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For the degree of Master of Science	
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### EVALUATION OF EARLY SUPPLIER INVOLVEMENT IN PRODUCT DEVELOPMENT

A Thesis

Submitted to the Faculty

of

Purdue University

by

Yunker Chen

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

August 2010

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West Lafayette, Indiana

#### ACKNOWLEDGMENTS

Standing outside the Knoy BS440, I was waiting for the dissertation defense result. Few minutes later, Prof. Schmidt, my committee chair, came to me, gave me one big warm hug and said, "Congratulations!" Suddenly, the memory in the past two years, all the pains and pleasure at Purdue University, came up to me. This is the moment I had waited for so long, but this is also the moment I was unwilling to face because of the coming goodbye. Nevertheless, I knew things I learnt and people I met there will be the valuable asset in my life and will be with me all the time.

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#### TABLE OF CONTENTS

	Page
LIST OF TABLES	
LIST OF FIGURES	
ABSTRACT	V11
CHAPTER 1. THE PROBLEM	
1.1. Introduction	
1.2. Statement of the Problem	
1.3. Significance of the Problem	
1.4. Purpose of the Study	
1.5. Assumptions	
1.6. Delimitations	
1.7. Limitations	
CHAPTER 2. LITERATURE REVIEW	
2.1. New Product Development (NPD)	
2.2. Concurrent Engineering (CE) & Collaborative Product Development (CPD).	
2.3. Buyer-Supplier Relationship	
2.4. Early Supplier Involvement (ESI)	
2.5. Product Lifecycle Management (PLM)	
2.6. Buyer-Supplier Performance Evaluation Method	
CHAPTER 3. METHODOLOGY	
3.1. Measurement	
3.2. The Questionnaire	
3.3. Data Collection Mechanism	
3.4. Participants	
3.5. Recruitment method	
3.6. Survey Analysis	
CHAPTER 4. DATA ANALYSIS	
4.1. Analysis of Respondent Profile	
4.1.1. Job function.	
4.1.2. Business model	
4.1.3. Number of parts	
4.2. Analysis of Suppliers' Contribution	28
4.2.1. Between four measurements.	
4.2.2. Within each measurement.	
4.3. Analysis of Suppliers' Contribution	34

	Page
CHAPTER 5. CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS	35
5.1. Conclusions and Discussion	35
5.2. Recommendation	36
LIST OF REFERENCES	38
APPENDICES	
Appendix A. Questionnaire	44
Appendix B. Culturally Appropriate Letter	

#### LIST OF TABLES

Table	Page
Γable 2.1 Elements of PLM solution (Amann, 2004)	10
Table 2.2 Four Quadrants of Buyer and Supplier performance (Quesada, Syamil, & D	oll,
2006)	
Table 2.3 The elements contributing to suppliers' co-design performance (De Toni &	
Nassimbeni, 2001; Nassimbeni & Battain, 2003)	14
Γable 3.1 Four measurements to assess suppliers' capability in the stage of product	
concept and function design (Nassimbeni & Battain, 2003)	
Γable 3.2 (Continued) Four measurements to assess suppliers' capability in the stage	
product concept and function design (Nassimbeni & Battain, 2003).	
Table 3.3 List of research questions	
Table 3.4 (Continued) List of research questions	
Γable 4.1 Simple statistics of four measurements. Each contains three research questi	
individually.	29
Γable 4.2 Pearson correlation analysis for research questions related to technological	
expertise	
Table 4.3 Pearson correlation analysis for research questions related to new technology	_
identification	
Γable 4.4 Pearson correlation analysis for research questions related to technological	
1	33
Table 4.5 Pearson correlation analysis for research questions related to technological	
expertise	34
Table 5.1 Barriers to ESI between the Company and its key suppliers (McIvor &	27
Humphreys, 2004)	3 /
Appendix Table	11
Table A.1 Questionnaire - Introduction in English	
Table A.2 Questionnaire - Introduction in Chinese	
Table A.3 Questionnaire - Section one	
1 auto A.4 Oudshumane - Section two	4 /

#### LIST OF FIGURES

Figure	Page
Figure 1.1 The Scope of Product Lifecycle Management (Abramovici, 2007)	2
Figure 2.1 Major Enterprise Lifecycles (Amann, 2002)	11
Figure 2.2 Structure of the Supplier Performance Evaluation mode (Le Dain, Calvi,	&
Cheriti, 2007)	13
Figure 3.1 Questionnaire Development Process (Churchill & Iacobucci; 2002)	15
Figure 3.2 The flow to complete the survey	20
Figure 3.3 Three principles of data collection method (Sekaran, 2003)	21
Figure 4.1 The number and percentage of respondents' job title or function structure	25
Figure 4.2 The number and percentage of business models of respondents' projects of	or
companies	26
Figure 4.3 The dot plot of part numbers of the 62 samples including outliers	27
Figure 4.4 The dot plot of part numbers of the 59 samples after elimination of three	
outliers	27
Figure 4.5 The statistics summary of part numbers of the 59 samples	28
Figure 4.6 Compare the means and spreads of a1, b2, c1, and d1 in the box plot	30
Figure 4.7 Compare the means and spreads of a2, b2, c2, and d2 in the box plot	31
Figure 4.8 Compare the means and spreads of a3, b3, c3, and d3 in the box plot	32
Appendix Figure	
Figure B.1 Culturally Appropriate Letter	50

#### **ABSTRACT**

Chen, Yunker. M.S., Purdue University, August, 2010. Evaluation of Early Supplier Involvement in Product Development. Major Professor: Edie K. Schmidt.

In the Asia-Pacific Region, industries are tend to concentrate geographically, link together vertically or horizontally and create mutual reinforcing process. By taking advantage from such industry cluster (Porter, 1990; Porter, 1998; Tsai & Li, 2009), companies have collaborated with their suppliers more in the product lifecycle to gain benefits of quick response to market, lower product cost and better quality. Hence, improving suppliers' co-design ability appears to be an important index for suppliers' overall performance and project achievement. However, most companies neither know if their suppliers are capable of supporting their new product development nor have clear statistical reports about suppliers' co-design ability in industries for reference, which obstruct these companies from seeking effective ways to enhance suppliers' performance. To address these issues, this study examined suppliers' contribution and Product Lifecycle Management (PLM) solution satisfaction level toward suppliers' Collaborative Product Design (CPD) performance in the Taiwanese electronics industry. The result of this work provided statistical reports and advice to industries and PLM software vendors pursuing buyer-supplier relationship enhancement.

#### CHAPTER 1. THE PROBLEM

#### 1.1. Introduction

With the evolvement of globalization, various buyer-supplier relationships were formed to keep up with the competition of product development activities, especially in the electronics industry (De Toni, Nassimbeni, & Tonchia, 1999). The business models were transformed from the outsourcing of specific individual functions to Original Equipment Manufacturing (OEM), Original Design Manufacturing (ODM), and Original Brand Manufacturing (OBM), and even Collaborative Design Manufacturing (CDM) (Chu, Chang, & Cheng, 2006). Suppliers extended their role from simply negotiating price, ensuring supply, and cooperating in the supply chain, to participating in product design with project engineering teams in the development chain. This interaction of both internal business entities and the extended enterprises, including suppliers, business partners, and customers, makes design chain management more important. To effectively manage a product from concept to obsolescence with numerous stakeholders, the strategic business approaches, PLM, was then proposed.

