

The Impact of Purchasing and Early Supplier Involvement (ESI)
in a Manufacturing Firm

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ABSTRACT

Globalization has caused increasing competitive pressures to manufacturers worldwide such as rapid technological development, increasing level of end-product complexity, shorter product life cycle and lead time, clock speed competition, and increased outsourcing. Thus, early supplier involvement (ESI) in new product development is becoming vital to manufacturing industry in developing competitive advantage, ever since manufacturing sector is the forerunner of the economic growth in Malaysia. This paper examines ESI in four building blocks of design, procurement, supplier, and manufacturing requirements, through the use of in-depth case study on a German based company. The objectives of the research are to study the supplier involvement in the mutual inclusive building blocks of ESI conceptual framework, to identify the factors that lead companies to implement ESI, and to analyze the impacts of ESI implementation. In addition, barriers to the effective ESI implementation includes suppliers are not allowed to involve in the process of the production at the final stage, and suppliers being not cooperative and slow in delivery. The critical factors that attract ESI implementation are to create strategic partnership with robust supply base, in which to produce best qualities with continuous cost cutting improvements, more dependent on suppliers to meet increasing competition and close collaboration between buying firm and suppliers. The findings revealed that the company is less actively in practicing ESI, in approaching suppliers and sharing information on design manufacturability and cost improvement, as it gives great impact on purchasing decision to accommodate effective and efficient supply on parts and components. The case study highlights the early supplier involvement during new product development, which is served as a valuable benchmark and guidelines for practitioners.

ABSTRAK

Globalisasi menjadi salah satu faktor utama yang menyumbang kepada peningkatan kebersaingan di kalangan pengeluar seperti perkembangan teknologi, peningkatan tahap kerumitan produk akhir, kitar hidup produk yang singkat, pengurangan penggunaan masa dan peningkatan dalam proses *outsourcing*. Maka, Penglibatan Pembekal Secara Awal (ESI) dalam pembangunan produk telah menjadi suatu kepentingan kepada industri pengeluaran bagi mewujudkan kelebihan bersaing, memandangkan sektor pengeluaran merupakan penyumbang utama kepada pertumbuhan ekonomi di Malaysia. Kajian ini melihat tahap empat rangka kerja ESI terutama rekabentuk, pembelian, pembekal dan pembuatan ke atas sebuah syarikat pembuatan Jerman di Johor. Objektif kajian ini termasuk mengkaji penglibatan pengeluar dalam konsep rangka kerja ESI, mengenal pasti faktor organisasi melaksanakan ESI dan menganalisa kesan pengaplikasian ESI ke atas organisasi. Tambahan, antara halangan yang dihadapi oleh syarikat dalam pelaksanaan ESI termasuk pembekal tidak dibenarkan terlibat dalam proses pembuatan di peringkat akhir dan kurang kerjasama oleh pembekal dan lewat dalam penghantaran. Faktor kritikal dalam pelaksanaan ESI ialah mewujudkan rakan strategik dengan pangkalan pembekal yang dinamik, bagi menghasilkan pembekal berterusan dalam pengurangan kos, bergantung terus kepada pembekal dalam peningkatan bersaing dan kerjasama yang rapat antara firma membeli dengan pembekal. Hasil kajian mendapati syarikat tersebut tidak berapa aktif dalam mengaplikasi dan menguasai penggunaan ESI dengan menarik pengeluar berkongsi maklumat dalam reka bentuk pembuatan dan pembekal pengurangan kos berbanding, dan memberi impak kepada keputusan pembelian supaya lebih efektif and efisien dalam pembekalan komponen. Kajian ini mengetengahkan penggunaan ESI dalam pembangunan produk baru yang mana menjadikan sebagai penanda aras yang bernilai dan bimbingan kepada pengamal.

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THE LIST OF SYMBOLS AND ABBREVIATION

ABBREVIATIONS

ABC	-	Activity Based Costing
AIAG	-	Automotive Industry Action Group
APQP	-	Advanced Product Quality Planning
ASL	-	Approved Suppliers List
AV	-	Audio Visual
BPR	-	Business Process Engineering
CSFs	-	Critical Success Factors
DFQ	-	Design for Quality
DR	-	Design Recognition
EDI	-	Electronic Data Interchange
ESI	-	Early Supplier Involvement
ETA	-	Estimate-To-Arrive
E&E	-	Electrical and Electronics
GDP	-	Gross Domestic Product
GSQM	-	Global Supplier Quality Manual
IBM	-	International Business Machines
IMDS	-	International Material Data System
IPI	-	Industrial Production Index
JIT	-	Just-In-Time
MSA	-	Measurement System Analysis

NPD	-	New Product Development
ODM	-	Original Design Manufacture
OEMs	-	Original Equipment Manufacturers
PFMEA	-	Potential Failure Mode and Effects Analysis
PO	-	Purchasing Order
PPAP	-	Production Part Approval Process
PSZ	-	Perpustakaan Sultanah Zanariah
QA	-	Quality Assurance
RFQ	-	Request for Quotation
R&D	-	Research and Development
SAW	-	Surface Accoustic Wave
SDN. BHD.	-	Sendirian Berhad
SKU	-	Stock Keeping Units
SMEs	-	Small and Medium Enterprises
SPC	-	Statistical Process Control
TCE	-	Transaction Cost Economics
TQM	-	Total Quality Management
UTM	-	Universiti Teknologi Malaysia
VE	-	Value Engineering
WIP	-	Work-In-Process

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CHAPTER I

INTRODUCTION

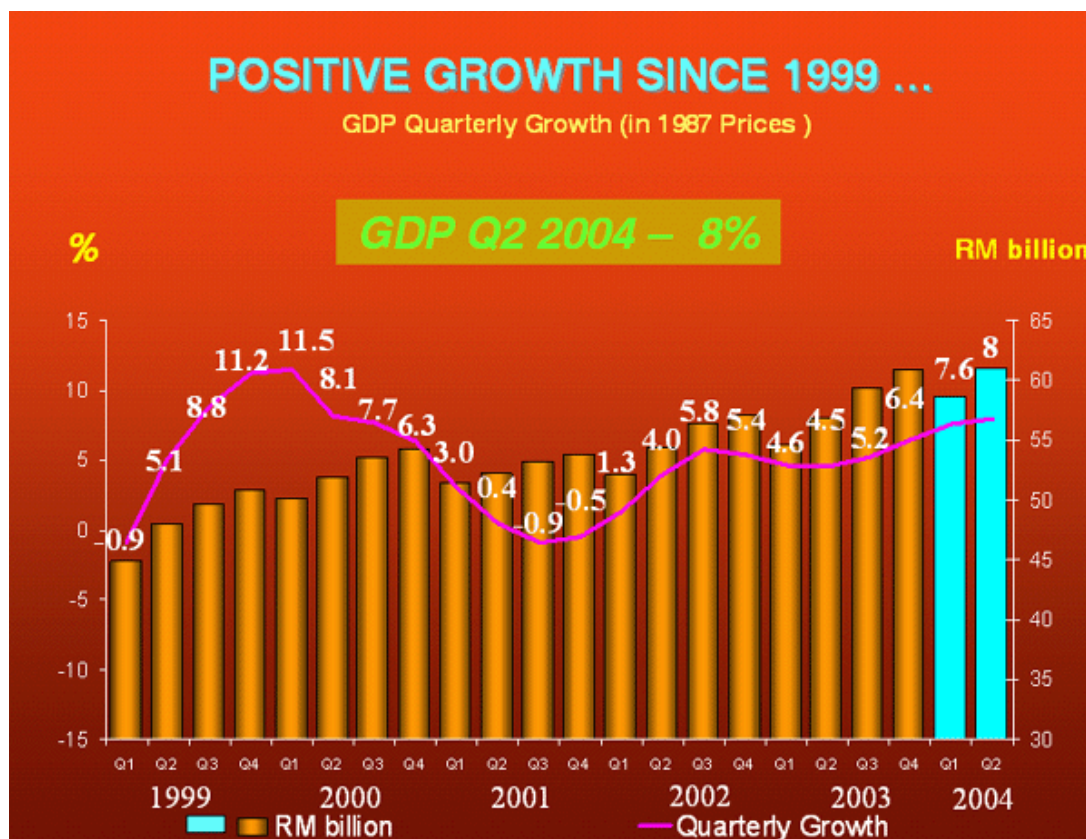
1.1 Introduction

The economy of Malaysia once relied principally on its endowment factors, which are the export of agricultural products and natural resources such as natural rubber, timber and palm oil. The Malaysian economy has also experienced rapid economic growth during the past three decades. This growth has been accompanied by low inflation, reduced unemployment, falling poverty, reduction in income inequalities, and rising per capita income. The manufacturing sector has played a decisive role in Malaysian economic success, contributing significantly to output, employment, and exports.

Manufacturing sector has been main key player in developing the economy the Malaysia through industrialization and the establishment of small-and-medium enterprises (SMEs) ever since 1985. Consequently, manufacturing industry especially electrical & electronic sector has gained its significance in the economy especially in trading which has contributed to the Gross Domestic Product (GDP).

As exhibited in Figure 1.1, the Malaysian economy registered a sharp growth of 7.6 percent in the first quarter of 2004 (Q1 2003: 4.6 percent), and subsequently 8 per cent in the second quarter of 2004, the strongest quarterly growth since the third quarter 2000. By year end 2004, with strong exports and the robust manufacturing and services sector the country recorded 7.1 % , however dropped

slightly 5% due to international sluggish economy and estimated 5.5% by year end 2006 (MOF, 2005/06).

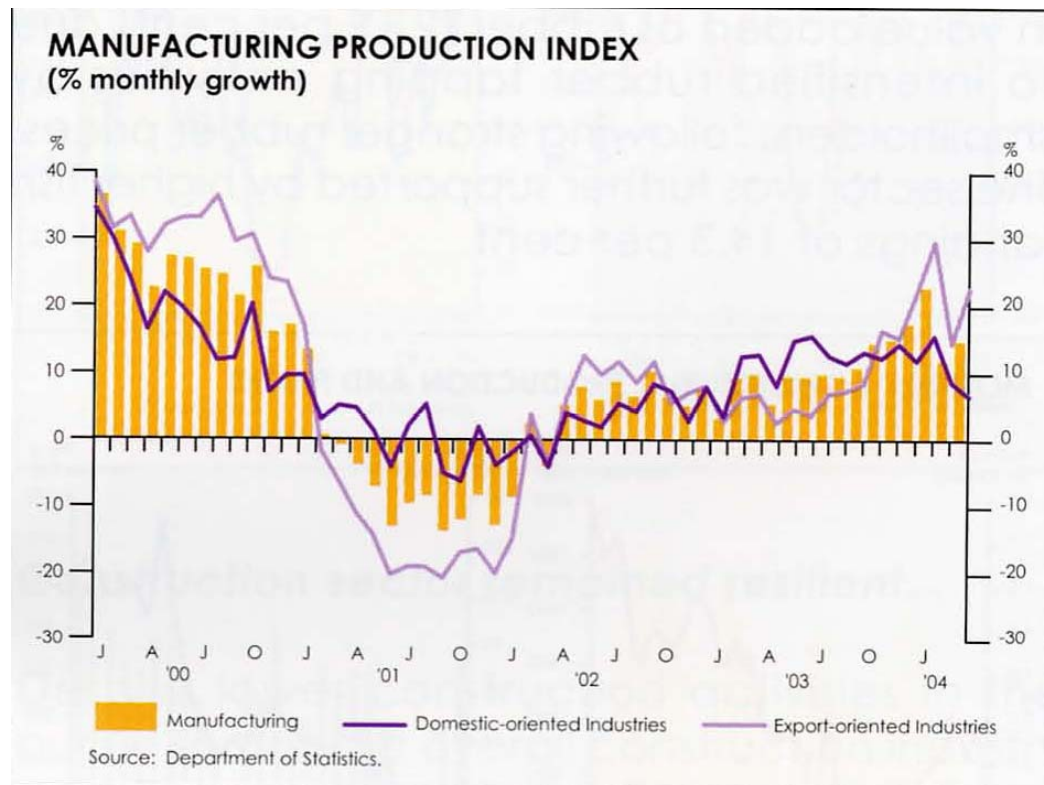


Source: Malaysia Ministry of Finance, 2004

Figure 1.1: GDP (Quarterly Growth Cycle)

According to Yau (2004), in a report from Avenue Securities Research, the index for manufacturing output, which makes up 70.4% of the industrial production index (IPI), the bullish manufacturing sector was backed by output increases in both export-oriented and domestic-oriented industries.

The manufacturing sector, the fore-runner of the economic growth, continued to perform impressively after going through turbulent in 2001, however strengthened back to post strong growth of 16.3 per cent from improved business confidence and global economic recovery, as shown in Figure 1.2, the manufacturing production index (MPI).



Source: Malaysia Ministry of Finance, 2004

Figure 1.2: Manufacturing Production Index (Quarterly Growth Cycle)

Due to the increased of global demand for semiconductors, output of export-oriented industries tripled to 22.1 per cent in the first quarter of 2004 (year-on-year). Improved sales of electrical and electronic (E&E) products to the Asia region, particularly to China and India, as well as higher value-added activities had boosted growth of the sector by 24.6 per cent.

