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The moderating effect of knowledge sharing on the relationship between manufacturing activities and business performance

Abstract

This paper investigated the critical role of knowledge sharing (KS) in leveraging manufacturing activities, namely, integrated supply management (ISM) and new product development (NPD), to improve business performance (BP), within the context of Taiwanese electronic manufacturing companies. The research adopted a sequential mixed method research design, which provided both quantitative empirical evidence as well as qualitative insights, about the moderating effect of KS on the relationships between these two core manufacturing activities and BP. Firstly, a questionnaire survey was administered, which resulted in a sample of 170 managerial and technical professionals providing their opinions on KS, NPD and ISM activities and the BP level within their respective companies. Based on the collected data, factor analysis was used to verify the measurement model, followed by correlation analysis to explore factor interrelationships, and finally moderated regression analyses to extract the moderating effects of KS on the relationships of NPD and ISM with BP. Following the quantitative study, six semi-structured interviews were conducted to provide qualitative in-depth insights into the value added from KS practices to the targeted manufacturing activities and the extent of its leveraging power. Results from quantitative statistical analysis indicated that KS, NPD and ISM all have a significant positive impact on BP. Specifically, IT infrastructure and open communication were identified as the two types of KS practices that could facilitate enriched supplier evaluation and selection, empower active employee involvement in the design process, and provide support for product simplification and the modular design process, thereby improving manufacturing performance and strengthening company competitiveness. The interviews authenticated many of the empirical findings, suggesting that in the contemporary manufacturing context, KS has become an integral part of many ISM and NPD activities and when embedded properly can lead to an improvement in BP. The paper also highlights a number of useful implications for manufacturing companies seeking to leverage their BP through innovative and sustained KS practices.

Keywords: knowledge sharing, integrated supplier management, new product development, Taiwan.

1. Introduction

In recent years, the advent of rapidly advancing information technologies and fierce global competition has forced manufacturing companies to rethink traditional business models. The strategic focus is shifting away from mass production to customized products, hence placing a greater emphasis on organisational and process flexibility, whereby horizontal business processes are replacing vertical departmental functions (Lummus and Vokurka, 1999; Li *et al.*, 2009). Great supply chain integration, which involves intensive collaboration and information sharing between suppliers and manufacturing companies, has gradually become the norm in this industry (Modi and Mabert, 2007; Li *et al.*, 2009). Moreover, information systems are now widely used for supporting real-time decision making throughout the entire geographically diverse operations of the modern manufacturing company (Lin and Zhang, 2005; Swafford *et al.*, 2008). Additionally, the importance of employee empowerment has been recognised and supported by organisational learning programs (Cabrera and Cabrera, 2002). Undoubtedly, literature supports the view that the integration of supply chains and innovative product development practices not just only involve the more visible flow of tangible resources and assets, but also the integration and reproduction of intangible assets such as expertise and knowledge (Lambert and Cooper, 2000; Lu and Yang, 2004).

Given integrated supplier management (ISM) and new product development (NPD) are two of the most essential business activities in manufacturing companies and intangible assets have come to the forefront in the knowledge economy (Tan *et al.*, 1999; Liu *et al.*, 2005), an important issue that has been raised within this context is how the knowledge sharing (KS) process can leverage ISM and NPD activities to gain sustained competitive advantage which is reflected by the business performance (BP). Past research studies have provided a great deal of knowledge about the essential roles of KS, NPD and ISM in improving the BP of manufacturing companies (Hsu, 2006; Antonio *et al.*, 2007; Modi and Mabert, 2007). More recently, research focus has shifted toward empirical studies that investigate the actual implementation of KS in manufacturing companies (Hsu, 2006; Lubit, 2001). A related issue that arises in this context is how KS can be applied to improve the NPD and ISM activities in terms of achieving desired BP more effectively and efficiently. However, empirical evidence on KS's moderating effect on the relationships between NPD and ISM with BP was not evident in the literature. Indeed it is timely for research on KS to provide more detailed answers about the link between KS and performance benefits (Foss *et al.*, 2010).

Asia has become the manufacturing centre of the modern world and Taiwanese electronic manufacturing companies have gained a dominant market share in the international IT hardware market within a relatively short period of 15 years (MIC/ITIS, 2007). It has long been understood how innovative ISM and NPD practices have helped position the Taiwanese electronic manufacturing sector to be a prominent global player (Wu, 2008), nevertheless there is still limited understanding as to how effective KS practices have directly or indirectly contributed to their success. An in-depth understanding on actual practices which demonstrate the interactions between KS, NPD and ISM within the context of the manufacturing industry in Taiwan is particularly lacking. The study reported by this paper attempted to shed some light on this issue, and aims to provide answers for the two overarching research objectives: (1) confirm the previously identified empirical relationships between KS practices, the targeted core manufacturing activities (i.e., NPD and ISM) and business outcomes (i.e., BP) in the Taiwanese context; and more definitively in this study (2) investigate whether and to what extent KS leverages heightened performance in NPD and ISM activities to achieve greater BP. The primary objective of this study was to provide evidence which supports the assertion that KS provides cognitive mechanisms for leveraging heightened outcomes from ISM and NPD processes, ultimately generating higher levels of BP. More importantly, the study also seeks to reveal some of the actual higher order KS practices implemented, which have been pivotal to its leveraging power to these processes, within Taiwanese electronic manufacturing companies. Such deeper insights could serve as invaluable references for their counterparts in the other economies, which are also striving to upgrade the technical and managerial competence of their manufacturing practices.

The remainder of the paper is structured as follows. Drawing on the perspectives of the Knowledge-Based View (KBV) of the firm (Grant, 1996a; Spender, 1996), dynamic capabilities view (Helfat *et al.*, 2007), theoretical perspectives of cognitive learning (Barab and Plucker, 2002; Brown *et al.*, 1989; Collins *et al.*, 1991; Gibson, 1986) and knowledge creation theory (Nonaka and Takeuchi, 1995; Nonaka *et al.*, 2006), the following section addresses the strategic importance of knowledge and KS, and theoretically posits KS functions as cognitive mechanisms in leveraging other business activities to add higher value. Then, the section illustrates KS implementations within the context of the dynamic manufacturing industry, and proposes hypotheses that posit the relationships between KS, NPD, ISM and BP, to facilitate the investigation of the theoretical proposition. The hypotheses are subsequently summarised into a theoretical framework. Section 3 conceptualises and operationally defines the constructs of the theoretical framework, illustrates the mixed method research design adopted for this study, and develops measurement scales for the constructs. Section 4 presents and discusses both the quantitative and qualitative data analysis. The paper concludes with a discussion on the theoretical contributions and managerial implications of the study in Section 5. Finally, Section 6 identifies study limitations and presents opportunities for future research.

2. Theory and Hypotheses

2.1 Strategic importance of knowledge and knowledge sharing

The KBV of the firm has become a very influential concept in a host of fields, such as organisation, strategic innovation and technological management (Foss, 2009; Grant, 1996b; Spender, 1996). The KBV assumes that knowledge accounts for the greater part of value added, moreover, the barriers to the transfer and replication of knowledge endow it with strategic importance (Spender, 1996). Therefore, at the heart of this theory is the idea that knowledge is the principal productive resource of the firm, and the fundamental role of the firm is the integration of individuals' specialist knowledge, furthermore, organisational capabilities are the manifestation of this knowledge integration (Grant, 1996a). From this perspective, the KBV asserts that under dynamic competition, superior profitability is likely to be associated with resource and capability-based advantages that are derived from superior access to and integration of specialised knowledge (Grant, 1996a).

By considering knowledge exploration, retention, and exploitation inside and outside organisational boundaries, Lichtenthaler and Lichtenthaler (2009) adopt an integrative perspective on dynamically managing a firm's knowledge base for the purpose of achieving sustained competitive advantages. They identify six 'knowledge capacities', which describe a firm's capabilities for managing different knowledge processes (e.g., acquiring, sharing, applying and creating knowledge), and further define Knowledge Management Capacity (KMC) as a dynamic capability, which reconfigures and realigns these knowledge capacities (Lichtenthaler and Lichtenthaler, 2009). In other words, drawing from the assertion of the dynamic capabilities view (Helfat *et al.*, 2007: 30-31), they perceive knowledge processes as mechanisms by which the firm puts its KMC into use, which simultaneously provides opportunities to further develop the current KMC level (Lichtenthaler and Lichtenthaler, 2009). According to Lichtenthaler and Lichtenthaler (2009), KS process is closely related to the company's capacity for exploring, retaining, and exploiting knowledge within and outside their boundaries. In this sense, KS is of special strategic importance. Indeed, KS has been seen as the central theme of Knowledge Management (KM) practice, and received extensive attention in research studies, since it presents a pressing and challenging theoretical research issue for the understanding and advancement of KM (Heisig, 2009; Chen and Mohamed, 2010).

KS through human interactions and communications has been addressed as an essential antecedent to the knowing and learning process by learning theorists. It has been asserted that cognition are not possessions of individual minds but are dynamic and contextualised acts or sets of relations distributed across individuals, social and physical resources (e.g., collaborators, experiences, computer representations) as well as the contexts through which they function (Brown *et al.*, 1989; Gibson, 1986). This implies that in the learning process, people's ultimate understanding of any object, issue, concept, process, or practice, as well as their ability to act competently with respect to using these, can be attributed to, and is distributed across, the physical, temporal, and spatial occurrences through which their competencies have emerged (Barab and Plucker, 2002). In a complex process involving joint problem solving among a team of individuals (e.g., a group of designers and suppliers), individual minds can not be considered the only locus for structures that organise thinking; instead, knowledge is distributed across multiple individuals and resources (Hutchins, 1993). In this sense, cognition is embodied, situated, and distributed (Barab and Plucker, 2002), and knowing and learning is gained through social interactions, communications and collaboration with peers and experts in a specific context (Collins *et al.*, 1991). In this line of thinking, individual ability arises in the dynamic transaction among individuals, physical environment, and socio-cultural context; and talent, or evidence of being knowledgably skilful, is considered present when individuals, frequently using multiple resources and always interacting as part of a socio-cultural world, demonstrate their propensity for forming particular relations (Barab and Plucker, 2002). The strategic implications of the assertions of cognitive learning are twofold. Firstly, KS provides cognitive and dynamic mechanisms to facilitate any creative activities involving learning and knowledge creation. As demonstrated by the 'SECI' model (Nonaka and Takeuchi, 1995) KS is an essential knowledge process for organisational knowledge creation. Secondly, KS fosters higher individual problem-solving ability, from which superior organisational level knowledge-based capabilities and better performance outcomes will emerge (Foss, 2009; Foss *et al.*, 2010). Therefore, within the context of profit-making companies, there is a need to understand the essential role of KS in production processes so as to amplify the benefits achievable from KS.