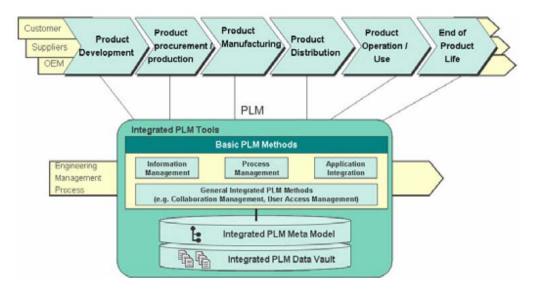


Figure 1.1 The Scope of Product Lifecycle Management (Abramovici, 2007)

PLM, evolved from Product Data Management (PDM), encompasses more extensive scope to support product development, manufacturing, process control and so on (see Figure 1.1). Although previous research agreed on the benefits of supplier's timely involvement in New Product Development (NPD) processes, it is difficult to attain such an advantage from existing PLM solutions. The complexity of new product management causes both PLM solutions with limited predefined templates that are provided mainly by software vendors and the necessary customization effort that is only possible in large user companies (Abramovici, 2007). In addition, many companies tend to take PLM technology as one solution for everything and falsely consider that as long as they invest in large amounts of money in implementing a PLM system, suppliers' codesign ability will be enhanced. PLM software vendors then furthermore provide unsuitable customization. How much effectiveness PLM software really brings to industries is unknown. Therefore, to help the electronics industry identify whether existing PLM systems are supportive of suppliers' performance in new product development, this research surveyed suppliers' contribution and the gap of PLM solution's satisfaction levels toward suppliers' collaborative design in Taiwan's electronics industry.

#### 1.2. Statement of the Problem

Early supplier involvement in the product development process, along with a well implemented PLM system used in a collaborative manner, are contributing factors for companies' success in bringing products to market quickly at the lowest cost and best quality (Gentry & Savitskie, 2008; Liu, Maletz, & Brisson, 2009). However, identifying improvements to the collaborative product development process is difficult, as most companies do not recognize how much suppliers currently contribute to the process. In Taiwan's current industries, some companies rely on close collaboration with their suppliers and partners to compete with large global companies; others provide OEM or ODM services to large global companies to excel in the global market. This close interorganizational relationship makes it even necessary to provide both industries and PLM software vendors a clear direction to enhance suppliers' co-design ability.

#### 1.3. Significance of the Problem

Making a profit is the admitted objective for most enterprises all over the world. To achieve this objective, cutting cost is the most direct way. But, how to cut cost effectively and efficiently? As a result of intense competition by globalization, the fastest and obvious strategy is outsourcing and taking advantage of cheaper labor wages. Since the product design phase determines majority of the manufacturing cost for a product (Clark & Fujimoto, 1991; Ernst & Kamrad, 2000; Jaikumar, 1986; Wang, Shen, Xie, Neelamkavil, & Pardasani, 2002), having suppliers sharing new technology, providing product specification or supporting in Value Engineering (VE) during the early stage of product design to minimize product cost and maximize quality becomes a trend (McIvor & Humphreys, 2004). For various outsourcing strategies, the buyer-supplier relationships evolved to ODM or further to CDM, in which the collaboration has been more extensive than ever. Suppliers are not only involved in the early stage of product development but also in market analysis and product planning. Although there exists a contention about whether the earlier involvement the better (McGinnis & Mele Vallopra, 1999), the viewpoint that involvement timely while needed in new product development was agreed (Primo & Amundson, 2002), and the benefits of shortened product lifecycle in response

to market, lowered product cost and higher quality were approved by earlier studies (Birou & Fawcett, 1994; Bonaccorsi & Lipparini, 1994; Bozdogan, Deyst, Hoult, & Lucas, 1998; Clark, 1989; Handfield, Ragatz, Petersen, & Monczka, 1999; Wynstra, van Weele, & Weggemann, 2001). This early supplier involvement phenomenon caused core product engineering teams have frequent interaction with external suppliers for higher achievement in new product development (Petersen, Handfield, & Ragatz, 2003) and was considered a reflection of the recent economic change in the Asia-Pacific Region, especially in the electronics industry in Taiwan, which has gradually transferred its successful experience to China (Chu, Chang, & Cheng, 2006).

In addition to the importance of early supplier involvement in product development processes, Abramovici and Seig (2002) also believed that an integrated PLM platform or system is a need to fully support collaborative product design between internal engineering teams and external suppliers. Although many researchers have identified why suppliers' involvement is significant and what suppliers contributed in new product development, there has no quantitative report which shows how much suppliers contribute to which aspect of new product development activities for industries to use for comparison. This study examined the level of Early Supplier Involvement (ESI) in the electronics industry. By adding to the existing research on this topic, suppliers would be able to clarify the perception gap in co-design work and seek to provide better service to manufacturing firms' product development, manufacturing firms may evaluate their suppliers on historical facts, and PLM software vendors would have a better understanding of how to improve suppliers' collaboration ability for electronics manufacturing firms.

#### 1.4. Purpose of the Study

The purpose of this study was to analyze suppliers' contribution in the early stage of the product development process and to help identify whether the existing PLM systems effectively help suppliers engage in product development in the Taiwanese electronics industry. Measurements summarized from previous research related to

suppliers' co-design ability were evaluated and modified to create a new survey. There are three research questions in this study:

- 1. How important is it to involve suppliers early in collaborative product development?
- 2. How much do suppliers contribute to new product development?
- 3. How much do existing PLM solutions help suppliers contribute to collaborative product development?

Although the research was limited to the electronics industry in Taiwan, the findings could be generalized to Chinese business enterprises (Tsai & Li, 2009).

#### 1.5. Assumptions

Owing to the complexity and complication of integrating suppliers in product design, three assumptions are defined in this study.

- 1. Although some studies indicated the earlier the suppliers involve the better, in this study the proper timing of suppliers' integration is considered any moment needed in new product development processes (McGinnis & Mele Vallopra, 1999; Primo & Amundson, 2002).
- 2. It is assumed that the respondents keep mutually dependent relationship with suppliers in collaborative engineering and take CPD, which has been prevalent in the Asia-Pacific region, as an effective approach of helping them remain competitive (Chu, Chang, & Cheng, 2006).
- 3. The barriers of early supplier involvement in new product development were intentionally ignored in order to have better focus on the suppliers' contribution.

#### 1.6. Delimitations

Manufacturer-supplier relationship is evaluated using by numerous factors. To restrict the scope of this study, three delimitations are listed:

1. This study was limited to the electronics industry in Taiwan located in Asia-Pacific Region.

- 2. Respondents in this research were in buying companies' side and in the role related to new product development or participated in new product introduction projects.
- 3. Respondents should answer the questions according to their experience of participation in new product development projects.

#### 1.7. Limitations

Since convenience sample was adopted in this study, the response bias that the selected sample is not representative may occur. The targets of interest are the Taiwanese electronics industry located in Asia-Pacific Region so the result and finding may not be generalizable to other regions and industry sectors.

#### CHAPTER 2. LITERATURE REVIEW

In the following paragraphs, literatures related to this study is reviewed, analyzed and compared to provide comprehensive context of this study, intellectual progress of related topics and major debates. Since this study is interested in the early stage of new product development, the importance of development chain and the evolvement of CE and CPD are identified. In the section of buyer-supplier relationship and ESI, the change of suppliers' role in the manufacturing industry is reviewed. To take advantage of suppliers' contribution in new product development, multiple buyer-supplier performance evaluation method is also examined.

#### 2.1. New Product Development (NPD)

The stage of product design determines majority of the manufacturing cost for a product (Clark & Fujimoto, 1991; Ernst & Kamrad, 2000; Jaikumar, 1986; Wang, Shen, Xie, Neelamkavil, & Pardasani, 2002), and the potential for additional savings lies in the degree of integration between product design and the supply chain. Many researchers have addressed the managerial issues in order to have better control of product design and its relationship to manufacturing management. The narrowed product competition gap among manufacturers and a shift to design and engineering was pointed out by Clark and Fujimoto (1991). Stalk and Hout (1990) also emphasized the managerial aspect of product design more than that of manufacturing. In addition to that, control of product development and the subsequent part purchasing decisions necessary to support product life have been addressed by Cattani (2005), Cattani and Souza (2003), and Bradley and Guerrero (2008). In recent years, a deeper investigation was conducted by Sood and Tellis (2005) in order to see the technological evolvement and radical innovation at the phase of new product development. Curran et al. (2007), and Solomon, Sandborn and

Pecht (2000) provided deeper insight on the level of design effort necessary to manage product life. Regardless of their topic focus, their studies put emphasis mainly on the management of product development, which can be seen as the core value of manufacturing companies.

