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Full Length Research Paper

Effects of virtual teams of supply chain collaboration on new product development

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Through different case studies in an information technology (IT) manufacturing firm, this paper investigated how the collaborations among the supply chain partners in the form of virtual teams affect the performance of the new product development (NPD). This paper proved that it can be achieved by enhancing their NPD performance through supply chain collaboration (SCC) in the form of virtual teams under the web-based IT platform environment. Overall performance of the NPD increases significantly after adoption of collaboration, especially in the form of virtual teams. Product and IT technologies are basic survival factors that can be learned quickly, but cultural and behavioral components are the firm's source of differentiations.

Key words: Supply chain collaboration, product data management (PDM) new product development, case study, virtual team

INTRODUCTION

As organizations face increasing global competition, reduced product life cycles, mass customization, and the rising needs to quickly respond to customers, more and more firms are managing new product development (NPD) process by virtual teams (McDonough et al., 2001). Getting high-quality innovative and market-driven new products to market on time is one of the most crucial aspects of success in business and it is also the most difficult part to achieve (Cooper, 1994). Companies such as DuPont, Exxon, Proctor and Gamble, and Corning, adopt the systematic winning game plan to launch many successful new products (Cooper, 1994). This paper investigates via case studies in an IT (information technology) original product manufacturing (OEM) firm the effect of the virtual teams on NPD performance in a collaboration context of supply chain supported by IT platform. Through case study, we will test if the virtual teams can improve the NPD performance of the OEM firms manufacturing IT product. Similar to most of the other high-tech products, life cycles of the IT products have been compressed to be shorter than ever. Under such circumstances, improvement of product quality, reduction of product price, and shorter time-to-market become the basic factors of survival (Smith and Reinertsen, 1991; Kleczyk, 2008).

The firm must take necessary measures at the very beginning of the product design phase with the help of IT tools to meet these three factors. In the case studies on this IT OEM firm, the study compare the NPD performance with supply chain collaboration (SCC) to that without SCC, that with virtual teams to that with non-virtual teams, and that with virtual teams supported by conventional IT tool to that with virtual teams supported by web-based IT platform. Product and IT knowledge are neutral technologies that every firm can learn very quickly.

But trusts needed for collaboration and virtual teams are more human behavior and culture oriented, which take longer time to establish.

Managements of the collaborating firms shall help the virtual team foster high level of trust adapting to the existing cultural context and make the collaboration be the key success factor.

Steps of case study suggested by Yin (1994) are followed. The case study includes four different products

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lines in the focal firm. The interviews, data collections and the coding of data are conducted by research members. Finally, the four independently researched results are compared in different time periods as well as in the same period. Four propositions are developed through literature review.

Data were collected from the real documented records obtained by in-depth interviews of the working managers related to the product lines. Analyzed data are used to test the propositions. The triangulation mechanism is provided by having a research program wrap-up meeting with executives. Reliability and validity of the research are investigated.

LITERATURE REVIEW

New product development process

Prior researchers suggest several different systems of NPD processes. For example, Cooper's stage-gate system (Cooper, 1994) was the major concept of NPD process used in the current computer industry. The stage-gate system includes the key stages such as Discovery, Scoping, Build the Business Case, Development, Testing and Validation, and Launch. Production is included in the launch stage (Cooper, 2001; Hussain, Ghaffar and Aslam, 1990).

Each stage involves multiple functions and consists of a set of prescribed and parallel activities. There is a gate between each two contiguous stages and it serves as a quality-control checkpoint.

Three quality issues are checked, that is, quality of execution, business rationale, and quality of action plan. When the essential tasks and deliverables are completed, and all the related departments accept the quality levels of the current stage, the project can then be proceed to the next stage.

McGrath (1996) suggested five phases for the implementation of concurrent engineering. They are Concept Evaluation, Planning and Specification, Development, Test and Evaluation, and Product Release. The main purpose of the concurrent engineering is to develop the product with all the associated processes being carried out at the same time. Song and Weiss (1998) proposed that there were six basic segments of NPD processes, that is, Strategy Planning, Innovation, Idea Development, Business and Market Chance Analysis, Technology Development, and Product Test and Product Merchandize.

The aforementioned different NPD models can be converged to Cooper's (1994) seven stages NPD process. In the computer industry, there are many companies adopting Cooper's (1994) concept as a based structure for their NPD programs. Table 1 shows the summary of the previous researches on NPD. The process used in this study is also listed for comparison.

In the last row of Table 1, NPD processes of the focal firm used for this case study, that is, e-company, are listed for comparison. E-company adopts the processes that are similar to stage-gate system. Their entire NPD process is shown in Figure 1, which is called as C-process. There is a stage-gate between every two contiguous stages to control "go or no-go" decisions similar to the other stage-gate system. But e-company is an OEM firm who receives purchase orders from retailers and then manufactures products if the orders are accepted. In the purchase order, the required functions of the product are already outlined. OEM firms do not need to create from scratch totally new products that do not yet exist. They survey the possible buyers in the market and approach them to complete some sales processes. Then, they receive orders with the most basic requirements of product from the buyers and start to concept the product design. Therefore, they skip the first three stages of idea discovery, scoping assessment, and business concept (Cooper, 1994) NPD processes). They focus mainly on the design, development and production stages. Hence, the SCC of OEM firm focuses more on the pre-manufacturing stages such as market survey, design and development stages; just because the OEM firm, suppliers and customers need more interactions to decide the final specifications of the product as early as possible for product design and development before official manufacturing.

Supply chain collaboration (SCC)

The objective of SCC is to improve the overall supply chain performance (Horvath, 2001). Collaboration can provide the competitive advantages to all the business partners in a supply chain (Griffin and Hauser, 1992; Hwang and Huang, 2011). In the globalization context, competition no longer takes place among the individual businesses, but among the entire supply chains or networks (Sahay, 2003). Firms need to collaborate and coordinate with strategic partners to ensure that the supply chain is both efficient and responsive to the dynamic market needs (Boyaci and Gallego, 2004). Lockamy and McCormack (2004) argued that as supply chains continued to replace individual firms as the economic engines for creating values, understanding the relationships between supply-chain management practices and performance had become increasingly important. Stevenson and Spring (2007) emphasized that a flexible supply chain collaboration strategy would reduce unwanted uncertainty. SCC reduces search costs, lowered inventory level, and tightened links to customers (Johnston and Vitale 1988).Although, SCC has many advantages, it also has its downsides, such as IP (Internet protocol) issues, information leakage, lack of trust, and imbalance of power in relationships, etc. These downsides will impede the progress of SCC among members, but they can be overcome. Members need to

Table 1. Summary of new product development process researches.

