

# Identifying key enablers to improve business performance in Taiwanese electronic manufacturing companies

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## **Identifying key enablers to improve business performance in Taiwanese electronic manufacturing companies**

### **Abstract**

**Purpose** – Integrated supplier management (ISM), new product development (NPD) and knowledge sharing (KS) practices are three primary business activities utilised to enhance manufacturers' business performance. The purpose of this paper is to empirically investigate the relationships between these three business activities (i.e. ISM, NPD, KS) and business performance (BP) in a Taiwanese electronics manufacturing context.

**Design/ methodology/ approach** – A questionnaire survey was firstly administered to a sample of electronic manufacturing companies operating in Taiwan to elicit the opinions of technical and managerial professionals regarding business activities and business performance within their companies. A total of 170 respondents from 83 companies responded to the survey. Factor, correlation and path analysis was undertaken on this quantitative data set to derive the key factors which leverage business outcomes in these companies. Following empirical analysis, six semi-structured interviews were undertaken with manufacturing executives to provide qualitative insights into the underlying reasons why certain business activity factors were the strongest predictors of business performance.

**Findings** – The investigation showed that the ISM, NPD and KS constructs all played an important role in the success of company operations and creating business outcomes. Specifically, the key factors within these constructs which derived business performance were: (1) supplier evaluation and selection; (2) design simplification and modular design; (3) IT infrastructure and systems; and (4) open communication. Accordingly, sufficient financial and human resources should be allocated to these important activities to derive accelerated rates of improved business performance. These findings were supported by the qualitative interviews with manufacturing executives.

**Originality/ value** – The paper depicts the pathways to improved manufacturing business performance, through targeting efforts into the above mentioned factors within the ISM, NPD and KS constructs. Based on the empirical path model, and the specific insights derived from the explanatory interviews with manufacturing executives, the paper also provides a number of practical implications for manufacturing companies seeking to enhance their business performance through improved operational activities.

**Keywords** – integrated supply management, new product development, knowledge sharing, electronic manufacturing, Taiwan.

## **Introduction**

When facing highly competitive and expanding global marketplaces, manufacturing companies are seeking ways to improve their competitiveness. To achieve this, they have been focused on producing products of superior quality, reliability, flexibility and performance, while reducing costs and introducing product to the market faster (Choy *et al.*, 2005). Therefore, a proportion of company resources has been allocated towards: (1) better management of their suppliers, since manufacturing companies consider their suppliers as an extension of their business operation (Tan *et al.*, 1999); (2) better design and technical practices in order to improve time to market, reduce product development time, and reduce deficiency of product quality and manufacturability (Liu *et al.*, 2005); and (3) innovatively reused and shared managerial and technical knowledge to enhance employee's ability and their job performance, which eventually contributes to business performance (Lubit, 2001). These business practices are essential components of the manufacturing process, namely integrated supplier management (ISM), new product development (NPD) and the management and sharing of the strategic asset of knowledge.

Since the 1980s, supply chain management (SCM) has become one of the most important business practices for manufacturing companies to gain a competitive advantage in the current global environment (Lambert and Cooper, 2000). The primary focus of SCM is to achieve continuous improvement in manufacturing quality and efficiency through supply chain integration (Chin *et al.*, 2006). One of the major SCM approaches is integrated supplier management (ISM) whereby manufacturing companies integrate their suppliers' production capacity and technological competence to sharpen their own competitive edge (Tan *et al.*, 1999; Lambert and Cooper; 2000).

Additionally, it has been reported that NPD is one of the most important business activities in helping manufacturing companies to survive and gain market share (Liu *et al.*, 2005). Since a product's life cycle has become much shorter than before, companies need to design new products innovatively and co-operate with their suppliers at an early stage of product design (Tan *et al.*, 1999). These approaches can ensure the successful launch of new products in time to serve a targeted market.

Moreover, a company's knowledge sharing (KS) capabilities, with respect to communicating, capturing, organising and disseminating knowledge allows them to improve decision making, process efficiency, quality, timeliness, customer satisfaction and cost reduction (Artail, 2006). Through sharing and harnessing internal knowledge and know-how as well as absorbing external knowledge, a company will improve business practices, which will ultimately lead to advanced competitive advantage and performance (Ingram and Simons, 2002).

Manufacturing has been the mainstay driving force of Taiwan's economy, accounting for approximately 40 per cent of gross national product in early 2008 (Taiwan Economic Statistics, 2008). The exponential growth in information technologies has shifted Taiwanese manufacturing companies' strategic efforts away from the resource economy, which mainly focuses on managing tangible resources, e.g. land, materials and labour forces, to the knowledge economy, which concentrates on creating business value through the utilisation of intangible knowledge (Yeh *et al.*, 2006). Within the context of Taiwanese manufacturing industry, highly integrative supply networks, fast adaptive product design, and knowledge management/sharing are considered to be three of the most important core competencies, which have a strong potential to improve profitability, reduce operational costs and heighten the attractiveness of a company's products (Matsui *et al.*, 2007).

Hence, like their counterparts around the world, most manufacturing companies in Taiwan are seeking ways to improve their ISM, NPD and KS practices (Liu *et al.*, 2005; Lambert and Cooper, 2000; Ingram and Simons, 2002; Matsui *et al.*, 2007). Given this, it is necessary to identify the specific business activities that are strongly associated with business outcomes. This would help manufacturing companies to focus their resources on implementing those activities that could effectively improve certain aspects of business performance (BP). These targeted outcome areas may include business competitiveness, manufacturing performance, customer satisfaction and process efficiency (Hsu, 2006; Antonio *et al.*, 2006; Petersen *et al.*, 2005).

Given the importance of ISM, NPD and KS activities in the knowledge economy this study aimed to provide

both empirical and qualitative evidence on the relationship between the most significant of these activities (i.e. factors) and business performance (BP). In order to achieve this research objective, a theoretical framework was designed to examine such relationships within electronic manufacturing companies operating in Taiwan. A mixed method research design was adopted for the study incorporating correlation and path analysis to derive significant relationships and semi-structured interviews to explain them. Management implications are presented which synthesise study findings. Finally, conclusions, limitations and research directions are provided. The principle contribution of this paper is the identification of the critical activities within ISM, NPD and KS constructs, which actively leverage BP outcomes, thereby providing manufacturing companies with a more visible agenda for allocating their limited human and financial resources.

## **Theoretical Framework**

The following sections provide a summary on the literature review conducted for the three constructs pertinent to this study, namely ISM, NPD and KS. Moreover, the relationship between these constructs and BP was confirmed in the literature. The review culminated in a theoretical framework consisting of three overarching hypothesised relationships.

### *Integrated supplier management*

Within the context of the manufacturing industry, a supply chain (SC) consists of all stages involved, directly or indirectly, in fulfilling a customer request (Chopra and Meindl, 2001). Accordingly, the SC can be seen as an integrated process where various business entities (i.e., suppliers, manufacturers, distributors, and retailers) work together in an effort to acquire raw materials, to convert raw materials into final products and to deliver these final products to retailers or customers (Beamon, 1998).

SCM coordinates and integrates all operational activities into a seamless process, which links the business partners in the chain including various departments within a company and the external partners such as suppliers (Ndubisi *et al.*, 2005). A key point in SCM is that the entire process must be viewed as one system. Any inefficiencies incurred across the SC (suppliers, manufacturing plants, warehouses, customers, etc.)

must be assessed to determine the true capabilities of the process (Lambert and Cooper, 2000). In general, SCM seeks to improve manufacturing performance through eliminating waste, as well as an improved leveraging of internal teamwork and external supplier capabilities and technologies.