The KBV perceives a firm as a dynamic, evolving, quasi-autonomous system of knowledge production and application (Spender, 1996), and a wide array of knowledge is a critical input of any value-adding production process (Grant, 1996a). Hence knowledge processes are deeply embedded into production processes and production related directives, procedures and routines (Grant, 1996a). From the cognitive learning perspective, KS provides various cognitive mechanisms that help to integrate specialised knowledge of individuals into value-adding production processes, and functions as a dynamic action-based platform to facilitate other essential production related activities, such as NPD, to add more value. Given this, this study theoretically proposes that firstly KS activities are performed as an integral part of business activities; and secondly rather than functioning as attributes of these activities, the essential role of KS activities lies in their capacity of providing cognitive mechanisms for leveraging managerial and operational activities to generate higher value. In other words, the greater the extent KS activities are carried out and encouraged, the better the performance can be achieved by other business activities. Hence the theoretical proposition highlights the moderating role of KS in the relationships between business activities and BP.

Until recently, the published empirical studies primarily focused on investigating the direct influence of KS on macro level constructs, such as BP (Law and Ngai, 2008), task performance (Haas and Hansen, 2007; Hsu and Wang, 2008) and technological capabilities (Zahra *et al.*, 2007). Even though the empirical evidence derived from these studies support positive association of KS with business outcome constructs, deeper insights into how KS helps to improve the effectiveness of the production process has not been clearly revealed. This study aims to shed light on this issue by investigating the theoretical proposition within the context of the Taiwanese electronic manufacturing industry.

2.2. Knowledge sharing within the context of manufacturing industry

Under the pressure of globalisation and dynamic market competition, manufacturing industry has been experiencing some fundamental changes in doing business (Tan *et al.*, 1999; Ndubish *et al.*, 2005). The primary changes include fast new product development, greater sharing of information between suppliers and customers (i.e., manufacturing companies), shift from mass production to customised products and greater emphasis on organisational and process flexibility, increased reliance on purchased materials and outside processing with a simultaneous reduction in the number of suppliers, necessity to coordinate processes across many sites, greater focus on employee empowerment and involvement (Tan *et al.*, 1999; Ndubish *et al.*, 2005). In order to manage the challenges brought by these changes manufacturing companies adopt strategies such as effectively managing outsourcing activities and relationships with their suppliers and customers (Tan *et al.*, 1999), streamlining operations as well as minimising the time-to-customer for products (Ndubish *et al.*, 2005). In particular, efficient and effective product and service development through continual innovation has become essential for the companies to achieve sustainable business success in the increasingly complex and competitive business environment (Lubit, 2001).

Within the context of manufacturing companies, KS occurs through a variety of mechanisms, e.g., training, communication, observation, technology transfer, replicating routines, presentations, interactions with suppliers and customers, and involving various forms of intra- and inter-organisational relationships (Chua and Pan, 2006). It has long been suggested that KS could improve the performance of both manufacturing companies and their suppliers (Modi and Mabert, 2007; Fugate *et al.*, 2009). Furthermore, effective KS enhances design performance through the development of new insights and capabilities (Chen and Huang, 2009). As a result, KS is considered essential for manufacturing companies that seek to achieve desired performance through innovation (Cabrera and Cabrera, 2002). It appears that KS provides cognitive mechanisms, which are required to understand the background of problems and challenges arising in business processes, and functions as a dynamic action-based platform for manufacturing activities such as supplier management and product design to produce innovative solutions. Hence an essential issue that arises within this context is how KS can be applied to improve the NPD and ISM activities in order to achieve higher value-adding. As NPD and

ISM activities absorb a substantial proportion of the resources (e.g., budget and manpower) of manufacturing companies (Tan *et al.*, 1999; Lubit, 2001), the intricate relationships between KS and these two primary manufacturing activities was taken as the foci of this study in order to reveal insights of how KS improves the effectiveness of NPD and ISM. The positive influence of KS on an organisational outcome of manufacturing companies has been established (Law and Ngai, 2008). In fact, the significant link is perceived as a prerequisite for KS to leverage other business activities in achieving better BP. This discussion provided the persuasion for the first proposed hypotheses for this study, namely:

H1-1: Knowledge sharing is positively associated with business performance.

2.3. Knowledge sharing and new product development

Dramatically decreased product-life-cycles has shifted manufacturing companies' strategic emphasis to a faster and efficient NPD process, which is expected to result in shorter and more cost effective design cycles as well as quicker time to customer/market (Ndubisi *et al.*, 2005; Tan and Vonderembse, 2006). Four crucial NPD practices often highlighted are: (1) design simplification (i.e., component reduction and standardised); (2) modular product design (i.e., modules can be reused and interchanged to maximize product variety); (3) design for quality and manufacturability; and (4) employee involvement. Since effective NPD is especially sensitive to gaps in knowledge, sharing prior design knowledge is one of the critical approaches to assist in improving the competitive cycle (Antonio *et al.*, 2007). The main aim is to enable the creation of robust design practices in less time with lower production costs (Baxter *et al.*, 2007). It has been reported that sharing design knowledge helps to improve the crucial NPD practices and typically results in lower rates of rework and fewer defective products, which consequently reduces cost, increases production efficiency, and often shortens the overall product development time (Antonio *et al.*, 2007; Peterson *et al.*, 2005). It appears that the NPD processes are knowledge intensive and require strong support from cognitive mechanisms of KS.

The NPD process generally has five stages, namely, concept development, system design, detail design, testing and refinement, and manufacturing production evaluation. The first two stages (i.e., concept development and system design) are often referred to as 'front-end stages' by the industry, and require intensive KS activities to occur among the product development teams (Hong *et al.*, 2005; Chen *et al.*, 2005). Appropriate design knowledge integration during the 'front-end stages' can ensure the quality of concept development and avoid major design flaws. Many product development projects have failed due to a lack of clear understanding on the 'front-end stages'; by the time design flaws were discovered in a later stage, a significant proportion of costs have already been incurred (Chen *et al.*, 2005). Moreover, KS should also be promoted continually throughout all remaining stages of the product development process, including the later more defined stages, such as testing and refinement and the manufacturing production evaluation process (Chen *et al.*, 2005; Hong *et al.*, 2004). In addition, knowledge-based product design methods are normally supported by a common design database, which serves two primary purposes: firstly capturing and formalizing the rationale that underpins the design process; and secondly, providing a framework where design knowledge can be stored, retrieved and shared (Baxter *et al.*, 2007). Sharing design knowledge is critical for increasing product development capacity and reducing both the duration and costs associated with a particular development cycle. Hence providing methods or mechanisms for reusing and retrieving design knowledge is one of the most important tasks for information managers (Antonio *et al.*, 2007). In summary, KS action-based cognitive mechanisms need to be established as early as possible during the NPD process in order to integrate both tacit and explicit knowledge of the stakeholders (e.g., customers, designers, suppliers) into innovative designs, which are critical attributes to BP and competitiveness of manufacturing companies. This means the greater the extent to which KS activities are implemented, the more conducive the cognitive mechanisms would become, which would leverage the NPD activities to achieve better BP. This argument gives rise to the second group of hypotheses:

- H2-1: New product development is positively associated with business performance; and
- H2-2: Knowledge sharing moderates the relationship between new product development and business performance.

2.4. Knowledge sharing and integrated supplier management

A supply chain (SC) consists of all stages and activities involved, directly or indirectly, in fulfilling a customer and market request (Chopra and Meindl, 2001). Manufacturing companies have long been focused on supplier evaluation and involvement strategies to improve the management of their SCs. Through robust selection and evaluation processes, manufacturing companies are able to ensure that their suppliers fulfil their requirements on cost, quality and efficiency, whilst simultaneously building collaborative mechanisms to share resource and knowledge (Hsu, 2006). Involving suppliers in the early stage of the product design process can help manufacturing companies to create cost-effective design options, develop alternative conceptual solutions, select the most suitable and affordable materials, components and technologies, thereby reducing lead-time, improving products' performance, and launching new products faster into market (Ndubisi *et al.*, 2005). It has been reported that qualified supplier involvement in the product development and production process has a strong positive impact on the business performance of manufacturing companies (Vonderembse and Tracey, 1999; Das *et al.*, 2006).

Manufacturing companies and their suppliers are increasingly intertwined in the manufacturing process and KS serves as an action-based cognitive mechanism to facilitate supplier integration (Das *et al.*, 2006). KS activities such as providing training and on-site problem solving assistance for suppliers could help their employees to improve skills and productivity, which could result in better manufacturing performance (Hult *et al.*, 2006). Moreover, manufacturing companies increasingly capture their best ISM practices into knowledge repositories for the purpose of continual SC improvement (Chin *et al.*, 2006). It has been reported that KS have become key determinants of SC competitiveness (Cheng *et al.*, 2008; Spekman *et al.*, 2002). This argument has been endorsed by an empirical study, based on a survey of 105 research and development partnerships within the global telecommunication industry (Feller *et al.*, 2006), which concluded that the application of KS mechanisms among SC partners could lead to better learning diffusion and operational performance. This implies that the greater the extent to which KS activities are implemented, the more conducive the cognitive mechanisms would become, which would leverage the ISM activities to improve BP (Hult *et al.*, 2006; Tan *et al.*, 1999; Ryu *et al.*, 2009). The evidence presented in the literature lead to the third group of hypotheses:

- H3-1: Integrated supplier management is positively associated with business performance; and
- H3-2: Knowledge sharing moderates the relationship between integrated supplier management and business performance.

2.5. Manufacturing industry in Taiwan

Due to the advantages of low labour cost, integrative supply networks, and fast adaptive capability, the Taiwanese electronic manufacturing industry has emerged to be one of the most innovative and competitive over the last three decades (Lu and Yang, 2004; Wu, 2008). Over the decades, small- and medium-sized companies have developed core competency in their fields and established integrated supply networks during the boom of the electronic and IT hardware manufacturing industry. These integrated supply networks enabled those aggressive manufacturing companies to compete in the global environment, by offering quality and low cost products to the market in a timely manner (Wu, 2008). This evidence demonstrates that Taiwan's electronic and IT manufacturing industry has been a strong performer, providing exemplars for other newly industrialised countries, which are eager to be globally competitive in the manufacture of technology products (Lu and Yang, 2004).