Reference	New product development stage					
	0	1	2	3	4	5
Booz et al. (1982)	Survey market	Survey innovation	Professional analysis	Product development	Test	Merchandized
Clark and Fujimoto (1991)	Concept development			Product plan Product design Engineering Scheduling	Prototype test	Mass production
Cooper, 1994	Idea Discovery	Scoping preliminary assessment	Build the business concept	Development	Test and validation	Launch
Urich and Eppinger (1995)		Concept development	System level design	Detailed design	Test and refinement	Production ramp-up
McGrath (1995)		Concept evaluation	Planning and specification	Development	Test and evaluation	Product release
Song and Montoya Weiss (1998)	Strategy planning	Idea select, development market survey	Technology development		Product test	Product merchandize
This Study	Market survey, design concept	Product defined, preliminary design	Prototype mock up, detailed design	Production design and tooling	Pilot run test	Mass production launch

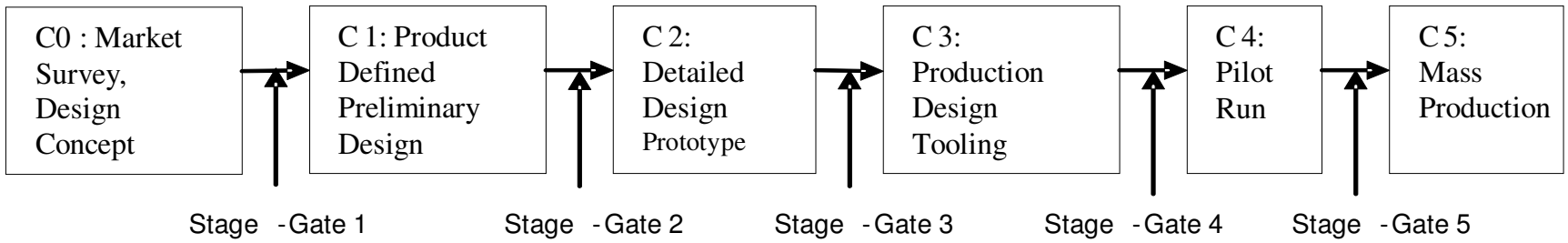

Figure 1. E-company's NPD processes: C-process diagram.

build up mutual trusts to solve together the problems caused by the downsides. The final NPD performance will depend on how effectively the problems are solved. The effectiveness of such problem solving depends on the level of trust that has been built among SCC members. The study will review in detail in the forthcoming section the issues of trust. In the four propositions that it formulate in the forthcoming sections will be based on the upsides of SCC. Then the results of the case study on the focal firm will test if the impacts of the downsides of SCC are bigger than the advantages of SCC. If it is bigger, then the propositions are not supported. For IT OEM firms, retailers are their customers. Supply chain consists of three main members including the firm, customers and suppliers. After the products are delivered to the retailers and sold to consumers, consumers' complaints and suggestions will be fed back to the firm through retailers. Then firms and retailers have to work very closely together to design the new products that can meet customer's needs. To the firm, retailers purchase products from him so that he can survive and grow. This special relationship can make the trust in-between be formed easier. Furthermore, the issues to discuss with retailers in designing the products normally involve mainly functional aspects of the products, which are not that sensitive as technical issues. Therefore, collaboration with customers will start first.

During the design of new products, the firm will demand suppliers to supply new components but not yet in collaborative form due to more sensitive technical issues will be involved. In addition, there are always new suppliers waiting for supplying new components to the firm. Therefore, trust between the firm and suppliers need much longer time to establish. Before trusts are built between the firms and suppliers, real collaboration can hardly be started. In the following, this study follows such sequence to discuss collaborations with customer first and then with suppliers plus customers.

NPD with customer involvement

Customer involvement in NPD has been shown to enhance product concept effectiveness (Brown and Eisenhardt, 1995). Griffin and Hauser (1992) and Souder et al. (1998) argued that there was great time saving to design product with good communications with customers. Gatignon and Xuereb (1997) debated that customer influenced NPD. Sheu et al. (2006) studied supplier-retailer (in here, OEM firm is the supplier and retailer is the supplier's customer) collaboration and found that the collaboration also enhanced supplier-retailer performance. Goffin and New (2001) debated that customer's support was an essential element in successfully marketing high-tech computer networks. Many aspects of supports are strongly influenced by the product design as well as customer support during new product development stage. Maylor (1997) found in an empirical study of the concurrent NPD that its main achievements were the improvements in "meeting customer needs" and "time to market". Based on the aforementioned review, the study obtains a proposition as follows:

P_1: Supply chain collaboration with customers will improve the NPD performance.

NPD with supplier involvement

Lee et al. (2007) contended that integration with the supplier was the best strategy to achieve reliable supply chain performance. Several researches have been done in association with the development process of the early and extensive supplier involvement (Gupta and Wilemon, 1990). Early supplier involvement reduces overall development time, development cost and ECR (engineering change request) frequency (Swink et al., 1996). In the focal firm, the evolvement of collaboration is incremental over time. The supplier collaboration is implemented after customer collaboration has been soundly installed. The supplier collaboration cannot be carried out independently but executed with the fact that customer collaboration already exists. Therefore, similar to proposition 1, the study obtains the proposition 2 as follows:

P_2: Supply chain collaboration with customers/suppliers will improve the NPD performance.

Virtual teams

Virtual relationship

Schmidt et al. (2001) defined a virtual team as a geographically and temporally dispersed and electronically communicating work group. In their empirical tests of NPD project decision making, it was found that virtual teams performed more effectively than face-to-face teams and individuals. The members of virtual teams of the SCC include vendors, firms, and customers (Whipple and Frankel, 2000). The relationships among the virtual team members are called virtual relationships. The virtual relationship can exist between employee levels and management levels working together in the organizations of customers, suppliers, or government agencies in the form of virtual team. It provides essential support competencies, such as research, design, manufacturing, and marketing to the organizations (Grenier and Metes, 1995). Such relationship is called virtual because it is really not an official organization but a hybrid of groups and individuals from different companies whose purpose is not for a long-term purpose. Therefore, supply chain collaboration in the form of virtual team involves the virtual relationships among employee levels and management levels in the firm, suppliers and customers.

Benefits of virtual teams

Synchronous collaborative technologies linking geographically dispersed individuals (virtual team) can save companies millions of dollars by facilitating effective communication (Goodbody, 2005). Virtual teams cut down time and costs of travel. Virtual teams offer flexibility, responsiveness, lower costs, and better resource utilization that are necessary for the survival of the firm in the highly competitive and turbulent business environment (Mowshowitz 1997). Virtual teams allow global companies to leverage their expertise, catch the pulse of diverse markets, promote broader participation in key strategic decision making, increase job flexibility, lower travel costs and pool the knowledge of experts. In McDonough et al.'s (2001) empirical study, it was found that the virtual teams without cultural diversity had better NPD performance than that with cultural diversity, but the use of virtual team with cultural diversity was on the rise. Influences of cultural diversity can be explained with Hofstede's (1991) five cultural dimensions, that is, power distance, individualism, masculinity, uncertain avoidance and long-term orientation. These cultural dimensions will be reflected in people's value system, attitude and behavior, and consequently in business practice (Morgan, 1986). Virtual team members communicate mainly through IT networks. Under such condition, it is already not easy to establish mutual understanding and mutual trust for the members of the same culture. For members from different cultures, that is, people with different business practices, the communications become even worse. It needs much longer time to build up mutual trust for virtual team members with cultural diversity than those of the same culture. With less trust among members, virtual team with cultural diversity is outperformed by that without cultural diversity.

Key properties of virtual teams

Virtual team members typically work with minimum supervision and rely heavily on their own abilities and initiatives to perform their tasks. Team members need to foster mutual trust. Yeh (2005) debated that trust was positively related to the continuity of the cooperative electronic relationship. If there is trust among team members, communication in the team becomes simpler (Jarvenpaa and Leidner, 1999). Several studies suggest that global virtual teams will encounter challenges in communication, culture, technology, and project management (Kayworth and Leidner, 2000). Kim and Oh (2005) contended that sharing the decision-making process indeed had a significant boost on the collaboration performance. Such sharing needs the trust among the partners. Therefore, trust is a key factor that will affect the effectiveness of virtual teams. Summarizing the aforementioned reviews, the study obtains proposition 3 as follows:

P_3: Shared decision-making process among supply chain partners in the form of virtual teams will achieve better NPD performance than those in non-virtual teams.

