexibility	4.179	0.831							
Volume flexibility	3.239	0.968	0.266*						
Launch flexibility	4.149	0.929	0.422**	0.443**					
Technology-quality emphasis	4.743	0.633	0.343**	0.302**	0.311**				
Cost emphasis	4.815	0.667	0.059	0.004	0.059	0.067			
Delivery emphasis	5.130	0.637	0.139	0.175	0.165	0.420**	0.348**		
Quality roadmap	4.833	0.852	0.310**	0.317**	0.389**	0.480**	0.117	0.457**	
Technology roadmap	4.181	0.890	0.347**	0.421**	0.451**	0.493**	0.022	0.208*	0.539**

Note. *significant at 0.05; ** significant at 0.01

Relationships Testing

The relationships described by the model (Figure 1) were tested using regression analysis. The assumptions of such analysis were tested using standard procedures such as partial plots for linearity, normal p-p plot for normality of error terms, Durbin Watson (shown in the table) for autocorrelation of the error terms, and VIF for multicollinearity of independent variables. Except for the analysis involving product flexibility, where one outlying observation had to be removed, the tests prove satisfactory and Table 4 summarizes the results of the multiple regression analysis.

TABLE 4
REGRESSION RESULTS FOR MANUFACTURING
FLEXIBILITY VS. SUPPLIER SELECTION STRATEGY

	Manufacturing flexibility		
	Product	Volume	Launch
R^2	0.142	0.095	0.099
F-value	4.814**	3.088*	3.211*
Standard error of estimate	0.730	0.936	0.897
Durbin-Watson	1.872	1.646	2.121
Independent variables	Standardized coefficient (β)		
Technology-quality emphasis	0.344**	0.274*	0.296**
Cost emphasis	0.083	–0.040	0.0280
Delivery emphasis	0.035	0.074	0.0310

Note. *significant at 0.05 level; **significant at 0.01 level

The explanatory power of the supplier selection strategies on manufacturing strategies ranges from a low of 9.5% (for volume flexibility) to a high of 14.2% (for product flexibility). However, only the technology-quality emphasis contributes significantly to the variations in the three flexibility dimensions. in all three cases, the impact of technology-quality emphasis on the three manufacturing flexibility dimensions is positive. This means that the greater the emphasis on technology and quality when selecting suppliers, the greater will the achieved manufacturing flexibility be.

The non-significance of cost emphasis and delivery emphasis, however, does not implies that these two supplier selection strategies have no impact on manufacturing flexibility; as the impact may be moderated by the two hypothesized moderators, namely technology and quality roadmaps. This is discussed next.

Moderator Effect

As suggested by Sharma, Durand, and Gur-Arie (1981), 3-stage hierarchical regressions were used to test the moderating effects of supplier management strategies on the relationship of supplier selection strategy and the manufacturing flexibility. At the first stage, the independent variables (technology, quality, cost, and delivery performance) are input as a block. At the second stage, the moderators namely, technology roadmap and quality roadmap are inserted in as the new block. In the final stage, the interaction terms (for example, cost emphasis*technology roadmap; cost emphasis*quality roadmap) are included in the third block. The following discussions discuss the result of these analyses.

Moderating Effect of Quality Roadmap on the Relationship Supplier Selection Strategies and Manufacturing Flexibility

Tables 4a–4c summarize the results of the hierarchical regression analysis for the impact of supplier selection strategies on product flexibility, volume flexibility and launch flexibility, respectively, with quality roadmap as the moderator.

TABLE 4a
MODERATING EFFECT OF QUALITY ROADMAP ON SUPPLIER SELECTION STRATEGY – PRODUCT FLEXIBILITY RELATIONSHIP

	Model		
	1	2	3
R^2 change	0.142	0.020	0.018
F-change	4.814**	2.105	0.606
Variables	Standardized β		
Technology-quality emphasis	0.344**	0.285	0.331
Cost emphasis	0.0827	0.084	0.218
Delivery emphasis	0.0350	–0.022	–0.772
Quality roadmap		0.173	–0.701
Technology-quality-quality roadmap interaction			–0.126
Cost-quality roadmap interaction			–0.222
Delivery-quality roadmap interaction			1.630

Note. *significant at 0.05; **significant at 0.01

TABLE 4b
MODERATING EFFECT OF QUALITY ROADMAP ON SUPPLIER SELECTION STRATEGY – VOLUME FLEXIBILITY RELATIONSHIP

	Model		
	1	2	3
R^2 change	0.095	0.036	0.027
F-change	3.088*	3.588+	0.903
Variables	Standardized β		
Technology-quality emphasis	0.274*	0.194	0.935+
Cost emphasis	–0.040	–0.036	0.750
Delivery emphasis	0.074	0.002	–0.700
Quality roadmap		0.228+	1.116
Technology-quality-quality roadmap interaction			–1.463
Cost-quality roadmap interaction			–1.321
Delivery-quality roadmap interaction			1.502