Globalization has ultimately caused sensational changes to manufacturing industries whereby increases the challenges faced by manufacturers as trade barriers fall and markets open up. Consequently, products should become more homogenized and rationalized (Prasad and Sounderpandian, 2003) since practitioners have to compete in the market globally that is beyond their boundaries. The competitive pressures include rapid technological development, advances in transportation technology, shorter product life cycle, shorter lead time, faster

MANUFACTURING PRODUCTION INDEX (% annual change)							
	2002	2003	2003				2004
			Q1	Q2	Q3	Q4	
Overall Manufacturing	4.5	10.5	7.6	8.2	10.1	15.7	16.3
Export-oriented industries	5.5	8.9	5.5	3.8	7.8	18.1	22.1
Electronics & electrical	8.1	8.1	5.4	3.3	7.3	22.1	24.6
Wood products	-6.0	0.9	4.3	-0.4	1.1	-0.9	13.8
Textiles & apparel	-6.2	-2.2	0.8	2.2	0.4	-11.0	-10.4
Rubber products	2.1	17.6	9.6	14.3	24.1	21.5	27.4
Domestic-oriented industries	3.5	12.1	9.8	13.0	12.6	13.1	10.4
Chemical & chemical products	1.1	14.6	8.6	22.8	10.8	17.4	18.1
Plastic products	5.5	30.6	31.3	25.1	34.1	31.7	15.2
Non-metallic minerals	5.5	10.8	10.6	12.5	10.8	9.5	-1.1
Food manufacturing	4.8	10.9	6.6	17.9	15.5	3.9	4.3
Transport equipment	6.2	-5.5	-6.6	-13.5	-3.8	3.4	0.8
Crude oil refineries	-1.3	1.7	3.6	15.8	-8.7	-1.6	-2.1
Iron & steel	2.0	12.9	16.9	1.6	19.4	15.2	6.1
Fabricated metal products	0.8	7.4	3.8	7.9	0.5	17.5	28.2
Paper & paper products	12.8	8.1	15.1	-3.3	17.5	3.9	-0.9

Source: Malaysia Ministry of Finance, 2004

Table 1.1: Manufacturing Production Index (Quarterly Growth Cycle)

response time to customers' demands, and producing innovative products.

According to Prasad and Sounderpandian (2003), shorter product life cycle means that firms need to profit from their new products quickly. Shorter product life cycles and competitive pressures have firms to find new ways to manage the supply chain of their products (Mikkola and Larsen, 2003). The competitive pressures include rapid technological development, advances in transportation technology, shorter product life cycle, shorter lead time, faster response time to customers' demands, and producing innovative products. Therefore, the ability of an organization to remain competitive is largely dependent upon the amount, quality, cost and timing of its materials and supplies and the effectiveness of its supply chain (Dowlatshahi, 1997). Effectiveness of supply chain would be the dominant factor that enables organizations to succeed in the intensely competitive market.

Past studies have linked supply chain performance to share holder value and showed that total supply chain costs account for more than half of the finished cost of a typical product (Sumantra, 2004). Hence, many supply chain strategies have been implemented to attain shorter time-to-market and higher profitability while expanding market share in the competitive market. Just-in-Time (JIT), lean manufacturing, concurrent engineering, business process engineering (BPR), total quality management (TQM) and other schemes to improve productivity might not be a source of competitive advantage in the future, but a minimum entry standard to compete in the global market. According to Thorne and Smith (2000), these currently fashionable tools and techniques will not provide the essential elements for the survival of any business beyond the year 2005.

World-class organizations in this new millennium will have to focus outwardly and involve their suppliers and customers in a strategic alliance that accept social and environmental responsibilities, thereby maintaining a cohesive, positive society and producing the best possible conditions for business growth. Companies that will prosper and gain competitive edge are those that develop strategic collaboration and integration with nation and international suppliers as the key to success by wise and future-oriented managers (Dowlatshahi, 1997).

1.2 Background

Early supplier involvement (ESI) has gained its importance in manufacturing sector in developing competitive advantage and to outperform rivals in market share while defending against competitive forces. It is generally known that approximately 80 per cent of the manufacturing cost of a product is determined by the design of the product (Mikkola and Larsen, 2003). Original Equipment Manufactures (OEMs) today are relying on their approved suppliers to drive efficiencies, heighten visibility, and help them get to market faster (McKeefry, 2000). OEM is similar to component integration or value added reselling and specifically refers to those manufacturers who re-labeling a product to sell it under their own brand name. By practicing early supplier involvement (ESI), suppliers in

approved suppliers list (ASL) will work closely together with manufacturers (customers) in sharing information, technological capabilities, knowledge, technical skills and experience.

In numerous industries, shorter product life cycles and increased competition have raised the level of interest in the management of new product development (NPD) processes. Many firms are looking for ways to decrease concept to customer development time and, improve quality and significantly reduce the cost of the resulting product simultaneously. One approach which many companies are taking is to involve material suppliers earlier in the design process. According to Monczka, *et. al.* (1997), supplier involvement ranges from simple consultation on design ideas to making suppliers fully responsible for the design of components, systems, processes, or services they will supply.

Early supplier involvement (ESI) has been advocated as a means of integrating suppliers' capabilities in the buying firm's supply chain system and operations. Partnerships with suppliers were formed together to take advantage of their technological expertise in designing and manufacturing (Dowlatshahi, 1998). The implementation of early supplier involvement (ESI) in these manufacturing sectors focusing on electrics and electronics industries is one of the strategies that companies should acquired to face the challenges in globalizations. In addition, nowadays, designing the relationship between customers and suppliers is very important and essential to sustain competitiveness within the marketplace. Liker, *et. al.* (1998), leading companies need more specific guidance in defining the optimal timing and integration of suppliers.

Great benefits and advantages can be obtained if suppliers are involved in the customer's product development as early as possible. Huang and Mak (2000) proposed that the rationale is that suppliers frequently possess vital product and process technology that can lead to improvements in product design and the new product development process itself. A cross-national study by Clark (1989) showed that much of the Japanese advantage in concept-to-market time was attributed to supplier involvement in the NPD process.

Smith and Zsidisin (2002) also proved that by engaging suppliers early in product design, the organization has recognized significant cost savings and enhanced its competitive position. ESI has come to be considered a critical activity since that 80 percent of the products' cost are locked during the design phase. And organizational contribution from ESI includes obtaining leverage with the supply base, improving design capabilities and instituting internal documentation of best practices for organization learning.

Early supplier involvement has beneficial to both suppliers and buyers. Benefits of ESI practices include reduced development costs, early availability of prototypes, standardization of components, visibility of the cost performance trade-off, consistency between design and supplier's process capabilities, reduced engineering changes, higher quality with defects, consistency between product tolerances and process capabilities, refinement of the supplier's processes, availability of detailed process data, reduced time to market, early identification of technical problems, reduced supplier's engineering time, acquisition of supplier's production capacity and supplier innovation (Bonaccorsi and Lipparini, 1994).

1.3 Problem Statement

The role of suppliers in the operations of manufacturing industry in Malaysia has eventually gained tremendous importance ever since the globalization. Organizations that can master the essential processes required in generating new products to market stand to foresee competitive benefits that may lead to faster product lead time, improved quality, lower cost, higher market share, and greater intellectual property. Rapid technological development, shorter product life cycle, clock speed competition, and increased outsourcing have prompted many firms to involve their suppliers early in their new product development activities (Mikkola and Larsen, 2003). The increasing level of end-product complexity, combined with

myriad product choices, makes early involvement with a few key suppliers vital. (McKeefry, 2000).

The available literature lacks specificity on ESI implementation plans and their results (Dowlatshahi, 1999). Moreover, it is believed that extensive problems exist with ESI implementation are still hidden and awaited to be disclosed. Such obstacles have more or less led most manufacturers not to attempt implementing ESI.

In Malaysia, the manufacturers of electrical and electronics (E&E) industry are still not acquainted with ESI concept. It could be attributed to the lack of theoretical and conceptual framework or no benchmark available to implement ESI. According to Brown & Eisenhardt (1995), it is not clear exactly how or when suppliers and customers are appropriately involved in the development process, and the evidence is not unanimous. There has been traditionally been minimal involvement by suppliers in the development of new or future products. The lack of trust towards suppliers in the stage of product development is usually predominant. (Dowlatshahi, 1997). Moreover, there is no formal mechanism in place to initiate and solidify early supplier involvement.

Besides, both manufacturers and suppliers are doubtful and lost their interests in implementing ESI as they are still haunting and obsessing with the problem of outweighing between costs and benefits of implementing ESI. Issues in supplier integration include tier structure, degree of mutual responsibilities in specific requirements of processes, timing (*when*) to involve suppliers in the process, inter-company communication, intellectual property agreements, supplier membership on the project team, and alignment of organizational objectives with regard to outcomes. Burnes and New (1996) deduced that the more an activity involves changes in both the customer's and supplier's operations the more there is likely to be an even distribution of costs and benefits. Therefore, the tradeoffs between risks and rewards of both parties in partnering relationships have to be studied.

Therefore, the researchers intend to embark the study on the implementation of early supplier involvement concept in Electrical and Electronics (E&E) industry whereby the interdependent relationships between suppliers and manufacturers are significant in creating competitive advantages to those challenges.

1.4 Objectives

1. To identify the level of supplier involvement in a company that implements ESI.
2. To identify the constraints or barriers in implementing ESI

1.5 The Significance of the Research

This research serves as a valuable benchmark for companies both Original Equipment Manufacture (OEM) and Original Design Manufacture (ODM) in Malaysia to review on the effectiveness of early supplier involvement in coping with global challenges. This research will be able to provide insights regarding the conceptual framework of ESI developed by S. Dowlatshahi, a renowned author of supply chain expertise. Most probably it could provide some guidelines for those manufactures that are interested to implement early supplier involvement (ESI) concept.

In addition, real ESI practice by the manufacturing plants in the state of Johor will be explored in the researcher's case studies. The results from the case studies might be a general review regarding ESI recognition and the willingness of those electrical and electronics (E&E) manufacturers in Malaysia region to implement it.

By the availability of this research, manufacturers are able to shorten the time as well as to save their efforts of implementing the early supplier involvement

concept with the ESI conceptual framework and practices which have been pinpointed in this research. By implementing ESI successfully, manufacturing sector may leverage the revenues that may ultimately lead to economy growth and increase the Gross Domestic Product (GDP) of Malaysia.

Besides that, this research is aiming to create the awareness and increase the recognition among manufacturers in Malaysia region of how vital is the suppliers' roles as a competitive edge. This research can serve as a base to rectify the misperception of those manufacturers that are not aware or neglect the importance of their supplier partnering relationship.

1.6 Scope

The study targeted on electrical and electronic company in Senai industrial areas of the district of Johor, a foreign multinational company. Case study was conducted in an E&E industry. The scope of the research will focus on the four stages in ESI, which includes product design and development, procurement, supplier and manufacturing aspects of buyer-supplier relationship, an ESI conceptual framework suggested by Dowlatshahi (1998).

1.7 Limitation

This study is only limited to one multinational company in E&E industry as such the generalizations of the findings are according to only a particular company surveyed and the limited sample might affect the accuracy of the result gained.

In addition, researcher incurred the unwillingness from the respondents to be investigated to avoid company's confidentiality. Furthermore, since the project is

not funded, researcher faced with fund and recruiting research assistant without fund allocation. To some extent it effect the smooth and the extensiveness of the project in meeting goals and schedule.

1.8 Conclusion

As a conclusion, suppliers' roles are vital in contributing to the success of the manufacturing sector as well as the economy growth in Malaysia region in facing the globalization challenges. Hence, much more efforts should be spent to increase the competency and efficiency in the aspect of supply chain management in any manufacturing company. Supplier partnering relationship should be streamlined and consolidated in order to be mutually beneficial. A conceptual framework, as a model for effectively implementing ESI will be discussed and followed by the review of the related literature and a description of the proposed framework by Dowlatshahi (1998).

PART II

LITERATURE REVIEW

2.1 Introduction

Supply chain management is touted as a strategy of choice for enhancing the competitiveness (Rich and Hines, 1997). The links between organizations are managed carefully to improve overall performance with the managerial of supply chain, rather than focusing solely on operating issues within a single firm. Success is no longer measured by a single transaction; competition is, in many instances, evaluated as a network of co-operating companies competing with other firms along the entire supply chain (Spekman, *et. al.*, 1994). Therefore, the role of suppliers in the operations of manufacturing enterprises has gained tremendous importance.

Early Supplier Involvement (ESI) has been advocated as a means of integrating suppliers' capabilities in the buying firm's supply chain system and operations (Dobler and Burt, 1996). It is a practice that involves one or more selected suppliers with a buyer's product design team early in the specification development process. Based on the research paper by Dowlatshahi (1997), ESI is viewed by some authors as a mechanism for the involvement of preferred suppliers in the early phases of product design and development. The supplier's expertise and experience can be utilized in developing a product specification that is designed for effective and efficient manufacturability. Suppliers have to work in a completely integrated fashion with the manufacturer in a systematic and formal way. As a result of this, a conceptual framework for implementation of ESI has been developed by Dowlatshahi (1998) to monitor easily the efficiency of collaboration between suppliers and buyers.

2.2 Factors that Lead to the Implementation of ESI

In fact there is no company likely to have sufficient technological expertise to internalize all design and production effectively. Trying to do everything in house may lead to a competitive disadvantage. According to Dowlatshahi (1997), no company can afford to own all the requisite technology. Suppliers usually possess state-of-art knowledge availability as well as the most advanced technologies for their parts and materials (Dowlatshahi, 1997). Thus, manufacturers need to focus on doing what is most critical to its competitive success and what it is best equipped to do, and rely on external sources for the rest. Integrating and involving suppliers earlier in the design and development process is one of the approaches to gain competitive advantage for companies which are facing global competition and markets that demand for innovative and higher quality. The current trend for companies to focus on their core competencies is leading closer forms of co-operation between customer and its supplier namely through the establishment of different company networks (Jagdev and Thoben, 2001).

According to Liker, *et. al.* (1998), high supplier technological capability will be associated with greater levels of supplier involvement in design. With this, suppliers with the greatest internal technical resources are most likely to be selected for early and influential involvement in the process of product development to satisfy a number of requirements in terms of design capability, quality, delivery reliability and price reduction capabilities. Design for quality (DFQ) necessitates earlier supplier involvement (Dowlatshahi, 1997) since costs of quality is substantial and burdensome to the manufacturers. Cost of quality is defined as the cost of doing things wrong, that is, the price of nonconformance (Heizer and Render, 2004), which are prevention costs, appraisal costs, internal and external failure costs. Suppliers may have the expert skills that the buyer does not have, and the early involvement of suppliers enable the manufacturer to use the unique technology of the vendor.