Manufacturing companies are streamlining all operations and minimising the time-to-customer for their products. These changes constitute new challenges which need to be effectively managed. The primary changes highlighted in the literature (Tan *et al.*, 1999; Ndubisi *et al.*, 2005; Lummus and Vokurka, 1999) include: greater sharing of information between suppliers and manufacturers; horizontal business processes replacing vertical departmental functions; shift from mass production to customised products and greater emphasis on organisational and process flexibility; increased reliance on purchased materials and simultaneous reduction in the number of suppliers; necessity to coordinate processes across many sites; and competitive pressure to introduce new products more quickly.

To manage these changes, SC integration has become increasingly critical for most manufacturing companies (Tan *et al.*, 1999). Implementing ISM can help manufacturing companies utilise their suppliers' processes, technologies, and capabilities to enhance their own competitive advantage, and effectively coordinate manufacturing, logistics, materials, distribution and transportation functions between the manufacturing company and its suppliers. Therefore, one of the most significant paradigm shifts in the manufacturing industry is that individual businesses no longer compete effectively in isolation, but rather as integrated SCs (Lambert and Cooper, 2000). Accordingly, the ultimate success of business depends on management's ability to integrate the complicated network of SC relationships.

Since the 1980s, ISM has come to the forefront of public notice. Many manufacturing companies reaped the benefits of establishing intensive collaborative relationships within and beyond their own company (Beamon, 1998). Three important factors have motivated this strategic shift. Firstly, manufacturing companies have become increasingly specialised in their products and technology (Ahire and Dreyfus, 2000). They realised that better profits and streamlined procedures can be made by searching for suppliers who can provide low cost, quality materials rather than having their own source of supply. Therefore, supplier evaluation and selection is one of the strategies adopted by manufacturing companies, to assess and select potential

suppliers, which helps to ensure that these suppliers fulfil company requirements with respect to cost, quality and efficiency (Hsu *et al.*, 2006; Petersen *et al.*, 2005). Simultaneously, primary production companies also build more effective relationships with their suppliers through the evaluation and selection process. It becomes critical for the companies to manage the entire network of supply to optimise overall performance (Lummus and Vokurka, 1999). Secondly, the strategy of involving the supplier during the product development and production process is recognised as a significant practice in reducing costs and improving quality in the production life cycle (Pearson and Ellram, 1995). Early supplier involvement in the product design process can provide the following benefits: more cost-effective design choices; alternative conceptual solutions; better selection of materials, components, and technologies; and concurrent assessments on both the design and production process (Ndubisi *et al.*, 2005). Based on this approach, suppliers' involvement can help the manufacturing company to reduce lead times, improve product's performance, and introduce new products faster into the market. It has been reported that early supplier involvement has a strong positive impact on business performance (Vonderembse and Tracey, 1999). Thirdly, from the manufacturing operational perspective, the performance of a key supplier directly influences a manufacturing company's performance. On average, manufacturing companies spend over 50 per cent of their revenues on purchasing materials (Kannan and Tan, 2002). Supplier management strategy addresses a manufacturing company's efforts in improving its suppliers' performance and capabilities, through creating a strategic culturally integrated alliance that achieves both short- and long-term supply needs (Chin *et al.*, 2006).

The above critical review on SCM literature resulted in the ISM construct being operationalised with the following three dimensions: (1) supplier evaluation and selection; (2) supplier involvement; and (3) supplier management strategy. Moreover, the above discussion suggests that strong empirical evidence existed that efficient and effective ISM leads to heightened BP (Tan *et al.*, 1999; Ndubisi *et al.*, 2005; Lambert and Cooper, 2000). Therefore, the key research questions that this study intended to provide answers for include: (1) can empirical evidence be established for such an argument within the context of the Taiwanese manufacturing industry? and (2) if the evidence can be established, then which ISM activities have a significantly stronger influence on BP? Figure 1 illustrates each of the derived dimensions within the ISM construct and its hypothesised relationship with the BP construct. Correlation analysis and path modelling presented in a later section of this paper provided answers to the outlined research questions.

### *New product development*

The NPD process coordinates a series of important aspects including concept formulation, design planning, system level design, detailed design, testing and refinement (Hong *et al.*, 2005). At the same time, the product design stage also involves the product development team from various functions to clarify targets and to receive, analyse and disseminate knowledge among team members. The development and introduction of innovative new products is one of the most important challenges for manufacturing companies facing uncertain and competitive business environments (Matsui *et al.*, 2007).

The product development process (PDP) is concerned with the implementation of the various design activities which contribute to the effectiveness of NPD (Hong *et al.*, 2005). Lambert and Cooper (2000) explained that if new products can be seen as the lifeblood of a company, then product design and development is the lifeblood of a company's new products. Both the manufacturing company and its suppliers must be integrated into the PDP in order to reduce time to market and produce better quality products. Moreover, as product life cycles shorten, the desired products must be developed and successfully launched in ever shorter timeframes in order to remain competitive and to increase profit.

Market competition requires companies to procure and apply resources to create value by offering better quality products in a timely manner and with continuously improving efficiency. In order to pursue these objectives, companies must emphasise faster and more efficient development processes, shorter and more cost effective design cycles and quicker delivery time (Tan and Vonderembse, 2006). In addition, Ahire and Dreyfus (2000) explained that an effective product design and development process has been recognised as an important market leadership tool by successful companies in competitive industries.

Two major dimensions of the NPD have been identified as: (1) speed of new product development; and (2) number of components used in products. The first dimension explains the ability of a manufacturing company to frequently offer new products, new designs and/or new services to the marketplace and customers (Ahire and Dreyfus, 2000). The second dimension is design simplification, i.e., component standardisation and modular product design, which directly affect product cost and performance through

their impact on the number of parts used in the product (Ahire and Dreyfus, 2000). Therefore, the speed of NPD and components reduction in product designs, are two major indicators of product design performance.

The efforts of designers are usually focused on introducing not only more but better products. Such efforts should take into account the manufacturability of the proposed products. Therefore, design simplification and component reduction are important hallmarks of good design performance (Ahire and Dreyfus, 2000; Matsui *et al.*, 2007). Parts reductions allow engineers to produce new products faster by working with previously designed and built components for which costs, standards, bills of materials, and lead times are already known. As can be imagined, process complexity is a function of design complexity; a lower number of parts per product should result in more streamlined production. Fewer and standardised components result in lower inventory costs and easier management of inventory. Simplified production and the engineer's prior experience with standardised parts should also result in lower scrap, rework and fewer defective units, which leads to cost saving and production efficiency (Tan *et al.*, 1999; Ahire and Dreyfus, 2000).

The term 'Product family' is often described as a group of related products which share common features, components, design, technologies, and subsystems or modules, so that they can satisfy a variety of market and customer needs in a relatively short period of time (Zha and Sriram, 2006). The development of a product family, or so-called modular product design or modularisation, has been recognised as an efficient and effective means to realise sufficient product variety, to satisfy a range of market and customer demands in support for mass customisation (Zha and Sriram, 2006).

In addition, design is not only a cost driver, it is also recognised as a major determinant of quality because most companies considered that quality can be designed into the product, at least as much as it is built in during the manufacturing process. According to Petersen *et al.* (2005), there are a number of influencing factors that are important to the creation of successful new products. Two of these factors relate to design for quality and design for manufacturability within a manufacturing company. Good design takes every detail into account which contributes to a company's ability to develop and produce new products more quickly by minimising engineering changes. Such changes are the main reason for production delay and cost variance. In other words, good design makes great contributions to three traditional measures of operational outcomes,

which consist of cost, quality and timeliness (Lu and Yang, 2004; Fynes and Burca, 2005).

What is more, product development is a knowledge intensive activity that must involve all appropriate employees to create successful new products by linking upstream activities such as research and development (R&D), marketing and product conceptualisation with downstream activities such as manufacturing design, operations and supplier management (Hong *et al.*, 2005). Successful product development requires the integration of these activities to create an employee-oriented environment that facilitates information exchange and shared decision-making. Previous studies show that a higher level of involvement of related employees could result in better product development performance (Hong *et al.*, 2005; Ahire and Dreyfus, 2000).