Note. +significant at 0.1; *significant at 0.05; **significant at 0.01

TABLE 4c
MODERATING EFFECT OF QUALITY ROADMAP ON SUPPLIER SELECTION STRATEGY – LAUNCH FLEXIBILITY RELATIONSHIP

	Model		
	1	2	3
R^2 change	0.099	0.077	0.119
F-change	3.211*	8.084**	4.734**
Variables	Standardized β		
Technology-quality emphasis	0.296**	0.180	0.139
Cost emphasis	0.028	0.033	1.243*
Delivery emphasis	0.031	–0.074	–1.515*
Quality roadmap		0.333**	–0.217
Technology-quality-quality roadmap interaction			0.109
Cost-quality roadmap interaction			–2.087*
Delivery-quality roadmap interaction			2.973*

Note. *significant at 0.05; **significant at 0.01

When product flexibility is the dependent variable, the inclusion of quality roadmap as the predictor (Model 2) improves the explanatory power of the model by a mere 2%; and when it was included as a moderator (in the form of interaction terms with supplier selection strategies – Model 3), quality roadmap provides an additional 1.8% in explanatory power. These improvements are

marginal and thus, one can conclude that quality roadmap does not act as a moderator in the relationship between supplier selection strategies and product flexibility; though there is some evidence (at 0.1 significance level) that it does act as a predictor variable.

A similar pattern can be observed for the dependent variable of volume flexibility, where the marginal increase in explanatory power is 3.6% and 2.7% for Models 2 and 3, respectively. In like manner, quality roadmap seems to act as a predictor of volume flexibility rather than as a moderator in the relationship.

However, Table 4c provides strong evidence that quality roadmap moderates the impact of cost emphasis and delivery emphasis on launch flexibility. The inclusion of quality roadmap improves the explanatory power of the model significantly (approximately 20%). To better illustrate the moderating effect of quality roadmap on these relationships, we produce multiple plots by categorizing the independent variables into three levels (low, moderate, and high; using percentiles) and dichotomizing (poor and good; using median) the moderator; the results of which are shown in Figures 2 and 3 for cost emphasis and delivery emphasis as the independent variable, respectively.

They both show that managing the supplier using good quality roadmap provides for better launch flexibility, for all levels of emphasis placed on cost and delivery performance when selecting suppliers. However, the impact of cost and delivery emphases have on launch flexibility differ by the level of quality roadmap.

When the quality roadmap is poor, emphasizing cost in supplier selection has negligible effect on launch flexibility achieved. On the other hand, when the quality roadmap is good, the impact of cost emphasis on launch flexibility is positive for low to moderate level of emphasis on cost, and negative when the cost emphasis goes beyond moderate level. What this means is that good quality roadmap enhances the impact of cost emphasis on launch flexibility only up to moderate level of cost emphasis; beyond which, further emphasizing on cost when selecting supplier will negates the needs of a good quality roadmap, resulting in reduced launch flexibility. In summary, emphasizing cost when selecting supplier will have no effect on launch flexibility, provided that the quality roadmap is good, and even then the emphasis should be up to moderate level only.

Figure 3 shows that for all levels of emphasis on delivery performance, launch flexibility is always higher when we have a good quality roadmap. Further, in the absence of a good quality roadmap, delivery performance should be emphasized only up to moderate levels to ensure it contribute positively to launch flexibility. On the other hand, if there is a good quality roadmap to manage suppliers,

delivery performance should be emphasized at least at moderate level to gain the positive effect of the selection criteria on launch flexibility.

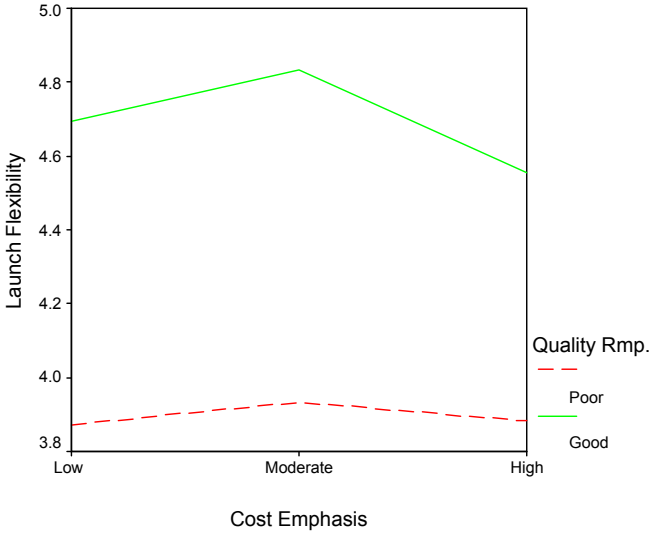

Figure 2. Moderating effect of quality roadmap on cost emphasis – launch flexibility relationship