The characteristics of a component may affect the level of supplier involvement. Design newness and product complexity would lead to higher task uncertainty. Liker, *et. al.* (1998) argues that in an environment where product uncertainties run high, a firm needs to invest in developing and maintaining a close partnership with a select group of suppliers. Technologically complex designs with outcome ambiguity would require higher levels of engineering effort and thus increase the specificity and complexity of communication with the supplier, making decision to “make” the product in-house more attractive (Liker, *et. al.*, 1998).

On the other hand, the relationship between the buyer and supplier do affect the level of supplier involvement in the product development. The quality and the efficiency of technical communication are crucial to effectively working with suppliers on product development. A well-trained technical liaison that acts as a single point of contact in the buyer’s offices will lead to greater levels of supplier involvement (Liker, *et. al.*, 1998). These well-trained technical liaisons, such as experienced engineers, should be able to understand the value of the contribution of suppliers and incorporate their inputs into the design and products. This encourages suppliers to involve earlier in the process of product development.

The increasingly shorter product or service development cycles in the industry increase the interest of supplier involvement and collaboration. According to Ragatz, *et. al.* (2002) and Abu Bakar and Rohaizat (2002), using suppliers’ knowledge and expertise to complement internal capabilities reduce concept-to-customer cycle time, costs, quality problems, and improve the overall design effort. A firm is able to compete effectively in the market with shorter cycle time and this forces firm to make strategic planning of its resources as well as the regime appropriateness of the innovation with respect to the market and competitors.

2.3 ESI Conceptual Framework

According to Dowlatshahi (1998), the ESI conceptual framework is based on four building blocks of design, procurement, supplier, and manufacturing

requirements. To implement an effective ESI program, the internal and external areas of an organization are both important, and these requirements represent three relevant and important internal functional areas (design, manufacturing, and procurement) as well as an external area (suppliers). Figure 2.1 presents the ESI conceptual framework and indicates the letter D stands for Design, the letter P stands for Procurement, the letter S stands for Suppliers and the letter M stands for Manufacturing.

The four building blocks in Figure 2.1 consist of a set of specific tasks essential for the implementation of each building block of an ESI program within the general umbrella of a firm's supply chain system (Dowlatshahi, 1998). The four components are interrelated and their interaction effects determine the scope and nature of ESI. The two-sided arrows show the existence of the collaboration and interrelationships among these four requirements. This means that each set of tasks is grouped within its respective building blocks, the tasks are no more considered as mutually exclusive from the tasks of other building blocks.

In addition, from the research recited by Dowlatshahi (1999), in the ESI conceptual framework, each requirement area should consider the impact of all other relevant tasks in addition to its own requirements. The raw material costs contribute largely to the overall production cost and have a significant impact on the competitiveness of an organization. The issue of determining the raw material costs at the design level (D7), based on the conceptual framework this decision cannot be made in isolation. The procurement (P2) task of negotiating a fair and reasonable price should be shared and discussed with the designer before a decision regarding material selection is made. Contacts made to the selected suppliers to determine the part, which is a standardized item (S1). According to this requirement made, the ability of a supplier to provide material at a reasonable price and on a timely basis is affected. The size of production runs (M3) which is the task of the manufacturing is affected by the availability and the timing of the defect-free supplies. Other possible scenarios in Figure 2.1 can be considered and analyzed.

The conceptual framework, as well as a formal product development team, serves as a systematic problem-solving mechanism where constraints, contributions and concerns of functional areas are considered (Dowlatshahi, 1998). In addition to that, this cross-functional approach in involving suppliers ensures that their inputs are taken into account at the early stages of product development.

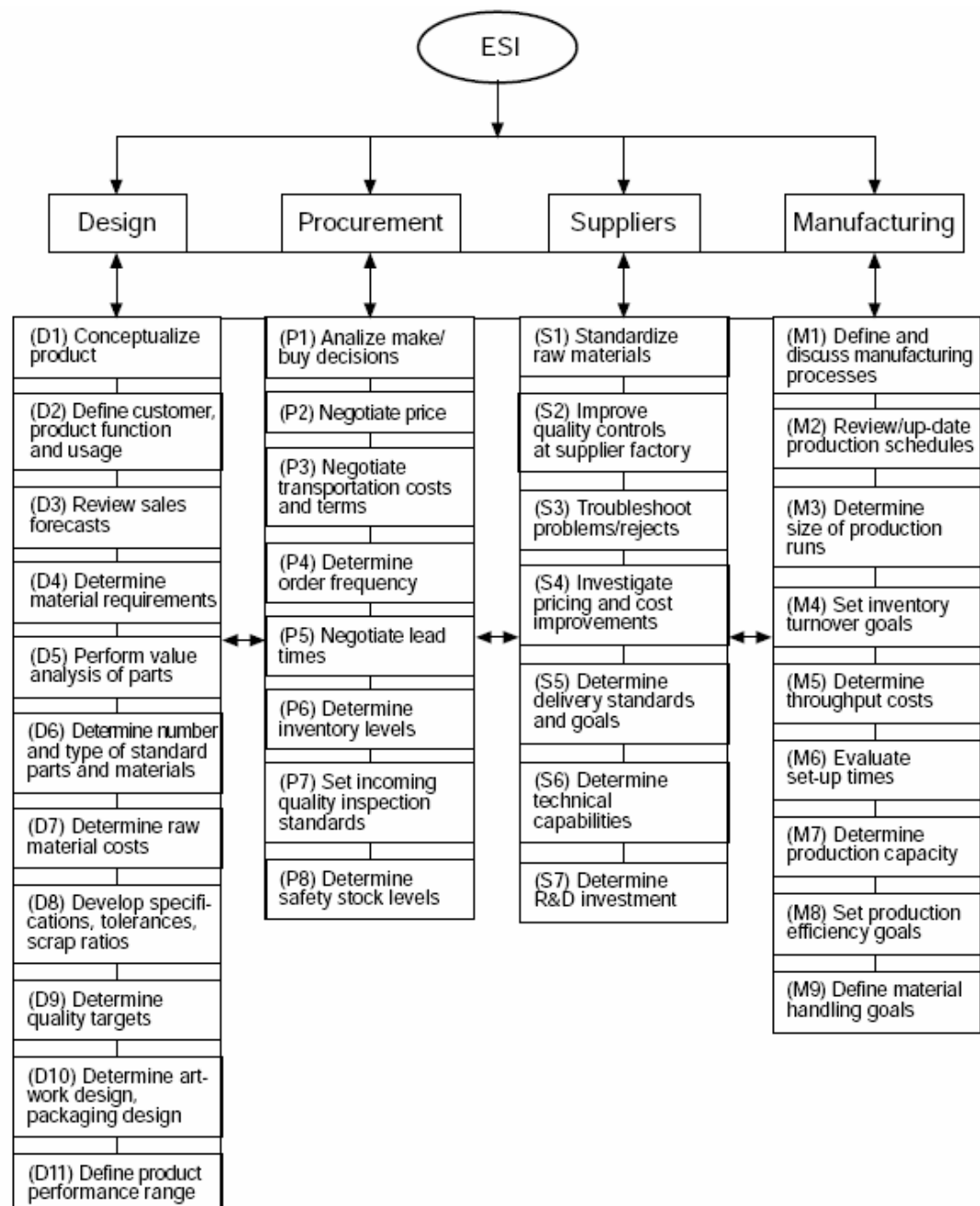


Figure 2.1 ESI conceptual framework (Dowlatshahi, 1998)

2.4 Proposition of the ESI Conceptual Framework

2.4.1 Design

The first component of the ESI conceptual framework is design. Design engineering translates the customer's quality requirements into operating characteristics, exact specifications, and appropriate tolerances for a new product or revision of an established product (Besterfield, 2004). According to Huang and Mak (2000), suppliers should be involved early at the stage of production design or even earlier, at the stage of detailed part design. With the early supplier involvement, suppliers' knowledge and expertise to complement manufacturer's internal capabilities help in the reduction of concept-to-customer cycle time and improve the overall design, to enhance one's competitiveness. The role of suppliers is evolving from the provision of components to a role that includes the provision of design information and knowledge (Culley, *et. al.*, 1999). This is a situation where designers now are relying heavily upon suppliers for information and expertise throughout the engineering design process. Therefore, there must be a free flow and sharing of information between buyer and suppliers in the part and product design stage.

Conceptualize the product (D1) is a stage where a process of transformation of different stakeholders' needs into output information, which corresponds to a manufacturable design. To conceptualize a product, the perceptual dimensions of the product should be visualized (Dowlatshahi, 1997). The customer, the function of the product, and its usage should be defined. With the involvement of suppliers in project teams adds information and includes expertise regarding new ideas and technology help to identify potential problems and are able to resolve them early. According to Leenders *et. al.* (2002), involving suppliers in cross-functional teams at the product design stage can produce substantial benefits and is common in discrete goods manufacturing industries, such as automotives and consumer electronics. It is an optimum point for including suppliers at the design stage as the decisions made here have significant impact upon the subsequent activities of the manufacturing firm.

When the design and product parameters are considered, the marketing requirements should be clearly specified where the customer, the function of the product, and its usage should be defined (D2). The designer should collaborate suppliers in the process of product design to avoid providing tight and difficult-to-achieve design specifications and tolerances to suppliers. Besterfield (2004), as tolerances are tightened, the complexity of the production processes and quality cost may increase. Suppliers should know the product objectives that would allow them to develop the how and whys of material development to produce quality product and meet or exceed customer expectations. Supplier performance measures the supplier's ability to successfully accomplish the objectives that the manufacturer demands (Tracey and Vonderembse, 2000).

Sales forecast (D3) need to be reviewed from time to time for the design purposes due to the uncertainty of the market demand. The production processes would have adequate capacity to produce the volume of products that customers want with the help of periodically review of sales forecast. A product design would affect the production processes and process design directly. The volume of products that should be produced according to the sales forecast, whereby the production processes and equipment are chosen based on the consideration of the cost and the optimum profit. According to Besterfield (2004), process selection and development is concerned with cost, quality, implementation time and efficiency. The capability of the production processes should be studied to identify the ability of the process to meet specifications. Suppliers can then determine the manufacturing processes of their products. Inaccurate sales forecasts affect production schedules and inaccurate production schedules can affect the suppliers' ability to meet the buyer's needs (Dowlatshahi, 1999).

The material acquisition function (D4) for a world-class manufacturer must focus on managing long term relationship with suppliers (Gooley, 1997). An effective of supplier integration in product development would secure competent supply sources that will provide an uninterrupted flow of required materials at a reasonable price (Hahn, 1990). Therefore, it is essential to initiating ESI in the

process of determining material requirements to save time and investment in materials. Dowlatshahi (1999) recited that material requirements such as types, grades, compositions, durability, and availability should be determined in collaboration with suppliers in the early stages of product design.

According to Leenders, *et. al.* (2002) and Abu Bakar and Rohaizat (2002), involving the supplier and the buyer in the early stages can lead to improvement in processes, design, redesign, or value analysis. Value engineering (VE), proposition (D5), is a procedure that analyzes the costs versus the benefits of a currently purchased component or an assembly process (Hirakubo, 2000). As suppliers generally know more about the parts they are producing than the buyer's product designer, suppliers' expertise should be used in the firm's VE effort. Suppliers possess specialized expertise to innovate independently and deliver the best technological solutions to enhance performance of the system (Mikkola and Larsen, 2003). ESI brings the supplier and the firm closer in sharing not only knowledge and learning, but technological risk as well.

Manufacturing enterprises in today's global market place are hard pressed to deal with diversity, in both products and technologies. They typically need to customize their products and processes to respond to customer's rapidly changing needs. Dowlatshahi (1997), the company initiating ESI should discuss the number and type of standardized parts with manufacturing and suppliers at the early stages of product development. The determination of the number and type of standard parts (D6) is essential for the planning, availability, affordability and manufacturability purposes. By using standard components and hardware, the production cost can be reduced as a firm produces a limited number of expensive products or mass production products with expensive tooling. Intensified competitive pressures during the early 1980s have forced Western assemblers to look for further savings from their components (Mikkola and Larsen, 2003).

A study by Nevins and Whitney (1989), shows that 70% of the life cycle cost of a product is determined at the design stage. The life cycle cost here refers to the cost of materials, manufacture, use, repair and disposable of a product. Raw

material cost (D7) always the major portion of the final product cost. On average, more than half of each dollar received from the sales revenue of manufactured goods is spent on the purchase of materials and equipment required to produce the goods (Dowlatshahi, 1997). As a result, the changing of raw material requirements might affect the costs and operations. Designers, buyer and suppliers should know and discuss about the implications of raw material costs in terms of their delivery, processing, usage and disposable.

The quality requirements by customers are translated into exact specifications and appropriate tolerances for a product, and should communicate them with suppliers, so that quality components and products are produced according to their capabilities. According to Leenders, *et. al.* (2002), the quality concept argues that an organization's products or services are inseparable from the processes used to produce them. The appropriate level of specifications, tolerances, and scrap ratios (D8) should be developed by design, manufacturing and suppliers since they affect quality targets, production processes and total product cost (Dowlatshahi, 1999). It is constantly necessary to take new technology and customer demand into consideration as the product specifications are becoming increasingly variable. Tolerance is the permissible variation in the size of the quality characteristic, and the selection of tolerances has a dual effect on quality (Besterfield, 2004). As tolerances are tightened, a better product usually results; however, the complexity of the production processes and quality cost may increase.

Quality is not the responsible of any one person or functional area; it is everyone's job (Besterfield, 2004) and quality has always been one of the key issues in supply management (Leenders, *et. al.*, 2002). Therefore it is essential to involve suppliers in the process of setting the quality target (D9) for a product. Acceptable quality targets should be agreed upon in the early stages of product development in collaboration with suppliers (Brill, 1993). Design engineers and suppliers should come to an agreement on the quality, safety and performance of the product. Quality targets are based on the product performance characteristic, functionality and also customer requirements. Manufacturers are able to achieve a product's quality requirement with the collaboration with their specialized suppliers, which

will result in a lower transaction costs during the product development. ESI may also give access to heterogeneous resources and capabilities, which are controlled by the suppliers.