For better understanding of trust which is so important to the virtual team, review of the characteristics of trust is elaborated in the next section.

Trust

Trusts in the virtual team for SCC are gradually evolving. As explained in the next paragraphs, it starts from initial trust, goes through gradual trust and finally enters into unconditional trust for real collaboration.

Definition of trust

Mayer et al. (1995) defined trust as: the willingness to place oneself in a position of disadvantage (Rousseau et al., 1998) due to his feeling on the performance of the other party's competence, openness, benevolence and reliability; the willingness is based on truster's expectation that trustee's specific action is very important to him (Lewicki et al., 1998), whether he has the ability to control or monitor trustee (Williams, 2001). Rouseau et al. (1998) defined trust as psychological status of one party who was willing to place oneself in a vulnerable situation owing to one's positive expectation on the other party's behavioral attempt. In other words, trust is the confidence exhibited during two parties' exchange of something. The confidence is that the other party will not put him in risk, or any party will not take advantage of the weakness of the other side (Bateson, 1988). Therefore, trust per se involves vulnerability, uncertainty and risk (Doney and Cannon 1997).

Initial trust

The development of trust relationship is a process of confidence establishment on three dimensions: process-based trust, characteristic-based trust and institution-based trust (Ali and Birley, 1998). The three dimensions correspond to Lewis and Weigert's (1985) three dimensions of trust base, that is, behavior, emotion and cognition, respectively. Process-based trust is built through continuous process of interactions, characteristic-based trust is generated due to the emotional feeling of identity, and institution-based trust is the confidence on the cognition of social system and social norms. As such, trust-building is a dynamic process (Rousseau et al., 1998) of interweaving enhancements of these three dimensions. Different degree of trust generated by interactions of both sides should be differentiated. McKnight et al. (1998) postulated that the first step of the dynamic process during interaction was

"initial trust". Initial trust is a very important stage in the dynamic process of trust building that will finally lead to unconditional trust, which influences whether transaction will be continued or not (Murphy and Blessinger, 2003; Abbasi, et al., 2010).

Gradual trust

After initial trust is established, more trusts are accumulated over time when people have more interactions. Gradual trust is formed by continuous interactions between people (Williams, 2001). General speaking, initial trust is quite vulnerable that even minor violation behavior such as having not followed simple and unimportant promise will hurt such weak relationship. After the graduate trust is established due to frequent interactions, minor violations will be forgiven and both sides will start to consider sharing adequately some confidential knowledge without even thinking of taking opportunistic action (Jones and George, 1998). In contrast to initial trust's emphasizing on reputation, embargo, formal role and reliance (Meyerson et al., 1996), gradual trust is based on more knowledge sharing and historical interaction. Through the experience of interacting with trustable people and many successful exchange of knowledge, individual will tend to believe the others will not take advantage of his weakness and become more willing to exchange sensitive and important knowledge (Whitener et al., 1998).

Unconditioned trust and conditioned trust

Jones and George (1998) classified trust as conditional or unconditional. With conditional trust, both parties are willing to transact with each other, as long as each behaves appropriately. Attitudes of both parties are favorable enough to support continuous interactions in conditioned trust. The initial and gradual trusts earlier mentioned belong to such category, which are the transitional states before reaching unconditional trust.

Jones and George (1998) asserted that Unconditional trust started when individuals abandoned the "pretense" of suspending belief, because shared values now structured the social situation and became the primary vehicle through which those individuals experienced trust. With unconditional trust, each party's trustworthiness is now assured, based on confidence in the other's values that is backed up by empirical evidence derived from repeated successful interactions, and thus relationships become especially significant and often involve a sense of mutual identification. The quality of the exchange relationship upgrades and converts a group into a team. With teamwork, what one person does is determined by what all others are doing, and the parties must be constantly alert to the ways others are behaving in order to be able to respond appropriately. In unconditional trust, all parties look more to the future than the present with positive moods and emotions manifested in interpersonal cooperation and teamwork, and have the strong desires of team members to contribute to the common good. Cooperation often makes people feel good and stimulates others to act in a similar fashion by reinforcing shared values and positive attitudes and affection.

IT Support to NPD

Proper IT management can save manpower and shorten NPD process (Spekman et al., 1997). Adopting collaborative computer-based information systems has become a major trend in today's business environment. Such systems link firms with their suppliers, distributors, and customers, and thus enable the flow of information across the supply chain. The trend has been accelerated by the emergence of the Internet and the wide adoption of web-based tools in product design (Grossman, 2004). Through these IT supports, the virtual teams are able to work together very efficiently through mobile, ubiquitous and time-limitless virtual space. The following two paragraphs will explain the two generic IT platform tools, PDM (Product data management) and e-PDM, with which members of supply chain virtual teams from the firm, suppliers and customers can communicate and work together, that is, conducting SCC. The main difference is that PDM works on the members' internal private networks such as intranets that are connected by low speed leased lines, which is less flexible. E-PDM is a web-based IT platform, which can provide real mobile, ubiquitous and time-limitless convenience and flexibilities through Internet.

Product data management (PDM)

Product data management (PDM) is an IT tool that helps Research and Development (R and D) engineers to manage the product data and NPD process. According to CIMdata (2001)[1], the PDM system can be applied to manage all the electronic documents, digital files and the records of data warehouse. There are five major functions for users, that is, data vault and document management, work flow and process management, product structure management, classification and program management. Yeh (2002) conducted empirical studies on three R and D departments and found that PDM could really help engineers improve NPD processes, minimize the item code in database, and provide the managing reports. The PDM can help enterprises reduce the cost efficiently and gain the competitive advantages (Yeh, 2002).

[1]CIM data is a company who provides worldwide strategic Product Lifecycle Management (PLM) consulting and program support including PLM, PDM, SCM (Supply Chain Management), CAD and ERP (Enterprise Resource Planning) etc.

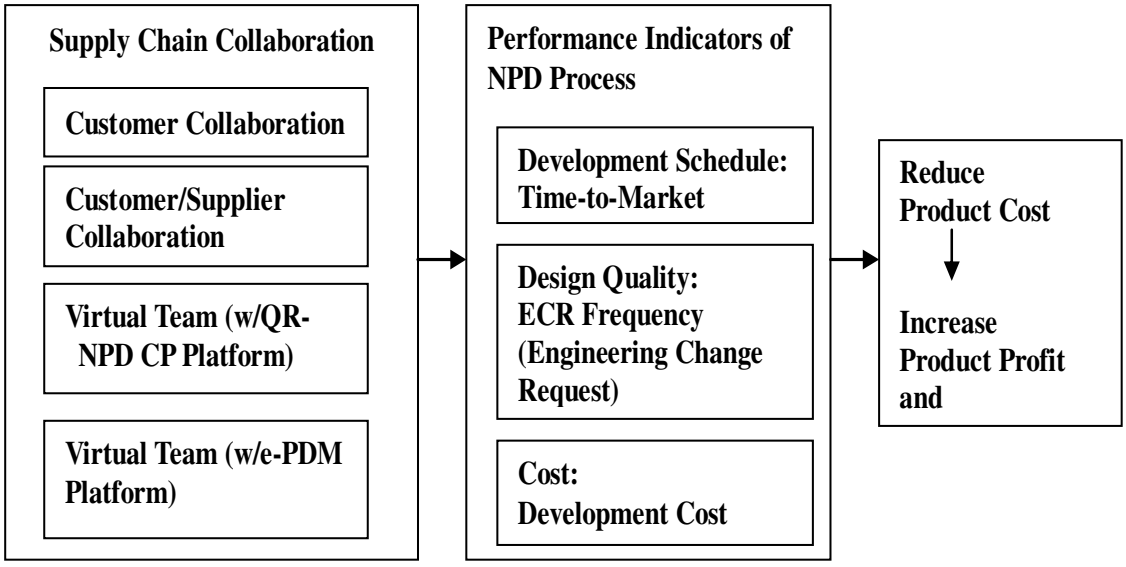

Figure 2. The structure of conceptualization.