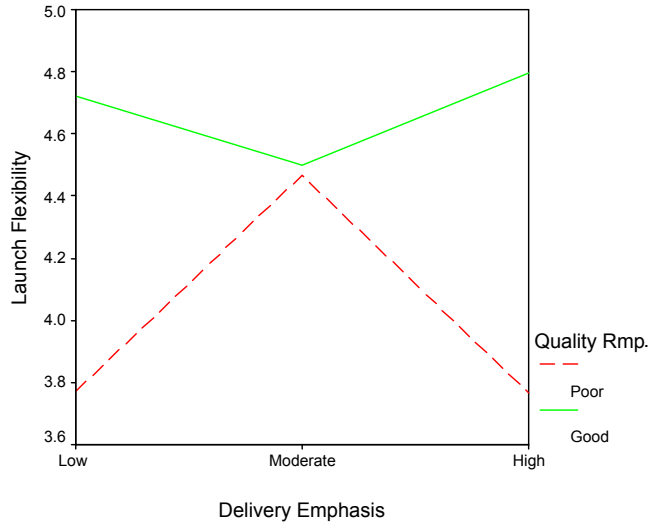

Figure 3. Moderating effect of quality roadmap on delivery emphasis – launch flexibility relationship

Moderating Effect of Technology Roadmap on the Relationship between Supplier Selection Strategies and Manufacturing Flexibility

Results of the hierarchical regression analysis to address the moderating effect of technology roadmap are summarized in Tables 5a–5c.

The moderating effect of technology roadmap mirrors that of quality roadmap, in that it moderates the relationship only when the dependent variable is launch flexibility, whilst becoming a predictor variable for both product and volume flexibilities. However, there are also subtle differences in the moderating effects of technology roadmap compared to that of quality roadmap. Firstly, we notice that the improvement in the explanatory power of the models with the inclusion of technology roadmap is higher compared to quality roadmap: 6% as opposed to 3% for product flexibility model, 10% compared to 6% for volume flexibility, and 25% compared to 20% for launch flexibility. Like quality roadmap, technology roadmap moderates the impact of cost emphasis on launch flexibility; but unlike quality roadmap, technology roadmap moderates the impact of technology-quality emphasis (rather than delivery emphasis) on launch flexibility. Figures 4 and 5 illustrate the moderating effect of technology roadmap on the relationship between cost emphasis and technology-quality emphasis and launch flexibility.

Like quality roadmap, launch flexibility is higher for all levels of cost emphasis and technology-quality emphasis, when the technology roadmap is good. In the relationship between cost emphasis and launch flexibility, we note that when the technology roadmap is poor, cost emphasis has positive effect on launch flexibility only when the level of emphasis is moderate to high. The effect is negligible when the emphasis is low to moderate. On the other hand, when the technology roadmap is good, the effect of cost emphasis on launch flexibility is an inverted U-shaped; positive when cost emphasis varies from low to moderate, and negative when it is moderate to high. The above suggests that when the technology roadmap is good, there is a lower limit on cost emphasis before it begins to positively affect launch flexibility; whereas when the technology roadmap is poor, there is an upper limit on the positive impact of cost emphasis on launch flexibility.

The moderating effect of technology roadmap on the relationship between technology-quality emphasis and launch flexibility is somewhat different. Figure 5 shows that irrespective of whether the roadmap is poor or good, emphasis on technology-quality when selecting supplier positively affects launch flexibility. However, the slope of the curve representing poor technology roadmap is steeper than the slope for good technology roadmap. This indicates that the emphasis on technology-quality when selecting suppliers enhances launch flexibility more in

the case when the technology roadmap is poor than when it is good. Alternatively, one can argue that in the absence of a good technology roadmap, greater emphasis on technology-quality issues has to be addressed when selecting suppliers, in order to ensure a certain level of launch flexibility.