The packaging design (D10) affects greatly the product's total costs, ease of use, and perception of consumers. The design of artwork and packaging is therefore important to the supplier, manufacturer, and as well as the end user. Supplier's assistance would be sought through supplier involvement and collaboration in the packaging design and artwork. The design of packaging has the responsibility to preserve and protect the quality of the product. Besterfield (2004), control of the product quality must exceed beyond production to the distribution, installation, and use of the product. It is crucial to have suppliers' assistance early in the design stage to prevent and eliminate potential problems that might occur during transit, loading, unloading and warehousing.

In order to meet customers' expectations and requirements, the product's performance range (D11) and normal operating conditions should be defined through the meeting between manufacturer and suppliers. The product performance range and operating conditions should be developed and specified before the actual procurement and manufacturing take place (Brill, 1993). Adjustment should be made towards the product parts and processes from time to time to make sure the excellence performance of a product.

2.4.2 Procurement

Procurement or purchasing can be defined, in a narrow sense, as the act of buying goods and services for a firm or, in a broader perspective, as the process of obtaining goods and service for the firm. The formal definition, purchasing consists of all those activities necessary to acquire goods and services consistent with user requirements (Coyle, *et. al.*, 2003).

According to Fung (1999), purchasing is traditionally viewed as primarily a cost reduction function, affecting directly a firm's profit and return-on-asset and hence the competitive position in industry. The ultimate objectives of purchasing functions are to purchase materials of the right quality, at competitive prices, in economic quantities, at the required delivery time, and from reliable sources.

Early supplier involvement (ESI) helps assure that what is specified is also procurable and represents good value (Leenders, *et. al.*, 2002). While Ng, *et. al.* (1997) pointed out that purchasing must be involved in the initial design stage of new products to prevent designs that create unnecessary sourcing and quality problems later. By involving purchasing teams early in the design stages together with suppliers in ESI program, needless product specifications could be modified or eliminated without affecting product quality. Besides, purchasing management directly impacts on the nature of the firm's relationships with the suppliers.

Supplier involvement together with the advices is critical during the processes of analyze make or buy decisions (P1) in the design stages especially those decisions that probably impact the core competency and critical success factors of the buying company. Critical success factors (CSFs) are those relatively few activities that make a difference between having and not having a competitive advantage (Heizer and Render, 2004). Commitment of top level management, engineers and manufacturing representatives are essential since the implications of the decisions regarding costs and profits incurred are hardly be estimated.

Negotiation is an attempt to find an agreement that allows both parties to realize their objectives (Leenders, *et. al.*, 2002). Price negotiation (P2) between supplier and buying company is not the most important factor in ESI partnership but the overall cost structure of the materials bought. Overall cost structure encompasses the life cycle costs of the materials that affect the product characteristics and functionality. Besides, sales forecasts, quality requirements, specifications and tolerances, volume, supplier service and liability should be highlighted during the negotiation.

Purchasing representatives should involve during product design to negotiate transportation costs and terms (P3). Transportation cycle time of raw materials and all necessary component parts can influence the manufacturing process, and on the customer's perception channel. Thus, any attempt to reduce total cycle time effectively must consider the transportation cycle time (Ng, *et. al.*, 1997). Transportation costs could be reduced through ESI partnership from the reliable delivery schedule, better scheduling, and more economical routing fares due to freight consolidation. Commitment and coordination between purchasing and suppliers in determining carrier designation and routing, filing of loss and damage claims, transshipments, and other transportation cost reduction projects.

The role of purchasing to determine order frequency (P4) with coordination of supplier during product design stages could probably increase the efficiency of the supplier's plant, optimize the inventory carrying costs from the buying company as well as the warehouse spaces designed for the placement of the materials from supplier. Since the order frequency is dependant on shelf life, lead times, sales forecast, and production schedules (Dowlatshahi, 1999) of the buying company, thus reliable delivery schedules and accurate response from the supplier must be always be compatible with the planned production activities at the buying company. The size, weight and dimensions of packages and boxes should be compatible with the buyer's physical facilities and equipment (Dowlatshahi, 1999).

The next contribution of purchasing in ESI is to negotiate lead-time (P5). Lead time in purchasing systems, is defined as the time between placing on order and receiving it; in production systems, it is the wait, move, queue, setup and run times for each component produced (Heizer and Render, 2004). The information should be shared between ESI participants in this phase inclusive forecast of future market demands, volume of production, inventory levels, product lead times, and logistic concerns.

In advance of the actual material orderings during product design stages, suppliers should carry the inventory level whereas buying company should be specified to facilitate the process of determining inventory costs (P6). In the long-term basis, this practice may lead to Just-in-time (JIT) purchasing environment that substantially reduce total cost for the buying company. Inventory turnover is an indicator in measuring inventory management improvement.

In order to set incoming quality inspection standard (P7), agreement of both supplier and buying company should be made. Supplier certification is important for the buying company since quality inspection activities are considered non-value added that prolong the product cycle time. A certified supplier is one that can supply quality materials on a long-term basis (Besterfield, 2004). Certification enables supplier to load the shipments directly to the point of use with only an identity check and statistical evidence of quality.

The last process is to determine safety stock levels (P8), whereby coordination between supplier's capabilities and buying company's desired safety stock levels will take place. Safety stock is extra stock kept on hand to help in avoiding stock outs (Render, *et. al.*, 2003). Supplier commitment is crucial to deliver prompt shipments when urgent to satisfy market demands variability as well as to help buying company to reduce total inventory costs at a desired service level.

2.4.3 Suppliers

Early supplier involvement increases product development efficiency and effectiveness, as well as tap into suppliers' technological capabilities (Mikkola and Larsen, 2003). It is virtually impossible for any firm to possess all the technical expertise needed to develop a complex product with the rising of the technical difficulty of designing and manufacturing of most products. The involvement of suppliers in the process of product development increases the need for effective coordination mechanisms, as higher levels of interdependence are required between a local firm and their suppliers of development information. The opportunity to

improve product design performance by involving suppliers in the integrated product development process identifies a definite need to understand better the basic structure of buyer-supplier relationships (Birou and Fawcett, 1994).

According to Mikkola and Larsen (2003), intensified competitive pressures during the early 1980s have forced Western assemblers to look for further savings from their components. Thus, the design and use of standardized parts and materials (S1) in the production are discussed between the manufacturer and supplier to shorten design time, lower design and production costs, reduce quality problems and significantly inspection, handling and administrative costs. Standardization has been defined as agreement on definite sizes, designs and so forth (Leenders, *et. al.*, 2002). With the increasing use of industry standard materials and products may facilitate the continuous improvement of the new product development process. Design engineering should utilize proven design and standard components whenever possible in order to increase quality and reliability of a product (Besterfield, 2004).

The quality controls should be implemented at the supplier factory (S2) in order to build in quality and minimize defective items at the source (Dowlatshahi, 1999). According to Burton (1988), the quality programs (Statistical Process Control, supplier certification) in ESI begin at the supplier's plants, as the supplier's plant is an extension of the buyer's operations. Large manufacturers transfer personnel permanently or for a long term to oversee and manage a supplier firm to reach the product development goals of performance, time to market and cost. With this supplier certification process, quality supplies of materials are assured on a long-term basis.

With the involvement of suppliers, the issues regarding to troubleshoot rejected items and supply problems can be addressed and resolved (S3). The rejected items are returned to the suppliers and reworked at the supplier's expense in order to ensure that a defective part does not proceed in the production line. Supplier's engineers are more likely to understand their manufacturing processes at a far deeper level and, therefore, are more apt to have solutions for their own parts. It is most suitable to have the supplier to rectify problems with parts that they produced.

Dowlatshahi (1997) stated that good suppliers should be able to suggest an alternative design or solution for a product – something different that performs similar functions with higher quality, lower cost, and faster time to market.

Increasing competition in the marketplace forces firm to reduce the costs of products in a continuing basis (Hahn, *et. al.*, 1990). Since material costs comprise 80 to 85 percent of the product cost, collaboration among internal entities and the suppliers is the key to a company's success. For the supplies, the investigation of the price and cost improvement (S4) should be done in a continuous basis by material substitutions, standard parts, and through combining volumes and lot sizes (Dowlatshahi, 1999). The firm is able to maintain its competitive edge in the market with the pricing and cost structure improvements.

According to Dowlatshahi (1997), manufacturer should state product objectives, delivery standards and goals to the suppliers (S5), and allow them to develop proper material development. It is essential as the suppliers are aware of the buyer's expectations. The product being supplied should compatible with the stated objectives. The supplier's accessibility may be critical to have delivery of products on time.

In fact, no company can afford to own all requisite technology; therefore supplier's technical expertise (S6) should be identified and utilized by manufacturer to meet customer expectations during the process of product development. The exchange of technical information would be more effective if designer-supplier collaboration took place during the early phases of product design and development (Dowlatshahi, 1999). Suppliers usually possess the knowledge regarding the availability as well as the most advanced technologies for their parts and material that are useful to have the conformance of the products to manufacturing requirements and quality standards.

The existence of mutual trust between buyer and supplier is the key to successful joint which generates synergies through mutual problem solving and the

achievement of economies of scale in production and transportation (Hirakubo, *et. al.*, 2000). Dowlatshahi (1997) asserted that only suppliers with long-term contract are willing to make R&D investment (S7), which has a major impact upon product viability. If a supplier has a long-term contract with a buyer, the supplier will set up its tooling and production processes differently that if it had only short term, one time contract. The supplier's production and distribution facilities has therefore become an extension of the buyer's production line that results in better prospects for improved manufacturability.

2.4.4 Manufacturing

The last component of the ESI conceptual framework is manufacturing. It is crucial that all designed parts or products should easily be produced in a lowest cost and speedy manner by capable manufacturing processes and technologies. As speed or time-to-market is increasingly a key supply chain differentiator thus supplier involvement in manufacturing processes is important. By practicing ESI, manufacturing performance and supplier performance are inter-related and correlated. It has been proven by the previous study that has been done by Tracey and Vonderembse (2000) and is presented in Figure 2.2.

In this context, the researchers will focus on the impact of supplier performance towards manufacturing performance. Since the implications of implementing ESI in manufacturing will only be highlighted in this phase, thus the approved strategic suppliers will certainly have fulfilled the supplier selection criteria.

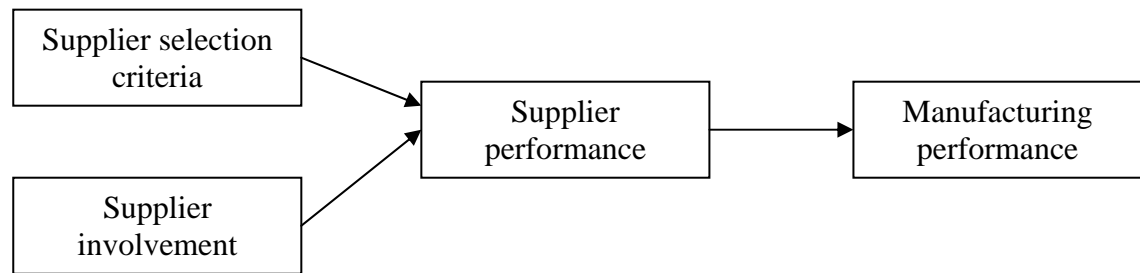


Figure 2.2: Supplier Relations and Manufacturing Performance (Tracey and Vonderembse, 2000)

Supplier performance measures the supplier's ability to accomplish the objectives that the manufacturer demands successfully. For instance, delivery of the quality products correctly and timely, with minimal in-transit damage from supplier. Manufacturing performance measures the ability of the manufacturer to meet the standards established by their customers. This embraces low rework and production costs, increasing outgoing product quality, reducing work-in-progress, and cutting material handling costs, increasing products' manufacturability and reliability, and minimizing the occurrence of stock out (Tracey and Vonderembse, 2000).

Supplier performance has a direct influence on manufacturing performance. As supplier performance increases, the manufacturing performance of the firm being supplied should increase as well (Tracey and Vonderembse, 2000). It is understood that supplier performance affects the manufacturer's ability to produce and deliver products to its customers in a timely and cost-effective manner. In long-term basis, the goal of low production and rework costs, low work-in-process inventories, high-quality finished goods, and on-time delivery to customers could be achieved by manufacturers as suppliers consistently deliver the high-quality products on time with minimal in-transit damage.

Both suppliers and manufacturers participating in ESI should take initiative to define and discuss the buyer's manufacturing processes (M1). Suppliers could certainly bring improvement to the buyer's processes capabilities and operations as

they could provide valuable suggestion based on the proprietary expertise that manufacturer might not have. It is mutual beneficial as regular discussion and review between suppliers and manufacturers will notify suppliers in advance regarding any changes in manufacturers' operation lines, models, and production processes. Consequently, it would certainly decrease the chances of supplier incapability in fulfilling the manufacturers' needs while maintaining a good relationship within each other. Besides, suppliers could be more understood on how their products affect the manufacturer's final products in the aspects of tolerances, design specifications and logistic operations.

Manufacturer should constantly review or up-date production schedules (M2) with suppliers as they are playing an important role in providing sufficient materials, which eventually affects the manufacturing lead-time. Manufacturing lead-time is a measure of the elapsed time between release of a work order to the shop floor and the completion of all work necessary to achieve ready-to-ship product status (Bowersox, *et. al.*, 2002). Manufacturer's production plans could be streamlined and leveraged in achieving its goals by sharing the production plans with suppliers in a timely basis. Suppliers in return could update their own production plans in utilizing human and capital resources properly while meeting the manufacturer's production plans.

Suppliers should be well informed and collaborate with manufacturers to determine the size of production runs (M3) although most of the manufacturers have their own group technologies to run few similar stock keeping units (SKU) or products in order to minimize the production costs and maximize resources utilization. It is because investments, products delivery schedules, material availability of supplier could adversely affect the size of the manufacturer's production runs. It means the mutual understanding and coordination of buyer-supplier production activities is essential towards short and long term implications on investments.