The paper announced by Tonsoft[2] indicated that the benefits of the PDM implementation included 10% of cost reduction in engineering, 20% of time decreasing in product developing, 30% of responding time increasing in order handling, and 40% of engineering change reducing in R and D process. In general, the dimensions of benefits include improvement of product quality, increase of productivity, reduction of design cost, increase of customer attraction, and provision of better communication with suppliers.

Collaborative product commerce (CPC) Tool: e-PDM

Pramatari (2007) pointed out that the technologies for SCC practices had evolved from the classical electronic data interchange (EDI) approach to web-based collaboration. Collaborative product commerce (CPC) is an advanced tool of PDM to support the global design teams working on NPD. CPC is the globally integrated PDM with the web-based concurrent engineering collaboration capabilities and is named as "e-PDM". Recent studies have shown that the use of the Internet and web-based tools efficiently supported team operations in a virtual environment (Huang et al., 2002; Raghu et al., 2001). E-PDM is an Internet-based platform built on the soundly managed IT system that enables concurrent engineering practices. Trygg (1993) claimed that the concurrent engineering could reduce design cycle time.

The main purpose of e-PDM is to speed up design phase and shorten the time-to-market. In the product development stage, the strategic team members concurrently join and manage the development and collaboration. Cassivi (2006) asserted that e-collaboration tools facilitated access to information, affected knowledge creation capabilities, and assisted in the design of flexible supply chains. Summarizing the above, the study obtains a new proposition as follows:

P_4[3]: NPD performance achieved by virtual teams utilizing the web-based e-PDM tool for SCC, is higher than that achieved by them adopting the classical EDI approach.

Research conceptualization

The SCC during the NPD process focuses on the early involvement of the whole virtual team that can design the right specifications in every early product development stage to get the shorter lead-time for product launch, and eliminate product amendment cost and wasted time. Quality, time-to-market and cost are the most vital measures for the NPD performance. Smith and Reinertens (1991) debated that in order to improve the performance of NPD projects, firms needed to balance their efforts in the three objectives, that is, development speed, development cost and product quality. Therefore, in this study, the paper use time-to-market, product cost and design quality as the three performance indicators for NPD.

[2]The report (2) of PDM technology discussion in depth, September 2000, pp. 1-2. http://www.tonsoft.com/erpzs/pdm/pdm4_big5.htm. Accessed July 2005

[3] Both PDM and e-PDM utilize technique of electronic data exchange (EDI) as the basic communication means. Classic EDI approach means the older IT techniques such as low speed leased lines, dial-up telephone lines, and low capacity switching and storage devices like modem and diskette, etc. E-PDM utilizes the latest EDI approach such as high speed optical networks, high capacity switching and storage devices, and more sophisticated software packages which are the main constituents of today's web and internet.

The structure of conceptualization is shown in Figure 2. By using a case study on a Taiwanese IT firm, the study will investigate whether the customer collaboration practices, supplier's collaboration, virtual team collaboration and e-PDM system implementation have positive influences on the NPD performance, that is, shortening the time-to-market for product development schedule, compressing the ECR (engineering change request) frequency for product design quality, and reducing the product cost. Propositions 1 to 4 will be tested based on the results of the case study.

RESEARCH METHODOLOGY

Yin (1994, p.13) defined case study as an empirical inquiry that investigated a contemporary phenomenon within its real life context, depending on multiple sources of evidences with data needed to converge in a triangulating fashion, and were benefited from the prior development of theoretical propositions to guide data collection and analysis. This study stick to this definition and thus follow Yin's (1994) case study steps to conduct the case studies on a Taiwanese IT OEM firm by collecting NPD performance data from the firm's working managers, and holding meetings with the executive levels to testify the results of data analysis. The data collection and the direction of data analysis are guided by the propositions obtained from the literature reviews. To analyze the data, we adopted Yin's (1994, p.113) method by collecting the NPD performance data of the projects of the four product lines occurred at different stages or time periods. In the projects of the earlier years sampled for this study, simple SCC with limited IT tools was adopted for NPD. For the sampled projects of the medium term, virtual teams using classical EDI were applied to the SCC. The sampled projects that were closest to the time of the conducting of the study were those using web-based IT platform during SCC of NPD.

The steps of case study introduced by Yin (1994) include developing theory, selecting case, designing data collection protocol, conducting case study, analyzing data, and drawing case conclusion. As for the step of "developing theory", the study have obtained four propositions as mentioned in the foregoing sections and finally tested by the coding results of collected data as shown in Table 2.

Selecting case

In Taiwan, all the OEM firms have almost the identical characteristics. The main common characteristics of the OEM firms in Taiwan are: (1) having only very marginal gross profit at 3 to 4% of revenue on average; (2) very efficient in mass production to keep the manufacturing cost to the minimum; (3) working too hard to have quality of life; (4) competing fiercely among one another for the orders released by the big companies with global brands; (5) having no their own brands and thus having no marketing capabilities and costs; and (6) having the management levels mainly composed of people with Taiwanese nationality, that is, the same culture and mentality. With these common characteristics, the focal IT OEM firm in the study can represent sufficiently Taiwanese IT OEM firms. They look all the same. The managements of those firms used to work together in the same firm in the early days when the Taiwanese OEM business was just taking off. The current employees are also changing jobs among these OEM firms.

Taiwan Industrial Bureau recommends a medium-sized IT OEM firm as the target or focal firm of the case studies upon the authors' request. 98% of the Taiwanese enterprises are small and medium-sized enterprises (SME). The recommended firm is quite a representative firm of SME and OEM firms. The focal firm, e-company has the following characteristics that make it suitable for the study: (1) being in IT industry with R and D departments for about 19 years, which is suitable for the study; (2) having NPD programs to develop products for the global market, which is a typical OEM firm; (3) having implemented global SCC, which is suitable for the SCC study; and (4) having several product lines, which is suitable for building competing models.

In e-company, the four selected product lines are handled by different members. Corresponding to the selected four product lines, during the interviews of the working managers, data collections and coding of the collected data to the unified form.

E-company profile

When we conducted this study, e-company had 19 years' experience in the manufacturing of IT products with the capital of US$ 100 million. There are totally about 7,000 employees in seven associated companies and fifteen subsidiaries all over the world. The main business of e-company is manufacturing IT products for the big IT system companies such as Dell and HP on the OEM basis. Its services include pure OEM (manufacture following buyer's design), and ODM (Original Design Manufacturer, that is, design and manufacture for buyer). Both pure OEM and ODM are basically the same OEM business. With such a large scale of operations, e-company owns a big R and D team.

They need to work closely with the partners of the supply chains in the early stage to decide the right specifications of the products that fit customers' requirements. Therefore, early involvement in setting specifications for product design in the NPD process is an indispensable solution to reduce the rework costs and thus launch on time the products of good quality.