TABLE 5a
MODERATING EFFECT OF TECHNOLOGY ROADMAP ON SUPPLIER SELECTION STRATEGY – PRODUCT FLEXIBILITY RELATIONSHIP

	Model		
	1	2	3
R^2 change	0.142	0.032	0.025
F-change	4.814**	3.287+	0.879
Variables	Standardized β		
Technology-quality emphasis	0.344**	0.244*	–0.119
Cost emphasis	0.0827	0.084	0.418
Delivery emphasis	0.0350	0.031	0.215
Technology roadmap		0.205+	0.463
Technology-quality-technology roadmap interaction			0.861
Cost-technology roadmap interaction			–0.676
Delivery-technology roadmap interaction			–0.398

Note. +significant at 0.1; *significant at 0.05; **significant at 0.01

TABLE 5b
MODERATING EFFECT OF TECHNOLOGY ROADMAP ON SUPPLIER SELECTION STRATEGY– VOLUME FLEXIBILITY RELATIONSHIP

	Model		
	1	2	3
R^2 change	0.095	0.098	0.018
F-change	3.088*	10.528**	0.621
Variables	Standardized β		
Technology-quality emphasis	0.274*	0.097	0.499
Cost emphasis	–0.040	–0.035	0.423
Delivery emphasis	0.074	0.072	0.137
Technology roadmap		0.359**	1.790
Technology-quality-technology roadmap interaction			–0.914
Cost-technology roadmap interaction			–0.866
Delivery-technology roadmap interaction			–0.095

Note. +significant at 0.1; *significant at 0.05; **significant at 0.01

TABLE 5c
MODERATING EFFECT OF TECHNOLOGY ROADMAP ON SUPPLIER SELECTION STRATEGY – LAUNCH FLEXIBILITY RELATIONSHIP

	Model		
	1	2	3
R^2 change	0.099	0.118	0.139
F-change	3.211*	13.078**	6.032**
Variables	Standardized β		
Technology-quality emphasis	0.296**	0.102	-0.672+
Cost emphasis	0.028	0.033	0.906*
Delivery emphasis	0.031	0.029	0.471
Technology roadmap		0.395**	1.267
Technology-quality-technology roadmap interaction			1.846*
Cost-technology roadmap interaction			–1.741*
Delivery-technology roadmap interaction			–0.942

Note. +significant at 0.1; *significant at 0.05; **significant at 0.01

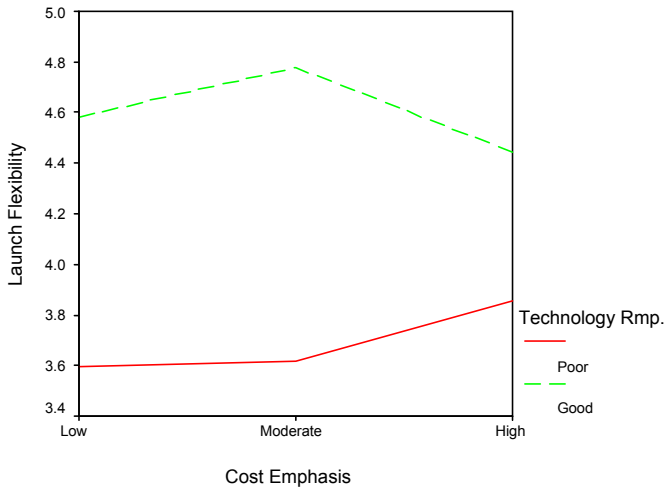

Figure 4. Moderating effect of technology roadmap on cost emphasis – launch flexibility relationship

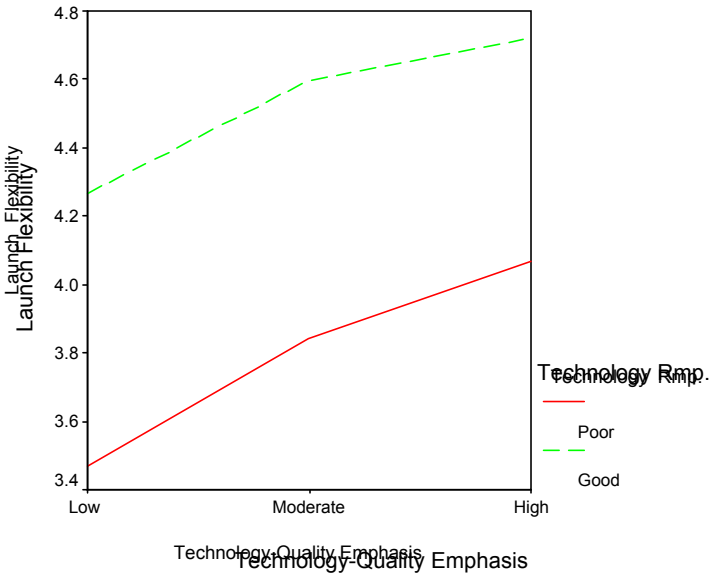

Figure 5. Moderating effect of technology roadmap on technology-quality emphasis – launch flexibility relationship

In general, the findings of the study may be summarized in Table 6.