In the trend of globalisation and facing increasingly uncertain environments, Taiwan's manufacturing companies have been investing in product/service innovations for the purpose of sustaining their competitive advantage (Hsu and Wang, 2008). The electronic and IT hardware manufacturing industry in particular requires intensive knowledge sharing, since it is essential for manufacturers to incorporate knowledge into new product design, production processes and customer service to meet the demands of the fast-changing market. Therefore, successful integrative upstream and downstream partnerships, shortened product development cycles, and active knowledge sharing have been recognised as the three most important ingredients of the electronic manufacturing industry in Taiwan (Yeh *et al.*, 2006;

Wu, 2008; Lin and Chen, 2007). The paradigm shift to the knowledge economy should mean that companies are seeking to implement and monitor their KS policies, strategies and practices. However, there is still limited research addressing the effectiveness of such KS initiatives across a range of industry sectors in Taiwan (Hsu and Wang, 2008). Moreover, empirical evidence on KS's moderating effect on the relationships between NPD and ISM with BP was not evident in the literature. In view of this research need, this study attempted to investigate the research questions and test the proposed hypotheses within the specific context of Taiwanese electronic manufacturing companies. We expect that the findings derived from the investigation would help to shed light on the moderating role of KS in the manufacturing production process and to externalise the lessons learnt by some the strong performers.

2.6. Theoretical framework

The preceding discussion presents intricate relationships among KS, NPD, ISM and business outcomes (i.e., financial and non-financial performance, business competitiveness, and process efficiency). The review of the literature was also transposed to the context of the Taiwanese electronic manufacturing industry. In line with the theoretical proposition, the discussion suggests that higher levels of KS could strengthen core manufacturing business activities (i.e., NPD and ISM), to achieve better business outcomes. In other words, companies can use a variety of advanced KS practices to create new or strengthen existing manufacturing processes which should eventually enhance their BP. In summary, this study translates the theoretical proposition into a theoretical framework (graphically illustrated in Figure 1) that is: (1) specific to the context of the manufacturing companies; (2) composed by four constructs (i.e., KS, NPD, ISM and BP); and (3) the hypothesised relationships between them represented by the five hypotheses (i.e., H1-1, H2-1, H2-2, H3-1 and H3-2). In essence, this framework theoretically proposes that functioning as cognitive mechanisms KS has a moderating effect on the relationship between core manufacturing activities (i.e., NPD and ISM) and BP. The four constructs (i.e., KS, NPD, ISM and BP) of the theoretical framework were operationalised based on previous empirical research studies (Tan *et al.*, 1999; Petersen *et al.*, 2005; Hsu, 2006 and etc).

[INSERT Figure 1]

3. Research Methods

3.1. Conceptualisation and operationalisation of the constructs

3.1.1. Knowledge sharing

Within manufacturing context creative KS approaches should result in enhanced employee capabilities, improved efficiency, higher productivity, and increased revenues in practically any business function (Law and Ngai, 2007). Therefore, KS is essential for manufacturing companies to achieve desired business performance (Cabrera and Cabrera, 2002). Recent empirical studies (Lubit, 2001; Alavi and Leidner, 2001; Tseng, 2008; Stewart, 2008; Yeh *et al.*, 2006; Modi and Mabert, 2007) provide basic measurable items for operationally defining several crucial dimensions. These items represent organisational practices (including both processes and mechanisms) that help to achieve effective sharing of knowledge, such as top management support, information technology support, collaborative communication, organisational learning and sharing, and incentives or rewards. *Top management support* refers to managers' general perception on the value of KS as well as their inclination to direct financial and human resources to its implementation within the company. *Information technology (IT) support* is concerned with the maturity and support level of IT infrastructure and applications. *Collaborative communication* represents as an important medium to share data, information and knowledge and deal with difficulties that impede communication. *Organisational learning and sharing* refers to those continuously occurring activities which facilitate KS. *Incentives or rewards* refer to the monetary and non-monetary commission structures which support KS activities. Table 1 summarises the operational details of the KS construct in terms of the developed dimensions along with their measurement variables and associated references.

3.1.2. New product development

Effective product design and development processes have long been recognised as successful strategies to gain market leadership within the competitive electronic manufacturing industries (Ahire and Dreyfus, 2000; Tan and Vonderembse, 2006). Table 1 provides a summary on the NPD constructs' various dimensions and associated measurement variables. This includes *design for quality and manufacturing* which refers to the product design practice and effort that influences product quality and manufacturability. *Design simplification* represents the component standardisation and simplification practices utilised during the product design stage. *Employee involvement* is concerned with the degree of employee participation and training within the company. Finally, *modular design* refers to the extent of modular product design practice utilised across the portfolio of products.

3.1.3. Integrated supplier management

ISM 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, carriers, third party companies, and information systems providers (Ndubisi *et al.*, 2005). Any inefficiencies incurred across the supply chain (suppliers, manufacturing plants, warehouses, customers, etc.) must be assessed to determine the true capabilities of the process

(Ndubisi *et al.*, 2005; Lambert and Cooper, 2000). In general, ISM seeks to improve manufacturing performance through the elimination of waste and improved leveraging of internal teamwork and external supplier capabilities and technologies.

Several dimensions were identified as being the most representative of the ISM construct examined in this study, including supplier evaluation and selection, supplier involvement, and supplier management. *Supplier evaluation and selection* refers to the company's effectiveness in sourcing, evaluating and selecting potential suppliers. *Supplier involvement* encapsulates the degree of effort displayed and level of sharing of resources from suppliers in terms of market information, technology, design practices and operations. *Supplier management strategies* considers those strategies used to improve the suppliers' performance, such as periodic internal/external review, training, etc. The operationalisation of the ISM construct in terms of its dimensions along with associated measurement variables and references are presented in Table 1.

3.1.4. Business performance

Business performance was broadly defined to include some of the more prominent of the financial and non-financial indicators of company competitiveness. In order to operationalise the *Business Performance* construct, several measures frequently employed in past empirical studies to investigate the link between business activities and organisational performance were examined and evaluated (Kale and Arditi, 2003; Antonio *et al*., 2007; Hsu, 2006; Maiga and Jacobs, 2007; Panuwatwanich *et al.*, 2008). This resulted in three conceptual dimensions that can be used to represent the *Business Performance* construct, which included business competitiveness, manufacturing performance and process efficiency. *Business competitiveness* refers to the level of profitability, sales growth and total quality cost, as well as the ability of the company to gain or retain new business. *Manufacturing performance* is concerned with engineering change rates, production cycle times, operational cost, and internal and/or external customer satisfaction. *Process efficiency* examines whether the company has effective and efficient operational processes. Table 1 details a summary on the BP construct in terms of the developed dimensions along with their measurement variables and associated references.

[INSERT Table 1]

3.2. Analytical approaches

The research design predominantly followed a deductive approach, which began with the formation of logical relationships between constructs and then moved toward solid empirical evidence (Neuman, 2003). Hypotheses testing utilising moderated regression models as the relationship verifier, helped to enhance current understanding on the nature and extent of the influence of KS in leveraging heightened performance from NPD and ISM practices, resulting in higher levels of BP. To strengthen the statistical findings, a qualitative study was initiated which included a series of semi-structured interviews to provide greater insight into the specific nature (i.e., actual case practices) of KS moderating interaction effects on NPD and ISM and how this may have resulted in improved BP.

3.2.1. Quantitative study

The study was undertaken within the context of the Taiwanese electronic manufacturing companies, which is acknowledged to be a knowledge-intensive industrial sector. A mailed questionnaire was chosen as the data collection method. The questionnaire was developed based on the operational definitions of the constructs and designed with two major sections. Section 1 elicited respondents' opinions on the extent to which KS practices as well as NPD and ISM activities were being executed by the companies, and the perceived BP level at the time of the survey. Five-point Likert scales were used to measure the operationally-defined variables within each construct of the proposed theoretical framework. Section 2 gathered demographic information about the respondents and their companies. The questionnaire was pre-tested with forty (40) managerial and professional staff members to evaluate the questionnaire for clarity, bias, ambiguous questions, and relevance to the designated industries and operations of Taiwanese manufacturing companies. Thirty (30) respondents offered valid feedback and advice that was considered sufficient for serving the pilot study purpose (Burns and Bush, 1998). The data collection process began after the questionnaire had been finalised, based on the pre-test feedback.

A combination of medium- and large-sized electronic manufacturing companies represented the theoretical population because they provided a better organisational structure for implementing contemporary business activities than small companies (Liu *et al.*, 2005). A total of 241 electronic manufacturing companies listed in the Taiwan Stock Exchange Centre (TSEC) market were taken as the sampling frame. In total, 550 survey packages of self-administered surveys were mailed or delivered in person to relevant managerial or professional staff member(s) within these companies. A second round reminder survey was sent after the return due date to those firms not completing. At the completion of the survey process, a total of 170 useable questionnaires (i.e., containing no missing data) were received from 83 companies. No more than three 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 (Table 2). Data screening techniques were applied to all variables to ensure that the data complies with the assumptions of normality and linearity (Coakes, 2005; Pallant, 2001).

[INSERT Table 2]

3.2.2. 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 one medium and two large-sized Taiwanese manufacturing companies. Company A is a large manufacturing operation focused on communication, computing, consumer electronics and car electronics products, with net revenues exceeding US $40 million and over 4,500 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 peripherals and consumer products. All of these companies conduct their manufacturing activities in Taiwan and mainland China with design activities conducted in geographically diverse overseas offices. The interviewees included one managing director, four senior managers, and one assistant manager. All of them had over 10 years of work experience in the manufacturing industry and were highly knowledgeable about 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' manufacturing processes and performance.

3.3. Measurement scale development

Exploratory factor analysis (EFA) was utilised to assess and determine, whether and to what extent, the measurement variables represented their underlying factors within each construct. The 170 usable 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 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). Given that a small number of respondents completed the survey within each company, the common method variance (CMV) technique was applied in order to investigate spurious covariance shared among variables. Specifically, EFA was employed to assess CMV using Harman's single-factor test. The presence of a substantial amount of CMV is indicated by either a single factor emerging from factor analysis, or one general factor accounts for the majority of covariance in the dependent or criterion variables (Malhotra *et al.*, 2006; Podsakoff and Organ, 1986). In order to carry out the test, EFA was conducted on all 55 variables and results assessed against these criteria. The results showed that there were 13 components (factors) extracted with the first factor accounting for only 22.4 per cent of variance, indicating that unauthentic covariance was not at a concerning level in this study.