#### 2.2. Concurrent Engineering (CE) & Collaborative Product Development (CPD)

Since the early 1990s, concurrent engineering has become a significant strategy to achieve better product quality and reduce product development time and cost, proved by General Motors, Chrysler, Ford, Motorola and Intel (Abdalla, 1999; Clark, 1989; Wheelwright & Clark, 1992). As McGrath (1992) defined, in a conventional manner, "concurrent engineering means developing the product and all its associated process, that is, manufacturing, service, and distribution, at the same time" (p.91). This definition highlighted two essential elements of CE: synchronous communication and crossfunctional integration (Swink, Sandvig, & Mabert, 1996). From the late 1990s, with the keen competition and globalization, outsourcing from larger companies motivated by the benefits of cost reduction and core competency enhancement made concurrent engineering together with broader collaborative boundaries geographically and enterprise-wide to CPD (Chang & Chu, 2004). "The main goal is to integrate and leverage knowledge, technologies, and resources among all the collaborators, usually geographically distant, to quickly respond to the market and fulfill customer needs," as stated by Chu, Chang, and Cheng (2006). In such cases, different business models in the manufacturing industry based on different outsourcing relationship emerged: OEM, ODM, and OBM.

#### 2.3. Buyer-Supplier Relationship

The relationship between buyer and supplier has always been a popular topic in literature. The most well-known notion is the *spectrum of supplier integration* in which supplier's responsibility from least to most was none, white box, gray box, and black box (Monczka, Ragatz, Handfield, Trent, & Frayer, 1997). With the emergence of business

models like OEM and ODM, a detailed typology, supplier involvement portfolio, was defined, which is based on two dimensions: (a) the degree of autonomy of the supplier in the development process and (b) the degree of development risk (Calvi & Le Dain, 2003). Moreover, a new business strategy, CDM, evolves from original ODM in which the collaboration between buyer and supplier is deeper than ever. Suppliers are not only involved in the early stage of product development but also in the market analysis and product planning. This phenomenon was considered a reflection of the recent economic change in the Asia-Pacific Region, especially electronics industry in Taiwan that has gradually transferred its successful experience to China (Chu, Chang, & Cheng, 2006). To extend the vantage, high-tech design companies in Taiwan, servicing product brand owners or ODM manufacturers, taking advantage of industry cluster (Porter, 1998; Porter, 1990) and serving as an agent responsible for the NPD project, shaped the "One-stop Shopping" model (Chu & Cheng, 2007). Deeper and closer engineering collaboration is therefore affirmed. Based on these earlier researches, this study was aimed at the electronic industry in Taiwan and assume sample companies are all situated in the environment with close and early supplier involvement in new product development.

#### 2.4. Early Supplier Involvement (ESI)

Knowing the importance of product design, researchers broke down the detail of ODM business further. Procurement policies and supplier behavior in ODM were described in detail. Chang (2002) compared the behavior of the OEM and the ODM suppliers in the presence of a fixed, cost-plus contract. Supplier activities in ODM concerning Request for Information (RFI) and RFQ were included. Mikkola (2003) aimed to show the degree of supplier involvement and influence of early supplier involvement in NPD. Both Chang (2002) and Mikkola (2003) used real case studies to give more evidence of their findings.

#### 2.5. Product Lifecycle Management (PLM)

PLM, defined by CIMData, is a strategic business approach. It applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise from concept to end of life. Evolved from PDM, which was originally developed to manage CAD files for engineering department or workgroup, PLM extends the scope from the product design stage to the entire lifecycle and provides an information backbone for a company and its extended enterprise to integrate people, processes, business systems, and information (Amann, 2002; Amann, 2004, Faithi, Holland, Abramovici, & Neubach, 2007; Hartman & Miller, 2006). The multiple elements of PLM are summarized in Table 2.1.

Table 2.1 Elements of PLM solution (Amann, 2004)

Elements	Examples
Foundation technologies and standards	<ul><li> Visualization</li><li> Collaboration</li><li> Enterprise application integration (EAI)</li></ul>
Information authoring and analysis tools	<ul> <li>Mechanical computer-aided design (MCAD)</li> <li>Computer-aided manufacturing (CAM)</li> <li>Electronic design automation (EDA)</li> <li>Engineering simulation</li> <li>Analysis and technical publishing</li> </ul>
Core functions	<ul> <li>Product data management (PDM)</li> <li>Document and content management</li> <li>Workflow management</li> <li>Classification management</li> <li>Program management</li> </ul>
Functional applications	Configuration management
Specific technologies and functions for extended capabilities	<ul> <li>Strategic sourcing</li> <li>Automotive supplier</li> <li>Material compliance solution</li> <li>Plant inspection and maintenance solution</li> </ul>

Within the overall product lifecycle, Amann (2002) divided it into three major and tightly interacting processes: (a) product definition lifecycle, (b) product production lifecycle, and (c) operations support lifecycle (see Figure 2.1). The primary component of the PLM solution is the product definition lifecycle, which is responsible for the creation and management of intellectual property of a business from the earliest point of customer requirements and product concept to the end when the product is obsolete and field support has ceased. In addition to an individual business entity, the information, or the intellectual assets, also resides throughout the extended enterprise, including suppliers, business partners, and customers, who are being delegated more responsibility to participate in collaborative product development. The participation and collaboration of the internal business entity and extended enterprise in product definition lifecycle makes the design chain management becoming as important, or more important than the logistics and the production supply chain (Amann, 2002).

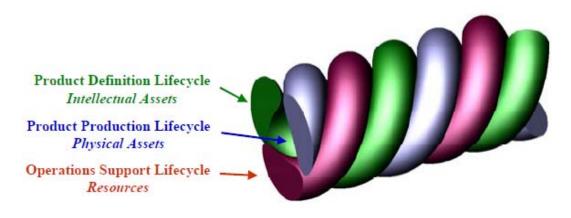


Figure 2.1 Major Enterprise Lifecycles (Amann, 2002)

The benefits of PLM to speed up product development, achieve higher customer satisfaction, and lower product cost are accepted and make PLM widely recognized as a business necessity (Liu, Maletz, & Brisson, 2009). However, because of the complexity of new product management, most PLM solutions have mainly provided by software vendors with generic predefined templates and the huge necessary customization effort is

only possible in large user companies (Abramovici, 2007). Among the numerous business requirements in new product development, this study helped examine the degree of collaborative product development between buying and supplying entities in order to provide advice for software vendors' future PLM solutions and companies' strategic plans.

#### 2.6. Buyer-Supplier Performance Evaluation Method

Quesada, Syamil and Doll (2006) divided the discussion of relationship between buyers and suppliers into four quadrants by supply chain and development chain, and targets of interest, vendors and buyers (see Table 2.2.) With regard to ESI, in the quadrant three and four, Primo and Amundson (2002) indicated that suppliers' performance evaluated by the variables of supplier's on-time delivery, quality and cost were proved to be significantly related to supplier involvement, especially in concurrent engineering. Although Quesada, Syamil and Doll (2006) and Primo and Amundson (2002) identified suppliers' influence in development chain, there had no systematic tool to numerically measure suppliers' influential level for industries' or researchers' reference and comparison. Looking for a tool to evaluate buying company's ability to collaborate with suppliers, the quadrant three, Le Dain, Calvi and Cheriti (2008) proposed a Customer Performance Evaluation (CPE) model. To evaluate suppliers' performance in new product development (Quadrant four), Le Dain, Calvi and Cheriti (2007) also introduced a Supplier Performance Evaluate (SPE) model, in which suppliers' contribution was categorized into: (a) product related, (b) process related, (c) project management related, and (d) social relation such as contractual commitment and bids response. Each category was further separated into three phases in new product development process (see Figure 2.2). Although the CPE and SPE frameworks take almost every aspects of buyer-supplier interaction into consideration, these models are conceptual and not ready to be applied to industries or future research. Different from the evaluation methods above, the framework presented by De Toni and Nassimbeni (2001) can numerically measure suppliers' co-design ability and was validated in their research. Fourteen measurements used in De Toni's and Nassimbeni's research (2001) are

illustrated in Table 2.3. Therefore, this research adopted the framework of De Toni and Nassimbeni (2001) as a tool to evaluate suppliers' co-design ability in Taiwanese electronics industry.