TABLE 6
SUMMARY OF EFFECTS

	Manufacturing flexibility		
Supplier selection strategies	Product	Volume	Launch
Technology-quality emphasis	D	D	D; M2
Cost emphasis	–	–	M1; M2
Delivery emphasis	–	–	M1
Supplier management strategies			
Quality roadmap	D	D	
Technology roadmap	D	D	

Note. D = direct effect; M1 = moderated by quality roadmap; M2 = moderated by technology roadmap

DISCUSSION AND IMPLICATIONS OF THE FINDINGS

Supplier Selection Strategies and Manufacturing Flexibility

The outcomes of this research are many. Firstly, in terms of the construct of manufacturing flexibility, our study shows that the dimension of launch flexibility deserves attention though the extant literature focuses mainly on product and volume flexibility. The factor analysis and the extent that this dimension of flexibility varies by the different selection strategies, indicate that this dimension of flexibility should be explored further, as it may prove to be the differentiating factor in today's competition.

Secondly, in terms of the supplier selection strategy, we see a convergence of the technology and quality emphasis in the Malaysian context. It is therefore possible to argue that under the current competitive scenario, technology and quality issues are highly correlated that it is difficult to differentiate between them. In the present context, where society is technology driven, quality is often treated synonymously with technology, and vice versa.

Thirdly, in terms of the direct impact on manufacturing flexibility, selecting suppliers on the basis of technology and quality performance outstrips the other two selection criteria. To achieve a wider range of product, be able to meet varying demand volumes, and be able to deliver fast enough to the market is crucial nowadays as competition gets more intense. Only firms with cutting-edge technology can out-compete its rivals by introducing extensive range of products to meet the different market segments, and able to deliver quickly to the market before competitors can do so. By selecting suppliers with leading edge technology, the manufacturer can leverage this competency in introducing more products and also enjoy the first mover advantages. Sun Microsystems involves key suppliers in the design of new workstations, networking systems and supercomputers to shrink cycle time. Sun taps on the latest and greatest technology of its suppliers to allow it to continuously introduce more new product quickly ahead of its competitors. Besides, the quality of new products that are entering the markets today far outstrip that of yesteryears, to meet the ever increasing demand of customers who are spoilt for choices. Thus, selecting suppliers of components, who are capable of meeting stringent quality specifications also, is critical to support manufacturing flexibility. In summary we find that emphasizing technology and quality performance in selecting suppliers will enhance all the three dimensions of manufacturing flexibility. However, this does not preclude the effect of the other two selection criteria, as we have found them to have effect on launch flexibility, though moderated by the supplier management strategies of technology and quality roadmaps. This is discussed next.

Moderating Effect of Quality Roadmap on the Relationship between Supplier Selection Strategies and Manufacturing Flexibility

This study finds that quality roadmap acts as a predictor, with positive effects on product and volume flexibility. This means that the effect of quality roadmap applies uniformly across all supplier selection strategies and all levels of the selected strategy. Thus, having a good quality roadmap in managing suppliers will enhance a manufacturer's product and volume flexibilities irrespective of how it choose its suppliers. When the supplier and the manufacturer have similar quality roadmap, it means they have identical quality expectation. This allows the supplier to fulfill the manufacturer's requirement easily with less cost incurred along the partnership. Further, with a good quality roadmap, ensuring quality standards in new product is less costly since a lot of understanding and expectation have been calibrated. This finding supports that of Handfield et al. (2000), who proposed a supplier development program to create an expectation on quality roadmap between manufacturer and suppliers. BMW published a Supplier Partnership Manual and held seminars for suppliers to present their "Roadmap to Quality". Again, the quality roadmap prepares a good platform for product development and ensures smooth manufacturing. It enhances the supplier's delivery performance by eliminating or reducing re-work or other corrective quality up-grade situations. In short, good quality roadmap reduces the cost to supplier and manufacturer while improving the delivery performance for new product introduction.

Further, in the case of launch flexibility, the study finds that apart from the better launch flexibility accruing from good quality roadmap, the impact of supplier selection strategies that emphasize cost and delivery performance on launch flexibility varies by the quality of the roadmap. The quality roadmap has to be good if the emphasis on cost when selecting suppliers is to have any positive effect on launch flexibility; however the emphasis on cost should not go beyond moderate level. This is logical given that a cost strategy is anathema to innovativeness and flexibility in general. Pursuing a cost strategy allows for greater slack resources (financial) to the manufacturer to deal with the demand of launch flexibility; but this will only work if supported by a good quality roadmap. However, over-emphasizing the cost strategy when selecting suppliers will limit the choice of suppliers, thus curtailing the positive effect of a good quality roadmap, leading to a deterioration in the level of launch flexibility. Thus, manufacturers should only pursue selection strategy on the basis of cost only when a good quality roadmap is in place, and that it should not be overemphasized.