According to the above examination on literature covering the NPD process, a total of four dimensions were identified to measure the NPD construct: (1) design simplification; (2) modular product design; (3) design for quality and manufacturability; and (4) employee involvement. It is also strongly evident in the literature, that well engineered NPD processes lead to superior BP (Ahire and Dreyfus, 2000; Petersen *et al.*, 2005; Fynes and Burca, 2005). Accordingly, this study plans to provide answers for the following research questions with respect to NPD: (1) within the context of the Taiwanese manufacturing industry, does empirical evidence provide support for the relationship between NPD and the BP? and (2) if this relationship is supported, what specific NPD activities have a stronger impact on the level of BP? Figure 1 illustrates each of the derived dimensions within the NPD construct and its hypothesised relationship with the BP construct.

#### *Knowledge management and sharing*

Haag *et al.* (2006) explained that mountains of information are of little use unless they are extracted and made available to the people or systems that need meaningful information (i.e., knowledge) at the right place and at the right time. Knowledge is rapidly becoming a critical asset for sustaining a company's future success. It is becoming increasingly acknowledged that leveraging knowledge in managerial and technical activities can derive long-term value to a company (Tseng, 2006).

Liu *et al.* (2005) proposed that knowledge has become the main manufacturing resource and a prerequisite for success in the production environment. Competitiveness and the resulting rewards can be obtained by taking advantage of knowledge management (KM) and sharing. Manufacturing companies have been creating, coding, storing, retrieving, transmitting and applying knowledge in their production process increasingly. For example, training and employee development programs have been used to facilitate knowledge acquisition; products reports and manuals have been used to disseminate best practices (Law and Ngai, 2007). In addition, manufacturing companies have become increasingly knowledge focused since the dawn of the knowledge economy era, whereby the strategic role of knowledge has been repeatedly addressed (Sanchez, 2001). Some recent studies reported that an effective KM program can help to promote innovation by: encouraging the free flow of ideas; improving customer service by streamlining response times; boosting revenues by getting products and services to the market faster; enhancing employee retention rates by recognising the value of employees' knowledge; and streamlining operations and reducing costs by eliminating redundant or unnecessary processes (Lubit, 2001; Hsu, 2006).

Knowledge sharing is defined as employee behaviours which facilitate the dissemination or transfer of his/her knowledge to others (Hsu, 2006). Within the context of the manufacturing industry, KS occurs through a variety of mechanisms, including personnel movement, training, communication, observation, technology transfer, replicating routines, presentations, interactions with suppliers and customers, and other forms of intra- and inter-organisational relationships (Chua and Pan, 2006).

According to Davenport and Prusak (1998), most KM programmes have one of three aims: (1) to make knowledge visible and show the role of knowledge in an organisation, mainly through education, training, open communication and information technology (IT) tools; (2) to develop a knowledge-intensive culture by encouraging and aggregating behaviours such as knowledge sharing and proactively seeking and offering knowledge; and (3) to build a knowledge infrastructure not only a technical system, but a system of connections among people given space, time, tools and encouragement to interact and collaborate. Hence, within an organisational context, KS is the most critical component of any KM programmes which aim to improve business performance (Lubit, 2001).

According to Bock and Kim (2002), KS is the most important part of KM. KS arises from individuals' efforts to share knowledge within the organisation. As a creative approach it can result in improved efficiency, higher productivity, and increased profits in practically any business function (Ahmed *et al.*, 1999). There are several crucial factors contributing to an improved KS process, such as top management support, organisational learning and sharing, information technology support, collaborative communication and incentives or rewards (Lubit, 2001; Alavi and Leidner, 2001; Hsu, 2006; Tseng, 2006; Yeh *et al.*, 2006).

It is well known that top management support and understanding is crucial to a successful KS implementation (Tseng, 2008), because it is likely that any KS initiative will encounter some form of resistance from employees. Therefore, employee's trust in leaderships is one of the key drivers of employee commitment and willingness to share knowledge. Davenport and Prusak (1998) reported that when top managers perceive knowledge as a key strategic resource and KS as the foundation for value creation, they will fully support a range of KM practices that aim to facilitate KS within organisations. Moreover, Hsu's case study (2006) revealed that companies that showed a higher level of dedication to establishing KS practices were found to have top management support. Thus, the initiation and implementation of KS practices should start with a top management that sees knowledge as a source of competitive advantage.

IT support refers to the fundamental building of infrastructure and systems that support and coordinate knowledge management activities, such as knowledge repositories, web-based platforms, performance monitoring and evaluation systems, integrated operational support systems, etc. (Yeh *et al.*, 2006; Stewart, 2008). IT can enable the rapid access and retrieval of information, and supports collaboration and communication between team members. In essence, IT and KS functions are becoming ever more integrated, as they are both ultimately seeking to aid the propagation of structured knowledge within the organisation. The goal of most organisations is to use the advancement of IT infrastructure and systems to conduct KS (Alavi and Leidner, 2001; Chen and Mohamed, 2007). Taylor (2006) discovered that advanced IT can facilitate the sharing and transferring of information and provide channels to obtain information, which have a direct and indirect influence on the motivation for sharing knowledge.

In addition, companies need to overcome defensive attitude inhibiting communication when implementing

KS. Open communication is an important medium to read out knowledge which resides within the individuals (Modi and Mabert, 2007). Davenport and Prusak (1998) and Lubit (2001) emphasized that KS is a process of communication and also explained that it is a main process in which people transfer and share knowledge. Moreover, KS is the factor leading to task or goal accomplishment by different organisations, departments, or individuals and is the process in which they accomplish the exchange of resources, knowledge and experience through effective cooperation and mutual communication.

According to Hsu (2006), an organisation that applies effective KS will constantly develop its employee's competency. As an employee's capability becomes enhanced, their job performance can be improved, which will ultimately contribute to business performance. Lubit (2001) explained that any previous work experiences can be transferred to others which should improve the performance of those within a work team. Moreover, organisational learning and sharing experience accumulated in different work teams strengthens the overall competitiveness of the company, which should help them to outperform any competitors without effective KS practices. Thus, the KS activities among intra- and inter-organisational work teams are fundamental for both the functioning of their members and the competitive dynamics of the company (Law and Ngai, 2007).

KS activities facilitate learning among employees and enable them to resolve problems, similar to situations encountered by others in the past; therefore, this helps quicken response times to problems and often results in cost saving (Ipe, 2003, Sher and Lee, 2004). However, there are still some key factors that need to be addressed for a company to successfully leverage its knowledge application. Firstly, it is necessary to develop a knowledge sharing culture. Secondly, companies need to overcome defensive routines inhibiting open communication. Lastly, an incentives or rewards system needs to be developed that encourages employees to make full use of the electronic means of information transfer and storage, and increase willingness to share their knowledge constantly (Lubit, 2001; Hsu, 2006).

A total of five dimensions were evident in the literature review as measurement variables for KS, namely: (1) top management support; (2) organisational learning and sharing; (3) IT infrastructure and systems; (4) open communication; and (5) incentive/rewards. As discussed above, the empirical evidence presented in the

literature suggests that a developed culture of KS in a manufacturing company leads to improved BP (Hsu, 2006; Lubit, 2001; Law and Ngai, 2007). Given this, the present study aims to answer the following research questions: (1) can empirical evidence be established within the Taiwanese manufacturing context to support a relationship between KS and BP? and (2) if this relationship exists, what particular KS activities are strongly associated with the level of BP? Figure 1 illustrates each of the derived dimensions within the KS construct and its hypothesised relationship with the BP construct.