Table 2.2 Four Quadrants of Buyer and Supplier performance (Quesada, Syamil, & Doll, 2006)

Area/Performance	Firm Performance	Supplier Performance
Operations (The Supply Chain)	Q1	Q2
NPD (The Development Chain)	Q3	Q4

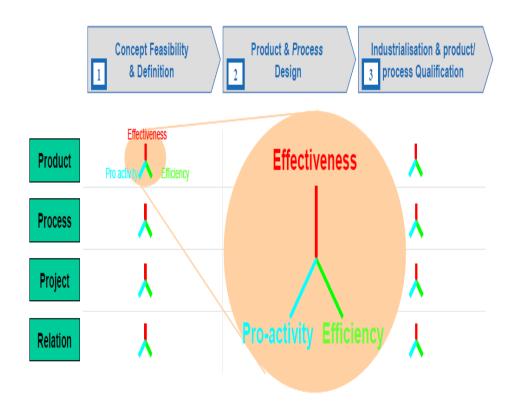


Figure 2.2 Structure of the Supplier Performance Evaluation mode (Le Dain, Calvi, & Cheriti, 2007)

Table 2.3 The elements contributing to suppliers' co-design performance (De Toni & Nassimbeni, 2001; Nassimbeni & Battain, 2003)

NPD stage	Measurement/Element
Product concept and	(a) Technological expertise.
functional design	(b) New technologies identification.
	(c) Support in value analysis/engineering activity.
	(d) Support in value analysis/engineering activity.
Product structural design	(e) Support in product simplification.
and engineering	(f) Support in modularization activities.
	(g) Support in component selection.
	(h) Support in standardization choices.
	(i) Efforts to make product and process compatible.
	(1) Promptness and reliability in prototyping.
	(m) Prompt communications of engineering changes.
	(n) Support in FMEA activities.
Process design and	(o) Support in DFM/DFA activities.
engineering	(p) Support in process engineering requirement.

#### **CHAPTER 3. METHODOLOGY**

To present a picture of suppliers' co-design ability in the Taiwanese electronics industry, this research employed questionnaire survey as the data collection method, which provided efficiency in terms of researcher time, energy, and cost during data collection (Sekaran, 2003). The process of questionnaire development follows the nine steps recommended by Churchill and Iacobucci (2002), which is illustrated in the Figure 3.1, and the entire survey process was reviewed and approved by Institutional Review Board (IRB) to ensure the rights and welfare of the subjects in this study. In addition to the procedure, the elements to develop the questionnaire and how the data was collected and analyzed are explained in detail in this chapter.

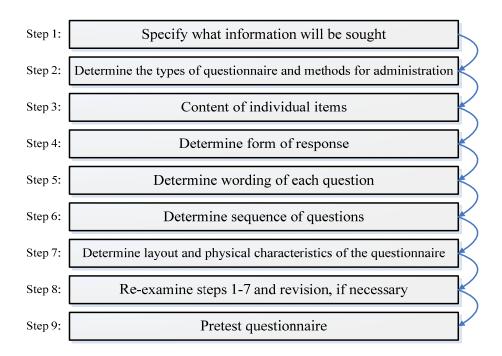


Figure 3.1 Questionnaire Development Process (Churchill & Iacobucci; 2002)

#### 3.1. Measurement

The measurements used to evaluate suppliers' co-design ability were based on the study of De Toni and Nassimbeni (2001). In De Toni's and Nassimbeni's (2001) work, fourteen measurements were categorized by three stages in new product introduction process (see Table 2.3). The three stages are (a) product concept and functional design, (b) product structural design and engineering, and (c) process design and engineering. Because this research focuses on the early stage of new product introduction process, only four measurements (see Table 3.1) of the product concept and functional design were used. Among the four measurements, technology expertise and new technologies identification assess how fully suppliers co-operate in product development projects (Von Hippel, 1988). Support in the development of product specifications (Dowlatshahi, 1998; Guy & Dale, 1993) and support in value analysis (VA) /engineering (VE) activities (Tatikonda, & Tatikonda, 1994; Williams, Lacy, & Smith, 1992) are techniques and methodologies suggested beneficial to supplier's co-design.

In this study, each measurement is considered as a group including three research questions. There are 12 survey questions in total (see Table 3.2). In De Toni's and Nassimbeni's (2001) design, five-point Likert scale was used for the survey questions. In this research, the scale was changed to seven-point in order to investigate the spread of respondent data in detail.

Table 3.1 Four measurements to assess suppliers' capability in the stage of product concept and function design (Nassimbeni & Battain, 2003).

Measurement	Motivations of suppliers' involvement
(a) Technological expertise.	Knowing which technologies are available
	within the main suppliers can influence the
	designer's and the product manager's choice in
	the development of a new product.

Table 3.2 (Continued) Four measurements to assess suppliers' capability in the stage of product concept and function design (Nassimbeni & Battain, 2003).

	Using the suppliers as "gatekeepers", the	
(b) New technologies	buyer firm has a greater possibility of coming	
identification.	into contact with innovative ideas and	
	choosing the most promising ones.	
	The supplier can help the buying firm by	
(c) Support in the development of	identifying and calculating the importance and	
product specifications.	technological impact of each product	
	specification.	
	The aim of VA and VE is to manufacture a	
	product at the lowest cost, but with the highest	
(d) Support in value	degree of all the functions appreciated by the	
analysis/engineering activity.	customer and without those functions whose	
	utility is not perceived. Here the contribution	
	of the suppliers can be determinant.	

Table 3.3 List of research questions

Measurement	Survey Questions
	(a1) It is very important that the supplier provides complete and true information regarding the technological expertise.
(a) Technological expertise.	(a2) The supplier has provided complete and true information regarding the technological expertise.
	(a3) The information system in your company has significantly helped the supplier provide complete and true information regarding the technological expertise.

Table 3.4 (Continued) List of research questions

(b) New technologies identification.	<ul> <li>(b1) It is very important that the supplier contributes to the identification of new materials and new product and process technologies.</li> <li>(b2) The supplier has contributed to the identification of new materials and new product and process technologies.</li> <li>(b3) The information system in your company has significantly helped the supplier contribute to the identification of new materials and new product and process technologies.</li> </ul>
(c) Support in the development of product specifications.	process technologies.  (c1) It is very important that the supplier makes
	significant contribution to the product specifications.
	(c2) The supplier has made significant contribution to the product specifications.
	(c3) The information system in your company has significantly helped the supplier make contribution to the product specifications.
(d) Support in value analysis/engineering activity.	(d1) It is very important that the supplier contributes significantly to the activity of VA/VE.
	(d2) The supplier has contributed significantly to the activity of VA/VE.
	(d3) The information system in your company has significantly helped the supplier contribute to the activity of VA/VE.

#### 3.2. The Questionnaire

The questionnaire consists of introduction and two sections of questions. The introduction describes the purpose of the study. The first section of survey questions is to collect the demographic information and to screen out unsuitable samples. The reason to collect the demographic information is to ensure respondents are not from specific one or two manufacturing companies, which may cause bias result. To screen out samples unrelated to this research, respondents had to first specify their role in the new product development projects. If their roles were not found in the pre-defined options of the question, they were required to confirm whether they need to work with suppliers in the new product development projects. Respondents were allowed to continue to the section two only if they confirmed the necessity to work with suppliers in the new product development projects. In addition, one of the questions in this section was to screen out

respondents who are not from the targeted industry of this research, the electronics industry. In the section two, 12 survey questions explained in Table 3.2 were covered. The complete questionnaire is presented in the Appendix A, and the entire flow to complete this questionnaire is illustrated in the Figure 3.2 below.