Suppliers involvement is important is helping manufacturers to set inventory turnover goals (M4) since supplier could strive to meet the supply requirement.

Inventory turnover is the ratio of the cost of goods sold to the average inventory and it indicates how fast inventory items move through a business (Dowlatshahi, 1999). It is one of the indicators to determine the effectiveness of the ESI program in manufacturing. Basically, inventory turnover goals will consider the market demands, production schedules, delivery schedules, material costs, space availability and product's shelf life. Here, suppliers who might have a strong network and closer relationship with customers could provide information regarding the demands trend of market niche to the buyers. More over, contractual collaboration between suppliers and buyers on setting the material costs and delivery schedule will certainly ease the setting inventory goals processes.

Supplier involvement could aid manufacturers to determine throughput cost (M5), which is an integral part of entire cost structure. According to Dowlatshahi (1997), throughput costs include procurement cost, non-recurring manufacturing cost, recurring manufacturing cost, facilities cost, initial logistics or support cost, and cost of quality. Throughput costs are directly affecting the major product manufactured costs then the selling price to the potential customers. One of the objectives of ESI is to minimize the total throughput costs through supplier involvement into buyer's manufacturing processes. Thus buyers should hold a regular discussion with the supplier especially those who in-charge of the expensive parts or materials so that the most cost-saving process could be applied to the products.

Supplier could contribute to assist buyers to evaluate set-up times (M6) as well as to improve the set-up times through timely material deliveries, methods engineering, and proper lot sizing. Set-up times could be improved in the aspect of operations, production runs, changeover tools and other relevant factors. According to Dowlatshahi (1999), buyer-supplier who has a long term contract will set up tooling and production processes differently than those only have a short term, one-time contract. Thus, mutual understanding of capabilities and requirements between both parties in ESI program could accelerate the set-up times through sharing of technical know-how.

In order to determine production capacity (M7), buyer must inform the suppliers in ESI program. The three primary constraints that influence manufacturing operations are capacity, equipment, and setup or changeover (Bowersox, *et. al.*, 2002). Capacity is a measure of how much product can be produced per unit of time (Bowersox *et. al.*, 2002). Since the decision whether to make an item in-house to replace the parts bought from supplier or to increase the production capacity by using mixed capacity strategies that require substantial input from the supplier would directly affects the supplier.

Suppliers' efforts are crucial in helping the manufacturer to set production efficiency goals (M8). Production efficiency goals are measured in terms of labor and machine utilization, production downtime, material wasted and reworks. In this case, suppliers can work out to improve the parts design that sold to buyer. It means suppliers can assist the designers in determining part substitution, developing specifications, part redesign, part elimination, part standardization, and part simplification (Dowlatshahi, 1999). All these are done smoothen the production processes in the buyer's manufacturing plants and reduce material wastage during production. Compromise or contractual collaboration between buyer and supplier is important since maximizing in-house production efficiency of the buyer would lead to inefficiency of a supplier to product the desired parts in terms of costs and resources.

Buyer should coordinate with ESI suppliers to define material handling goals (M9). It is inclusive material handling procedure, standard pack quantities and Kanban scheduling to manage the work-in-process (WIP) materials properly. This attempt is important since material handling activities is a non-value added activity that may contribute to the potential risk of product damage (Dowlatshahi, 1999) and incur loss to the manufacturer. Kanban scheduling is defined as demand scheduling, which could minimize the work in process between processes and reduce the cost associated with holding inventory (Gross and McInnis, 2003). Standard pack quantities that are determined between buyer and supplier could certainly ease the material handling processes while increasing production efficiency.

2.5 The Impacts of ESI Implementation

In the current international competitive environment, many manufacturers are focusing on supplier management as a tool for achieving long-term competitive advantage while meeting customers' expectations. As market demands are evolving manufacturing from mass production to mass customization whereby smart and conscious consumers demand more value, reliability, and smaller batches products in a timely basis, product development in quickly responding to customer needs through collaborative process are necessary for companies. Moreover, according to Rouibah (2002), collaboration aims to improve product development efficiency (product cost and quality) and effectiveness (development cost and quality). Hence, supplier partnership is becoming essential to bypass slow and costly efforts to build one's capabilities and to access new opportunities.

Companies nowadays have slowly migrated from being vertically integrated enterprises to ones that focus on delivering high quality cost effective solutions to the end customer. To accomplish the mission of delivering solutions that enhance its value to its customer, a company must align and involve suppliers early during design, procurement, development, and manufacturing all the way through the final production stages. A firm's ability to produce a quality product at a reasonable cost, and in a timely manner, is heavily influenced by its suppliers' capabilities (Hahn, 1990).

Effective integration suppliers into the product value or supply chain will be a key factor for some manufacturers in achieving the improvements necessary to remain competitive. The increasing trend that many manufacturers actively facilitate supplier performance and capability improvements through supplier integration is to consolidate the supply base while reaping the benefits of implementing early supplier involvement in new product development (NPD). Suppliers are included in the development process because they frequently possess design and technology expertise (Birou and Fawcett, 1994). Suppliers may provide innovative product or process technologies that are critical to the development effort.

According to Hirakubo, *et. al.*, (2000), nearly 40 percent of Japanese suppliers have research and development capabilities, and 17 percent possess technologies that the buying organizations do not have. The suppliers may have better information or greater expertise regarding these technologies than the buying company design personnel. This enables companies not only to share risks and costs, but also focus upon their core competencies.

Involving suppliers in new product development decisions and continuous improvement efforts enables the manufacturers to share knowledge and increase learning so that better solutions can be found to complex, inter-company problems that impact performance (Tracey and Vonderembse, 2000). Dowlatshahi (1997) stated that if a company or a supplier waits until a design specification or a bill of materials is available, it will be too late to reap the benefits of the knowledge and expertise of a supplier without a costly re-design, measured in time and money. According to Dowlatshahi and Contreras (1999), the failure of IBM to consider supplier involvement in the product design phase was one of the reasons mentioned for the lack of profitability of IBM compared to Compaq.

As today firms focus on their core competences, they become more dependent on their suppliers to meet ever-increasing competition (Krause and Ellram, 1997). According to Mikkola and Larsen (2003), due to greater complexity, higher specialization, and new technological capabilities, outside suppliers can perform many activities at lower cost and with higher value added than a fully integrated company can. Supplier can have a significant impact on a manufacturer's performance, through their contributions towards cost reduction, eliminate inconsistency in the designer's manufacturing processes, minimize high-cost material items, share technical expertise and processes within each other, enabling the constant improvement of quality, share technology capabilities, and increase responsiveness of buying companies. A buyer's bases of power estimated that suppliers account for 30% of the quality problems and 80% of product lead-time problems (Burton, 1988).

Moreover, by involving suppliers in the process, buying company can access to a wide pool of talent all focused on the needs of its customers (Leenders, *et. al.*, 2002). By keeping the customer-partner's future needs in mind, decisions of suppliers regarding investments, new product, new process or system could be facilitated. Thus, the possibility of misjudgment or wrong strategy made would be reduced.

Besides, involving suppliers early during the development process is one way to cope with the risks of outsourcing (Dowlatshahi, 1998). It is because through component outsourcing, manufactures have to share their technological knowledge with their suppliers, and meanwhile competitors can gain access to such knowledge, which has been a source of incentive for many entrepreneurial firms. Moreover, from transaction cost economics (TCE) perspective (Williamson, 1996), outsourcing will cause manufacturer firm bonds into a contractual agreement with a supplier, hence transferring the ownership and decision rights of the outsourced function to the supplier.

Hahn, *et. al.* (1990) proposed that suppliers involved in partnerships can carry additional inventory to satisfy the buyer's delivery requirements. This is an important feature of the buyer-supplier relationship in achieving Just-In-Time manufacturing, especially when a manufacturer (buyer) does not assist the supplier to revise its system to meet the buyer's shipment dates in a timely fashion.

2.6 Barriers to Effective ESI Implementation

It is important and essential to manage the involvement and integration of suppliers properly into the process of product development to achieve the effectiveness of ESI. But, traditionally there has been minimal involvement by suppliers in the development of products because of some barriers to effective supplier integration.

At the stage of product development, the lack of trust between the buyer-suppliers is usually predominant (Dowlatshahi, 1997). Such problems like the extent of technical and technological information exchange between both supplier and buyer that would affect the long-term collaborative relationship. The risks of collaborative product development that include leakage of information, loss of control or ownership, longer development lead time, and collaborators becoming competitors (Mikkola and Larsen, 2003) have caused the role of suppliers become insignificant in most of the companies. Confidentiality is perhaps the biggest obstacle to supplier participation, particularly when a new product design is involved (Leenders, *et. al.*, 2002). Such problems like both suppliers and buying company over protect their proprietary cost information until collaborative relationship could not be formed and gradually fail the ESI program. Therefore, there is always a challenge for buying company to identify and integrate suppliers which possess credible capabilities while align with the buying company's objectives and working ethics within a certain limited timeframe.

Partnership between suppliers and buying company require a tolerance toward errors and a real commitment to make the relationship effective. Suppliers could cause problems to the buying company and one of them is in-house capability of the suppliers (Mikkola and Larsen, 2003). Probably it causes the manufacturers to spare resources and efforts to improve the capabilities of the suppliers or substitute the supplier for a better one. It may cause unforeseeable impacts to the manufacturers such as longer product lead-time.

For the buying company, purchasing and engineering departments might hesitate or even resist against the decisions of the suppliers when the suppliers do not have a finished product to base their decision on. Sometimes, the feel of honor and culture among the engineers of the buying company force them to become unwilling to hand over the design or technology development responsibilities to the suppliers.

Technologically complex designs with outcome ambiguity would require higher levels of engineering effort and thus increase the specificity and complexity

of the communication with supplier, making the decision to “make” the product in-house more attractive (Liker, *et. al.*, 1998). Besides, buying company prefers to make the component(s) in-house due to both greater product complexity and technological uncertainty that are likely to increase the cost of writing fully-specified contracts which would result in higher transaction costs compared with the option of doing the design and production work in-house at a lower coordination costs.

In a technology-driven world, intellectual rights to new technology are extremely valuable and the preservation of secrecy a vital concern (Leenders, *et. al.*, 2002). This problem is more obvious in high-technology industries where joint product development would cause conflict over intellectual property rights and ownership. Both trust and legal agreement are playing an important role to overcome this issue.

Outsourcing and the subsequent supplier involvement is only possible when a system can be decomposed in such a way that interface of the components are well specified and standardized (Mikkola and Larsen 2003). In this case the determinants are the technological complexity of the system and buying company’s NPD capabilities as well as on the suppliers’ capabilities in developing the component at lower cost and faster lead times than by the firm itself.

2.7 Conclusion

Literature review above aids theoretical development of early supplier involvement and the researchers employed an in-depth study in the research methods. The next chapter lays out the research methodology that the researches had conducted in order to gain a better understanding about the phenomena of early supplier involvement in the process of product development.

PART III

METHODOLOGY

3.1 Introduction

This chapter covers the data collection method and data analysis method in the research, type of research design, research instrument and sampling design that are essential to conduct a research. The type of our research study, from the viewpoint of the objectives, is categorized as exploratory research. Exploratory research is usually carried out when a researcher wants to explore areas about which the researcher has little or no knowledge (Ranjit, 1996). In this case, researcher has conducted a research study to gain knowledge regarding Early Supplier Involvement (ESI) concept and practice that are applied in manufacturing industry. Qualitative approach is one in which the inquirer often makes knowledge claims based primarily on constructivist perspectives or advocacy / participatory perspective or both (Creswell, 2003). In a qualitative study, deductive mode is not applied whereby researcher does not start with testing or verifying a theory. Instead, the inductive model of thinking is used, whereby a theory may emerge during the data collection and analysis phase of the research or be used relatively late in the research process as a basis for comparison with other theories.

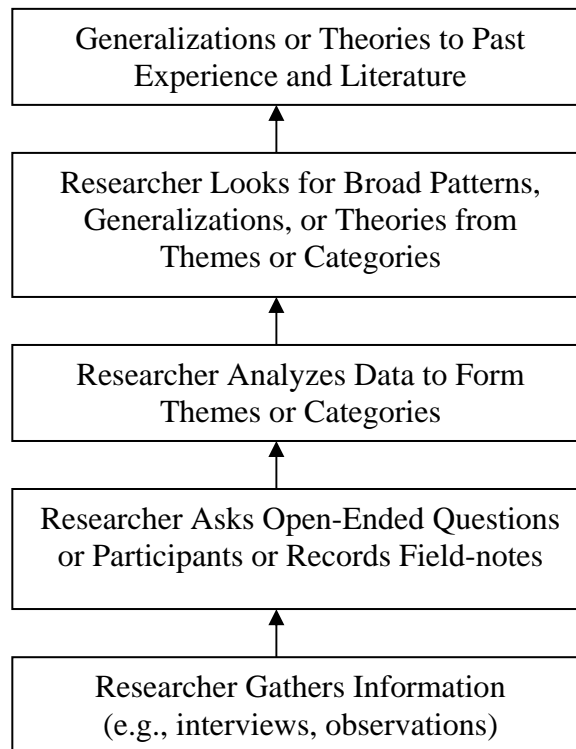


Figure 3.1: Inductive Logic of Research in a Qualitative Study (Creswell, 2003)

3.2 Research Design

According to Kerlinger (1986), a plan, structure and strategy of investigation conceived as to obtain answers to research questions or problems. The plan is the complete scheme or program of the research. It includes an outline of what the investigator will do from writing the hypothesis and their operational implications to the final analysis of data. According to Ranjit (1996), a research design is a procedural plan that is adopted by the researcher to answer questions validly, objectively, accurately, and economically.

In case studies, the researcher explores a single entity or phenomenon (“the case”) that bounded by time and activity (a program, event, process, institution, or social group) and collects detailed information by using a variety of data collection procedures during a sustained period of time (Merriam, 1988). Qualitative case

studies share with other forms of qualitative research, the search for meaning and understanding, the researcher as the primary instrument of data collection and analysis, an inductive investigative strategy, and the end product being richly descriptive (Merriam, 2002).