[INSERT Figure 1]

The above mentioned literature review on both empirical and qualitative studies addressing ISM, NPD, KS and BP in the manufacturing context provided the basic measurable variables for operationally defining the four constructs of the theoretical framework. The following section describes the method for measurement development and relationship identification.

## **Research method**

This study predominately followed a deductive approach which started with the formation of rational relationships between constructs and then progressed to seeking supporting empirical evidence. Following this quantitative approach, qualitative research utilising a series of semi-structured interviews, was then conducted to provide greater insight into the significant path relationships (Neuman, 2003; Panuwatwanich *et. al.* 2009).

### *Quantitative study*

This study uses a cross-sectional design and path model analysis techniques to extract the key factors within the ISM, NPD and KS constructs which leverage enhanced BP within electronic manufacturing companies operating in Taiwan. Data were gathered over a period of five (5) months via a mail questionnaire survey to elicit respondents' opinions on ISM, NPD, KS activities as well as the perceived BP level in their company. In the questionnaire, five-point Likert scales were used to measure the operationally-defined variables within each construct of the proposed theoretical framework. Demographic information about the respondents and their associated companies were also collected and summarised in Table I.

[INSERT Table I]

The questionnaire was pre-tested with forty (40) managerial and professional staff members to evaluate it for clarity, bias, ambiguous questions, and relevance to the designated industries and operations of Taiwanese manufacturing companies. Thirty (30) respondents offered valid feedback and useful suggestions (Burns and Bush, 1998). The data collection process began after the questionnaire had been finalised, based on the pre-test feedback.

The sampling frame consisted of 241 manufacturing companies randomly drawn from those listed in the Taiwan Stock Exchange (TSE) market. A mixture of large- and medium-sized electronic manufacturing companies represented the theoretical population because they provide a relatively better organisational structure for implementing contemporary business activities compared to small companies. Self-administered questionnaires were mailed or delivered in person to the managerial and professional staff member(s) within targeted companies. A total of 170 usable responses were received from 83 companies representing 34.4% of the research population. No more than five (5) usable (containing no missing data) questionnaires were chosen from each company to avoid bias in the data. The responses were considered a good representation of the opinions of the population, since the majority of the respondents were middle-aged, well-educated, experienced, and knowledgeable about manufacturing operations and management within their companies.

#### *Qualitative study*

Following empirical analysis, six semi-structured interviews were undertaken to provide more insight into the phenomenon under investigation. The interviewees were managerial and professional staff members representing 3 medium and large-sized manufacturing companies. Company A is a large manufacturing operation focused on communication, computing, consumer electronics and car electronics, with net revenues exceeding US \$40 billion and over 4,000 employees worldwide. Company B's core business is the design and manufacturing of Internet phone technology as well as a variety of wireless communication products. Company C specialises in the design and manufacture of electronics, computer parallels and consumer products. All of these companies conduct their manufacturing activities in Taiwan and mainland

China with design activities conducted in diverse offices globally. The interviewees included one managing director, four senior managers, and one senior engineer. All of them have over 10 years of work experience in the manufacturing industry and are highly knowledgeable about all of the operational and management aspects within their companies.

In light of this, it was considered that the interviewees were sufficiently qualified to provide specific cases and practical reflections that could help to clarify and deepen understanding on their companies' business activities, manufacturing processes and performance. Specifically, these interviews sought to ascertain the interviewees' perceptions as to the potential effectiveness and efficiency of any applied ISM, NPD and KS practices, strategies and related systems within their companies. Moreover, the interviews were focused on identifying the most important factors for improving the performance of the manufacturing process. The concise summary of their comments presented later substantiates the main findings of the empirical study.

### **Quantitative Data Analysis**

Exploratory factor analysis (EFA) was applied to determine whether and to what extent the measurement variables represented their underlying factors within each construct. Based on these scales, correlation was performed to determine significant relationships between identified factors. Following this, path models were assessed to simultaneously examine interrelationships with the aim to determine the most active factors. Data examination, EFA and correlation analyses were performed by the Statistical Package for Social Sciences Software (SPSS version 15.0). Version 5 of AMOS (Analysis of Moment Structure), the structural equation modelling (SEM) software, was then used to perform the path analysis. Data screening techniques were applied to all variables to assess their distribution and ensure that normality and linearity are reasonably upheld (Coakes, 2005).

#### *Measurement scale development*

EFA was adopted for identifying the structure among the set of measurement variables for each construct and also data reduction. The VARIMAX method for orthogonal rotation under the component factor model was chosen to give a clear separation of the factors. The 170 cases met the acceptable sample size of 100 for undertaking the factor analysis; and was much larger than the minimum requirement of 80, that was five (5)

times as many subjects as the variables to be analysed for the construct with the largest number of variables (KS; N=16) (Hair *et al.*, 1998). Checks were undertaken to ensure factorability is upheld for all factor analysis scenarios. With the sample of 170, a factor loading of 0.50 and above was considered significant at the 0.05 level to obtain a power level of 80% (Hair *et al.*, 1998); thus, variables having a factor loading of less than 0.50 were eliminated. The cumulative percentage of total variance extracted, by successive factors, for each of the four factor analyses conducted, ranged from 69.1% to 78.1% and are considered satisfactory solutions in the social sciences (Hair *et al.*, 1998). Moreover, the reliability coefficient of all measures was above 0.70, indicating good consistency of the scales for the constructs and their factors (Hair *et al.*, 1998). Since the constructs were conceptually defined based on a combination of the literature review and previous empirical studies the factors' scales were considered to have face validity (Hair *et al.*, 1998). The factor analysis results for each construct are summarised in Table II.

Firstly, the analysis uncovered two (2) factors for the ISM construct. ISMF1 represents a company's effort with respect to sourcing, evaluating and selecting potential strategic suppliers. ISMF2 reflects the early involvement of suppliers. These two factors suggest that both the manufacturing company and its suppliers need to make efforts in order to improve ISM activities. Secondly, the analysis found two (2) factors for the NPD construct. NPFD1 reflects employees' contributions in the product development process. NPFD2 represents improvement in the practices of the design process such as design simplification and modular design. These two factors were considered to be the primary foci of NPD improvement in manufacturing companies. Thirdly, the analysis identified three (3) factors for the KS construct. KSF1 denotes the contribution of robust IT infrastructure systems and support for KS in a company. KSF2 reflects the extent of continuous sharing and open communication. KSF3 denotes the gained organisational learning achieved through learning platforms and collaborative communication. These three factors represent KS activities that are commonly implemented to improve business performance in a manufacturing company. Finally, the analysis identified three (3) factors for the BP construct. BPF1 indicates a company's competitive ability in terms of profitability, sales growth and quality. BPF2 represents long-term manufacturing performance from both an operational performance and customer satisfaction perspective. BPF3 reflects production and service efficiency. These three factors measure BP based on competitiveness, manufacturing performance, and process efficiency in the Taiwanese electronic manufacturing industry.

[INSERT Table II]

In summary, EFA developed measurement scales for the four (4) constructs shown in Table II, each having satisfactory reliability, validity, dimensionality, and conceptual definitions. These scales were used in the following correlation and multivariate analyses for identifying the relationships between factors within each construct.