Following CMV analysis, EFA was again applied to identify the potential 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 Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy ranged from 0.61 to 0.71, being well above the acceptable level of 0.50 (Hair *et al*., 1998). With the sample of 170 cases, 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). The cumulative percentages of total variance explained 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 concepts and their factors (Hair *et al.*, 1998). Since the constructs were conceptually defined based on a combination of the literature review, previous empirical studies, and the pilot study, these scales were considered to have face validity (Neuman, 2003), and they sufficiently measure the level of KS, NPD, ISM and BP within the research context. These scales' validity was confirmed by the regression analyses, which is outlined in the following section (Hair *et al.*, 1998).

As presented in Table 3, the analysis identified three 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. These three factors represent KS practices that are commonly implemented to improve business performance within manufacturing. Secondly, the analysis found two factors for the NPD construct. NPDF1 reflects employees' contributions in the product development process. NPDF2 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 practices. Thirdly, the factor analysis identified two 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 measure the joint efforts that manufacturers and suppliers invest into their ISM activities. Finally, the analysis identified three 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 3]

In summary, the EFA process resulted in measurement scales for the four constructs shown in Table 4, 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.

4. Data analysis, results and discussion

4.1. Quantitative data analysis

To provide statistical support for the research hypotheses, gathered data were analysed using a number of statistical techniques such as data examination, correlation and regression analyses processed through SPSS version 15.0. The following sections detail each of these analysis stages.

4.1.1. Hypotheses H1-1, H2-1 and H3-1

Correlation and regression analyses were employed to analyse the relationships between the constructs and their extracted factors. Correlation analysis showed that the KS, NPD and ISM constructs were all positively associated with the BP construct, with Pearson correlation *r* (coefficient of correlation) values of 0.617, 0.575 and 0.564, respectively (significant at the 0.01 level) (see Table 4). Table 5 presents the correlation analysis results for the factors related to the KS, NPD and ISM constructs, which were also positively associated with the BP factors. The results of the correlation analysis provided the basis for undertaking the regression analysis detailed below.

[INSERT Table 4]

[INSERT Table 5]

During the regression analysis, in order to remove any possible confounding effects, two Control Variables (CV), namely firm size and nature of business, were examined to determine whether they significantly influence the relationship between the KS, ISM and NPD within a firm and BP. These two CV were selected since they are potential influencing factors within the electronic manufacturing industry context that may significantly affect the hierarchical moderated regression analysis. This analysis process involved entering the CV and each construct into multivariate regression equations simultaneously. Firstly, the testing of H1-1, concerning the relationship between KS and BP was completed, following this process. The two CV were entered into the first model as shown in Table 6. The CV explained 0.6% of the variance in BP. The direct effect of KS was then entered into model 2 as shown in Table 6. As the results indicated, the finding is significant at the $p < 0.01$ level, and the construct explained 38.1% of variance in BP ($R^2 = 0.381$, Adjusted $R^2 = 0.370$, F change = 34.093, d/f = 3/169). In support of H1-1, KS was positively related to BP ($\beta = 0.613$, $p < 0.01$). The examination of the CV revealed that the nature of business was not significantly ($\beta = -0.100$, $p > 0.10$) related to BP, nor firm size ($\beta = 0.013$, $p > 0.10$). The result indicates that KS had a significant influence on BP with or without the presence of the two CV. Similarly, testing H2-1 (relationship between NPD and

BP) was conducted and the result presented in model 3. NPD explained 33.0% of the variance in BP (R^2 = 0.330, Adjusted R^2 = 0.318, F change = 27.309, d/f = 3/169) and the finding was significant at the $p < 0.01$ level. The predictor variable NPD was significantly and positively related to BP (β = 0.571, $p < 0.01$). Thus, H2-1 is supported. An examination of CV revealed that the nature of business (β = -0.030, $p > 0.10$) and firm size (β = 0.005, $p > 0.10$) were not significantly related to BP. Finally, testing H3-1 (relationship between ISM and BP) was conducted and the result shown in model 4. ISM explained 31.8% of the variance in BP with the relationship registering significance at the $p < 0.01$ level (R^2 = 0.318, Adjusted R^2 = 0.306, F change = 25.828, d/f = 3/169). This result supported H3-1, with ISM being positively related to BP (β = 0.561, $p < 0.01$). Again the examination of the CV revealed that nature of business (β = -0.069, $p > 0.10$) and firm size (β = 0.037, $p > 0.10$) were not significantly related to BP.

[INSERT Table 6]

The analysed hierarchical regression models revealed that KS, NPD and ISM significantly explained the variance of BP by 38.1%, 33.0% and 31.8%, respectively (Tables 5 and 6). The results therefore supported hypotheses H1-1, H2-1 and H3-1, that KS, NPD and ISM could be used to predict the variance of BP. It should be noted that the hierarchical moderated regression findings indicated that KS was the strongest predictor of BP, from the three business activity constructs measured in this study. The strong direct relationship of KS with BP provided confidence that this construct would serve to moderate the relationship between NPD and ISM with BP. This primary research aim of this paper is explored in detail in the following sub-section.

4.1.2. Hypotheses H2-2 and H3-2

According to Arnold (1982), moderated regression analysis provides the most straightforward method for testing hypotheses in which an interaction is implied. Interaction effects are found to be significant if they explain a significant greater portion of the variance in the dependent variable than that portion already explained by the other independent variables. Moderated regression analyses with interaction terms (e.g., NPD·KS) were performed at both the construct and the factor levels to investigate the respective effect of ISM and NPD on BP, at different levels of KS (i.e., low, medium, high). Both the overall model validity (*F* test) and the population correlation coefficient (*t*-test) of the derived regression models were significant at the $p < 0.01$ level (Bowerman *et al.*, 1986). In order to minimise multicollinearity, the independent variables (IVs) were centred and the interaction terms were formed by multiplying together the two centred terms (Aiken *et al.*, 1991). The 170 cases in the data file satisfied the minimum sample size of 50 for supporting the case-to-IV ratio of 50 to 1 required by moderated regression analysis with two IVs (Tabachnick and Fidell, 2001). Multicollinearity was absent from selected models where tolerance values were much higher than 0.1.

The results for the statistical models revealing the moderating effect of KS on the relationship between NPD, ISM and BP (i.e. H2-2 and H3-2) are presented in Table 7. As shown in the table, the final model (i.e. Model 3) that includes the CV, the independent variables, the moderating variable and the interaction effects is significant at the $p < 0.01$ level ($R^2 = 0.665$, Adjusted $R^2 = 0.650$, F change = 11.332, $d/f = 2/162$). This final model which included the moderating variable and analysed interaction effects has a higher R^2 value (i.e. 0.047 increase) than the second model (i.e. Model 2, $R^2 = 0.618$, *Adjusted* $R^2 = 0.606$, F change = 87.418, $d/f = 3/164$) which excluded them, therefore demonstrating the degree of importance of moderating effects KS·NPD and KS·ISM to explain the relationship. The hypothesised interaction model explains 66.5% of the variance in BP. Therefore, the results provided support to hypotheses H2-2 and H3-2. Specifically, the findings revealed the moderating effect of KS on the relationship between NPD and ISM with BP are significant and positive ($\beta = 0.190$, $p < 0.01$ and $\beta = 0.172$, $p < 0.05$, respectively). In general, the change in the R^2 value due to the inclusion of interaction effects is generally small, where a 0.02 change is considered to be an acceptable threshold (Frazier *et al.*, 2004). The 0.047 change in the R^2 value resulting in this study demonstrates a reasonable interaction effect. In addition, the examination of the CV revealed that the nature of business and firm size were not significantly related to BP in both Models 2 and 3 as presented in Table 7.

[INSERT Table 7]

As the analysis has demonstrated that the two CV had no significant influence upon the hypothesised relationships, hierarchical regression models excluding the two CV were analysed to reveal the interaction terms' contribution in explaining the variance of BP. As presented in Table 8, in comparison with the hierarchical regression model (with NPD as the IV), the moderated regression model with interaction term NPD·KS had a larger predicting power over the variance of BP. This result was indicated by the significant increase in the adjusted R^2 value when interaction terms were included (0.318 increased to 0.398). Table 8 also presents a significant regression model ($p < 0.05$) which represents the interaction term of ISM·KS. However, compared with the hierarchical regression model with ISM as the IV, this moderated regression model only increases the adjusted R^2 value from 0.306 to 0.317.

[INSERT Table 8]

According to Aiken *et al.* (1991), the values of KS were chosen to be one standard deviation below the mean (KS low = - 0.3016), at the mean (KS medium = 0.00), and one standard deviation above the mean (KS high = 0.3016). Hierarchical regression lines were then generated by substituting these values (-0.3016, 0.00, 0.3016) into the moderated regression models with the interaction terms (i.e., NPD·KS, ISM·KS). As a result of this computation, three hierarchical moderated regression equations were produced (Figures 2), where the influence of KS on the relationships between the NPD and BP constructs is revealed. The statistical significance of the slopes of these regression equations were also analysed and established (Aiken *et al.*, 1991). The hierarchical regression equations detailed in Figure 2 indicate a significant ($p < 0.05$) positive regression of BP on NPD at all three levels of KS. The equation lends support for the concept that the higher the KS level, the steeper the slope. This suggests that KS has a positive moderating effect on NPD's contribution to BP. This finding authenticates the hypothesis H2-2, that the higher the KS, the stronger the association of NPD with BP. In view of this, it was considered beneficial to further explore the moderating effect of each individual KS factor on the relationships between the various factors contained within the NPD and BP constructs. Through similar analysis the moderated regression equations were derived and illustrated in Figure 3, which show a significant ($p < 0.05$) positive regression of BP on ISM for all three levels of KS. This analysis suggested that the KS construct has a positive, whilst not strong, impact on ISM's contribution to BP. However, individual factors within the KS construct may have stronger leveraging power than others, thus requiring further investigation on H3-2. Therefore, it was necessary to conduct moderated regression analyses with the strongly correlated factors within the ISM, KS and BP constructs, to identify if any particular KS factors have a strong moderating effect with certain ISM factor's relationship on BP factors.

[INSERT Figure 2]

[INSERT Figure 3]

4.1.3. Post-hoc factor level analysis

A factor level hierarchical moderated regression analysis with post-hoc probing of the significant moderating effects was conducted. The aim of this additional analysis stage was to provide further in-depth verification on the construct level interaction effects (Holmbeck, 2002) and to undertake detailed investigation into the relationship between specific factors explaining business activities and business outcomes. All such analysis served to enrich the study findings and associated discussion.

A detailed presentation of factor level hierarchical moderated regression analysis and post-hoc probing of significant interaction effects is detailed in Tables 9 and 10, and sample interaction relationships illustrated in Figures 4 and 5.