In this study, researcher has conducted a case study in terms of carry out an in-depth study the practice of ESI in manufacturing companies. The process of conducting a case study begins with the selection of the “case” (Merriam, 2002). The selection was done purposefully, not randomly; that was, particular manufacturing companies in electric and electronics (E&E) industry with different origins within a bounded system, in Johor Bahru.

3.3 Sampling Design

In this study, the population consists of electrical and electronic (E&E) company in Senai industrial areas of the district of Johor Bahru. This study was conducted on German based company that has implemented ESI.

Managers, especially project manager, purchasing manager, manufacturing manager and engineering manager from the company was selected as the respondents of this study. The purpose of choosing them as the respondent was that they were usually the personnel who plan for the whole production of a product and might also planned for the stage of supplier involvement along the process of product development.

3.4 Data Collection Method

Data collection procedures in qualitative research involve four basic types: observations, interviews, documents, and visual images (Creswell, 1994). According to Hessler (1992), qualitative data gives the researcher depth of

understanding in terms of the inner workings of human organizations. There were two types of data sources that researcher obtained from the data collection approaches above to provide the necessary input for further analysis of this study. These two types of data sources were primary data and secondary data.

3.4.1 Primary Data

Primary data are collected specifically for the analysis desired (Hanke and Reitsch, 1994). Primary data collection usually involves the originated data that has been collected by the researcher for a purpose to delve specific research problems. Researchers are responsible to collect the data in an efficient and useful format for decision-making as the data is not exists in a compiled form. The primary data collected using the methods below to enhance the validity of the findings. The data collection strategy used is determined by the question of the study, and also by determining which source of data will yield the best information with which to answer the question.

3.4.1.1 Interview

King (1994) defines the research interview as an interview, whose purpose is to gather descriptions of the life world of the interviewee with respect to interpretation of the meaning of the described phenomena. The goal of any interview is therefore to see the research topic from the perspective of the interviewee, and to understand how and why he or she comes to have this particular perspective. A key feature of the interview method is the nature of the relationship between interviewer and interviewee (King, 1994). They added that the qualitative research interview is ideally suited to examining topics in different levels of meaning need to be explored.

Interviews were conducted with open-ended questions for this study to allow interviewee to expand upon particular points or make general comments about the research topic. Researcher prepared an interview guideline and listing topics that the researcher attempted to cover in the course of the interview. The main topics included in the interview guideline were (1) the background of the company, (2) the level of early supplier involvement, (3) factors that attract the implementation of ESI, (4) the impacts of ESI implementation in the company, and (5) barriers to effective ESI implementation. Tape recording and note taking were used to take information during the interviews and face-to-face interviews were conducted at three different companies to collect data for this research.

3.4.1.2 Observation

The term ‘observation’, and in particular ‘participant observation’, is usually used to refer to methods of generating data which involve the researchers immersing themselves in the research setting, and systematically observing dimensions of that setting, interactions, relationships, actions, events and so on (Mason, 1996), and is at the heart of qualitative research (Esterberg, 2001). According to Merriam (2002), observational data represent a firsthand encounter with the phenomenon of interest. Observation is the best technique when an activity, event, or situation can be observed firsthand, when a fresh perspective is desired, or when participants are not able or willing to discuss the phenomenon under the study.

Researcher had undergone observations at this company. Researcher acted as complete observer to obtain information related to the implementation of ESI, as they had no influence on the ongoing process of the company. Notes were taken to record the observations and interpretations of the settings, and also their feeling about what was happening. Aids such as video or audiotapes, photography, diagrams and charts were used during observations so that visual images gave additional data that was needed for research purpose.

3.4.2 Secondary Data

Secondary data is a resource of information that has been collected from other alternatives by the researcher or any other authors. According to Hanke and Reitsch (1994), secondary data are the statistics that already exist, and they had been gathered for a previous purpose, not for immediate study at hand. In addition, they have already been compiled and are available for statistical analysis. It is also important to support the efforts of the researcher in gaining any additional information about interconnection with the research that has been done. Secondary sources include things like historians' or sociologists' analyses, as well as the accounts of people who were not eyewitnesses and are not scholars (Esterberg, 2002).

3.4.2.1 Documentation

Documents are one of the major sources of data. Documents can be written, oral, visual or cultural artifacts (Merriam, 2002) whereby public records, personal documents, and physical material are types of documents available to the researcher for analysis. He further reiterated that the strength of documents as a data source lies with the fact that they already exist in the situation; they do not intrude upon or alter the setting in ways that the presence of the investigator might. According to Atkinson and Coffey (1997), the collective organization of work is dependant on the collective memory that written and electronic records contain.

Documents such as office memos, annual reports, transaction records and others were analyzed as we need further investigation and understand how the companies work with suppliers. Researcher gained information on how the organizations function with the implementation of ESI, therefore they took account of the role of recording, filing, archiving and retrieving information. These

documents were used to examine their place in organizational setting, the cultural values attached to them, their distinctive types and forms.

3.4.2.2 Media Accounts and Electronic Text

Media accounts such as journals, books, magazines, newspapers, paper work, case study and past thesis were taken into account to accomplish this research. These accounts were useful to provide an overview of the problems that the researchers were investigating. They were easily accessible and cheap where they were available in the library of Sultanah Zanariah (PSZ), UTM. Internet and electronic text are becoming widely available; therefore the researchers relied on them to provide relevant and useful data for their researches. Online database provided by UTM was one of the approaches to obtain online journals.

3.5 Data Analysis Method

Data analysis refers to a process which entails an effort to formally identify themes and to construct hypotheses (ideas) as have been suggested by data and an attempt to demonstrate support for those themes and hypotheses (Bogdan, *et. al.*, 1975). Qualitative analysis is different from quantitative analysis because the activities of data collection, analysis, and writing the results are conducted simultaneously.

Classifying the substance of the data is the key to producing descriptions and drawing conclusions from qualitative data (Hessler, 1992). Content analysis will be applied as one of the data analysis method. A central idea in content analysis is that the many words of the text are classified into much fewer content categories (Weber, 1985). The basic steps in content analysis is to design categories that are relevant to the research objectives and to sort all occurrences of relevant words, phrases or other

recording units into these categories. Data “categorizing” is usually used to discover the commonalities across cases, or the constituents of phenomenon (Tesch, 1990). Content analysis can be useful as a stage of data analysis as it allows the relevance of preexisting theory to be tested, and it can be used as a way of assessing the applicability of a theory that emerges during thematic or content analysis.

3.6 Conclusion

Data collected through interviews, observations, documentations, media accounts and electronic texts were analyzed by qualitative analysis which had been discussed previously. The result gained from the analysis was reported in the following chapter.

PART IV

DATA ANALYSIS

4.1 Introduction

In data analysis, researcher is presenting findings from Lucas Automotive Sdn. Bhd. (LASB). The information gathered is based on structured interviews with supervisors or managers of the company, archival records, and company's websites and documents. The questionnaire used for conducting structured interviews was based on the propositions developed by Dowlatshahi. The interviewees were asked about the content of the propositions in conversational questions where they were not directly exposed to the propositions. These questions were posed to individuals who were deemed to have direct knowledge and, therefore, able to answer the questions.

4.2 Lucas Automotive Sdn. Bhd.

4.2.1 Company Background

Lucas Automotive Sdn. Bhd. is situated in Senai Industrial Estate, Johor, which is 30 kilometers from north of Singapore at the southern tip of Peninsular Malaysia. It was incorporated in Malaysia in 29 February 1960 in 168,000 square feet land area. This factory in Senai was commissioned in 1982, and from the subsequent investment, it has extended the total area to approximately 4000 sq.m. and currently operates with 110 workers. Lucas Automotive Senai is one of the organizations which are under the TRW Automotive public listed company group. The core products of Lucas are electronic components and they are supplying to

Honda Civic and Rover for the digital clock, Proton Waja and Gen2 for the vehicle timer, and Ford and Jaguar for the switches. Lucas is a main contractor and also Original Equipment Manufacturer (OEM) as it is producing its own final product and hence these products are sold to automotive industry. The annum sales revenue for Lucas Automotive in Senai plant is RM40 millions per year. Approximately 85 percent of Lucas's sales take place in overseas which are mainly focusing at switches whereby 15 percent of the local sales depends on Proton. There are about 100 suppliers spread out over Malaysia and Singapore.

Automotive market expectations continue to be high, requiring extreme business fitness for survival and profitable growth. TRW Automotive plans to maintain its business strength and create exceptional value for its customers via four priorities of best quality, lowest cost, global reach and innovative technology. Therefore, Lucas kept its product design in-house and it is done by research and development in United Kingdom and Germany. TRW Automotive has formed a TRW Automotive Global Purchasing which members are chosen from procurement department of every TRW's plant in the world. This team is lead by a commodity manager and formal meetings are held as the decisions of selection of suppliers are made by this group. A robust and adaptable supply base that understands Lucas and as well as TRW requirements, and are able to act with similar urgency demanded by customers, is key to achieving those priorities.

Lucas implement TRW's procurement strategy where its purchasing focus areas integrated into detailed supplier commodity strategies, sourcing excellence and cost reduction plans, superior new program development and flawless product launch. Additionally, to support achievement of operations excellence of the supply base, Lucas operating units would participate in and input into supplier sourcing decisions. The Purchasing focus and TRW Global Supplier Development Process are supported by major e-business initiatives that require, besides Internet based commerce, collaborative engagement with their suppliers in early sourcing, new product development, launch and on-going continuous improvement.

To ensure suppliers achieve the company's priorities and focus areas, the TRW Automotive Global Purchasing would deploy Lean/Sigma, Quality Product Engineering, Supplier Quality Assurance and Supplier Development Engineering personnel to assist their suppliers. Lucas deals with direct material and service suppliers according to the Global Supplier Quality Manual (GSQM) by TRW Automotive and it is holding the policy of TRW to achieve clear competitive advantages through continuous improvement in quality, service, delivery and cost from the suppliers in the total supply chain.

Lucas Automotive follows a series of processes/ procedures that have been defined as the TRW Automotive Supplier Development Management Processes. This details the methods and tools used by Supplier Development and Supplier Quality from the initial assessment at a potential new supplier through launch and into intensive supplier improvement and tactical monitoring within operations. The horizontal axis of the figure follows the product development stages, starting with Concept Validation.

4.2.2 Factors that Lead to the Implementation of ESI

Automotive market expectations continue to be high, requiring extreme business fitness for survival and profitable growth. Lucas Automotive plans to maintain its business strength and create exceptional value for its customers via four strategic priorities of best quality, lowest cost, global reach and innovative technology. A key to achieve these priorities is to have a robust and adaptable supply base that understands Lucas requirements, and acts with similar urgency demanded by customers.

Lucas cooperates with suppliers early in the process of product development in order to have continuous improvement towards the products. Lucas encourages and accepts suggestions proposed by suppliers of the products changes as they have the technological expertise which helps in the process of product development. The exchange of technical helps Lucas to produce a better quality and more complex

product which fulfill the needs of the customers such as quality, design changes and cost down for the products.

Lucas has been practicing early supplier involvement for decades as they believe that it is a necessary to participate suppliers in the process of product development as two ways communications happen between suppliers and manufacturers. Discussion often held when problem of production occurs. Suppliers sometimes might seek for assistance from Lucas when difficulties arise in producing components to meet the specifications. Engineers would be sent to the suppliers' plant to facilitate suppliers and overcome these production problems or develop contingency plan. This approach ensures quality products will be manufactured.

4.2.3 The Level of Supplier Involvement

4.2.3.1 Design

TRW Automotive has three main design centers which are situated in United Kingdom, German and Malaysia. Each of every center has its own task and responsibility in designing; therefore they will be performing in designing different products of TRW. Lucas Automotive involves suppliers early in the process of product development by using TRW Global Supplier Development Management Process. TRW Automotive New Product Introduction teams would define component criticality during the product development cycle and determines the involvement of TRW Supplier Development in the Advanced Product Quality Planning (APQP) and launch process of suppliers. Mr. Tan, the manager of research and development department explained that APQP is a report which is prepared by suppliers for a new product with regard to meeting the quality of the product, cost, performance and timing. Lucas cooperates with suppliers by allowing them to direct

access to the corporate website where information needed for product development can be accessed quickly.

New Product Launch initiates at design concept and runs through production launch of a new component. TRW Automotive New Product Introduction teams would define component criticality during the product development cycle. However in Lucas Automotive Senai, the product concepts are stated clearly in APQP, while the key milestones, deliverables and expectations of the suppliers are included. Lucas kept its core competencies in-house such as product design and development, and the final assembly of products. Engineers of Lucas work on the concepts to meet customers' specifications and requirements and design validation would be done during the design stage. A formal review and validation plan review involving a cross-functional team and the supplier where a rough overview of the product's function and usage is defined during the meeting and an action plan would be then generated from the open issues discussed during the review. Lucas mostly gives its suppliers the full responsibility for product development, and sometimes they are involved in the new product design.

Mr. Tan added that during this stage, suppliers are developing their tooling and processes to provide material for future serial production. Suppliers would be required to supply components for equipment tryouts and product validation builds and testing. Many suppliers of Lucas would be participating in Safe Launch Planning with the start of serial production after the approval of the Production Part Approval Process (PPAP). Suppliers are encouraged and welcomed to recommend product design modification target at improving quality as suppliers possesses the technical expertise needed to develop the respective component. Determination of Manufacturing Feasibility and Preliminary Capacity Study are required for every new or modified product design or process changes based on engineering changes. The end product design is not notified to prevent the leakage of technical and product information. Suppliers are not involved in the process of sales review but the parts delivery schedules and the targeted volume would be informed to make sure on time delivery by suppliers.