In similar vein, the study also finds that launch flexibility benefits from a good quality roadmap irrespective of the level of emphasis placed on delivery

performance when selecting supplier. The positive effect of selecting suppliers on the basis of delivery performance occurs under two situations: (1) when the delivery emphasis is low to moderate and the quality roadmap is poor, and (2) when the delivery emphasis is moderate to high and the quality roadmap is good. Choosing suppliers with lead-time reduction program and good on-time delivery performance, allows for greater time slack at the manufacturer's end. Putting too much pressure on suppliers to reduce supply lead time can lead to quality issues in the supplies, that may require more time for reworks, outweighing the time benefits of on-time deliveries. Thus, when the quality roadmap is poor, there is an upper limit as to what emphasis on delivery can contribute to launch flexibility. On the other hand, when the quality roadmap is good, low level of delivery performance of suppliers will only jeopardize launch flexibility. Insisting on quality supplies can lead to delays in delivery, which can outweigh the time saved from not having to rework supplies. Thus, when quality roadmap is good, there is a lower limit as to when emphasis on delivery begins to bring dividend to launch flexibility.

Moderating Effect of Technology Roadmap on the Relationship between Supplier Selection Strategies and Manufacturing Flexibility

As highlighted by Wynstra, Weele, and Weggemann (2001), technology roadmap can provide the right investment for both manufacturer and suppliers for new product introduction. If the manufacturer can configure its future technology requirement, it can collaborate with its supplier to develop the technology required for its future product. If this does not happen, the manufacturer will eventually expend more resources to source and manage the suppliers when in urgent need. This may not even be feasible if the lead time or time to market window is too short. In the worst-case situation, the manufacturer might even miss the launch schedule and be overtaken by its competitors who possess the technology. It is suggested that the manufacturer should pursue strategic investment in technology (Ndubisi & Jantan, 2003) and involve suppliers in formulating the technology roadmap to improve its launch flexibility.

Like quality roadmap, technology roadmap acts both as a predictor and a moderator in the relationship between supplier selection strategies and manufacturing flexibility; as a predictor in the relationship between supplier selection strategies and product/volume flexibility, and a moderator for launch flexibility. In its predictor role, it complements the positive effects of the selection strategies on product and volume flexibilities, just as in the case of quality roadmap. In the case of launch flexibility, it moderates the impact of cost and technology-quality emphases; though in both cases the level of launch flexibility is higher when the technology roadmap is good. However, we note that the positive effect of cost emphasis occurs only when it varies from low to

moderate level; indicating an upper limit to cost emphasis when selecting supplier, when the technology roadmap is good. On the other hand, when the technology roadmap is poor, the positive effect of cost emphasis becomes apparent when the emphasis is at moderate level or higher. As argued above, emphasizing on cost provides the manufacturer with slack that can be utilized to enhance launch flexibility; however, how much it should be emphasized depends on the management strategy used. When the emphasis is low to moderate, cost emphasis benefits launch flexibility when there is a good quality roadmap in place. However, when the emphasis is moderate to high, it enhances launch flexibility only when the technology roadmap is poor; suggesting that the requirements for a good technology roadmap outweigh the benefits of cost emphasis.

Similarly, when suppliers are selected on the basis of their technological and quality performance, managing them with a good technology roadmap will always be better in terms of launch flexibility. However, the marginal impact of this selection strategy is higher when the technology roadmap is poor. This suggests that when there is no strategy to manage suppliers in technological terms, the impact of strategy that selects suppliers on technological and quality terms, bring greater benefits to launch flexibility.

The findings of the current research suggest several general strategic and operational implications. The study provides an avenue to explore the strategic decision of supplier selection and supplier management with respect to different types of manufacturing flexibilities. Different types of manufacturing flexibility require different driver in supplier selection and supplier management. There is no one single formula that applies to all models. For example, the manufacturer who is focusing on launch flexibility need to emphasize more on technology in supplier selection, quality roadmap and technology roadmap in supplier management.

The manufacturer needs to identify its own types of flexibility before any strategic decision can be made for supplier selection and management. In the past, the manufacturer may need to concentrate on various types of flexibilities under one roof. With the trend of globalization, flexibility differentiation is becoming more common as global companies continue to disperse their product value creation chain around the globe to lower cost and increase product quality. Products are designed in US or Europe, and manufactured in Asia. This means that a company US operation is focusing on product and launch flexibility, while its Asian operation is focusing on volume flexibility. It is helpful for manufacturers to communicate future quality and technology propositions to the suppliers so as to enable them gear up for any challenges.

LIMITATIONS OF THE STUDY

A few limitations are identified and recognized while conducting this research. Although the research is considered successful in meeting the research objectives, it has few limitations. It assumes that the information collected from the primary research source, questionnaire survey, is valid and representative. It is also assumed that the respondents answered the questions honestly and to the best of their abilities.