[INSERT Table 9]

[INSERT Table 10]

Accordingly, Table 9 revealed that nine significant moderated regression models with interaction terms (i.e. NPDF1·KSF1, NPDF1·KSF2, NPDF1·KSF3, NPDF2·KSF1, NPDF2·KSF2 and NPDF2·KSF3) had comparatively significant predicting power on the BP factors, reflected by the adjusted R^2 values. The moderated regression model with the largest predicting power is taken as an example and illustrated in Figure 4. This equation indicates a significant ($p < 0.01$) positive regression of BPF1 (i.e. business competitiveness) on NPDF2 (i.e. design simplification and modular design) for all three levels of KSF1 (i.e. IT infrastructure and systems). The interaction terms of KSF1 and NPDF2 explained 44.7% of the variance in BPF1. As presented in Figure 4, when KSF1 was high there was a positive leveraging power of NPDF2 on BPF1, whilst there is no evident impact from a medium level of KSF1 on NPDF2 with BPF1. Adversely, when KSF1 was low, there appears to be a negative relationship between NPDF2 and BPF1. Moreover, the interaction terms of KSF2 (i.e. open communication) and NPDF2 explained 37.1% of the variance in BPF1. The interaction terms of KSF3 (i.e. organisational learning/sharing) and NPDF2 explained only 9.5% of variance in BPF1. These analyses further explain how particular KS factors serve as active facilitators in promoting design activities to improve business competitiveness, which are in line with the results from the construct level analysis.

[INSERT Figure 4]

Table 10 presents the three significant ISMF*i*·KSF*i* moderated regression models with interaction terms (i.e. ISMF1·KSF1 and ISMF2·KSF1). These three models explained a comparatively larger proportion of the variance of the BP factors, than the simple regression models. The regression model with interaction term ISMF1·KSF1 has a particularly strong predicting power, explaining 40.1% of the variance in BPF1. The moderated regression equations displayed in Figure 5 indicate a significant ($p < 0.01$) positive regression of BPF1 (i.e. business competiveness) on ISMF1 (i.e. supplier evaluation and selection) for all three levels of KSF1 (i.e. IT infrastructure and systems).

[INSERT Figure 5]

The factor level interaction models indicated that KS factors generally have significant positive moderating effects on the relationship between NPD and ISM factors with BP factors. The moderating effects of the significant KS factors are graphically illustrated in Figure 6, where the respective adjusted R^2 values have increased by more than 0.1. As demonstrated in this figure, the inclusion of the interaction term resulted in the adjusted R^2 increasing by as much as 0.447 from the simple regression models.

[INSERT Figure 6]

The factor level post-hoc analysis revealed a number of interesting findings that were not evident at the aggregated construct level. Firstly, for the two construct level moderated relationships displayed in Figures 4 and 5 there was an ISM or NPD induced increase in BP (even if only minor for low KS) with a low, medium or high level of KS. However, for some of the factor level relationships, a low level of KS combined with an increasing level of ISMF*i* or NPDF*i* having a negative effect on BP. This is illustrated in Figure 4, where enhanced *design simplification and modular design* (NPDF2) functions without the supporting *IT infrastructure and systems* (KSF1) appeared to have a detrimental affect on *business competitiveness* (BPF1). The high significance of this factor level moderating effect is also demonstrated by the adjusted R^2 value increasing from 0.093 to 0.540 when the interaction term is included. This may be due to the improved designs not yielding satisfactory business outcomes due to the poor IT infrastructure and systems preventing all relevant internal and external providers to the design and production process not being properly communicated the products functional specifications, therefore resulting in rework and/or poorer quality. Another important finding is that *IT infrastructure and systems* (KSF1) was the most active of the KS factors in moderating operational factors. KSF1 is undoubtedly an essential foundation and precursor for other KS factors to flourish. The below qualitative study further explores specific business activities pertaining to the factors and how they influence business outcomes.

4.2. Qualitative study findings and discussion

The qualitative study research design involved semi-structured interviews which sought to extract 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. Specifically, the purpose for such interviews was to uncover the characteristics of particular practices, which demonstrate the leveraging power of KS on the effectiveness of the herein focused business activities and the translated effect to BP. The concise summary of their comments presented below authenticates the main findings of the empirical study.

4.2.1. Value added from KS to business activities

All interviewees acknowledged that KS represent essential and integrative business mechanism utilised in the majority of their day-to-day operations, such as perform tasks, provide training and education, improve product quality and services, refine processes, solve problems and make decisions. They believed that the sharing of experience and knowledge among employees and across departments/sections could generate competitive capabilities, which can ultimately lead to company success. One interviewee revealed that the top management realised the opportunities and challenges of managing enormous volumes of invaluable knowledge that is constantly being produced by employees. He also indicated that for the company to fully benefit from this knowledge asset requires an appropriate mechanism that could help to make this knowledge available in the right format to the right people who need applicable knowledge at the right place and at the right time.

Moreover, successful KS must depend on the employees' ability and willingness to learn and share. All interviewees commented that KS needs to be an ongoing process, since market and customer demands are constantly changing. The current state of the electronic manufacturing industry was emphasized by the statement: "…In order to survive in the global 'cut-throat' competitive environment, satisfying customer requirements and following market tendency have become our first priority." They realised that the effectiveness of the KS process depends on open communication and the support of IT infrastructure and systems. Moreover, top management and employees' commitment to build an environment that helps to facilitate KS is the prerequisite to make the whole system to work properly. They all agreed that the company, which applies effective KS activities, would gradually strengthen its employee's competency. They further explained, as the employee's capability heightened, their job performance often improved, which ultimately would make a positive contribution to business performance both in the short- and long-term. The general agreement of this opinion can be best described by the comment: "…By sharing and applying knowledge in practical situations, employees are able to realise and appreciate synergistic results, which are much greater than those achievable by any individual alone." These comments highlight the positive functions that IT infrastructure systems and open communication have in enhancing employee's competency that can lead to produce ongoing improvement in business outcomes. The interviews also provided narratives as to how IT infrastructure systems and open communication played an important part in leveraging business activities (i.e., NPD and ISM) to achieve desired business performance.

4.2.2. Influence of KS on the relationship between NPD and BP

For manufacturing companies, strong product development capabilities are essential to maintain competitiveness (Petersen *et al.*, 2005; Ahire and Dreyfus, 2000). This was reflected by the comments of some interviewees: "…In the face of a highly competitive and dynamic global marketplace, sound NPD is certainly one of the most essential business processes for survival and renewal (of companies)." During an interview, a senior manager described knowledge sharing activities in the design simplification and modular design process: "…To encourage and involve employees to share technical experience, we have built a product engineering and education e-forum for our R&D staff members. This e-forum serves as a learning-and-sharing centre, which provides design guidelines, a component database and past project experiences. Staff members can communicate freely with each other through the e-forum, where they can share their ideas during collaborations in the product development process. …. NPD is a field with high uncertainty and complexity. This is the primary reason that motivated us to establish the e-forum. We have found that active knowledge sharing among staff members could improve product development practices. As a matter of the fact, the knowledge sharing facilitated by the e-forum actually has helped to cut down the overall development costs and duration quite considerably.” These interview findings suggested that the increased employees’ participation in the product development stage could lead to the continuous improvement of design practices. As a consequence, better manufacturing performance and business competitiveness can be achieved. This qualitative finding provides some insight into the empirically identified moderating influence of KS on the relationships between NPD and BP.

4.2.3. Influence of KS on the relationship between ISM and BP

All interviewees acknowledged supplier evaluation and selection as the most critical factor during ISM implementation, since it helped to identify and assess suppliers’ performance system, capability, culture and characteristics. They described that building a well-established supplier performance evaluation system is one of the critical steps to develop a quality production process. They further indicated that sharing experience with suppliers through the evaluation process could reduce potential deficiencies at the early stage of any collaborative partnership. One interviewee succinctly summarised: “…It is apparent that our suppliers’ performance positively contributes to our company’s performance.”

One interviewee provided an example of IT supported KS activities from an ISM perspective: “…our manager developed an intranet-based platform (called e-AVL platform) which supports employees to communicate freely and share experiences within sections or groups. This platform also helps in monitoring internal (e.g., operations) and external (e.g., suppliers) performance indicators generated from a variety of product development stages. To name a few, the indicators such as incoming reject rate (IRR), line fall out (LFO), outgoing reject rate (ORR), corrective action report (CAR), can be shared through e-AVL. This integrated information system assists us in performing a wide range of activities, e.g., task guidelines, standard operation procedure (SOP), employee training and education, recording lessons learned, as well as making informed decisions. Information sharing through this e-platform has helped our employees to effectively and efficiently monitor and manage internal/external operational processes both at home and in overseas offices. Through the e-platform we now are able to take preventive actions and formulate proactive plans for reoccurrence events. For this reason, we have confidence that we will see a continual improvement in the capabilities of our staff and suppliers. In view of this, we considered knowledge to be a critical and valuable asset that would help to improve the operational performance of our company and its suppliers.” These interview findings provided some insights into the strong relationship between the supplier evaluation process and the level of manufacturing performance that was empirically identified during the regression analyses. Moreover, it was clear from the interviews that open communication is an important trait required for successful management practices, since it instigated and sustained a mutual trust communication mechanism, whereby manufacturers and their suppliers were able to establish seamless cooperation that often yields benefits to all parties involved in supply chains.

5. Conclusions and Implications

This study was motivated by three primary objectives. The first was to posit the moderating effects of KS in the relationships between business activities and BP through theoretically proposing that KS functions as an action-based platform providing cognitive mechanisms for leveraging managerial and operational activities to generate higher value. The second was to investigate this theoretical proposition within the context of manufacturing companies. To fulfil this objective, the proposition was translated into a theoretical framework with context specific constructs and hypothetical relationships between them. In addition, both quantitative and qualitative approaches were employed to test the framework and to deeply understand the identified relationships, respectively. The third objective was to externalise the lessons learnt by some the strong performers of Taiwanese electronic manufacturing companies. All these three objectives were achieved by this mixed method study.