Incremental evolution of e-company's SCC during NPD

E-company selected the step-by-step evolving strategies over time in the implementation of collaboration system with partners. The evolution can be divided into four stages chronologically.

Done-by-own-team stage (without SCC): In the earlier days, R and D teams did all the work by themselves and had very limited collaboration with their partners. The biggest part of e-company's business lies in OEM. They need to follow the customer's requirements to complete the design, and then start the manufacturing. The core process of the manufacturing includes the tooling, and parts assembling. The collaboration initially only occurred during manufacturing process rather than the concept development and design development phases. The lead-time for the product launch based on the above NPD process was about six to ten months on the average. The ECR frequency for each product from the design stage to the product launch was six times on average due to the misunderstanding and change of the design process. It costs a lot of money and manpower to control each step of the original NPD process.

Stretch-out for collaboration stage (SCC using non-integrative IT tools): E-company's NPD process includes stage-gates. It is called "C-Process" as shown in Figure 1. The process management involves a lot of faxes, emails, phone calls, reports, and meetings for the communications among the team members, customers and suppliers. Non-platform IT tools is extensively used. Due to the fact that the communication tools are not integrated, it becomes the bottleneck in the product time-to-market, design quality and cost reduction in the NPD management. E-company is quite conservative in implementing collaboration program with partners.

Table 2. The performance of collaboration by products at different stages.

Stage	Performance indicators	Overall product	Desktop PC	Server	LCD PC	Media center
Without collaboration	ECR* (Times)	4.31	3.91	4	6.5	5
	Lead-time to MP** (Days)	203	193	181	288	193
	Lead-time to plastic tool (Days)	48	44	62	53	53
	Lead-time of metal tool (Days)	50	48	58	60	55
(a) Customer collaboration (using non-platform IT tools)						
With customer collaboration	ECR (Times)	0.86	0.86	0.5	2	2
	Lead-time to MP (Days)	119	107	144	127	95
	Lead-time to plastic tool (Days)	38	34	41	47	34
	Lead-time of metal tool (Days)	40	34	45	51	36
Reduced % of ECR		80	78	88	69	60
Reduced % of MP lead-time		41	45	20	56	51
Reduced % of plastic tool lead-time		21	23	34	11	36
Reduced % of metal tool lead-time		20	29	22	15	35
Cost reduction % of development cost		28	24	29	35	42
(b)Customer and supplier collaboration (using non-platform IT tools)						
With customer and supplier collaboration	ECR (Times)	0.78	0.83	0.5	2	2
	Lead-time to MP (Days)	116	105	144	127	95
	Lead-time to plastic tool (Days)	36	33	41	47	34
	Lead-time of metal tool (Days)	39	33	45	51	36
Reduced % of ECR		2	1	0	0	0
Reduced % of MP lead-time		1	1	0	0	0
Reduced % of plastic tool lead-time		4	2	0	0	0
Reduced % of metal tool lead-time		2	2	0	0	0
Cost reduction % of development cost		2	1	3	5	1
(c) Virtual team (VT) (using QR-NPD CP platform)						
With virtual team collaboration (QR-NPD CP)	ECR (Times)	0.58	0.5	0.5	1	2
	Lead-time to MP (Days)	115	103	144	125	95
	Lead-time to plastic tool (Days)	35	33	41	46	34
	Lead-time of metal tool (Days)	38	32	45	50	36
Reduced % of ECR		5	8	0	15	0

Table 2. Contd.

Reduced % of MP lead-time		0	1	0	1	0
Reduced % of plastic tool lead-time		2	0	0	2	0
Reduced % of metal tool lead-time		2	2	0	2	0
Cost reduction % of development cost		2	1	0	1	0
(d) Virtual team using web-based e-PDM System						
With e-PDM (Web-based)	ECR (Times)	0.93	1	0.5	0.5	2
	Lead-time to MP (Days)	121	112	144	122	95
	Lead-time to plastic tool (Days)	38	34	41	45	34
	Lead-time of metal tool (Days)	39	34	45	50	36
Reduced % of ECR		-8	-13	0	8	0
Reduced % of MP lead-time		-3	-5	0	1	0
Reduced % of plastic tool lead-time		-6	-2	0	2	0
Reduced % of metal tool lead-time		-2	-4	0	0	0
Cost reduction % of development cost		-4	-7	-1	2	-18

*ECR- Engineering change request, **MP- mass production; All the Reduced % and the Cost reduction % were the improvement percentage of that stage over the last stages.

Collaborations with the customers (retailers) are implemented first. After seeing the customer collaboration bring good NPD performance, E-company then starts supplier collaboration program.

Virtual team stage (SCC with traditional IT platform): To implement the virtual team collaboration, E-company used the first IT collaboration platform, QR-NPD CP, in 2005. It includes four modules, that is, tooling center management, product design management, project management, and strategic partner collaboration management. The QR-NPD CP is shown in Figure 3. It represents the first new NPD SCC platform of E-company, which works well and has a positive influence on the NPD performance. The first new system generates vertical and horizontal integrations. The vertical integration of the design collaboration covers design, validation and verifications. The horizontal integration connects customers and vendors for design concept, feasibility study, design and the manufacturing collaboration.

Web-based tool stage (SCC with Internet/web-based IT platform): Based on the experience in using the collaborative type of NPD platform, e-company implemented a new Internet/web-based e-PDM platform two years after QR-NPD CP had been introduced. With SCC platform, the interaction and the communications became more frequent, and the data transparency started to appear in the whole virtual teams on the platform. The daily NPD process in e-PDM platform covers from C0 to C5 in Figure 1. The virtual teams of the whole supply chain partners including the customers, the firm and the vendors work very closely through this web-based platform. The new NPD collaboration system, that is, e-PDM, for E-company is shown in Figure 4.

E-company invited customers and key vendors to join the product specification defining. In the new e-PDM system, customers propose product concepts and feature requirements. E-company would put all the relevant information and the design data into the e-PDM platform. All the virtual team members including customers can transfer the information to key component vendors through the e-PDM platform and record all the data in every step of the NPD process. All of the virtual team members can record and get the updated information and data through e-PDM system at anytime. The discussions made through the platform can be recorded for the product specification and design making. The resulted concept analysis can be used as valuable references for product feasibility study, and for future product roadmap formulating.

As such, e-company can have customers and vendors joining together the product concept and the specification definition discussions. Through the design-in and the spec-in processes in the early stage of the NPD process, the team can design products that meet market demand. On the other hand, e-company can review the design limitation for the new product in the early stage with customers to get the right and better design. Moreover, the databases of the design and the tooling are built through e-PDM system, and all the components data and activities are also recorded. The database can be used for other product development, too. The relationship with customers built in the process is not only for one-time business transactions but also for long-term cooperation. With e-PDM, several projects can be carried out in parallel on the same platform to generate higher productivity.