### *Correlation analysis*

Correlation analysis revealed strong and significant associations between business activity constructs (ISM, NPD, KS) and the BP construct, thereby endorsing these previously established relationships in the Taiwanese electronic manufacturing industry context. The Pearson correlation  $r$  (coefficient of correlation) values are 0.559, 0.574, and 0.609 (significant at 0.01 level). Correlation analysis was also employed to investigate the associations between the factors within the business activity constructs (ISM, NPD, KS) and those of the BP construct. The objectives of the correlation analysis were: (1) to identify the factor within each business activity construct that has the strongest association with the BP factors; and (2) to reveal the BP factors that are sensitive to variations in the business activity factors. Table III maps the Pearson correlation values between the various business activity factors and the BP factors. Indicated by Pearson correlation  $r$  values significant at the 0.01 level (2-tailed), ISMF1, KSF1, KSF2 and NPDF2 showed the strongest association with two BP factors (BPF1 and BPF2), suggesting their potential stronger influence on these two BP factors. Whilst, BPF1 and BPF2 were strongly associated with most of the business activity factors, correlation analysis indicated that they are more sensitive to the variance in ISMF1, KSF1, KSF2 and NPDF2. Based on this exploratory analysis, path analyses were then employed to confirm the impact of these four active business activity factors (ISMF1, KSF1, KSF2, and NPDF2) on the two sensitive BP factors.

[INSERT Table III]

### *Path analysis*

Based on the findings of the correlation analysis, a path model was formed to simultaneously estimate a series of separate, but interdependent, regression equations between the most active factors of ISM, NPD and

KS with the most sensitive factors of the BP construct. In the model fitting process the insignificant links represented by regression weights having a  $p$  value greater than 0.05 were removed. In the final path model, the estimates of both regression weights and variances are statistically significant at a 0.05 level. Table IV reports the unstandardised regression weights for both the initial and final path models. Figure 2 illustrates the final path model with standardised estimates, and the fit indices are indicative of satisfactory fit to data.

[INSERT Table IV]

[INSERT Figure 2]

Path analysis provided strong empirical evidence for the existence of significant causal relationships between ISMF1, NPDF2, KSF1, KSF2, BPF1 and BPF2. This finding suggests that the effectiveness of the supplier evaluation and selection approach has a strong positive influence on both business competitiveness and manufacturing performance. In addition, implementing practices of design simplification and modular design positively contributes to enhanced manufacturing performance. Moreover, as indicated by the comparatively larger standardised estimates, the findings revealed that by creating a company atmosphere which encourages employees to continuously communicate their ideas, share knowledge and experience, manufacturing performance can be improved. Finally, robust IT infrastructure systems and support has a strong positive impact on business competitiveness. The next section will outline a range of qualitative interview findings and associated discussions that qualify the empirical findings.

## **Interview Findings and Discussion**

### *Influence of ISM factors*

All interviewees acknowledged supplier evaluation and selection as being the most significant ISM factor. Specifically, it was indicated as the first and the most critical step to assess a supplier's system, ability, characteristics and performance, and can leverage a company's business performance. Most of the interviewed companies had an established system to evaluate their suppliers' performance. In responding to the constant changes in technology and customer requirements, the companies also made continual effort to improve their evaluation system. The interviews also suggested that properly selected superior suppliers

could help the manufacturing companies to achieve operational and business goals such as improving quality, cost, timeliness, even at the very early project stages. It also appeared that the companies and their key suppliers shared both benefits and responsibility through well established long-term partnerships. It was revealed during the interviews that within the cultural context of the Taiwanese manufacturing industry, mutual understanding and cooperation with suppliers would take a long time to build, since trust and friendship play a very important role in the building process of a business partnership. Under some circumstances early involvement of new suppliers in the manufacturing process might even reduce the efficiency of the production process due to the limited knowledge the manufacturers had about these suppliers' operations and competence. However, it was also said that once mutual understanding is developed, supplier involvement was able to provide accelerated business competitiveness, in the form of better quality and cost reduction, faster and better design solutions, profitability and sales growth. It appeared that interviewed companies and their suppliers interacted frequently to establish mutual trust. They committed to shared risk and responsibility through joint decision-making to achieve better profitability for both parties. This finding reflected that long-term business partnership and a collectivist oriented culture plays an essential role in business operations within Taiwanese business organisational mechanisms (Wu, 2008; Lloyd *et al.*, 2008). A collectivist culture helps manufacturing companies and its suppliers to develop more effective strategies for gaining competitive advantage over others. This study confirmed the previous argument (Lloyd *et al.*, 2008) that Taiwanese manufacturing companies constantly invested time and resources into building long term partnerships with their qualified suppliers. The interview findings also provided insights into the strong relationships between the supplier evaluation and selection factor and the business competitiveness as well as manufacturing performance factors, which were evident from path analysis. Moreover, it provided clues as to why a negative association existed between this factor and process efficiency, which was evident from correlation analysis.

#### *Influence of NPD factors*

New products are the nexus of competition in the manufacturing industry, hence NPD is perceived as a potential source of competitive advantage (Brown and Eisenhardt, 1995). The interviewees emphasised that most manufacturing companies recognised that NPD was one of the most essential business processes for the success, survival, and renewal of their businesses in the current fast-paced and highly competitive market. In

the meantime, they also perceived NPD as a field with high uncertainty and complexity, therefore, the dynamic interactions that occur amongst different organisational members and between different functional departments were critical for successful NPD. In addition, product quality and functionality were identified as two important foci of the NPD process. The interviewees pointed out that on one hand, it was true that cost-saving was one of the primary objectives in most of the manufacturing companies; whereas, on the other hand, retaining customers and enlarging market share were of even higher priority. Given this, they suggested that expenses for quality management as well as research and development (R&D) were well justified in terms of the value they create. This was best described by one of the interviewees: "... No quality product means no customer; no customer retained means no business." Furthermore, during the interviews, design simplification and modular design were highlighted as key attributes to product quality, functionality, and also an indicator of competitive capability of a company. In order to implement this approach successfully, multiple issues were identified as mission critical, such as product characteristics, functionality, quality, cost, delivery time, manufacturability, customisation, simplified and reliable product testing, to name a few.

For the particular context of NPD activities in the Taiwanese manufacturing industry, NPD is not entirely composed of research and development activities for new products, but also the development and production of a variety of similar products such as original equipment manufacturing (OEM) and original design manufacturing (ODM). According to the reflections from interviewees, design simplification and/or modular design were identified as the predominate activity within NPD processes. In order to respond to global competition quickly, Taiwanese manufacturing companies needed to cope with high product variety, mass customisation, shorter product life cycles, and increasing product development costs. Cost control is an important factor to consider in the NPD process. Since product design accounts for about 70% of total product life cycle costs. Hence, there are several trade-offs needed to be examined such as cost, quality, and functionality across a whole range of NPD processes. However, it all depends on the product attributes and market tendency. This finding was in line with the Antonio *et al.*, (2006) study which recommended that when dealing with mass customisation and product variety, modular product design is the most efficient way of providing a variety of products to market in a relative short lead time. The interview findings provided some solid exemplars for the empirically identified relationship between the design simplification and

modular design factor and manufacturing performance.

### *Influence of KS factors*

The interviewees confirmed the importance of KS activities in accelerating rates of business performance. KS activities was said to be essential, especially during the process where small/medium sized companies are trying to use more structured and integrative approaches to manage a larger business scope in a growing market. The interviews revealed that the top management generally understood the opportunities and challenges of managing the large volumes of invaluable knowledge being constantly produced by employees. They have realised that this knowledge remains as a silent power until such time it is applied to serve business purposes, such as to perform complex tasks, improve processes and quality, solve problems or make decisions. All interviewees believed that the exchange of knowledge among employees and across organisational units could generate competitive capabilities which ultimately lead to company success. This consensus of opinion is best described by the comment: "...By sharing their knowledge, employees can realise synergistic results, which are greater than those achievable by any individual alone."

Successful KS also depends on the employees' ability and willingness to learn. All interviewees commented that KS needs to be an ongoing process over longer time frames. Moreover, they felt that the effectiveness of this process depends largely on the sophistication of the IT infrastructure system as well as top management's commitment to build an environment that facilitates KS. They all agreed that the company which applies effective KS activities will constantly develop its employee's competency. They further explained, as the employee's capability heightened, their job performance often improved, which ultimately induced a positive contribution to business performance both in the short- and long-term. This process of learning and sharing knowledge is illustrated in the organisational knowledge creation model created by Nonaka and Toyama (2004). As a final note on this topic, most of the companies interviewed tended to invest heavily into training and supporting technical staff members at an early stage of their career, as advanced competency development in the technical areas generally took time. It was refreshing to see that technical staffs, particularly designers, were viewed as the most important knowledge assets.