The study is limited by both the sample selection and scope. First, the study is focused on the manufacturing firms in the northern region of Peninsular Malaysia. Thus, it may suffer from regional clustering bias. Second, up to 81.5% of the responding companies are foreign-owned multinational firms. It is needful to increase the number of local organizations to participate in the future research.

Readers should also note that the results obtained in this study are particularly relevant to the high volume-technology intensive businesses. This is because the manufacturers under survey are electronic, telecommunication and computer industry, which are mostly involved in high volume manufacturing activities. This also limits the generalizability of the findings.

SUGGESTION FOR FUTURE RESEARCH

There is limited literature on the supplier selection strategy and supplier management strategy with respect to manufacturing flexibility. There are other types of manufacturing flexibility such as material flexibility, equipment flexibility, program flexibility and market flexibility that is not covered in this study. Future research should be directed at these flexibilities.

This study has focused on manufacturing concern, thus the issue of manufacturing flexibility. Another question that needs addressing is the question of "Is flexibility valid for service operation? And if so, how can it be achieved?"

To complete the entire supply chain, the manufacturer must ensure that its downstream supply chain such as distribution channels, supporting organizations, and other out-bound logistics are robust enough to satisfy the customers apart from the upstream activities addressed in this study. This downstream chain should be examined for their flexibilities as well.

Moreover, study on the impact of supplier management strategy on the relationship between supplier selection strategies and manufacturing flexibility is

in its infancy. More research is definitely needed. Future research in this area should also replicate this study with an extension to other industries in Malaysia.

CONCLUSION

In conclusion, we find that launch flexibility, though largely ignored in the extant literature deserves attention when considering manufacturing flexibility. Further, manufacturing flexibility improves when suppliers are selected on the basis of technology and quality, and that good technology and quality roadmaps are in place to manage them. However, when launch flexibility is the focus and a selection strategy that emphasizes cost is used, good technology and quality roadmaps should be in place to manage suppliers, and the emphasis on cost should not go beyond moderate level. Alternatively, if the manufacturer uses delivery performance as a supplier selection criterion, a good quality roadmap should be used to manage the supplier and the emphasis on delivery should be high. Further, a good technology roadmap should be used to manage suppliers in conjunction with a supplier selection strategy that focuses on technology and quality performance. In summary, the choice of which selection strategy should be used to select suppliers depends on not only the focal manufacturing flexibility (product, volume, or launch) but also the ensuing strategy (quality and technology roadmaps) to manage the suppliers.

REFERENCES

Anand, G., & Ward, P. T. (2004). Fit, flexibility and performance in manufacturing: Coping with dynamic environment. *Journal of Production and Operations Management, 13*(4), 369–385.

Barad, M., & Sipper, D. (1988). Flexibility in manufacturing systems: Definitions and perti-net modeling. *International Journal of Production Research, 26*(2), 237–248.

Carter, P. I., Carter, J. R., Monczka, R. M,. Slaight, T. H., & Swan, A. J. (2000). The future of purchasing and supply: A ten-year forecast. *The Journal of Supply Chain Management, 36*(1), 14–26.

Christopher, & Martin. (1997). *Marketing logistics.* Oxford, England: Butterworth-Heinemann.

Forker, L. B., Ruch, W. A., & Hershauer, J. C. (1999). Examining supplier improvement effort from both sides. *Journal of Supply Chain Management, 35,* 40–50.

Germain, R., Droge, C., & Christensen, W. (2001). The mediating role of operations knowledge in the relationship of context with performance. *Journal of Operations Management, 19,* 4553–69.

Gerwin, D. (1993). Manufacturing flexibility: A strategic perspective. *Management Science, 39*(4), 395–410.

Goffin, K., Szwejczewski, M., & Colin, N. (1997). Managing suppliers: When fewer can mean more. *International Journal of Physical Distributions and Logistics Management, 27*(7), 422–436.

Gupta, Y. P., & Goyal, S. (1989). Flexibility of manufacturing systems: Concepts and measurements. *European Journal of Operational Research, 43,* 119–135.

Hahn, C. K., Watts, C. A., & Kim, K. Y. (1990). The supplier development program: A conceptual model. *Journal of Purchasing and Material Managements, 26*(2), Spring, 2–7.

Hair, J. F. Jr., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis* (5th ed.). Upper Saddle River, NJ: Prentice-Hall Inc.

Handfield, R. B., Ragatz, G. L., Petersen, K. J., & Monczka, R. M. (1999). Involving suppliers in new product development. *California Management Review, 42*(1), 59–82.

Handfield, R. B., Krause, D. R., Scannel, T. V., & Monczka, R. M. (2000). Avoid the pitfalls in supplier development. *Sloan Management Review,* Winter, 37–49.

Hauser, J. R., & Wernerfelt, B. (1990). An evaluation cost model of consideration sets. *Journal of Consumer Research, 16*(March), 393–408.