Designing data collection protocol

The collected data have to meet the need of the theory testing. Our theory refers to the propositions 1 to 4, which

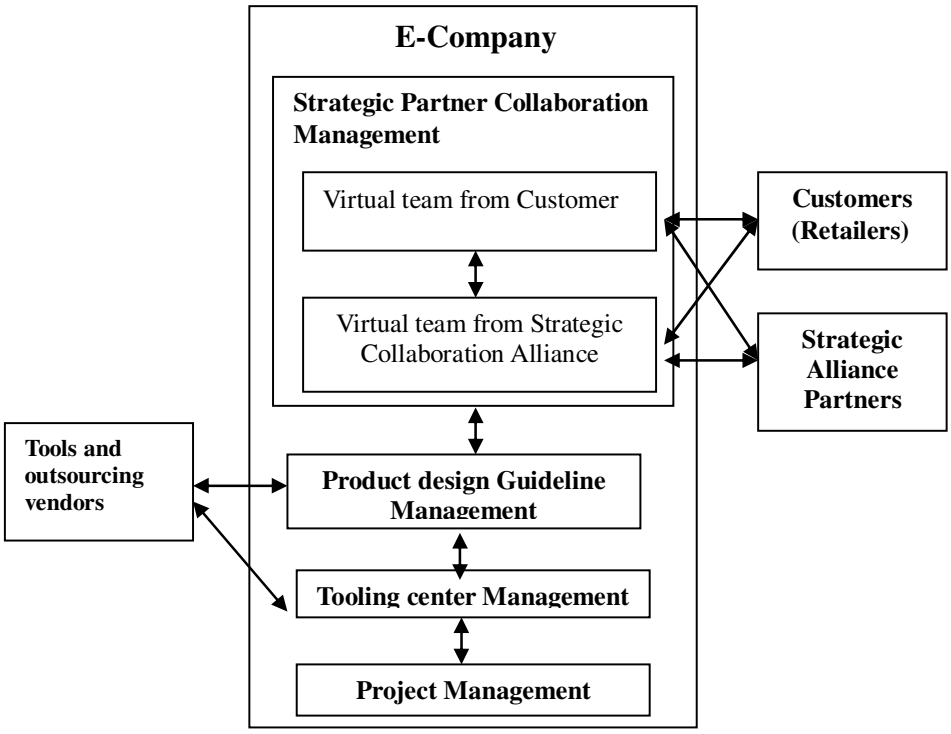

Figure 3. Quick Response NPD Collaboration Platform (QR-NPD CP).

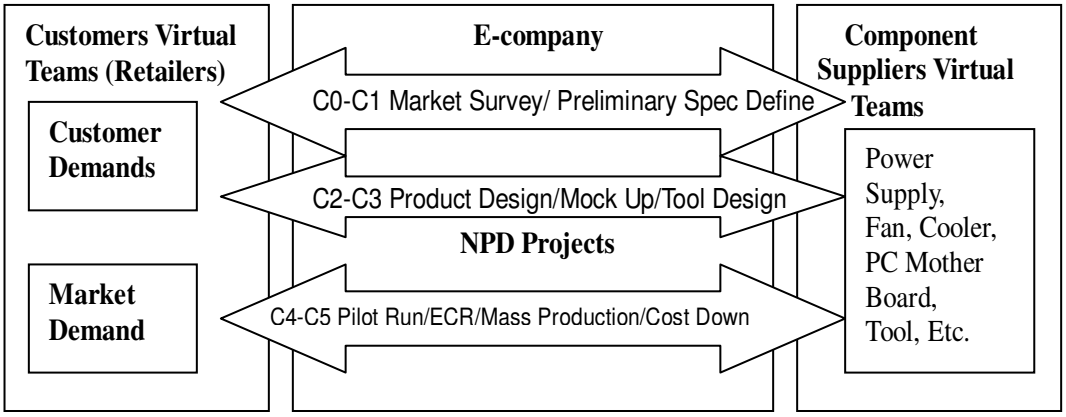

Figure 4. NPD Collaboration Process Flow in the New e-PDM Platform.

states that: (1) NPD performance is better by adopting SCC (propositions 1 and 2); (2) NPD performance is better by adopting virtual teams (proposition 3); and (3) virtual teams adopting web-based platform generate better NPD performance than virtual teams adopting traditional EDI tools do (proposition 4). The indicators of NPD performance are time-to-market, product quality and cost as shown in Figure 2. Therefore, this study designed the data collection protocols as follows:

1. The performance items to be compared include: (i) the status of NPD lead-time for time-to-market; (ii) the status of NPD ECR frequency for product quality; and (iii) the status of NPD design cost and product cost. The lead-time of NPD is accumulated from design concept phase to mass production phase. The design quality is evaluated by ECR frequency for every product. ECR is caused by several reasons that include the design issues, the customer's requests and the manufacturing requirements, etc. In order to get more accurate performance status for design quality, the comparison data are only based on the design issues. Therefore, the data of ECR frequency are used to represent product quality. The data of lead-time to mass production, lead-time to plastic tool and lead-time to metal tool represents time-to-market. Regarding the performance of cost reduction, focus is laid on the development costs relating to the NPD process.
2. The research framework is based on the NPD project with one product line as the basic unit of analysis. For each product line, the

NPD projects are selected. For the purpose of doing better analysis, this study specially focus in the analysis on the e-company's four main products that bring in 60% of the total revenues. The selected products are Desktop PC (personal computer), LCD PC (liquid crystal display personal computer), Server, and Media Center product lines. These products are low-margin items but with volume production, and thus need to be carefully handled to avoid loss.

3. The span of the identified projects covers the last seven years. This study looks for the projects of the same products that are operated with and without supply chain collaboration, with virtual teams using traditional EDI tools, and virtual teams with web-based platform.

Conducting case studies

Through the help of the member of the board of directors of e-company, in the research program kickoff meeting, Vice President, Sales and Marketing Director, R and D Director, e-PDM Director, Global Sales Director, and their working managers were invited to participate in the meeting. After our presentation on the program, VP and the directors instructed their managers to closely cooperate with us and provide all the data we requested on the understanding that our research result could provide them with the directions of improvement.

This study collected the data of R and D project of the selected products from their R and D project managers, and the data of cost reduction of development from financial managers. This study has spent tremendous amounts of time to identify from their records the data of lead-time to mass production, ECR frequency, lead-time to plastic tools, and lead-time to metal tools for the NPD projects of the four selected products. The four product lines all experience the five stages (or time periods), that is, (1) stage without SCC; (2) stage with customer SCC; (3) stage with customer/supplier SCC; (4) stage with virtual team SCC using traditional PDM platform; and (5) stage with virtual team SCC but using web-based e-PDM platform. But the span of each selected project of product line drops in one of the five stages. For product lines, the five stages represent the evolving stages of capabilities. The capabilities of the later stages cover those of the earlier stages. The project managers had to find the needed data from their old files, among which 30 projects were selected for the analysis of the NPD performance.

It took about one year to finish the interviews and data collection and another three months to sort them out, code the data and calculate the values of the parameters that were needed due to the abundance of the collected data. Having sorted out and analyzed the data, the study had a final meeting with the higher levels of management such as VP and Directors, to whom it showed the results and asked for their comments and clarifications of the results to provide the triangulation mechanism.

Analyzing data of different time periods

Table 2 is the final result of the collected data. It shows the data of the representing items of NPD performance indicators, that is, ECR frequency for product quality, lead-time to mass production for time-to-market, and lead-time to plastic tool and metal tool for product cost. For the four selected products and the overall products, performance data are listed for the five stages of NPD SCC.

The data of the first stage are used as the reference for comparison. The data of the other four stages are compared with that of the first stage. By doing so, this study get the improvement of performance in percentage of the other four stages over the first stage, respectively. Then it compare the aforementioned-obtained percentage of the third stage with the second stage, fourth stage with the third stage, and the fifth stage with the fourth stage, by subtracting the percentage of the lower stage from higher stage to see the improvement of each stage over the last stage. Table 2 shows the result.