The interviewees predominately expressed a similar viewpoint that as long as robust IT infrastructure is

provided and sufficiently supported by the company, the rest of it all depends on the level of commitment from top management and employees actions in day-to-day operations. They succinctly summarised the importance of this factor that without appropriate IT infrastructure and support, company would revert back to the 'stone age', since it would take too much time to deal with design and quality management data manually. In short, without reaching a reasonable level of IT maturity, the implementation of KS would be impossible.

One interviewee provided an example of IT supported KS activities from an operational management perspective. His company developed an intranet-based platform (called e-AVL platform) to constantly monitor internal (e.g. operations) and external (e.g. suppliers) performance indicators from various stages, such as the incoming reject rate (IRR), line fall out (LFO), corrective action report (CAR), to name a few. This integrated information system assisted the company with task guidelines, employee training and education, recording lessons learned, and making informed decisions. The company found that the e-platform paid itself off within only four months of implementation. Moreover, the e-AVL platform helped staff to effectively and efficiently monitor and manage internal/external operational processes and performance both nationally and internationally. Through the implementation of the e-platform, the company could take more proactive preventive actions rather than passively 'fire-fighting' whenever something happens. The staff could confidently ensure that problem-solving experience and know-how can be retained and mistakes would not be repeated.

In summary, all of the interviewees acknowledged that user-friendly IT infrastructure and applications, ongoing top management support, and open communication are the most significant KS factors for enhancing business competitiveness and manufacturing performance. This finding is in line with that of previous studies (Hsu, 2006; Lubit, 2001; Law and Ngai, 2007). From the responses of the interviewees, it is clearly noted that KS enablers, which include company structure, culture, information technology, people, and strategies, form the mechanism for the company to develop its knowledge and also stimulate the sharing of knowledge within the company. However, the most important enabler that must be active, before the execution of any KS strategy, is gaining the top manager's support. Building a KS culture among employees is also crucial. Similarly, any activities requiring the sharing of information need to be facilitated by the

support of IT. This supports Ruppel and Harrington's (2001) finding that the extent of the application of IT was directly proportional to the amount of mutual trust evident in the company culture.

## **Managerial Implications**

Managerial implications have been drawn from both the quantitative and qualitative findings of the study. Firstly, Taiwanese manufacturing companies considered suppliers as an extension of their business operation; therefore, improving any supplier related deficiencies meant improving the performance of the company itself. The study identified three pertinent ISM aspects that management should focus on:

- *Effective supplier integration*: managers should effectively integrate suppliers to ensure products, information and knowledge are readily accessible and distributed to the right people, at the right time, in order to accelerate operations, reduce costs and improve quality.
- *Collaboration mechanisms*: managers should establish mechanisms that maintain collaborative environments, thus ensuring streamlined approaches to planning and products/services delivery. This environment must be accessible by both manufacturers and their suppliers, so that they can share any operations and management actions or new initiatives instantaneously.
- *Cultural compatibility*: managers should continuously monitor their cultural alignment and compatibility with their suppliers, thereby ensuring that both the manufacturer and their suppliers work towards a more collaborative and longer term partnership.

Moreover, a number of core recommendations have surfaced which provide practical approaches to improving manufacturing performance through enhancing NPD activities, as listed below:

- *Cross-functional cooperation*: managers should recognise and promote a higher level of cross-functional cooperation and encourage a greater range of product related employees to get involved during the entire product development process.
- *Diverse education and training*: manufacturing companies should provide production and management education and training to designers, thereby expanding their knowledge base beyond their traditional design tasks to include a range of other operational practices.
- *Careful assessment of design simplification and/or modular product design initiatives*: when practicing design simplification and/or modular product design, managers should bear in mind the various trade-off issues such as cost, quality and functionality, since product modularity depends largely on product dimensions. Moreover, companies should selectively integrate standardised and customised modules in order to gain the benefits of product differentiation and modularise common components to reap the benefits of standardisation.

Finally, the majority of companies did not realise the power of knowledge and have only recently started to actively implement KS activities. Since people are the source of knowledge production, the sharing and application of knowledge includes more than just the systematic IT-based digitalisation of documentation. Its success is dependent on a combination of various socio-psychological and technological factors making it difficult to effectively implement KS. This study highlighted five KS related aspects requiring particular attention:

- *Promoting employee engagement in KS strategies*: managers need to stimulate employee willingness to mutually exchange their knowledge and collaboratively generate new knowledge by providing monetary and non-monetary incentives, promotion opportunities, education and training, etc.
- *Create supportive climate for KS*: managers should strive to create a supportive KS climate and the associated mechanisms for team members to actively pursue KS activities. KS can be enhanced if the company exudes a commitment to learn, backs innovativeness, and projects a shared vision on an organisation-wide basis.
- *Committed IT support*: chief information officers should fully commit to supporting the expansion and universalisation of knowledge thereby increasing the speed of knowledge and know-how dissemination. Moreover, appropriate IT resources need to be assigned for the frequent updating of implemented knowledge repositories.
- *Understand situational context KS enablers*: managers need to have a complete understanding on the key enablers for effectively implementing KS in their particular corporate environment/culture.
- *Chief knowledge management officer (CKMO) and dedicated business unit*: companies should establish a CKMO and dedicated unit for implementing KS practices. The units' role not only includes collecting knowledge, but also assisting and coordinating different departments, through effective communication during each of the various KS implementation stages.

## **Conclusions**

At a macro level, the study concluded that key business activities (i.e. ISM, NPD, and KS) are positively associated with BP within the context of electronic manufacturing companies operating in Taiwan. The targeted research findings revealed that some business activities, such as supplier evaluation and selection, design simplification and modular design, robust IT infrastructure system and support and open communication have the strongest influencing power on business outcomes in the form of competitiveness and manufacturing performance. In light of this, these specific business activities were identified as the key antecedents to business performance. In addition, the study concluded that the investigated three key types of activities are not conducted in isolation. Within the current Taiwanese manufacturing operational

environment, KS activities have become an integral part of every manufacturing process. Even though the practitioners define KS differently, to a large degree, they all perform the KS activities in their day-to-day production practices, e.g. sharing experiences with fellow design engineers and establishing collaborative communication with suppliers. In particular, IT infrastructure and systems for sharing explicit knowledge has become a prerequisite for effective manufacturing operations. Therefore, KS activities can be viewed as covert and are blending in the background of manufacturing operations. These activities intertwine with, and provide the platform for, the other business activities that are more overt in the foreground of the operations, such as ISM and NPD.

With respect to the relationship between ISM and BP, the study found that supplier evaluation and selection plays an essential part in improving business competitiveness and manufacturing performance. The findings emphasize the importance of applying appropriate assessment criteria and making the right decision, up front, about which supplier to work with. The supply base is now recognised as an extension of the manufacturing company. This suggests that the company and its suppliers need to closely cooperate together for striving toward a more radical and creative operation, which should ultimately lead to long term business achievement. Furthermore, the empirically determined relationship between supplier involvement and process efficiency was further augmented by the interviewed practitioner comments, that the decision to have early supplier involvement will mostly depend on collaborative communication and supplier capability. What is more, both the suppliers' capabilities and culture compatibility with the manufacturing company should be taken into account during the supplier evaluation process. Due to the collectivist oriented culture of the Taiwanese manufacturing industry, companies and their suppliers tend to share risk and responsibility and create long term partnerships. This specific cultural trait can be effective as it tends to create long term strategic alliances that enable Taiwanese companies to better respond to the customer or market requirements with low cost and quality products in a short lead time. Based on this finding, it is recommended that companies should have superior suppliers selected, involve suppliers early in the project, and be aware of the cultural issues associated with partnerships. This should ensure that they continuously improve operational processes, mitigate potential deficiencies and enhance product design efforts, which will ultimately strengthen business performance.