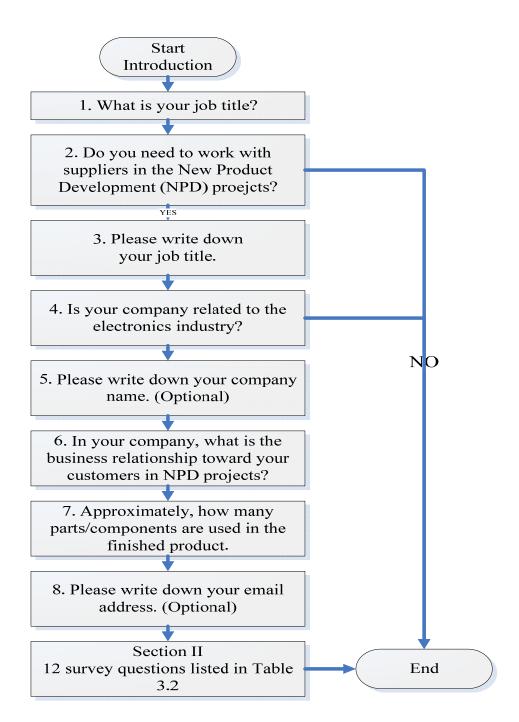


Figure 3.2 The flow to complete the survey

#### 3.3. Data Collection Mechanism

In addition to be reviewed and approved by Institutional Review Board (IRB), the data collection mechanism in this research followed three principles proposed by Sekaran

(2003): (a) principle of wording, (b) principle of measurement, and (c) general setup (see Figure 3.3). The important elements concerning to these three principles are described below.

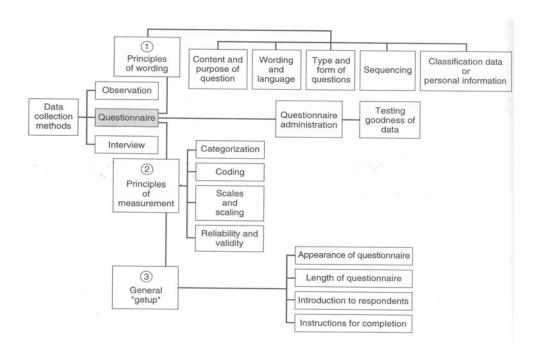


Figure 3.3 Three principles of data collection method (Sekaran, 2003).

- 1. Principles of wording. Because this research was conducted in Taiwan, the questionnaire was translated in both English and Chinese and was tested by five targeted respondents. In addition, this research along with survey questions in English and Chinese was proved culturally appropriate by one native Taiwanese faculty at Purdue University. The wording, translation and the culturally appropriate letter (see Appendix B) were all reviewed and approved by IRB.
- 2. Principles of measurement. Questions were arranged in a manner that makes for easy categorization and coding (Sekaran, 2003). The measurements used in this research were summarized and validated by De Toni and Nassimbeni (2001). Although the rating scale was modified from 5 to 7 points in order to investigate data spread in detail, the reliability of the ratings was not affected (Elmore & Beggs, 1975).

3. General setup. Since electronic questionnaires have advantages such as easy administration, very inexpensive, fast delivery (Sekaran, 2003), this questionnaire was set up online. The web-based survey software is hosted by Purdue University. The URL address of the online survey was included in the invitation emails for respondents to reach the questionnaire directly. Both invitation emails and the online questionnaire have a proper introduction which clearly discloses the researchers' identity and the purpose of the survey (Sekaran, 2003). In addition, to avoid biased answers and assure confidentiality of the information provided only researchers involved with this study have access to respondents' data (Sekaran, 2003).

#### 3.4. Participants

Anyone participating in new product development projects in the Taiwanese electronics industry and understanding how suppliers interact with his or her project teams is a targeted sample. Since developing an electronic product needs to incorporate engineers from multiple disciplines such as mechanical, software and hardware (Kerttula, 2006), the targeted population in this research includes, but is not limited to, engineers, purchasing managers, product/project managers and consultants. Collecting respondents' job title is for demographic purpose. Whether their job titles were listed in the predefined options or not did not affect respondents' qualification.

#### 3.5. Recruitment method

This research employed the snowball sampling technique for participant recruitment. Initially, invitation emails were sent to identified industry professionals, and these industry professionals forwarded the invitation emails to people in the targeted population of the research. Then, the invitation emails were be forwarded one after another continuously until the data collection due. This technique primarily screened the participants, and has be found to be economical, effective and efficient (Avico, Kaplan, Korczak, & Van Meter, 1988; Snijders, 1992).

#### 3.6. Survey Analysis

After data collection, pie charts were used to demonstrate the demographic information. Basic statistics such as mean and variation were listed to investigate respondents' perception of practicing ESI. To investigate the data spread and variance, multiple box plots were presented and compared. Finally, correlation coefficient was employed to assess the potential relationship between the survey questions.

#### CHAPTER 4. DATA ANALYSIS

After six weeks data collection, there were 214 surveys started online. To rule out surveys which were not completed and were terminated in the middle of their online sessions, there were 95 surveys left. Among the 95 completed surveys, respondents whose jobs are not related to new product development were eliminated. Only the remaining 62 surveys were considered effective. The effective rate, 62 over 95, is about 67.39%. In this chapter, reports and analyses are based on these 62 surveys. First, respondents' profile, with respect to the questionnaire's section one, is summarized to have an overall examination of business models and project types involved in the research. Then, descriptive statistics are employed to analyze the data concerning to the second section of the questionnaire. Finally, additional comments from the respondents are presented.

#### 4.1. Analysis of Respondent Profile

These 62 effective samples come from 36 different companies, which are responsible for at least 20 different kinds of electronic products in total. Except for the questions used to screen out the unsuitable samples, the demographic characteristics of the respondents are described by: (a) respondents' job titles, (b) companies' business models, and (c) number of parts used in products.

#### 4.1.1. Job function.

The 62 effective respondents all have working experience with suppliers and play important roles in new product development projects. Frequent contact with suppliers is unavoidable, which makes their opinions and response to the survey more reliable.

Among these effective respondents, five are software engineers, eight are hardware engineers, 32 are product or project managers, six are in the sourcing or purchasing department, and the rest 11 are at positions such as general managers and R&D engineers. Product or project managers, accounting for 51 percent of all participants, are the largest group among the respondents. Figure 4.1 presents the structure of the respondents' job functions.

#### Participant Job Titles Other job ■ Software functions Engineer Hardware that need to work Engineer with suppliers in 8 the NPD, 11, 13% 18% Purchaser /Buver/Sourcer etc. 6 10% Project/Product Manager 32 51%

Figure 4.1 The number and percentage of respondents' job title or function structure

#### 4.1.2. Business model.

For different outsourcing strategies and purposes, the business models between buyers and suppliers are commonly categorized into OEM, ODM, and OBM. In the survey of this study, most of the respondents' manufacturing firms designing or producing products branded by other companies are ODM. They take 55 percent. OBM and OEM account for 31 percent and five percent accordingly. The result truly reflects the structure of Taiwanese electronics industry's buyer-supplier business model and is

consistent with previous studies (Siu, Lin, Fang, & Liu, 2006; Chu & Cheng, 2007). In Figure 4.2, the data is presented in detail.

#### The Buyer-Supplier Business Model

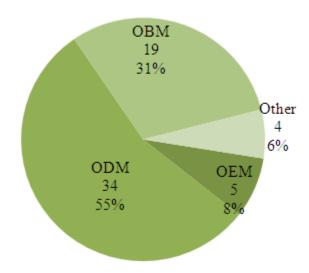


Figure 4.2 The number and percentage of business models of respondents' projects or companies

#### 4.1.3. Number of parts.

The number of parts needed to produce a product explains the product complexity (Yang & Yang, 2010; Clark & Fujimoto, 1991). Estimated by the 62 effective respondents, the number of parts used in the finished products and shown in the Bills of Materials (BOM) ranges from zero to one million. In Figure 4.3, the dot plot shows three potential outliers which are 20,000; 432,434; and 999,999. The average part numbers of the 62 samples is about 23,923. After eliminating these three potential outliers, the range is significantly narrowed down from zero to 3,300 (see Figure 4.4). The average part numbers of the rest 59 samples is about 522 and the median is 250. Figure 4.5 shows the detailed statistics summary of the part number.