In line with the arguments in, and the empirical evidence reported by, the literature, this study endorsed the hypotheses that KS, NPD, and ISM all positively contribute to the BP of Taiwanese electronic manufacturing companies. Furthermore, advanced from previous research investigations the study findings supported the hypotheses that the relationships between business activities (i.e., NPD and ISM) and business outcomes (represented by BP) are strengthened through increasing the extent to which KS is implemented and facilitated. Both the quantitative and qualitative findings presented herein provide support that there is a significant moderating effect of KS on the relationship between business activities and BP. Moreover, the analysis highlighted the critical roles that robust IT infrastructure systems and open communication play as the most powerful moderators, which are able to facilitate key NPD and ISM activities in improving BP. The conclusions derived from the empirical findings supported the assertion of the KBV of the firm (Grant, 1996a) that KS provides mechanisms that help to integrate the specialised knowledge of individuals into the value-adding production process. In addition, from a cognitive learning perspective (Barab and Plucker, 2002; Brown *et al.*, 1989; Collins *et al.*, 1991; Gibson, 1986), KS also functions as an action-based platform to facilitate knowing and learning through social interactions, communications and collaboration with peers and experts in a specific context, hence developing better individual abilities in executing managerial and operational processes (e.g., in NPD and ISM). The improved individual abilities build solid micro-foundations for more superior company-level knowledge-based capabilities indicated by higher BP (Foss *et al.*, 2010; Teece, 2007).

5.1. Theoretical implications

The study concluded that KS practices are integrated with almost all of the NPD and ISM activities, and KS practices function as cognitive mechanisms providing an action-based platform for exchange and flow of both tacit knowledge and information within these activities. By mapping the KS activities that are integrated within the NPD and ISM activities against the knowledge creation (the 'SECI') model proposed by Nonaka and Takeuchi (1995), we can clearly see that the socialisation process enables the exchange of ideas, skills and experiences through human interactions in both inter- and intra- organisational channels, e.g., with suppliers and between different design groups. This tacit knowledge interaction is facilitated by IT infrastructures, which help to synthesise and externalise any tacit knowledge generation into explicit knowledge, such as best practice exemplars, design modules and supplier performance indices. Additionally, such technologies allow this knowledge to be stored and instantaneously shared through e-platforms by different regional offices. In other words, the IT infrastructure not only assists the tacit knowledge externalisation, but also helps the externalised knowledge to be applied within the NPD and ISM processes through human interactions in a larger organisational scale, and/ or inter-organisational channels. It appears that KS helps to create the themes organising the experience of being together where knowledge evolves as active experience (Stacey, 2001). As a consequence of this application, individual knowledge and abilities evolve with increasingly challenging tasks (Barab and Plucker, 2002), and continuously contribute to company-level knowledge-based capabilities in dealing with NPD and ISM processes, which can eventually lead to improved BP (Foss *et al.*, 2010). Therefore, KS process and mechanisms can indeed help manufacturing companies to dynamically manage their knowledge base for the purpose of achieving sustained competitive advantages (Lichtenthaler and Lichtenthaler, 2009) through fast and innovative NPD as well as highly efficient supply chains.

NPD involves knowledge-intensive activities throughout the entire design process, especially at the early conceptual design stage, where proactive KS practices can increase both the speed and quality of NPD whilst reducing both immediate and overall product costs. Mediocre KS practices would not generate sufficient knowledge to support these highly technical and creative design activities; and low levels of KS could even jeopardise BP as evidenced by the empirical study. Hence, it is essential for manufacturing companies to create an environment that fosters cooperative relationships, not only between different design groupings within the same companies, but also with the suppliers' product development teams. This environment should enable open communication, empower employee involvement, and provide support for the development of IT infrastructure. Hence, such an environment is critical to produce both creatively designed and high quality products, which reflects the core competence of a manufacturing company. On the other hand, the leveraging power of KS upon supply chain efficiency and effectiveness is significant and tangible, however, not as strong as on the NPD process. This is most likely due to the nature of ISM activities, which are less knowledge intensive than NPD activities, and perceived as routine managerial procedures within the manufacturing context.

5.2. *Managerial implications*

The investigation results indicate that for Taiwanese electronic manufacturers, continual effort in KS implementation is the key to future success. As reflected by the study, a more structured approach needs to be adopted that creates conducive atmosphere for KS. Firstly, advanced information technology and systems have become a fundamental requirement for the delivery of a modern electronic manufacturing process. The implementation and continual development of such IT infrastructure and systems has become an ongoing concern at the corporate level of companies, which must approve an adequate level of funding and resources to ensure that IT investments are enacted in such a way that outcomes align with the strategic agenda. Under strategic guidance, the NPD and ISM departments should team with internal and/or external specialists to continuously improve design and/or operational practices and enrich the content in NPD and ISM repositories. Moreover, system design should focus heavily on the functions that enable the externalisation of tacit knowledge. Secondly, formal incentive policies should be implemented to encourage KS activities, e.g., supporting joint innovation projects across organisational boundaries and rewarding innovative achievements. Furthermore, there is a necessity to produce a benchmarking system to measure the ongoing effectiveness of KS in value-adding to NPD and ISM processes, enabling companies to undertake a self-assessment on the state of their KS practices and link this with their performance measurement system and associated incentive policies.

The study identified three pertinent ISM aspects that management should focus on. First, suppliers need to be integrated 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. Second, mechanisms should be established to 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. Third, 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. First, a higher level of cross-functional cooperation should be promoted and employees should be encouraged to get involved during the entire product development process. Second, designers need to be provided with production and management education and training, thereby expanding their knowledge base beyond their traditional design tasks to include a range of other operational practices. Third, 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.

In general the study findings suggested that various socio-psychological and technological factors should be taken into consideration for the KS process to be effective. This study highlighted five KS related aspects requiring particular attention in order to combine various socio-psychological and technological factors to make KS effective. First, top management 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. Second, 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. Third, 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. Fourth, managers need to have a complete understanding on the key enablers for effectively implementing KS in their particular corporate environment/culture. Fifth, a Chief Knowledge Management Officer (CKMO) should be appointed along the establishment of a dedicated business 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.

6. Limitations and future research

Despite its obvious contributions, this study has some limitations that should be addressed in the future to enhance the robustness of findings. It is worthwhile to note that the findings of this study were derived from a sample of only one industrial sector (electronic and IT hardware manufacturing companies) from a specific geographical region, i.e., Taiwan. The generalisability of the findings could be increased by future studies based on larger samples of participants from diverse industry sectors and cultural backgrounds. In addition, the study would benefit from a larger and more defined qualitative investigation whereby in-depth case studies are conducted that provide more insights into the phenomenon under the investigation, and help to provide further evidence for building a possible KS integration maturity benchmarking system. For example, in-depth comparative case studies could be used to reveal the attributes and intensity level of KS activities applied by Taiwanese (and/or other countries) manufacturing companies. Through comparison and analysis of the case studies, criteria could be established to scale the effectiveness of the KS activities into appropriate hierarchical levels. This approach would help companies to align KS activities with the desired business objectives they intend to achieve. Building upon the criteria, a benchmarking system could be developed to assist companies to undertake a KS self-assessment process, and also help to promote the best KS practices within industry.

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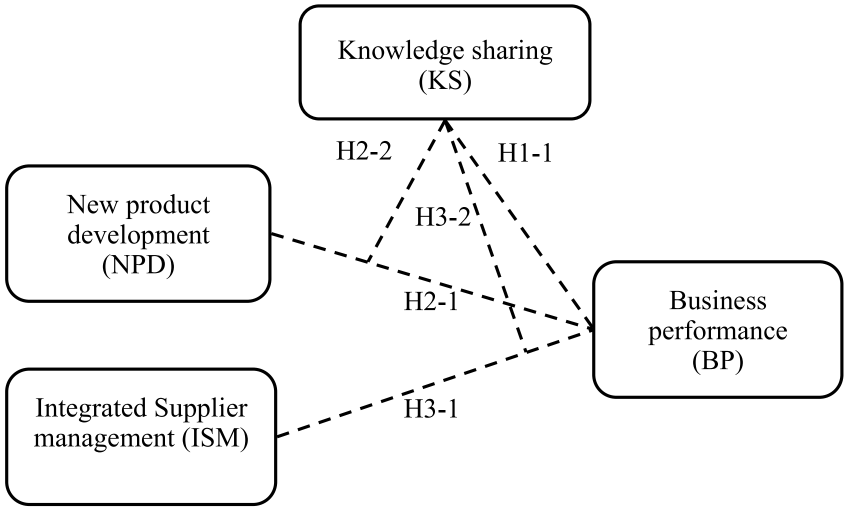