Hayes, R. H., & Wheelwright, S. C. (1984). *Restoring our competitive edge: Competing through manufacturing*. New York: John Wiley & Sons.

Inman, R. A., & Hubler, J. H. (1992). Certify the process, not just the product. *Production and Inventory Management Journal, 33*(4), 11–14.

Koste, L. L., & Malhotra, M. K. (1999). A theoretical framework for analyzing the dimensions of manufacturing flexibility. *Journal of Operations Management, 18(1),* 75–93.

Lemke, F., Goffin, K., & Szwejczewski, M. (2000). Supplier base management: Experiences from the UK and Germany. *The International Journal of Logistics Management, 11*(2), 45–58.

Lieberman, M. B., & Montgomery, D. B. (1988). First mover advantages. *Strategic Management Journal, 9*(1), 41–58.

Maidique, M. A., & Ziger, B. J. (1984). A study of success and failure in product innovation: The case of US electronics industry. *IEEE Transactions of Engineering Management,* November, 192–203.

McMath, R. M., & Forbes, T. (1998). What were they thinking: Marketing lessons I've learned from over 80,000 new product innovations and idiocies. New York: Times Business, 22–24; 129–130.

Morgan, J., & Monczka, R. M. (1995). Alliances for new products. *Purchasing*, January 12, 103–109.

Narasimhan, R., & Das, A. (1999). An empirical investigation of the contribution of strategic sourcing to manufacturing flexibilities and performance. *Decision Sciences, 30*(3), 683–718.

Ndubisi, N. O., & Jantan, M. (2003). Malaysian entrepreneurs and strategic use of information technology. *Malaysian Management Review, 38*(1), 32–42.

Pearson, J. N., & Ellram, L. M. (1995). Supplier selection and evaluation in small versus large electronics firms. *Journal of Small Business Management, 33*(4), 53–65.

Pender, R. (1993). Partnering for profit. *Total Quality Management, 4,* 13–16.

Robinson, W. T., Fornel, C., & Sullivan, M. W. (1992). Are market pioneers intrinsically stronger than later entrants? *Strategic Management Journal, 13,* 609–624.

Schroeder, R. G. (2000). *Operations management, contemporary concepts and cases*. Chicago: Irwin.

Sethi, A. K., & Sethi, S. P. (1990). Flexibility in manufacturing: A survey. *The International Journal of Flexible Manufacturing Systems, 2,* 289–328.

Sharma, S., Durand, R. M., & Gur-Arie, O. (1981). Identification and analysis of moderator variables. *Journal of Marketing Research, 18,* 291–300.

Suarey, F., Cusumano, M. A., & Fine, C. H. (1991). *Flexibility and performance: A literature critique and strategic framework*. Cambridge, Mass.: Sloan School, Massachusetts Institute of Technology.

Teague, P. E. (1997, May 5). Suppliers: The competitive edge in design. *Design News, 52*(9), SD5–15.

Trent, R. J., & Monczka, R. M. (1998). Purchasing and supply management: Trends and changes throughout the 1990s. *The Journal of Supply Chain Management, 34*(2), Fall, 2–11.

Upton, D. M. (1994). The management of manufacturing flexibility. *California Management Review,* Winter, 72–89.

Upton, D. M. (1995). What really makes factories flexible? *Harvard Business Review,* July/August, 74–84.

Vickery, S., Calantone, R., & Droge, C. (1999). Supply chain flexibility: An empirical study. *The Journal of Supply Chain Management, 35*(3), Summer, 16–25.

Vonderembse, M. A., & Tracey, M. (1999). The impact of supplier selection criteria and supplier involvement on manufacturing performance. *The Journal of Supply Chain Management*, Summer, 33–39.

Wacker, J. G. (1996). A theoretical model of manufacturing lead times and their relationship to a manufacturing goal hierarchy. *Decision Sciences, 27*(3), 483–517.

Watts, C., & Hahn, C. (1993). Supplier development programmes: An empirical analysis. *International Journal of Purchasing and Materials Management, 29*(2), 11–17.

Weber, C. A., & Current, J. R. (1991). Vendor selection criteria and methods. *European Journal of Operational Research, 50,* 2–18.

Wynstra, F., Weele, A. V., & Weggemann, M. (2001). Managing supplier involvement in product development: Three critical issues. *European Management Journal, 19(2),* 157–166.

Zelenovic, D. M. (1982). Flexibility: A condition for effective production systems. *International Journal of Production Research, 20*(3), 319–337.

Zhang, Q., Vonderembse, M. A., & Lim, J. (2003). Manufacturing flexibility: Defining and analyzing relationships among competence, capability and customer satisfaction. *Journal of Operations Management, 21,* 173–191.