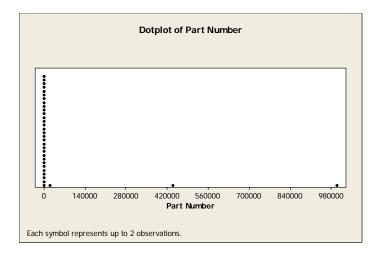


Figure 4.3 The dot plot of part numbers of the 62 samples including outliers.

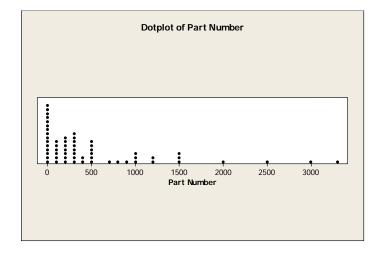


Figure 4.4 The dot plot of part numbers of the 59 samples after elimination of three outliers.

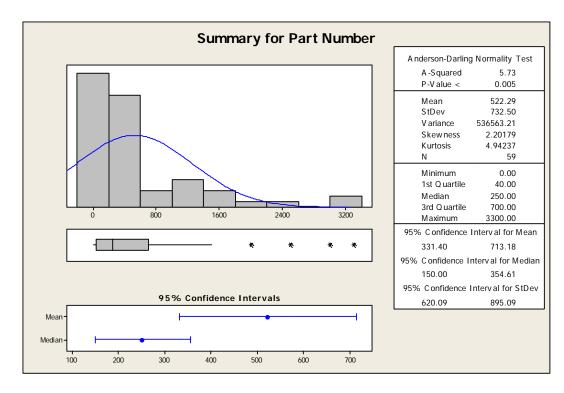


Figure 4.5 The statistics summary of part numbers of the 59 samples.

# 4.2. Analysis of Suppliers' Contribution

In the second section of the questionnaire, 12 questions are grouped by four measurements. Each group, with respect to one measurement, includes three research questions. In order to avoid unnecessary long wording and to enhance readability, the labels of survey questions such as a1, a2, a3, b1, b2 and b3 in Table 3.2 are used in the following paragraphs.

#### 4.2.1. Between four measurements.

In Table 4.1, the statistical data collected from each of the 12 questions is summarized. In the following paragraphs, four measurements are ranked by three research questions separately.

Table 4.1 Simple statistics of four measurements. Each contains three research questions individually.

Measurement	Survey Questions	N	Mean	Std Dev.	Min.	Max.
(a) Technological expertise.	a1	62	6.18	0.95	1	7
	a2	62	5.26	1.01	2	7
	a3	62	4.90	1.21	1	7
(b) New technologies identification.	b1	62	6.02	1.03	1	7
	b2	62	5.31	0.98	2	7
	b3	62	4.82	1.19	2	7
(c) Support in the development of product specifications.	c1	62	6.13	0.82	3	7
	c2	62	5.45	0.94	2	7
	c3	62	5.10	1.16	2	7
(d) Support in value analysis/engineering activity.	d1	62	5.87	1.06	2	7
	d2	62	5.00	1.09	2	7
	d3	62	4.87	1.17	2	7

# 4.2.1.1. <u>Level of importance</u>.

According to Table 4.1, the average scores of questions a1, b1, c1, and d1, which are 6.18, 6.02, 6.13, 5.87 in order, answered the first research question: How important is it to involve suppliers early in collaborative product development. The data affirmed that the four measurements used to evaluate suppliers' collaborative ability in the early stage of new product development are all important to the electronics industry in Taiwan. The importance level of the four measurements from the highest to the lowest are technological expertise (a1), support in the development of product specifications (c1), new technologies identification (b1), and support in VA/VE activity (d1). Figure 4.6 below also explains the lowest average of the fourth measurement, support in VA/VE activity. Unlike the data of a1, b1 and c1 mainly gathering between scale six and seven, parts of the respondents thought having suppliers to evaluate the benefits and the real costs of products is less essential, so the data spread of d1 is wider and the average is lowered.

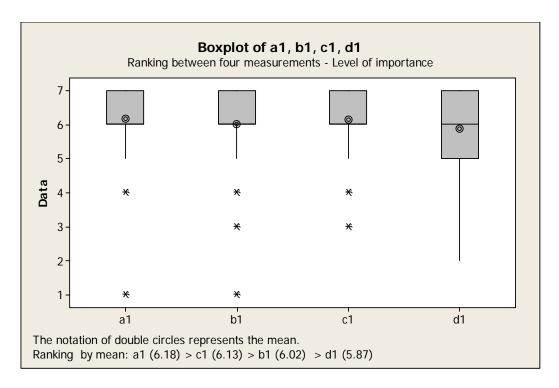


Figure 4.6 Compare the means and spreads of a1, b2, c1, and d1 in the box plot

# 4.2.1.2. <u>Level of suppliers' contribution</u>.

The statistics of a2, b2, c2, d2 in Table 4.1 respond to the research question: How much do suppliers contribute to new product development. The average scores are all above 5, which is between partial agree and agree. To some extent, suppliers' contribution in the early stage of new product development processes is assured and admitted by manufacturers, or buyers. Among the four measurements, suppliers' support in the development of product specification (c2) helps manufacturing firms in product design most. Next in sequence are new technologies identification (b2), technological expertise (a2), and support in value analysis/engineering activity (d2). The detailed data spreads are shown in Figure 4.7.

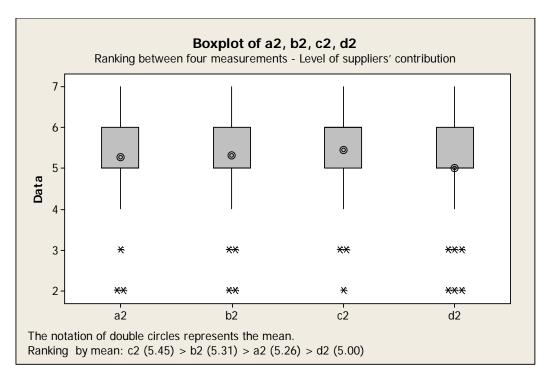


Figure 4.7 Compare the means and spreads of a2, b2, c2, and d2 in the box plot

# 4.2.1.3. Level of PLM solution contribution.

The third research question, how much existing PLM solutions help suppliers contribute to collaborative product development, is explained by statistical data of a3, b3, c3 and d3 in Table 4.1. Their averages are all higher than scale 4, which corresponds to the neutral position. Although the means are not as high as those of importance level and suppliers' contribution level in the previous two sections, and the data is spread more widely (see Figure 4.8), PLM solutions are still indicated helpful for suppliers to codesign with manufacturers.

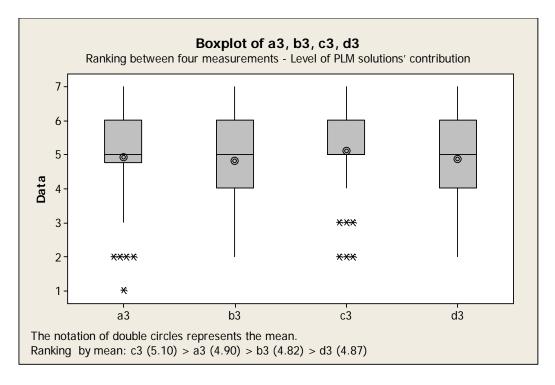


Figure 4.8 Compare the means and spreads of a3, b3, c3, and d3 in the box plot

#### 4.2.2. Within each measurement.

## 4.2.2.1. Basic statistics.

The Pearson correlation analyses in Table 4.2, 4.3, 4.4 and 4.5 reveals the correlated relationship between survey questions within each measurement group. For example, Table 4.2 shows the p-value of question a2 and a3 is 0.003, which is smaller than 0.05 alpha. It means the question a2 and a3 are significantly correlated and there is 37% chance that suppliers' contribution level of sharing technological expertise is explained by PLM solutions' effort in support of early supplier involvement. In addition to the question a2 and a3, the pairs of questions that are correlated include the question b1 and b2, the question b2 and b3, the question c2 and c3, the question d1 and d2, the question d2 and d3.