Figure 1. Proposed theoretical framework

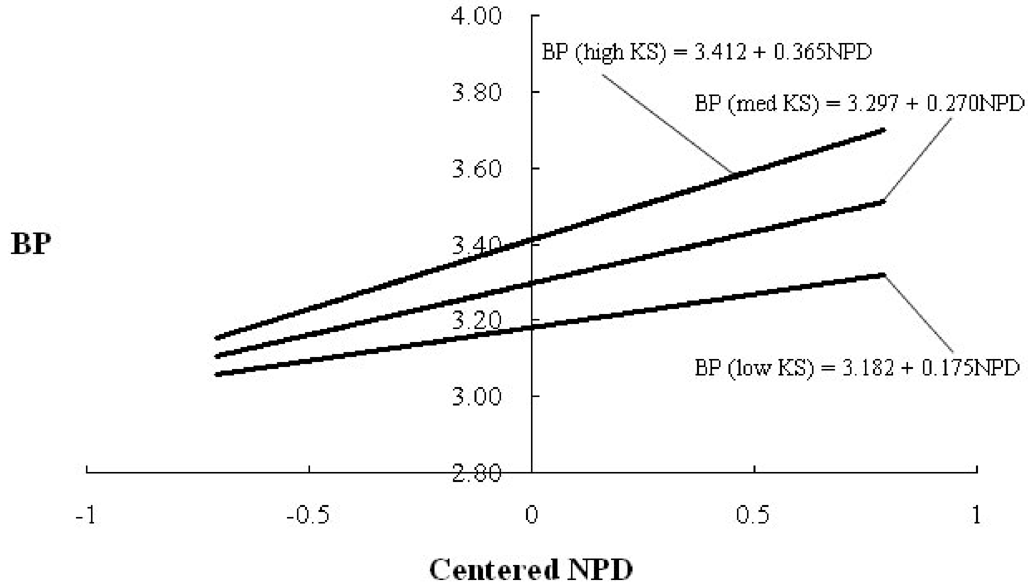


Figure 2. Regression of BP on NPD at different level of KS

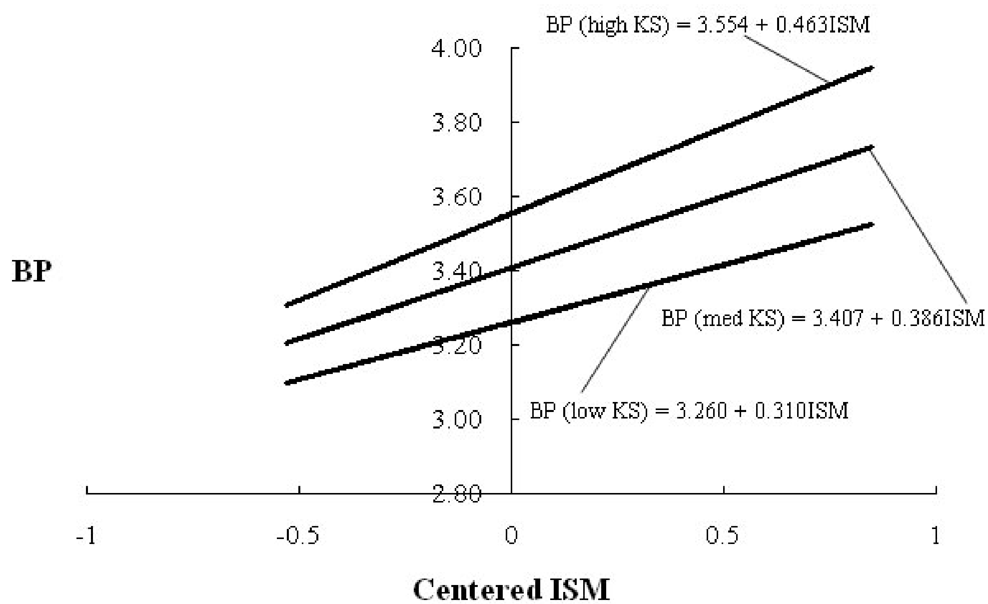


Figure 3. Regression of BP on ISM at different level of KS

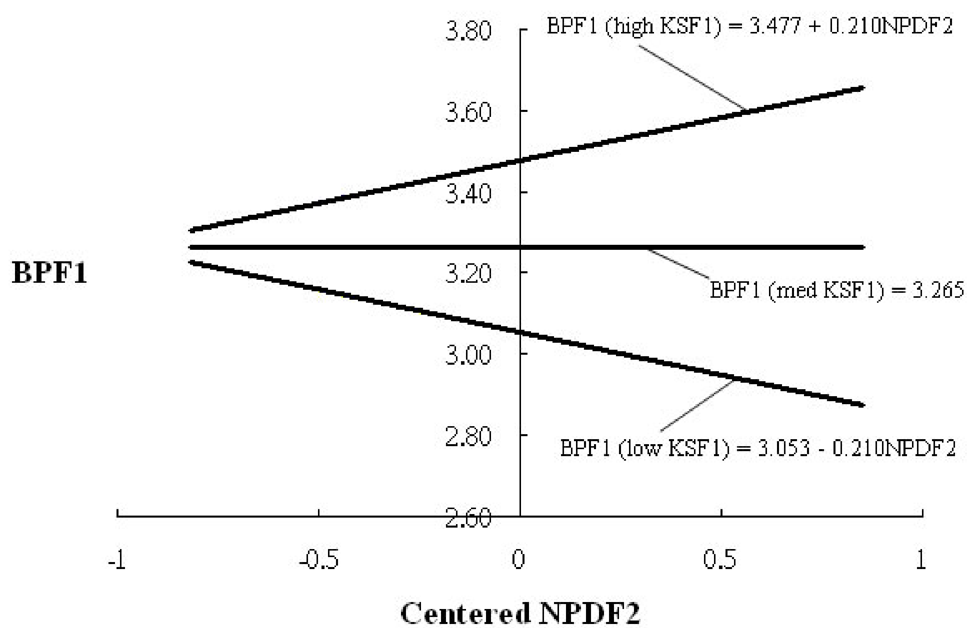


Figure 4. Regression of BPF1 on NPDF2 at different level of KSF1

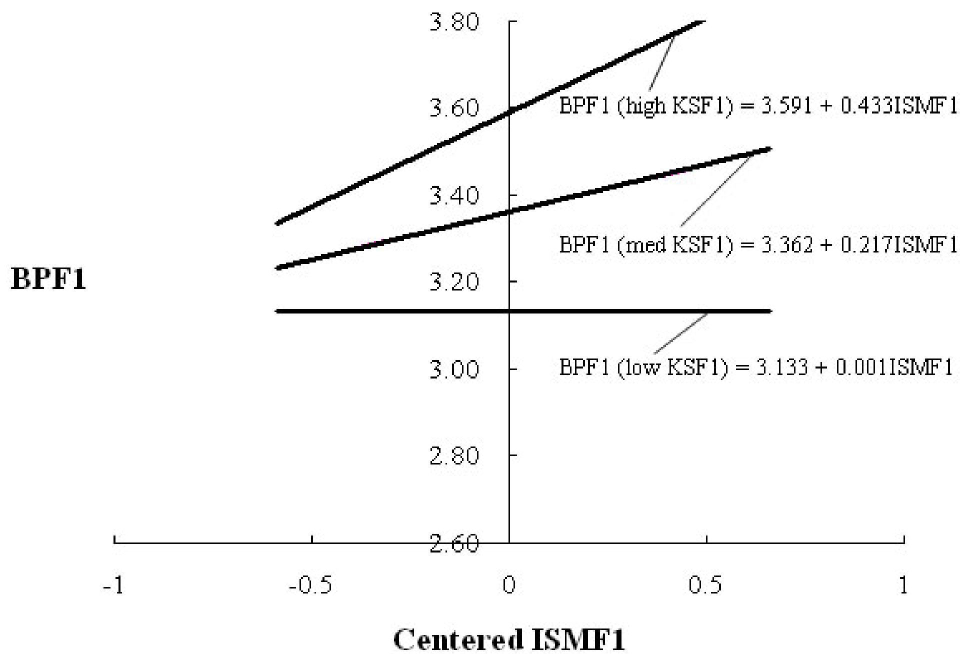
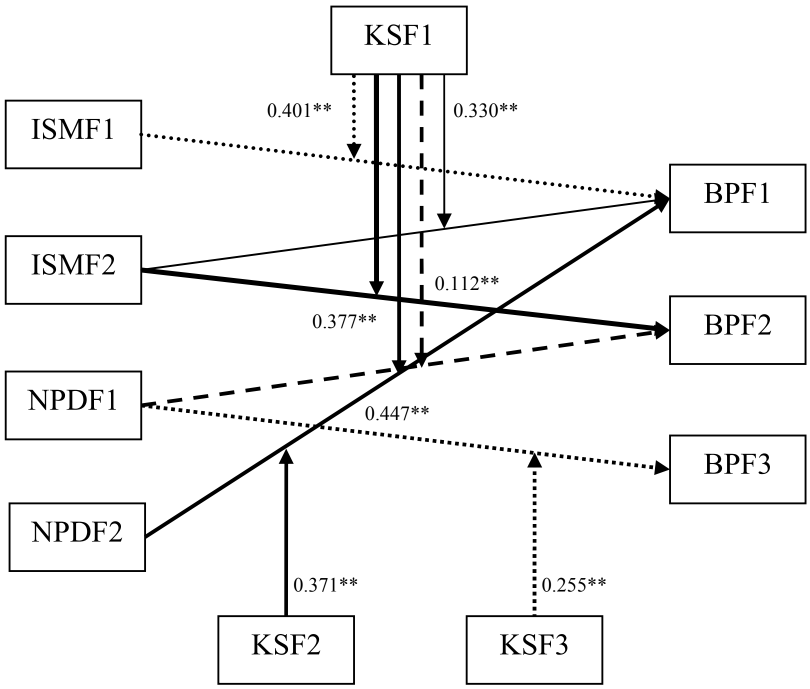
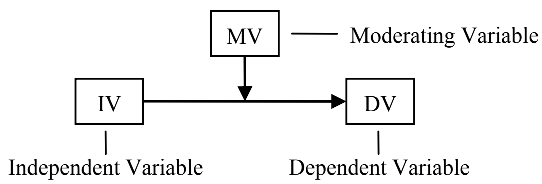


Figure 5. Regression of BPF1 on ISMF1 at different level of KSF1



Legend:



Change in *Adj.* R^2 due to the inclusion of the interaction term (**: significant at 0.01 level, *: significant at the 0.05 level.)

ISMF1: Supplier evaluation and selection
ISMF2: Supplier involvement
NPDF1: Employee involvement
NPDF2: Design simplification & modular design
KSF1: IT infrastructure and systems
KSF2: Open communication
KSF3: Organisational learning and sharing
BPF1: Business competitiveness
BPF2: Manufacturing performance
BPF3: Process efficiency

Note:

(dotted arrow): KSF1 moderates relationship between ISMF1 and BPF1
(thin solid arrow): KSF1 moderates relationship between ISMF2 and BPF1
(thick solid arrow): KSF1 moderates relationship between ISMF2 and BPF2
(solid arrow): KSF1 moderates relationship between NPDF2 and BPF1
(dashed arrow): KSF1 moderates relationship between NPDF1 and BPF2
(solid arrow): KSF2 moderates relationship between NPDF2 and BPF1
(dotted arrow): KSF3 moderates relationship between NPDF1 and BPF3

Figure 6. Factor level moderated regression relationships

Table 1 Operationalised constructs (i.e., KS, NPD, ISM, BP)

Constructs	Dimensions	Measurement Variables	References
Knowledge Sharing (KS)	Top management support	• Encourage and support KS activities • Understand the critical role of knowledge • Often seek out useful knowledge • Employee empowerment	Modi and Mabert, 2007; Lubit, 2001; Hsu, 2006; Tseng, 2008
	Organisational learning/sharing	• Learning platforms and resources • Established learning environment • Improved work processes	Lubit, 2001; Hsu, 2006; Taylor, 2006
	IT support	• IT systems for knowledge dissemination • User friendly IT support • Training and education	Hsu, 2006; Renzl, 2008; Taylor, 2006
	Open communication	• Enhanced employee abilities • Updated knowledge repository • Encourage intra- and inter- communication	Modi and Mabert, 2007; Lubit, 2001; Carr and Pearson, 1999
	Incentive or rewards	• Stimulate KS activities	Hsu, 2006; Lubit, 2001; Taylor, 2006
New Product Development (NPD)	Design for quality and manufacturing	• Design to improve quality • Design to enhance manufacturability	Matsui *et al.*, 2007; Ahire and Dreyfus, 2000;
	Design simplification and modular design	• Reduce product development time • Improve design efficiency • Component standardisation and/or reduction • Constantly improve design process	Antonio *et al.*, 2007; Matsui *et al.*, 2007; Fynes and Burca, 2005
	Employee involvement	• Appropriate staff inclusion • Awareness of project processes • Training on product design and quality	Antonio *et al.*, 2007; Matsui *et al.*, 2007
Integrated Supplier Management (ISM)	Supplier evaluation and selection	• Effective supplier assessment system • Appropriate supplier selection • Complementary supplier capabilities	Tan *et al.*, 1999; Chin *et al.*, 2006; Ndubisi *et al.*, 2005
	Supplier involvement	• Smooth functioned project • Expedited decision making • Fast problem resolution • Better design/technology for product	Tan *et al.*, 1999; Chin *et al.*, 2006; Ndubisi *et al.*, 2005
	Supplier management strategies	• Implement quality assurance program • Site visit/audit regularly • Provide training/education regularly • Provide communication channel	Tan *et al.*, 1999; Ndubisi *et al.*, 2005; Modi and Mabert, 2007;
Business Performance (BP)	Business competitiveness	• Total quality cost • Profitability • Sales growth • Competitive ability	Kale and Arditi, 2003; Antonio *et al.*, 2007; Hsu, 2006
	Manufacturing performance	• Reduced engineering change rate • Reduced production cycle time • Reduced operational cost • Customer satisfaction • Over all firm's reputation	Hsu, 2006; Darroch, 2005; Antonio *et al.*, 2007; Beamon, 1998
	Process efficiency	• Increased internal production rate • Improved customer response time • Reduced products defect rate	Yeung, 2007; Devaraj *et al.*, 2004; Maiga and Jacobs, 2007