Customer collaboration practice analysis (using non-platform IT tools)

From Table 2(a), it is found that the average ECR frequency for the overall product lines reduces from 4.31 times to 0.86 times, that is, 80% reduction. The average lead-time for the overall products decreases from 203 days to 119 days with 41% reduction. The average lead-time of plastic tool goes down from 48 to 38 days with 21% reduction. The average lead-time of metal tool decreases from 50 to 40 days with 20% reduction. The development cost has reduced by 28% reduction for the overall products. There are significant improvements on the overall product lines in product design development lead-time; the ECR frequency of design quality and the development cost after the customer collaboration is implemented. The improvements of each selected product line, Desktop PC, LCD PC, Server and Media Center, are also shown in Table 2, which means that the customer collaboration has a positive influence on the design quality in the NPD process. Lead-time to mass production for overall product lines across the two stages has a significant difference of 41%, which means customer collaboration has a positive influence on the time-to-market of the NPD process as well. One marketing manager said:

> "Knowing the customer needs during NPD helps us develop the products needed by the market and avoid significantly many reworks and the redesigns of the products."

Customer/Supplier collaboration practice analysis (using non-platform IT tools)

Similarly, in the situation of the customer/supplier collaboration, the data are compared with that of the customer collaboration. The performance indicators included ECR frequency, lead-time to mass production, lead-time to plastic tool and lead-time to metal tool, and the results of data analysis are shown in Table 2(b). Improvement is found from 1 to 4%, and 1 to 2% for the overall products and the desktop PC, respectively. But for the rest of the selected product, no improvement is identified. One of the R and D managers of LCD PC indicated:

> *"With sufficient earlier communications with suppliers, they provide us the specified components in time but with lowest cost."*

Virtual team collaboration practice analysis (using "QR-NPD CP" SCC IT- platform)

Table 2(c) lists the average figures for ECR frequency, lead-time to mass production, Lead-time to plastic tools, and lead-time to metal tools with or without virtual team collaboration practice. The improvement after the virtual team is implemented is from 0 to 2% for the overall products. For Desktop PC and LCD PC, there is some improvement from 0 to 2%. For server and media center products, there is no improvement. The IT manager admitted:

> *"Initially, people are not familiar with the new IT system. Some senior employees seem to resist it by always using their old ways. It takes time and efforts to train people in using the new platform proficiently."*

e-PDM System practice analysis (using web-based SCC IT-platform)

Table 2(d) lists the mean values for ECR frequency, lead-time to mass production, lead-time to plastic tools, and lead-time to metal tools from the selected projects. E-PDM was a brand new tool to e-company employees when they switched from the less sophisticated system, that is, QR-NPD CP, to this Internet or web-based SCC platform. While we were conducting the case study, they just started to use it. This explains why the improvement figures for most of the products except LCD PC are negative. The IT manager comments:

> "Changing from one already-familiar platform to a more advanced new platform is a nightmare initially. We have to not only train our people but also the suppliers' and retailers' employees in the virtual teams of different product lines."

Analyzing data of the same period

In Tables 2(a) and 2(b), SCC (whether with customer only or with customer/supplier) outperforms non-SCC. These two stages are launched before the virtual teams are involved in SCC. For the case of Table 2(c), desktop PC and LCD PC outperforms the other two. The production manager explained:

> "Desk-top PC is in volume production and LCD PC is tomorrow's star. The company invests more resources on these two product lines. Members of the virtual teams are pushed hard to proficiently use the new IT system. Comparing to these two hot products, servers and media center products are far less cared."

It means if the virtual teams functions well, the good performance would appear. Otherwise, the result is opposite. For the case Table 2(d), when the study is conducted, the production of desktop PC declines rapidly due to market change. In contrast, LCD PC becomes the cash cow and the production volume of which exceeds that of previous desktop PC many times. The company has to invest more resources on this product and push even harder all the members of the virtual teams to fully utilize the new web-based platform to cope with the booming market demand. Many employees having worked in the desktop PC lines are transferred to LCD PC lines. Therefore, desktop PC as well as server and media center line are cared much less than LCD PC. The production and marketing managers both agree:

> "The market demands for LCD PC are booming so rapidly. The production volumes grow larger than we can handle with the current manpower. We must use more advanced IT to cope with it."

Revisit executive levels for triangulation mechanism

Sorting out all the collected data and finishing the calculation of the improvement figures at each stage of Table 2, we had a research program wrap-up meeting with the executives, that is, VP and Directors, to discuss the results. The main points of the meeting minutes were as follows:

1. They confirmed that all the data they had provided to us were officially documented and authentic records.
2. The data shown in Tables 2(a) and 2(b) indicate that SCC did significantly improve the NPD performance. (This item supports propositions 1 and 2, which are explained in the preceding subsections "*Customer Collaboration Practice Analysis (using non-platform IT tools)*" and "*Customer/Supplier Collaboration Practice Analysis (using non-platform IT tools)*".)
3. The adoption of the Quick Response NPD Collaboration Platform (QR-NPD CP) stands for a big process change from non-platform IT tool to platform IT tool. Similarly, the implementation of e-PDM meant another stage of system change. E-PDM not only enabled the collaboration in virtual teams via the ubiquitous and time-limitless web, but also incorporated marketing, sales, and after-sale service into the operations of the NPD process, that is, a holistic approach. (This item supports propositions 3 and 4, which are explained in the preceding subsections "*Virtual Team Collaboration Practice Analysis (using "QR-NPD CP" SCC IT- platform)*" and "*e-PDM System Practice Analysis (using web-based SCC IT-platform)*".)
4. E-PDM Director pointed out that e-PDM system had increased NPD process efficiency significantly in their new projects that were not included in our study. Chief Technology Officer also explained that e-PDM system definitely strengthened the performance of the whole supply chain collaboration in NPD process. It not only compressed the ECR frequency but also reduced the development and product cost. Furthermore, the lead-time of the product development was also shortened. The Marketing Director indicated that with e-PDM system, they kept better track of new product launch time. It did reduce the development cost and product cost considerably (This item further strengthens the proposition 4).
5. The Financial Director also told us that compared to the early stage without SCC, the adoption of e-PDM made the "product cost" of desktop PC products reduced by about 10%, LCD PC, 12.7% , server product, about 19.9%, and the Media Center, more than 21%. (This is the statistic data provided by the Financial Director of E-company for all the projects in E-company, which is not shown in Table 2 that is for selected projects. But the statistic data strengthen the proposition 4.)
6. The improvements for LCD PC remained the same from customer to customer/supplier collaboration (Tables 2(a) and 2(b)), but increased in virtual collaboration (Table 2(c)). This was because the LCD PC, an innovative product then, was developed initially with a smaller production volume. Due to fast technology advance, it has rapidly become the main product in the timing of virtual team stage, and e-company poured a lot of resources on it. This fact also explains why it kept on improving in e-PDM stage while the other products regressed due to employees' lack of proficiency in using the new system (This item further clarifies the positive figures for LCD PC while those of Desktop PC are negative in Table 2(d), which is explained in "*Analyzing Data of the Same Period*". This item further validates proposition 4).
7. Desk-top PC improved positively in the QR-NPD CP stages, but became negative in e-PDM stage. There are two main reasons for this result. The first one is the unfamiliarity of the new system to the users. The second reason is because of the rising demand for LCD PC that rapidly replaced desktop PC in the timing of e-PDM stage. E-company withdrew the resources from it and transferred them to LCD PC. (This item further clarifies the positive figures of Desktop PC in Table 2(c) and negative figures in Table 2(d) for the same product, which is explained in "*Virtual Team Collaboration Practice Analysis (using "QR-NPD CP" SCC IT- platform)*" and "*e-PDM System Practice Analysis (using web-based SCC IT-platform)*". This item further validates propositions 3 and 4.)
(8) The improvements of the server and media center products kept the same in QR-NPD CP and e-PDM stages. It was because these two products were considered as the innovative products. The production volumes of them were comparatively smaller. Not considering them as the strategic products, the company thus invested a small amount of resources just enough to keep the products survive. Therefore, the effects of the incremental collaboration and e-PDM adoption on their improvements are not significant at all (This item further clarifies the figures that have not many changes for the server and media center products in Tables 2(c) and 2(d), which is