The quality target is set by the department of research and development of the company and Global Supplier Quality Manual (GSQM) is used to specify Lucas Automotive quality system requirements to suppliers. This manual is distributed via the posting on the TRW website at <http://vin.livmi.trw.com/>. While Lucas would communicate to the suppliers about major revisions to this manual, the suppliers are expected to remain up-to-date on the corporate requirements by frequently visiting the website. Visiting the website has become a business routine as TRW shifts to web based communications and applications. Questions and discussion about the specifications and tolerances can be directed through website to make sure consensus can be reached and a better product can be manufactured. To ensure compliance with the various legal and customer requirements, Lucas requires its suppliers to report information on materials within their respective components. The International Material Data System (IMDS) has been developed by vehicle manufacturers to collect and manage this data. Value Engineering (VE) is done by Lucas only after the product being launched as the effect of short product life cycle. A sourcing committee would deal with suppliers in this process in order to deliver the best product to the customers. The collaboration between the committee and suppliers necessitate a lower cost production with the improvement in lead time and also quality.

On the other hand, the required material and the volume of production would be notified at the stage of Request for Quotation (RFQ). Negotiation would be held when difficulties in meeting requirements faced by suppliers. Lucas would be pleased when suppliers voice up their opinion towards the customization and standardization of the parts. Suppliers do provide leads and assistance in finding sources for alternative raw materials which involves lower cost. Suppliers would hold a discussion with engineers prior to any changes of the quality aspect, tolerances, specifications and the use of raw material and submit a formal written request. However, any changes towards the design of the product require the approval from engineers of Lucas before the change is implemented.

There is no involvement of suppliers in the process of designing the artwork and packaging. Products of Lucas would be sent to customers in bulk and are arranged in a carton box. The outlook design of the packaging is not important to attract the customer in this case. The design of packaging will be done by the engineers in Lucas to preserve and protect the products.

4.2.3.2 Procurement

Lucas is performing a centralized purchasing function as TRW Automotive has formed a dedicated purchasing team. To deal with suppliers, this respective purchasing team with members chosen from the department of purchasing in every TRW plants. A commodity manager would be assigned to lead this team in their daily purchasing activities. They determine and select strategic suppliers according to the criteria and requirement of TRW Automotive. On the other hand, purchasing of Lucas is decentralized as the function of procurement is done on a local level towards the materials of plastic.

According to Miss Tay, the purchasing manager, the make or buy decision in the design process is made solely by the company according to the economic of scale of the product. In addition to that, Lucas would outsource according to the company's competencies, quality requirements and reliability of their suppliers. Suppliers are then responsible to meet the Global Supplier Quality Manual (GSQM) requirements as their failure to reach the stated specifications may result in the loss of existing and even future TRW business. Negotiations are allowed when suppliers unable to achieve the stated requirements and production volume. Suggestion by suppliers towards the reduction of transportation cost would be approved when improvement is available in the total production cost after assessment.

Lucas has a standard inventory and safety stock level by TRW Automotive. Suppliers are required to have an effective lot definition and traceability procedure due to the convenience in such way raw material can be traced back easily. Lucas

applies the analysis of Activity Based Costing (ABC) and Pareto as control of stock items. Lucas has the right to reject suppliers' product when the volume of delivery by suppliers exceed the quantity set in the agreement. Discussion with suppliers regarding the issues of inventory turnover and safety stock levels would be held though Lucas operates according to company's inventory policies. Lucas practices Just-In-Time for the purchasing of local materials; stock is only allowed for the overseas suppliers due to distance.

4.2.3.3 Suppliers

According to Miss Tay, most of the suppliers of Lucas are from Singapore as they have long term relationship with Lucas ever since it is being established in Senai whereby Lucas obtains plastic and stamping components from local suppliers. Suppliers to TRW Automotive as well as Lucas should be the third party certified to ISO 9001:2000 or ISO/TS 16949:2002 to ensure quality product would be supplied. The commodity manager in the purchasing team would lead the purchasing team to assess, select, negotiate and deal with matters related to suppliers. This team has its role to identify strategic and reliable suppliers from different countries for each and every product that is manufactured. Motorola is one of TRW Automotive strategic suppliers and has remained a very good relationship with it.

Suppliers can issue suggestions of improvements to the development of product through the commodity manager by submitting a written request for product or process change and obtain Lucas's approval prior to implement the change. Verbal request is not acceptable for any changes. As suppliers possess technical expertise which may helps in shortens design time, lower design and production cost and also decrease the number of quality problem, the suggestions by suppliers always critical in the stage of product development.

Mr. Tan explained that it is the policy of TRW to achieve a clear competitive advantage through continuous improvement in quality, service, delivery and cost

from suppliers in the total supply chain. Hence, suppliers would continuously improve their quality controls at their factories according to the ISO/TS 16949 2002 which is a documentation used by the automotive industry as a tool of quality control. Lucas's goal for all suppliers of materials and services affecting production material is to demonstrate compliances to ISO/TS 16949:2002. Suppliers also expected to comply with TRW Automotive specific requirements which are defined in the Global Supplier Quality Manual (GSQM). Lucas sends personnel to suppliers' plant to manage and facilitate suppliers to reach the company goals of producing a high quality product when there is necessary. Suppliers are recommended to use the latest Automotive Industry Action Group (AIAG) versions of the Advanced Product Quality Planning and Control Plan (APQP), Potential Failure Mode and Effects Analysis (FMEA), Measurement System Analysis (MSA), Production Part Approval Process (PPAP), and Statistical Process Control (SPC) manuals as guidelines for their system development.

Lucas does not depend on suppliers for the determining the delivery standards and goals. Suppliers are required to adopt the standards of Zero Defects and 100% On Time Delivery to Lucas. Suppliers are then expected to implement continuous improvement step toward shipment of components meeting the Zero Defect requirement. Lucas would perform various audits to confirm supplier capability. Suppliers that initially do not score acceptably would be required to develop action plans and timelines to correct any deficiencies and then request a re-audit to verify implementations of these actions. Supplier submission of non-conforming materials would be recorded as a supplier performance failure and could affect the supplier's performance rating. Suppliers are requested to submit a corrective action plan when troubleshoot problems occur and a systematic problem solving method such as 8D, 5 Phase, 7-Step and etc.

In addition, Lucas invests new tooling and equipment and hence installs them in suppliers' plant. This happens when specify tooling is needed for the respective components and indirectly Lucas introduces new technologies to suppliers. However, suppliers do not make any R&D investment during the product

development and are not allowed to have any investment in tooling in Lucas plant. The research is solely done by engineers from Lucas.

4.2.3.4 Manufacturing

Lucas rarely needs assistance from suppliers in their process of manufacture as the processing of their product is standardized and the technology complexity of output is low. According to Mr. Tan, suppliers' expertise and technical knowledge is not necessary during the production of Lucas. As the main reason of confidentiality, a minimal involvement of suppliers is applied in the process of manufacturing in Lucas. Moreover, it is the prevention of leakage of products' information to ensure competitiveness of Lucas in the market. Lucas would not review the production plan and schedules with suppliers. They would only notify suppliers with the volume of respective components, delivery schedule, annual forecast, delivery lead time.

Lucas coordinates with suppliers for the material handling goals on the mechanical parts which are critical and sensitive to handle such as cover that is easily scratched and fingerprint proof, and which need special packaging. Lucas and suppliers have to agree upon the packaging plan during APQP. Suppliers are expected to conduct periodically dock audits on packaged materials to assure that the packaging is sufficiently robust to withstand shipment by sea and arrive on time, without damage. Lucas uses a Safe Launch Plan which is a joint effort with the supplier to have similar Pre-Launch Control Plans at both the shipping and receiving facilities.

4.2.4 The Impacts of ESI Implementation

Collaboration between suppliers and Lucas at the early stage of product development helps Lucas to remain competitive advantage in the market as it's improves the capability to produce quality product at a reasonable cost. In addition,

early supplier involvement has a significant impact towards Lucas's performance and adds value to the process of manufacturing which enables Lucas to respond quickly to the uncertainty of customer demand.

The purchasing department and TRW Global Supplier Development Process require collaborative engagement with their suppliers in early sourcing, new product development, launch and on-going continuous improvement. This collaboration enables Lucas and its supply base to meet the OEM market demands of shorter product development cycles, flawless launches and exceptional quality.

4.2.5 Barriers to the Effective ESI Implementation

Lucas does not practice formal plans to control the exchanges of technical information with suppliers as what Proton used to do. The contractual agreement is usually being used by most of the companies to prevent the leakage of product information and losing the proprietary technology. Lucas has long term and good working relationship with most of the suppliers which indirectly increase the level of trust. Trust occurs between suppliers and Lucas and encourages Lucas to initiate informal exchange of technical information. However, the exchanges of information are limited which only included design of parts will be subcontracted, quality specifications and the product functions. This is to make sure the parts produced by the suppliers in terms of quality features are consistent and compatible with the parts produced by Lucas. Suppliers are not allowed to involve in the process of the production of the final product of Lucas. Though, suppliers are forthcoming in proposing and assisting Lucas in the process of product development.

Interpersonally problem occurs when dealing with suppliers as some of the suppliers are not cooperative and slow in time delivery. The flow of production of Lucas is affected and the delay happened. Therefore, Lucas practiced Annual Self Assessment whereby suppliers' performance would be evaluated regarding on their contribution to product's quality features. In order to improve the product's quality

which being supplied, Supplier Development Program is organized from time to time.

4.2.6 Summary

Table 4.1 Design Building Block – Lucas Automotive Sdn. Bhd.

Stage	Descriptions
(D1) Conceptualize product	The product concepts are stated clearly in APQP, while the key milestones, deliverables and expectations of the suppliers are included. APQP is a report which would be prepared by suppliers for a new product with regard to meeting the quality of the product, cost, performance and timing.
(D2) Define customer, product function and usage	A formal review and validation plan review involving a cross-functional team and the supplier where roughly overview by the product's function and usage is defined during the meeting and an action plan would be then generated from the open issues discussed during the review. Lucas mostly gives its suppliers the full responsibility for product development, and sometimes they are involved in the new product design.
(D3) Review sales forecasts	No involvement of suppliers
(D4) Determine material requirements	Suppliers developed their tooling and processes to provide material for future serial production. Suppliers would be required to supply components for equipment tryouts and product validation builds and testing.
(D5) Perform value	Suppliers of Lucas would be participate in Safe

engineering of parts	Launch Planning with the start of serial production. Suppliers are encouraged and welcomed to recommend product design modification target at improving quality. Determination of Manufacturing Feasibility and Preliminary Capacity Study are required for every new or modified product design or process changes based on engineering changes.
(D6) Determine number and type of standard parts and materials	Required material and the volume of production would be notified at the stage of Request for Quotation (RFQ). Negotiation would be held when difficulties in meeting requirements faced by suppliers and they are allowed to voice up their opinion towards the customization and standardization of the parts.
(D7) Determine raw material costs	Suppliers do provide leads and assistance in finding sources for alternative raw materials which involves lower cost.
(D8) Develop specifications, tolerances and scrap ratios	Suppliers would hold a discussion with engineers prior to any changes of the quality aspect, tolerances, specifications and the use of raw material and submit a formal written request.
(D9) Determine quality targets	The quality target is set by the department of research and development of the company and Global Supplier Quality Manual (GSQM) is used to specify Lucas Automotive quality system requirements to suppliers.
(D10) Determine art-work design, packaging design	No involvement of suppliers
(D11) Define product performance range	To ensure compliance with the various legal and customer requirements, Lucas requires its suppliers to report information on materials within their respective components. The International Material Data System (IMDS) has been developed by vehicle manufacturers to collect and manage this data.

Table 4.2 Procurement Building Block – Lucas Automotive Sdn. Bhd.

Stage	Descriptions
(P1) Analyze make/ buy decision	No involvement of suppliers. Lucas would outsource according to the company's competencies, quality requirements and reliability of their suppliers.
(P2) Negotiate price	Negotiations are allowed when suppliers unable to achieve the stated requirements.
(P3) Negotiate transportation costs and terms	Suggestion by suppliers towards the reduction of transportation cost would be approved when improvement is available in the total production cost after assessment.
(P4) Determine order frequency	Lucas has the right to reject suppliers' product when the volume of delivery by suppliers exceed the quantity set in the agreement.
(P5) Negotiate lead times	A sourcing committee would deal with suppliers in this process in order to deliver the best product to the customers. The collaboration between the committee and suppliers necessitate a lower cost production with the improvement in lead time.
(P6) Determine inventory levels	Discussion with suppliers regarding the issues of inventory turnover would be held though Lucas operates according to company's inventory policies.
(P7) Set incoming quality inspection standards	No involvement of suppliers.
(P8) Determine safety stock levels	Lucas has a standard inventory and safety stock level by TRW Automotive. Discussion with suppliers regarding the issues of safety stock levels would be held though Lucas operates according to company's inventory policies.

Table 4.3 Suppliers Building Block – Lucas Automotive Sdn. Bhd.

Stage	Descriptions
(S1) Standardize raw materials	Suppliers can issue suggestions by submitting a written request to commodity manager.
(S2) Improve quality controls at supplier factory	Suppliers should continuously improve their quality controls at their factories according to the ISO/TS 16949 2002. Suppliers also expected to comply with TRW Automotive specific requirements which are defined in the Global Supplier Quality Manual (GSQM). Personnel are sent to suppliers' plant to manage and facilitate suppliers.
(S3) Troubleshoot problems/ rejects	Suppliers are requested to submit a corrective action plan when troubleshoot problems occur and a systematic problem solving method such as 8D, 5 Phase, 7-Step and etc.
(S4) Investigate pricing and cost improvements	No involvement of suppliers.
(S5) Determine delivery standards and goals	No involvements of suppliers, but suppliers are required to adopt the standards of Zero Defects and 100% On Time Delivery to Lucas. Suppliers are then expected to implement continuous improvement step toward shipment of components meeting the Zero Defect requirement.
(S6) Determine technical capabilities	Lucas would perform various audits to confirm supplier capability. Suppliers that initially do not score acceptably would be required to develop action plans and timelines to correct any deficiencies and then request a re-audit to verify implementations of these actions.
(S7) Determine R&D investment	No involvement of suppliers.

Table 4.4 Manufacturing Building Block – Lucas Automotive Sdn. Bhd.