Table 2 Respondent profile summary

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

Table 3 Varimax rotated factor analysis for the four constructs

Construct Code: Factor	Ref.	Measurement Variables	Factor Loadings*
Knowledge Sharing (KS); Total Variance Explained = 69.6%; Cronbach's Alpha (α) = 0.766.			
KSF1: 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
KSF2: Open communication	K4	Enhanced employee abilities	0.899
	K5	Updated knowledge repository	0.792
	K6	Encouraged intra- and inter-communication	0.531
KSF3: Organisational learning/ sharing	K7	Learning platforms and resources	0.876
	K8	Established learning environment	0.744
New Product Development (NPD); Total Variance Explained = 69.1%; Cronbach's Alpha (α) = 0.739.			
NPDF1: Employee involvement	N1	Appropriate staff inclusion	0.751
	N2	Awareness of project processes	0.859
	N3	Training on product design and quality	0.926
NPDF2: Design simplification & modular design	N4	Product development time	0.725
	N5	Component standardisation	0.751
	N6	Design efficiency improvement	0.875
Integrated Supplier Management (ISM); Total Variance Explained = 77.5%; Cronbach's Alpha (α) = 0.706.			
ISMF1: Supplier evaluation & selection	S1	Supplier assessment system	0.945
	S2	Appropriate supplier selection	0.721
	S3	Complementary supplier capabilities	0.961
ISMF2: Supplier involvement	S4	Expedited decision making	0.869
	S5	Faster problem resolution	0.816
Business Performance (BP); Total Variance Explained = 78.1%; Cronbach's Alpha (α) = 0.849.			
BPF1: Business competitiveness	B1	Total quality cost	0.838
	B2	Profitability	0.885
	B3	Sales growth	0.942
	B4	Competitive ability	0.695
BPF2: 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
BPF3: 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 4 Descriptive statistics and Pearson correlations of the constructs

Constructs	MAX	MIN	Mean	S.D.	KS	NPD	ISM	BP
KS	3.89	2.89	3.37	.30	1			
NPD	4.67	3.17	3.88	.37	.37**	1		
ISM	5.00	3.71	4.18	.36	.20**	.46**	1	
BP	3.80	2.90	3.22	.28	.62**	.58**	.56**	1

Notes:
** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Table 5 Descriptive statistics and Pearson correlations for factors

Factors	MAX	MIN	Mean	S.D.	KSF1	KSF2	KSF3	NPDF1	NPDF2	ISMF1	ISMF2	BPF1	BPF2	BPF3
KSF1	4.00	2.67	3.26	.35	1									
KSF2	4.00	3.00	3.37	.33	.47**	1								
KSF3	4.50	3.00	3.66	.38	.28**	.74**	1							
NPDF1	5.00	2.67	3.65	.48	.54**	.47**	.20*	1						
NPDF2	5.00	3.33	4.10	.41	.07	.32**	.29**	.35**	1	.				
ISMF1	5.00	4.00	4.45	.43	.50**	.43**	.24**	.58**	.15*	1				
ISMF2	5.00	3.00	3.87	.56	.25**	-.02	-.05	-.05	-.01	.24**	1	.		
BPF1	4.00	3.00	3.24	.37	.68**	.44**	.08	.06	.32**	.45**	.47**	1		
BPF2	4.00	3.00	3.26	.32	.25**	.63**	.19*	.50**	.51**	.68**	.04	.57**	1	
BPF3	4.00	3.00	3.18	.35	.00	.19*	.34**	.20*	.21**	.06	-.35**	.05	.23**	1

Notes: ** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

Table 6 Main effects of KS, NPD and ISM on BP (standardised coefficients)

Variables	Model 1	Model 2	Model 3	Model 4
Hypothesis		**H1-1**	**H2-1**	**H3-1**
Control Variables:				
Nature of business	-0.077	-0.100	-0.030	-0.069
Firm size	0.018	0.013	0.005	0.037
Main Effect:				
Knowledge sharing (KS)		0.613**		
New product development (NPD)			0.571**	
Integrated supplier management (ISM)				0.561**
R^2	0.006	0.381	0.330	0.318
Adjusted R^2	-0.005	0.370	0.318	0.306
F change	0.540	34.093**	27.309**	25.828**
Durbin-Watson	1.072	1.076	1.153	1.594

Notes: **: Significance at $p < 0.01$ level; *: Significance at $p < 0.05$ level.

Table 7 Moderating effect of KS on NPD and ISM with BP (Standardised coefficients)

Variables	Model 1	Model 2	Model 3
Hypothesis			**H2-2 and H3-2**
Step 1: Control Variables			
Nature of business	-0.077	-0.069	-0.066
Firm size	0.018	-0.026	-0.026
Step 2: IV and MV			
Knowledge sharing (KS)		0.453**	0.437**
New product development (NPD)		0.237**	0.252**
Integrated supplier management (ISM)		0.360**	0.467**
Step 3: Interaction terms			
NPD x KS			0.190**
ISM x KS			0.172*
R^2	0.006	0.618	0.665
Adjusted R^2	-0.005	0.606	0.650
ΔR^2	---	0.611**	0.047**
F change	0.540	87.418**	11.332**
Durbin-Watson			1.874

Notes: **: Significance at $p < 0.01$ level; *: Significance at $p < 0.05$ level.

Table 8 Construct level hierarchical moderated regression models

Hypotheses	Significant regression models	*R*	R^2	*Adj.* R^2	*F*
H1-1	BP = 3.355 + 0.569**KS	0.617	0.381	0.370	99.56**
H2-1	BP = 3.261 + 0.437** NPD	0.575	0.330	0.318	80.33**
H2-2	BP = 3.297 + 0.270**NPD + 0.380**KS + 0.315*NPD·KS	0.642	0.412	0.398	22.85**
H3-1	BP = 3.373 + 0.435**ISM	0.564	0.318	0.306	75.92**
H3-2	BP = 3.407 + 0.386**ISM + 0.498**KS + 0.254*ISM·KS	0.575	0.328	0.317	43.41**

Notes: **: Significance at $p < 0.01$ level; *: Significance at $p < 0.05$ level.

Table 9 Factor level hierarchical moderated regression models (NPDF·KSF → BPF)

Hypotheses	Significant regression models	*R*	R^2	*Adj.* R^2	*F*
H2-2(1)	Without interaction term	0.330	0.109	0.093	18.91**
	BPF1 = 3.265 + 0.489**KSF1 + 0.483**NPDF2·KSF1	0.744	0.553	0.540	24.46**
H2-2(2)	Without interaction term	0.330	0.109	0.093	18.91**
	BPF1 = 3.257 + 0.365**KSF2 + 1.154**NPDF2·KSF2	0.693	0.480	0.464	87.38**
H2-2(3)	Without interaction term	0.220	0.048	0.031	7.59**
	BPF3 = 3.196 + 0.278**KSF3 + 0.646**NPDF1·KSF3	0.554	0.307	0.286	39.77**
H2-2(4)	Without interaction term	0.495	0.245	0.232	53.17**
	BPF2 = 3.413 + 0.160KSF1 + 0.379**NPDF1 + 0.553**NPDF1·KSF1	0.603	0.364	0.344	19.73**
H2-2(5)	Without interaction term	0.330	0.109	0.093	18.91**
	BPF1 = 3.242 + 0.224**NPDF2 + 0.828**NPDF2·KSF3	0.460	0.212	0.188	20.27**
H2-2(6)	Without interaction term	0.505	0.255	0.241	55.93**
	BPF2 = 3.296 + 0.361**NPDF2 + 0.469**NPDF2·KSF1	0.574	0.329	0.309	13.77**
H2-2(7)	Without interaction term	0.220	0.048	0.031	7.59**
	BPF3 = 3.271 + 0.381**NPDF1·KSF2	0.342	0.117	0.090	9.41**
H2-2(8)	Without interaction term	0.505	0.255	0.241	55.93**
	BPF2 = 3.361 + 0.198**KSF3 + 0.408**NPDF2 + 0.439*NPDF2·KSF3	0.556	0.309	0.288	5.85*
H2-2(9)	Without interaction term	0.495	0.245	0.241	55.93**
	BPF2 = 3.305 + 0.299**NPDF1 + 0.401**NPDF1·KSF3	0.550	0.303	0.282	12.48**

Notes: **: Significance at $p < 0.01$ level; *: Significance at $p < 0.05$ level.

Table 10 Factor level hierarchical moderated regression models (ISMF·KSF → BPF)

Hypotheses	Significant regression models	R	R^2	$Adj.\ R^2$	F
H3-2(1)	Without interaction term	0.499	0.249	0.235	53.33**
	BPF1 = 3.362 + 0.527**KSF1 + 0.217**ISMF1 + 0.498**ISMF1·KSF1	0.840	0.647	0.636	31.18**
H3-2(2)	Without interaction term	0.271	0.073	0.051	6.21**
	BPF2 = 3.303 + 0.120*KSF1 + 1.480**ISMF2·KSF1	0.667	0.445	0.428	109.80**
H3-2(3)	Without interaction term	0.428	0.183	0.168	35.62**
	BPF1 = 3.373 + 0.491**KSF1 + 0.129*ISMF2 + 0.230*ISMF2·KSF1	0.716	0.513	0.498	24.84**

Notes: **: Significance at $p < 0.01$ level; *: Significance at $p < 0.05$ level.