The study also provides strong quantitative and qualitative evidence on the positive influence of NPD upon BP. Production complexity generally stems from design complexity. Many companies are now promoting more simplistic design and production approaches that enable the development of a series of integrative product families. Design simplification and modular design was determined to be a critical factor in the Taiwanese electronic manufacturing industry, since it was evident from this study that it leads to better product design, improved product quality and faster design practice. The reason that this factor has high predictive power on manufacturing performance was that a simple NPD process, not only reduced design complexity and the product development life cycle, but also resulted in a more streamlined production with fewer quality and manufacturability issues. Therefore, a pertinent recommendation apparent from this study is that companies should constantly focus on design simplification and modular design aspects in the NPD process.

Both the empirical and qualitative findings revealed the essential role of KS activities in achieving and sustaining competitiveness in the dynamic electronic manufacturing industry. The process of creating, storing/retrieving and transferring knowledge do not necessarily lead to enhanced business performance; only through effectively managing, applying and conveying knowledge, to the right person at the right time, does. Business performance resulting from KS activities mainly depends on an employee's ability and commitment to absorb and apply new knowledge into more effective actions. To achieve this, robust IT infrastructure and support was indicated as a critical enabler for KS to occur. The study herein provided evidence that the utilisation of IT acts as a mechanism for enhanced dissemination of knowledge, which can lead to greater employee abilities in performing their tasks, solving problems and making decisions, which eventually contributes to business performance. Thus, it is strongly recommended that the companies establish a user friendly IT infrastructure and work environment that encourages KS activities to prosper over the long term. Although it was clearly noted that aside from the emphasised IT infrastructure and support factor, KS enablers also include company structure, culture, the use of IT, people and strategies. As a top priority, executives through to employees must work together to derive more innovative processes and radical ideas to better enhance knowledge sharing and application. An important recommendation that stemmed from this study was that companies should establish a dedicated unit for managing and promoting KS.

## **Limitations and Further Research**

Limited and constrained by available research resources, this study focused on electronic manufacturing companies in a unique geographical region, i.e. Taiwan. To enable better generalisability, future research would benefit from a larger sample size, as well as greater sample diversity in terms of size and category of companies, or could be from various cross-cultural contexts. It would seem plausible to conjecture that the greater the cultural distance between team members and partnerships, the greater the difficulty in exchanging knowledge and cooperation. In addition, future research could also attempt to identify different propositions depending upon the type of knowledge being transferred across various business activities. Lastly, the integrative role of KS activities in facilitating efficiency and effectiveness in the more overt business activities (e.g. ISM and NPD) within an electronic manufacturing company, and how the interaction between these factors leverages improved business performance, needs examination.

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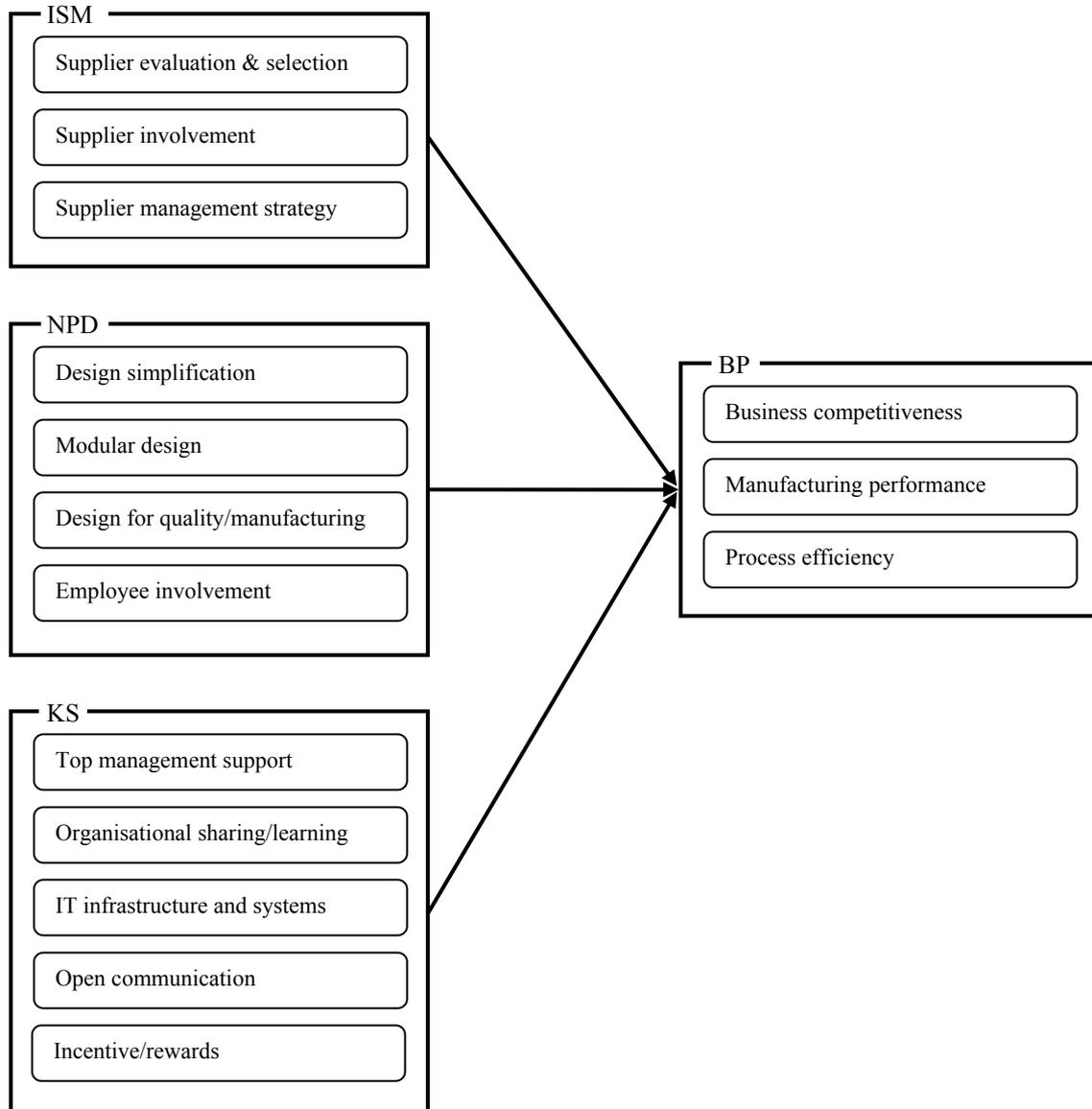
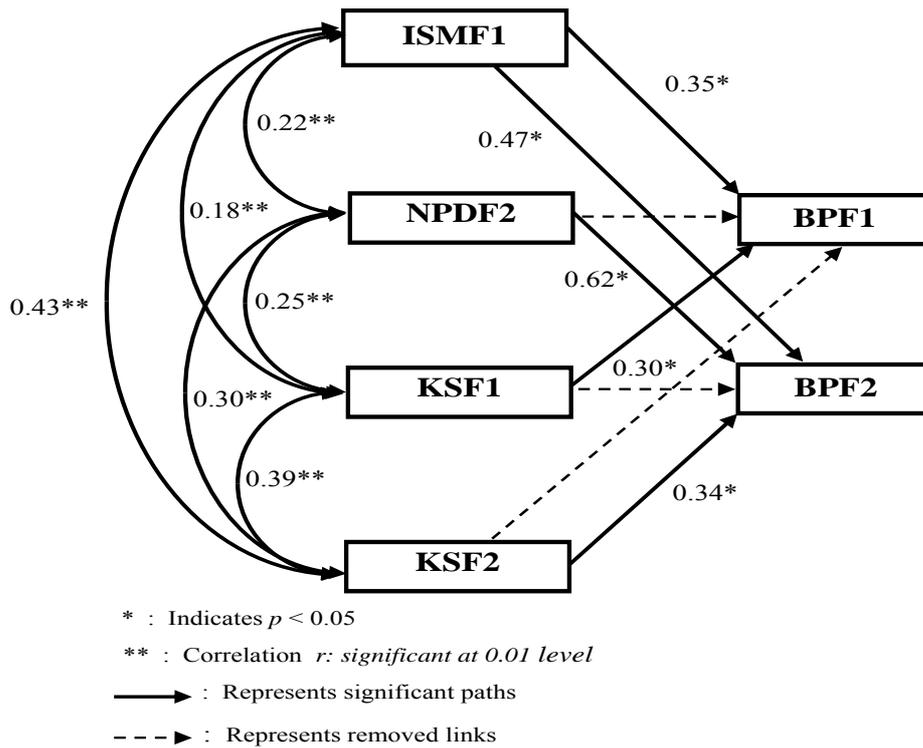