Table 4.2 Pearson correlation analysis for research questions related to technological expertise

Measurement	Research Questions	a1	a2	a3
(a) Technological expertise.	al	1	r = 0.208 p = 0.104	r = -0.028 p = 0.831
	a2	-	1	r = 0.370 p = 0.003
	a3	-	-	1

Table 4.3 Pearson correlation analysis for research questions related to new technologies identification

Measurement	Research Questions	b1	b2	b3
(b) New technologies identification.	b1	1	r = 0.382 p = 0.002	r = 0.082 p = 0.526
	b2	-	1	r = 0.409 p = 0.001
	b3	-	-	1

Table 4.4 Pearson correlation analysis for research questions related to technological expertise

Measurement	Research Questions	c1	c2	c3
(c) Support in the development of product specifications.	c1	1	r = 0.222 p = 0.083	r = -0.013 p = 0.919
	c2	-	1	r = 0.439 p = 0.000
	c3	-	-	1

Table 4.5 Pearson correlation analysis for research questions related to technological expertise

Measurement	Research Questions	d1	d2	d3
(d) Support in value analysis/engineering activity.	d1	1	r = 0.545 p = 0.000	r = 0.185 p = 0.151
	d2	-	1	r = 0.621 p = 0.000
	d3	-	-	1

# 4.3. Analysis of Suppliers' Contribution

Six additional comments were provided by six different respondents in the end of the survey. Among them, three meaningful to this research are listed below:

- 1. Most important information is on the basis of email and maintained by people rather than systems in my company.
- 2. Data in the PDM/PLM system normally is not updated.
- 3. Suppliers do not spontaneously suggest new technology or products. Engineers of the manufacturers have to be more professional than suppliers.

#### CHAPTER 5. CONCLUSIONS, DISCUSSION, AND RECOMMENDATIONS

# 5.1. Conclusions and Discussion

In literature, whether to involve suppliers in the early stage of new product development or not was determined by various factors such as industry types, business culture and scope of companies and was evaluated on the basis of all possible benefits and risk (Gentry & Savitskie, 2008). In this research, the survey findings indicate that in the Taiwanese electronics industry the importance of early supplier involvement is affirmed by new product development's project teams, and suppliers' contribution is considered positive. How to explain suppliers' co-design ability in the Taiwanese electronics industry is illustrated as follow. First, because acquiring new skills and technologies from suppliers is an important factor for innovative products to come out in the product concept and functional design stage of new product development, most engineers of the electronics industry in Taiwan agreed that technological knowledge shared by suppliers helps new product design. Second, the result shows that suppliers' effort in helping define product specifications is partially agreed by most respondents. It would infer that in the Taiwanese electronics industry suppliers have been providing some, but not all, extent of assistance to (a) identify and calculate the importance and technological impact of each product specification, (b) estimate the cost linked to it, and (c) modify the specifications that cause additional costs. Finally, in addition to cost evaluation for product specifications, the survey findings show that supplier's participation in VA/VE activities did somewhat assist with maximizing product functions at lowest cost without sacrificing product quality.

With respect to the third research question, although in the Taiwanese electronics industry it is common to include suppliers in new product design teams, the contribution of PLM systems which provide platforms for project teams to work together is not

obvious and has large variation in survey responses. This variation could be explained by two reasons. First, various kinds of electronic data exchange mechanism may cause incompatibility in PLM platforms between manufacturing firms and their suppliers (McIvor & Humphreys, 2004). Second, the effort electronics manufacturing firms spent on PLM systems has large discrepancies because PLM software vendors only provide limited predefined templates, and necessary customization effort is only possible in large user companies (Abramovici, 2007).

According to the Pearson correlation coefficients in Table 4.3, 4.4, 4.5 and 4.6, although survey questions randomly correlated between each other, there still has a pattern. The pattern shows that survey question two and three in every measurement group are always significantly correlated, which affirmed the relationship between suppliers' contribution in product design and how PLM systems are implemented. How much suppliers contribute to product development is correlated with how much PLM systems contribute to support early supplier involvement.

## 5.2. Recommendation

For manufacturing firms, it is recommended to repeat this research within their company. It helps the manufacturing firms to examine if their suppliers' contribution reaches the average in the electronics industry. For PLM software vendors, it is recommended to increase the built-in functions or templates related to the four measurements in this research. With more standardized templates, unnecessary effort on mass customization could be avoided, early supplier involvement could effectively fall into practice and the contribution of PLM systems could be enhanced in industries.

Several potential barriers between the manufacturing firms and key suppliers in the early stage of the product development process were investigated by McIvor and Humphreys (2004) and are listed in Table 5.1. On top of their findings and the numerical reports of this study, researchers are suggested continuing to investigate the relationship between these barriers and suppliers' contribution level to see how serious these barriers affect suppliers' co-design ability.

Table 5.1 Barriers to ESI between the Company and its key suppliers (McIvor & Humphreys, 2004)

- In some instances, the Company is still playing suppliers off against one another in the design process in order to extract more favorable terms.
- Currently, there is a lack of clarity and inconsistencies in the policy guidelines for the level of supplier involvement and the time of supplier selection in design.
- Influences from Corporate level can be detrimental to the management of ESI at local level.
- Design personnel resistant to increasing the level of involvement of suppliers in the design process.
- Conflict between members of the integrated product development team. For example, design attempts to make the supplier selection decision limiting the influence of the supply management function.
- Perceptions of the re-design cost reduction process as being that of switching suppliers still prevalent in the Company.
- Suppliers are suspicious of the motives of the Company when requesting cost information.
- Some suppliers may not have been confident enough of the accuracy of their costing structures to share them with their customers.
- Incompatibility of 'systems' of the Company and its key suppliers in the implementation of EDI.
- Not enough dedicated resource in the Company to jointly work with key suppliers to achieve fully the bene1ts of ESI.
- Annual contract negotiations perceived by suppliers as a barrier to effective cost improvement programs for the life of the contract.
- The exercise of power by the customer in the relationship can be detrimental to effective ESI.
- Culture of 'people' in both the Company and suppliers is a considerable barrier to the principles of ESI such as supply base reduction, cost information sharing and resource commitment from top management.



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# Appendix A. Questionnaire

Table A.1 Questionnaire - Introduction in English

Dear participants,

My name is Yunker Chen, a current graduate student in the Department of Industrial Technology at Purdue University. The questionnaire is for my research entitled "Evaluation of Early Supplier Involvement in New Product Development." The purpose of the research is to understand supplier's codesign ability in industry and to investigate the perception gap of the satisfactory levels and the expected levels of PLM technology. Your responses will give insights about suppliers' collaboration effort in new product development for the Taiwan's electronics industry.

Completing the survey is estimated to take about 5 minutes. I would like you to complete all questions and provide comments. This online survey will ONLY be used to collect information needed to complete our research. Confidentiality will be protected. ONLY researchers (Dr. Schmidt, Edie K. and Chen, Yunker) will have access to the data. The participation is voluntary and anonymous. You also must be 18 years or older. If you have any questions, please contact research investigators directly (Dr. Schmidt, Edie K. and Chen, Yunker). We sincerely appreciate your time and effort in completing this survey.