Stage	Descriptions
(M1) Define and discuss manufacturing processes	A minimal involvement of suppliers is applied in the process of manufacturing in Lucas due to confidentiality. Lucas would not review the production plan and schedules with suppliers.
(M2) Review/ up-date production schedules	Lucas would only notify suppliers with the volume of respective components, delivery schedule, annual forecast, delivery lead time.
(M3) Determine size of production runs	No involvement of suppliers.
(M4) Set inventory turnover goals	No involvement of suppliers.
(M5) Determine throughput costs	No involvement of suppliers.
(M6) Evaluate set-up times	No involvement of suppliers.
(M7) Determine production capacity	No involvement of suppliers.
(M8) Set production efficiency goals	No involvement of suppliers.
(M9) Define material handling goals	Suppliers are expected to conduct periodically dock audits on packaged materials to assure that the packaging is sufficiently robust to withstand shipment by sea and arrive on time, without damage.

4.5 Conclusion

The case study show that the level of supplier involvement in the product development varies. The discuss to the extent where suppliers are chosen and how

much responsibility in the process of new product development should be allocated to the suppliers according to the four building blocks in the ESI conceptual framework.

PART V

CONCLUSION AND RECOMMENDATION

5.1 Introduction

There are four major contribution of this paper. Firstly, the researchers described the factors which encourage companies to involve suppliers earlier in the product development. Second, the level of supplier involvement is modeled in four components which are design, procurement, suppliers and manufacturing. Comparisons were made according several propositions in four components in ESI which are grounded in the literature by Dowlatshahi (1997). Last and but not least, the researchers assessed the barriers and the impact of supplier involvement in the process of product development.

5.2 Discussions

5.2.1 Factors That Encourage ESI Implementation

The survey findings discussed previously indicate that Lucas journey of implementing early supplier involvement in their product development has been minimal. Lucas's suppliers are integrated in the process of product development as high quality products are required to be manufactured and this is consistent with the writings of Dowlatshahi (1997) and Jeffrey, *et. al.* (1998). Cost cutting is expected to achieve the same goals for best products quality and lowest cost to be produced. With these, companies are able to outstand and to capture market share in recent highly competitive manufacturing industry.

In fact, supplier's knowledge and expertise is used to complement internal capabilities according to Ragatz, *et. al.* (2002). From the result gathered, suppliers' recommendations are taken into considerations in the process of product development so as to provide assistance in expediting product design and development. Lucas admitted that they did not require sufficient technological expertise to develop the whole product from design to packaging stage, and this supports the literature by Dowlatshahi (1997). The early supplier involvement is believed to improve the product development efficiency and effectiveness. Therefore, integration and collaboration with suppliers occurred in order to create a product with higher reliability, maintainability, and the most important better quality with shorter product development lead times.

On the other hand, Lucas, has integrated suppliers to facilitate the process of product development in order to prevent production problems occur which would directly reduces the cost of quality of a product. This again proves that involvement of suppliers increase the efficiency of product development. With the availability of suppliers' technical expertise and their assistance, problems can be encountered easily or prevent before mass production of a product which enable a viable product line in the company.

5.2.2 Level of Supplier Involvement

5.2.2.1 Design

The findings suggest that the results gained by the researcher are in contrast to the current literature on the necessity of supplier involvement early at the product design by Huang and Mak (2000). The empirical evidence shows that the designers from Lucas did not depend heavily upon suppliers throughout the design process. There were some obstacles which prevented the sharing of information between the manufacturing company and the suppliers.

The picture that emerges from the existing literature discussed the cooperative partnership between suppliers and manufacturers at the design stage are essential. The researcher noted that the Lucas recognized that not all suppliers are capable of autonomous product development. Thus, they tend to be very selective with only a portion of suppliers deeply involved in the product development.

On the other hand, the proposition of reviewing the sales forecast, determining material requirements and value engineering is not a valid practice at Lucas. Lucas performed only internal review of sales forecast and did not notify the suppliers with those preliminary forecasts.

Proposal made by suppliers in the consideration of cost reduction in order to deal with the intensified competitive pressures lately which is similar to Mikkola and Skjoett-Larsen (2003). Lucas involved suppliers in the process of determining the raw material cost, since suppliers required to quote for the material specified and decisions were made accordingly. According to Dowlatshahi (1997), and Abu Bakar and Rohaizat (2002), the raw material cost is the major portion of the final product cost and this is verified by the findings where cost improvement in materials were the main target of all companies.

From the findings, Lucas set and developed the specification, tolerances, scrap ratios as well as the quality targets without receiving proper inputs by suppliers. This contradicts Dowlatshahi (1999) where the design, manufacturing and suppliers need to be integrated to develop the tolerances, scrap ratios, specifications and quality target. In addition, Lucas made a good use of suppliers' capabilities in the packaging design due to high expectation of customers. The company relied heavily on the suppliers' expertise and packaging knowledge.

Brill (1993) stated that the product performance range should be notified before the actual procurement and manufacturing take place. Findings revealed Lucas did not discuss the performance range with suppliers in advanced in order to obtain all components of a product to have consistent performances range.

5.2.2.2 Procurement

This study shows that generally during the new product development processes, the make or buy decisions were judged based on the consideration of the company core competencies. This view is concurrent with Dobler and Burt (1996) argument of make or buy decisions are only advisable when they impact a firm's core competency and critical success factors. Moreover, consideration of factors in regards to economic of scale and reliability of suppliers in meeting quality requirements were essential in making decisions.

Study shows that price negotiation between buying companies and the suppliers were mostly done by headquarter abroad or by purchasing department, written in formal business or price contracts. In reference to Dowlatshahi (1999), the overall cost structure is the focus of ESI partnership in price negotiation tasks.

According to Ng, *et. al.* (1997), supplier involvement in reducing total cycle time must consider the transportation cycle time and this study support the above conclusion. Lucas negotiate with suppliers on transportation costs and other relevant terms such as deliveries lead times and transportation mode, as written in a business contract. Suggestion by suppliers towards the reduction of transportation cost would be approved when improvement is available in the total production cost after assessment.

Findings from this study also indicated that Lucas practice to integrate suppliers in negotiating product lead times towards achieving low cost production with shorter production cycle time. There were dedicated purchasing teams and specific network system linkage in order to coordinate with suppliers. These findings support Brill (1993) research that effective ESI requires sufficient

coordination in terms of production lead times between buying company and suppliers involved.

According to Dowlatshahi (1999), involving cooperative suppliers to negotiate inventory levels and inventory turnover of buying company may contribute to buying company's JIT purchasing environment in long term. The findings of this study support Dowlatshahi (1999) research whereby Lucas discussed its inventory levels with suppliers and incorporate JIT purchasing of local materials.

This research further shows that there is lack of relationship in supplier involvement in setting quality inspection standard of buying company during the new product development stages. In other words, Lucas set incoming quality standards internally, either from the requirements of the companies' engineers or require suppliers to possess ISO certification, which suppliers had to abide to without any prior agreement. These finding contradicted with Dowlatshahi (1999) that the incoming quality standards should be agreed upon between the buying company and the suppliers in advance of orders.

Lucas set its own safety stock level according predetermined by their at corporate level, by involving the supplier involvement, in accordance to Dobler and Burt (1996) whereby discussion held with suppliers to determine safety stock level in order to reduce total inventory costs and fulfill unpredicted market demands, are encouraged.

5.2.2.3 Suppliers

Researcher found out that Lucas did not address the proposition of standardizing raw material directly to suppliers. Lucas had only some improvements towards standardization when sufficient suppliers' are allowed. Lucas believed that standardization allows cost savings in the process of product development which is similar to Mikkola and Larsen (2003).

Lucas requires its suppliers to conduct continuous improvement in their product according to the formal documentation as the tool of quality control. However, Lucas still relied heavily on incoming quality inspection rather than transferring personnel to facilitate suppliers in their plant.

In fact, the process of troubleshooting problems and rejects was verified in practice in Lucas. Lucas did not involve suppliers to investigate pricing and cost improvements. While, Dowlatshahi (1999) advocated that material substitution is one of the ways of price and cost improvement to achieve the manufacturing goals of lower production cost.

In addition, Lucas determined the delivery standards and goals and would discuss with suppliers to make sure suppliers perform accordingly to the standards set. As Dowlatshahi (1999) mentioned, this is the purpose of allowing suppliers to be aware of buyer's expectation.

Lucas does invest in R&D in suppliers' plant in order to achieve the economies of scale in production. Such investment was made based to the relationship with suppliers and also the volume of production (Dowlatshahi, 1997).

5.2.2.4 Manufacturing

Supplier' involvement in manufacturing related operations and processes were minimal due to the matter of confidentiality and possession of prominent manufacturing technologies, thus the assistances from suppliers were not required. While Dobler and Burt (1996) advocated that buying company's production volumes, schedules, and any changes in production activities should be communicated to suppliers on a timely basis. In this case, Lucas would merely notify main suppliers of the product in regards to the consumption volume of

respective components, delivery schedule, annual forecast, delivery lead time, and the schedule of mass production.

In Nevins and Whitney (1989), the buying company's material handling goals and procedures as well as standard pack quantities should be known and coordinated with ESI suppliers. Thus intensive supplier involvement in design and manufacture of mechanical equipments and special packaging could increase the effectiveness the production processes. However, both mechanical equipments and standard packaging were considered as indirect materials.

5.2.3 The Impacts of ESI Implementation to the Companies' Performance Dimensions.

According to Rouibah (2002), supplier partnership aims to improve capabilities of buying company in terms of product development efficiency (product cost and quality), and effectiveness (development cost and quality), as supported in this research. Besides, findings also support Krause and Ellram (1997) research that firms are getting more dependent on suppliers to meet increasing competition as they focus on their core competencies.

Thus suppliers' involvements have contributed to transformation from manual works to automated works in buying companies, continuous cost improvement of product parts and components, and shorten product development cycles, as represented by Hahn (1990). Suppliers' capabilities heavily influence a firm's ability to produce a quality product at lower cost, and in a timely manner.

Throughout supplier involvement and partnership, additional inventory can be carried to accommodate buying companies' delivery requirements in a timely basis (Hahn, *et.al.*, 1990). Consequently, this study show that ESI facilitated companies to meet volatile market demands of shorter product lead times.

Past literature indicates suppliers are involved in the product development process because usually they possess design and manufacturing technologies expertise, according to Birou and Fawcett (1994). This study supported the above notion, whereby collaboration between buying company and its suppliers are necessary to improve and streamline the manufacturing processes of the buying company.

5.2.4 The Barriers of Effective ESI Implementation

This research found that contractual agreement was used by Lucas to prevent the leakage of product information and losing the proprietary technology. Besides, buying company only passed over the design drawings of parts being subcontracted for suppliers to follow up, not the drawing of a complete set of product. Such restriction was to avoid supplier monopolies the outsourcing of a whole product. The above findings support Mikkola and Larsen (2003) research that the risks of collaborative product development include leakage of information, loss of control and ownership.

According to Leenders, *et.al.* (2002), confidentiality is perhaps the biggest obstacle to supplier involvement, particularly when a new product design is involved. This study reveals that Lucas enforced security management and prohibits suppliers from enter into the production lines.

Lucas also did not put trust on its suppliers in exchanging information and forming strategic partnership and ESI program, which is in support with Dowlatshahi (1997) argument of the lack of trust between the buyer-suppliers is usually predominant.

According to Liker, *et.al.* (1998), technologically complex designs with outcome ambiguity would increase the specificity and complexity of the communication with suppliers, until “make” the product in-house decisions more attractive. Similar by this study, findings indicate that Lucas prefer to produce in-house for those sensitive mechanisms which considered as the key performance parts of a product.

Beyond all the barriers stated in the past literatures, this study reveals two additional barriers that may hinder effective ESI implementation. Geographical factor was one of the barriers to buying companies whose supply bases were located mainly abroad. Although communications and co-ordinations between buying company and supplies could be done by all means such as emails, telephones and faxes, yet it will lessen the opportunities of face to face interaction and discussion and will affect the partnership.

Besides, interpersonal problems were encountered by Lucas when dealing with its suppliers. Such interpersonal problems include uncooperative suppliers that provide unreliable product deliveries and incurred substantial quality issues to buying company. Moreover, suppliers with different backgrounds, cultures and languages from a buying company caused troubles in implementing ESI program effectively. Such troubles include communication misunderstandings and inconsistent working styles between a buying company and a supplier.

5.2.5 Recommendation for Future Research

This research focuses on early supplier involvement in the companies during product development, with regards to four building block of ESI framework developed by Dowlatshahi. Besides, factors that affect manufacturers to implement ESI program throughout the product development stages are identified. Moreover, the research seeks to analyze the impacts of ESI practices to the companies, as well as to identify the barriers to effective ESI implementation.

Future researches should be conducted among other companies in E&E industry which have different country of origins other than Germany. For example, conduct a research on American, Japanese, Taiwan, China, and Singapore based companies. This will certainly provide beneficial insights into the ESI program. Other potential manufacturing industries would also include such as wood products and rubber products are worth to be studied as they are essential in contributing to GDP.

Future researches are suggested to be conducted in quantitative form which utilises statistical method to interpret collected data and findings. By using quantitative method, level of ESI implementation in companies could be measured and determined from the rating.

Last but not the least, future researches should conduct other geographical areas within Malaysia such as Selangor and Penang, which have high concentration of manufacturing firms that would further facilitate a comprehensive research in the subject matter.

5.3 Conclusion

As a conclusion, Lucas has integrated suppliers in product development. It was argued that the most significant impact and benefits of ESI are obtained when the involvement of supplier early in the design stage. To underline this significant, several propositions are presented in four components in ESI framework by Dowlatshahi (1997). Thus, each proposition was evaluated in practice and from the results gained; there are still a lot of propositions that Lucas did not validate in practice before embarking on the ESI implementation. Early supplier involvement has been proven as the core tool to enable a company to outperform in this high competitive market, it is, therefore, essential to consider the issue of involving suppliers early in the process of product development.

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