Figure 1 Proposed Theoretical Framework



Notes:

ISMF1: Supplier evaluation and selection  
 NPDF2: Design simplification and modular design  
 KSF1: IT infrastructure and systems  
 KSF2: Open communication  
 BPF1: Business competitiveness  
 BPF2: Manufacturing performance

Fit indexes:

Absolute fit indexes:  $\chi^2 = 5.940$  (df: 4);  $p = 0.204$ ; GFI = 0.989; AGFI = 0.941.  
 Incremental fit indexes:  $\chi^2/df = 1.485$ ; NFI = 0.986; CFI = 0.995.  
 Parsimonious fit index: RMSEA = 0.054  
 Sample adequacy: Hoelter's critical N = 378 at 0.01 level (> 200) indicative adequate sample size.

Figure 2 Final Path Model with Standardised Estimates

Table I Respondent Profile Summary

<b>Category</b>	<b>Frequency</b>	<b>Percentage</b>
<b>Age</b>		
More than 31 years old	124	72.9%
<b>Educational background</b>		
A bachelor degree or higher	141	82.9%
<b>Position</b>		
Executives	31	18.2%
Managers	68	40.0%
Senior engineers	71	41.8%
<b>industry experience</b>		
More than 4 years	127	74.7%
<b>Company operation year</b>		
More than 6 Years	65	78.3%
<b>Company categories</b>		
Product design and manufacturing function	60	72.3%
Product manufacturing function	13	15.7%
Product design function	10	12.0%
<b>Company scale</b>		
Multinational	61	73.5%
National and/or regional	22	26.5%
<b>No. of Employee</b>		
≤ 200	12	14.5%
201 ~ 500	46	55.4%
> 500	15	18.1%
Others	10	12.0%

Table II Varimax Rotated Factor Analysis for the Four Constructs

Construct	Ref.	Measurement Variables	Factor Loadings*
Code: Factor			
<b>Integrated Supplier Management (ISM)</b> ; Total Variance Explained = 77.5%; Cronbach's Alpha ( $\alpha$ ) = 0.706.			
ISM1: Supplier evaluation & selection	S1	Supplier assessment system	0.945
	S2	Appropriate supplier selection	0.721
	S3	Complementary supplier capabilities	0.961
ISM2: Supplier involvement	S4	Expedited decision making	0.869
	S5	Faster problem resolution	0.816
<b>New Product Development (NPD)</b> ; Total Variance Explained = 69.1%; Cronbach's Alpha ( $\alpha$ ) = 0.739.			
NP1: Employee involvement	N1	Appropriate staff inclusion	0.751
	N2	Awareness of project processes	0.859
	N3	Training on product design and quality	0.926
NP2: Design simplification & modular design	N4	Product development time	0.725
	N5	Component standardisation	0.751
	N6	Modular design	0.875
<b>Knowledge Sharing (KS)</b> ; Total Variance Explained = 69.6%; Cronbach's Alpha ( $\alpha$ ) = 0.766.			
KS1: IT infrastructure and systems	K1	IT systems for knowledge dissemination	0.818
	K2	User friendly IT support	0.783
	K3	Training and education	0.830
KS2: Open communication	K4	Enhanced employee abilities	0.899
	K5	Updated knowledge repository	0.792
	K6	Encouraged intra- and inter- communication	0.531
KS3: Organisational learning/sharing	K7	Learning platforms and resources	0.876
	K8	Established learning environment	0.744
<b>Business Performance (BP)</b> ; Total Variance Explained = 78.1%; Cronbach's Alpha ( $\alpha$ ) = 0.849.			
BP1: Business competitiveness	B1	Total quality cost	0.838
	B2	Profitability	0.885
	B3	Sales growth	0.942
	B4	Competitive ability	0.695
BP2: Manufacturing performance	B5	Reduced engineering change rate	0.669
	B6	Reduced production cycle time	0.825
	B7	Customer satisfaction	0.895
	B8	Overall firm's reputation	0.845
BP3: Process efficiency	B9	Increased internal production rate	0.895
	B10	Improved customer response time	0.876

Note: \*Each construct was analysed separately using varimax rotated factor analysis to extract significant factors.

Table III Correlation Analysis Results

	Pearson Correlation Coefficient		
	BPF1	BPF2	BPF3
ISMF1	<b>0.45**</b>	<b>0.68**</b>	0.06
ISMF2	0.47**	0.04	-0.35**
KSF1	<b>0.68**</b>	<b>0.25**</b>	0.03
KSF2	<b>0.44**</b>	<b>0.63**</b>	0.19*
KSF3	0.08	0.19*	0.34**
NPDF1	0.06	0.49**	0.21**
NPDF2	<b>0.32**</b>	<b>0.50**</b>	0.20**

Notes:

The active business activity factors and the sensitive BP factors have been bolded.

\*\* Correlation is significant at the 0.01 level (2-tailed)

\* Correlation is significant at the 0.05 level (2-tailed)

Table IV Regression Weights of the Initial and Final Path Model

Path link			Initial path model				Final path model			
			URW	SE	CR	<i>p</i>	URW	SE	CR	<i>p</i>
BPF1	←	KSF1	0.49	0.05	10.56	***	0.52	0.43	12.07	***
BPF2	←	NPDF2	0.26	0.04	6.68	***	0.26	0.04	6.59	***
BPF2	←	KSF2	0.11	0.02	6.90	***	0.11	0.02	6.94	***
BPF1	←	ISMF1	0.09	0.02	5.58	***	0.10	0.01	6.79	***
BPF2	←	ISMF1	0.14	0.01	9.91	***	0.14	0.01	9.89	***
<i>BPF1</i>	←	<i>NPDF2</i>	<i>0.08</i>	<i>0.04</i>	<i>1.75</i>	<i>0.08</i>	<i>n</i>	<i>n</i>	<i>n</i>	<i>n</i>
<i>BPF2</i>	←	<i>KSF1</i>	<i>-0.04</i>	<i>0.04</i>	<i>-0.96</i>	<i>0.34</i>	<i>n</i>	<i>n</i>	<i>n</i>	<i>n</i>
<i>BPF1</i>	←	<i>KSF2</i>	<i>0.02</i>	<i>0.02</i>	<i>1.02</i>	<i>0.31</i>	<i>n</i>	<i>n</i>	<i>n</i>	<i>n</i>

Note: URW: unstandardised regression weights; SE: standard errors; CR: critical ratio; *n*: deleted links; \*\*\*: < 0.0005.