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# Table A.2 Questionnaire - Introduction in Chinese

# 親愛的業界先進:

您好,麻煩耽誤您約五分鐘的時間,撥冗填寫本問卷。本學術研究問卷,目的是想要瞭解「台灣電子產業的供應商在新產品開發階段的協同設計能力及貢獻」,對於目前專案狀況及公司系統支援程度進行初步的探討及認知差異的了解以做爲將來供應商協同開發時的參考,並提供資訊系統建置商及軟體供應商確切的系統需求,以期有效改善新產品開發的時程及效率。

本問卷共分成兩個部份,第一部分爲基本資料。本問卷所收集的資料僅供學術研究分析之用,不做爲其他用途,個人資料絕對保密,請放心填寫。第二部份則爲供應商在產品協同開發能力的貢獻度。每一個項目,請您根據您目前主要參與的專案狀況和產品及專案中主要協同開發的供應商,依照個人的實際感受回答問題。

您寶貴的意見對本研究具有相當的重要性及參考價值,墾請您惠予協 助與支持。在此,先向您致上最誠摯的謝意,非常感謝您花費寶貴的時間 與精神完成這份問卷。

若您對本問卷有任何意見,敬請批評指正。

Dept. of Industrial Technology Purdue University West Lafayette, IN. USA Professor: Edie K. Schmidt

Schmidte@purdue.edu

Researcher: Yunker Chen (陳云可) Chen329@Purdue.edu

# Table A.3 Questionnaire - Section one

1. 您的職位頭銜與下列何者最爲接近?
What is your job title?
□ 軟體工程師 (Software Engineer)
□ 硬體工程師 (Hardware Engineer)
□ 專案/產品經理 (Project/Product Manager)
□採購部門相關人員 (Purchaser/Buyer/Sourcer)
□ 其它 (Other)
2. 您的工作內容是否需要和外部供應商溝通及合作以完成新產品開發?
Do you need to work with suppliers in the New Product Development (NPD)
projects?
□是(Yes)
□ 否 (No)
3. 請填寫你的職位頭銜。
Please write down your job title.
4. 貴公司是否屬於電子資訊/軟體/半導體相關產業,例如電腦及消費性電
子、光電及光學、電子零組件、半導體、電信及通訊等相關研發及製造產
業? Is your company related to electronics industry?
□是 (Yes)
□ 否 (No)
5. 請塡寫貴公司名稱 ( 該問題是用於確認問卷的有效性及塡寫公司的離
散程度 )。
Please write down your company's name (Optional).
6. 請問貴公司在新產品開發的產出物或產品爲何?(例如:手機、電腦、
電子零件等) What is your company's main product in the New Product
Development (NPD) projects?
7. 請問貴公司在新產品開發專案中和客戶的合作模式爲何?
In your company, what is the business relationship toward your customers in
New Product Development (NPD) projects.
□原設備製造商 / 專業代工生產 (OEM, Original Equipment Manufacturer)
□原設計製造商/專業代工設計製造 (ODM, Original Design Manufacturer)
□ 自有品牌 (OBM, Own Brand Marketing)
□ 其它 (Other)
8. 請根據物料清單 (BOM) 約略估計該產品的零件總數。
Approximately, how many parts/components are used in the product?
9. 請填入您的聯絡電子郵件。
Please write down your email address (Optional).

Table A.4 Questionnaire - Section two

a. 供應商的專業技術	Strongly Disagree <-> Strongly Agree
(Technological expertise.)	211011-9-7 - 1011-9-7 - 19-00
(al) 我認爲利用供應商提供其專業	
知識和技術經驗以協助新產品開	
發,是非常重要的。It is very	1. 2. 3. 4. 5. 6. 7.
important that the supplier provides	1. 2. 3. 1. 5. 6. 7.
complete and true information	
regarding the technological expertise.	
(a2) 根據我所參與的新產品開發專	
案,供應商都能提供詳盡的專業知	
識和技術經驗以協助新產品開發。	1. 2. 3. 4. 5. 6. 7.
The supplier has provided complete	
and true information regarding the	
technological expertise.	
(a3) 根據我所參與的新產品開發專	
案,公司內部的資訊系統 (例如	
PDM/PLM )都能充份協助供應	
商,使其能有效提供完整的專業知	
識和技術經驗。The information	1. 2. 3. 4. 5. 6. 7.
system in your company such as	
PDM/PLM has significantly helped	
the supplier provide complete and true	
information regarding the	
technological expertise.	
b. 創新科技的識別及發掘 (New	Strongly Disagree <-> Strongly Agree
technologies identification.)	Strongry Disagree> Strongry Agree
(b1) 我認爲利用供應商來認識和發	
掘新的科技知識,對於新產品開發	
是非常重要的。It is very important	1. 2. 3. 4. 5. 6. 7.
that the supplier contributes to the	1. 2. 3. T. 3. U. /.
identification of new materials and	
new product and process technologies.	

Table A.4 Questionnaire - Section two (continued).

(b2) 根據我所參與的新產品開發專	
案,供應商都能盡力提供及介紹新	
的科技知識以協助新產品開發。The	1. 2. 3. 4. 5. 6. 7.
supplier has contributed to the	1. 2. 3. 4. 3. 0. 7.
identification of new materials and	
new product and process technologies.	
(b3) 根據我所參與的新產品開發專	
案,公司內部的資訊系統 (例如	
PDM/PLM、ERP 等) 都能充份協	
助供應商,使其能有效提供新的科	
技知識。The information system in	1. 2. 3. 4. 5. 6. 7.
your company has significantly helped	
the supplier contribute to the	
identification of new materials and	
new product and process technologies	
c. 支援產品規格的開發 (Support in	
the development of product	Strongly Disagree <-> Strongly Agree
specification.)	
(c1) 我認爲利用供應商提供充分的	
資訊以協助產品規格的開發,是非	
常重要的。It is very important that	1. 2. 3. 4. 5. 6. 7.
the supplier makes significant	
contribution to the product	
specifications.	
(c2) 根據我所參與的新產品開發專	
案,供應商都能提供充足的資訊以	1 2 2 4 5 6 7
協助產品規格的開發。The supplier	1. 2. 3. 4. 5. 6. 7.
has made significant contribution to	
the product specifications.	
(c3) 根據我所參與的新產品開發專	
案,公司內部的資訊系統 (例如	
PDM/PLM、ERP等)都能充份協	
助供應商,使其能提供完整的資訊	1. 2. 3. 4. 5. 6. 7.
以進行價值分析/價值工程。The	1. 2. 3. 4. 3. 0. /.
information system in your company	
has significantly helped the supplier	
make contribution to the product	
specifications.	

Table A.4 Questionnaire - Section two (continued).

d. 支援價值分析/價值工程 (Value Analysis/Value Engineering),使企業能針對開發設計中或是現有產品進行"成本"及"功能"分析,以最低的成本來製造最佳的產品或提供最完善的服務。(Support in VA/VE activity.)	Strongly Disagree <-> Strongly Agree
(d1) 我認為利用供應商提供資訊以協助價值分析/價值工程,是非常重要的。It is very important that the supplier contributes significantly to the activity of VA/VE.	1. 2. 3. 4. 5. 6. 7.
(d2) 根據我所參與的新產品開發專案,供應商都能提供充足的資訊以協助價值分析/價值工程。The supplier has contributed significantly to the activity of VA/VE.	1. 2. 3. 4. 5. 6. 7.
(d3) 根據我所參與的新產品開發專案,公司內部的資訊系統 (例如PDM/PLM、ERP等) 都能充分協助供應商,使其能提供完整的資訊以完成價值分析/價值工程。The information system in your company has significantly helped the supplier contribute to the activity of VA/VE.	1. 2. 3. 4. 5. 6. 7.
您寶貴的意見	Your comment

## Appendix B. Culturally Appropriate Letter

To: IRB Review Board, Purdue University

From: Chien-tsung Lu, Department of Aviation Technology

Re: Ms. Yunker Chen's Thesis Proposal, Department of Industry Technology

#### To Whom It May Concern:

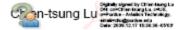
This letter is to support Ms. Yunker Chen's data collection process for the master's thesis —"Evaluation of Early Supplier Involvement in Product Development" which will be conducted in Taiwan in January 2010.

As a native Taiwanese and a Purdue faculty, I have reviewed Ms. Chen's project which does not conflict with the national value, religions, or diverse cultures in Taiwan based on the following reasons:

- The survey questions will focus on the general co-design capabilities of suppliers in Taiwan;
- The survey questionnaire does not collect confidential information or national security materials; &
- The survey is on a voluntary basis which participants have the right to attend or withdraw anytime during the study.

The nature of this project is culturally appropriate in Taiwan. Should you have any questions, please feel free to contact me. Thank you.

#### Cordially,



Chien-tsung Lu, Ph.D. Associate professor Department of Aviation Technology Purdue University ctlu@purdue.edu; 765-494-6517

Figure B.1 Culturally Appropriate Letter