explained in "*Virtual Team Collaboration Practice Analysis (using "QR-NPD CP" SCC IT- platform)*" and "*e-PDM System Practice Analysis (using web-based SCC IT-platform)*". This item further validates propositions 3 and 4).
(9) The R and D Director pointed out that the e-PDM SCC could solve the bottlenecks of NPD process and increase the firm's competitive advantages. The Vice President concluded that supply chain collaboration enhanced the firm's competency to gain a better chance of success in the market. It also helped the whole supply chain partners upgrade their competitive position in the industry (This item further strengthens proposition 4).

RESULTS AND DISCUSSION

From the analysis of Tables 2(a), 2(b), and 2(c), we can tell that Propositions 1, 2, and 3 are supported, respectively. Table 2(d) does not seem to support Proposition 4 by initially looking at it, except the LCD PC product. The working managers clearly explained that the members of the virtual teams belonging to the LCD PC product were forced to use the platform proficiently in the shortest time due to the importance of it to the firm. As time goes by, when the virtual teams of the other products become familiar with the new platform, the NPD performance for the other products will also be improved, which is verified by e-PDM Director (item (4) of the meeting minutes). Therefore, it can be said that proposition 4 is also supported.

From the data analysis in the same period, Table 2(c) demonstrates that among the four competing models, product lines such as desktop PC and LCD PC that emphasize virtual teams SCC has better performances. In contrast, server and media center do not make any progress due to less emphasis in virtual teams. Table 2(d) gets the same conclusion as that of Table 2(c). For the cases of Tables 2(a) and 2(b), the performances for the four competing model are about the same under the condition that no virtual team existed. In short, proposition 4 is also supported from the same-period perspective.

Reliability means that the data obtained are consistent by different approaches at the same time or by the same approach at the different time. All of the data collected are from the documented records. Anyone who does the same study at the different time, or any two groups of people do the same research at the same time will get the same data and results. It can be said that this case study has high reliability. The theory test is re-validated by triangulation which means this case study has high internal validity. The propositions are tested and proved hold by data analysis at different time periods and the same period. Using two different methods and get the same results, it further exhibits the high internal validity of the study. This paper explained that the focal firm of ths study can represent the IT OEM firms in Taiwan. Additionally, in this case study, it will build four competing models and test them with four independent studies to prove that the propositions are supported, which reflect this study has high degree of external validity in IT OEM industry (Yin 1994).

Conclusion

This paper develops four propositions by reviewing the literatures of NPD, collaborations, virtual teams and trust. Steps of case study recommended by Yin (1994) are conducted in a Taiwanese OEM firm. Data of different project phases are collected from working managers and are verified by triangulation method from executives. Four competing models (product lines) are built and analyzed by different time periods and in the same period to prove that the four propositions are all supported. Virtual teams of SCC are concluded to play very important role in NPD. This paper also analyzes that this study has high reliability, internal validity and external validity and possesses the rigorousness of scientific research.

The finding of this study is that: (1) The uniqueness of NPD process in an OEM firm is identified, which focuses more on the product design stages; and (2) if the top management of the firm invests sufficient cares and resources on the product line like LCD PC, the overall performance of NPD for that product line increases significantly after adoption of collaboration, especially in the form of virtual teams. Otherwise, the product line like Desktop PC that receives less attention from the firm will have poor NPD performance during the transition from old IT SCC platform to new platform. Slower learning curve due to lack of firm's attention is attributed to this poor performance.

Under keen competition when the IT manufacturing firms are requested by market to lower product cost, shorten time-to-market and improve product quality, the contribution of this study is that it proves that these market requests can be addressed by enhancing their NPD performance through supply chain collaboration (SCC) in the form of virtual teams under the web-based IT platform environment. The enhancement of NPD performance increases the competitive advantages of the firm.

This paper shows the benefits of the adoptions of the virtual teams of SCC by utilizing the web-based IT platform in e-company's NPD process. Although this paper verifies that the studies have high external validity in IT OEM industry, the future researches can be extended to the whole manufacturing industry by conducting more case studies to doubly validate the results. In addition, the collaboration to reduce the cost should not only be limited to the NPD phase, but also be extended to the later phases (Labro, 2006).

To improve the NPD performance, virtual teams of SCC should not be the only means. Other means such as customer relationship and culture of the organization should also be considered for future studies. For example, Sammon and Hanley (2007) suggested that to create an e-supply chain, an organization to ensure a common understanding was needed. Fawcett et al. (2008) found that the people in the organization were the key bridge to successful collaborative innovation and should not be overlooked. In addition, Vachon and

Klassen (2006) linked SCC to green environmental monitoring and collaboration. We may consider including all the above issues in the future study.

This study shows that the use of virtual teams of SCC results in better NPD performance. But Madhavan and Grover (1998) argued that virtual teams might not be the best vehicles for NPD because cognition was shaped by the technological and other artifacts that were embedded in the physical setting. Such difference might be caused by the fast progress of IT platform between 1990's and 2000's. It is worthwhile to do further studies to find out the real causes.

Managerial Implications

For practitioners, from the analysis of data of this case study, there are some managerial implications identified as follows:

1. Supply chain collaboration can improve the new product development performance (induced from Tables 2(a) and 2(b) corresponding to propositions 1 and 2) under the condition that the members of SCC have sufficient proficiency in using the deployed IT SCC platform (induced from Tables 2(c) and 2(d) for LCD PC and Desktop PC).
2. Due to globalization, there are more and more world-wide geographically diversified workers inside the firm as well as among the supply chain partners. The geographical diversifications also cause temporal diversification, for example, time-zone difference. To manage SCC under such diversifications, Managers can consider building virtual teams to solve the problem.
3. The most important factor to have virtual team work efficiently is the trust among team members, in addition to the technical aspect of the web-based IT platform. The firm has to pay more attention to the issues of cultural diversity and solve such "trust" problems among the virtual team members.
4. Web-based SCC platform is the most cost-effective and efficient tool to provide ubiquitous and time-limitless communication solutions to the international virtual teams. It is especially helpful for firms like E-company who has many offices located in different continents. But due to the fact that web-based platform has become more and more powerful and sophisticated, the usage of the platform appears to be more and more complicated. The members of the virtual team need more knowledge to use it proficiently. Training in IT tool using for the employees seems to be very important and urgent (based on the effect of learning curve (Wright 1936)).
5. Product and IT knowledge can be learned very fast. All the competing firms have about the same technological level since firms can get supported from platform vendors if they pay. They are the basic competences to compete in the market. But the cultural and behavioral competences need longer time to cultivate. They are the real differentiations of the firm that cannot be imitated by competitors once established. SCC Virtual team is such competence. It is worthwhile for the managements to invest time and efforts on it.

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