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A structural equation model for analyzing the impact of ERP on SCM

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ABSTRACT

Enterprise resource planning (ERP) and supply chain management (SCM) represent important information technology investment options for operation or IT managers, and have been acclaimed in the practitioner and academic literature for their potential to improve business performance. The purpose of this article is to provide further insights into the adoption of ERP systems and the impacts on firm competence in SCM. We propose a model featuring ERP benefits to firm competences in supply chain management. We also hypothesize that three constructs of ERP benefits positively impact firm competences in SCM. To clarify the relationships among these constructs, structural equation model (SEM) is conducted to examine the model fit and nine hypotheses. The SEM results clearly demonstrate that there exist close interrelations among the benefits of implementing ERP systems and firm competences in SCM. The data from Taiwanese IT firms was collected through interviewing of experts and surveys. The results provide empirical evidence that the beneficial impacts of ERP on the supply chain do lead to better overall SCM competence. That evidence confirms that operational benefits, business process and management benefits, and strategic IT planning benefits of ERP in turn enhance firm competences of SCM in operational process integration, customer and relationship integration, and planning and control process integration.

1. Introduction

Business organizations today are facing a more complex and competitive environment than ever before (Chen & Lin, 2009a; Ellram, 1991). Business success is no longer a matter of analyzing only the individual firm, but rather the chain of delivering and supplying organizations; the individual firm is only a single part of the supply chain. Therefore, companies are focusing on supply chain strategies to streamline internal operations, boost plant productivity, improve product quality, and reduce manufacturing costs. One reason for these initiatives is the substantial cost reductions to be achieved by improving the firm competences of supply chain management. Another reason is the advent of the Internet economy. The internet is challenging the traditional supply chain structures that firms have employed to get goods and services to markets (Rahman, 2003). Markets are becoming more transparent; customer demands are being met in a more customized manner, and the rate of change in the business world keeps increasing (Ellram, 1991). All these developments are having a profound impact on the enterprises of supply chains. Therefore, how to enhance the firm competences on supply chain management is becoming more important.

The literature on new business models for the Internet age is growing rapidly. In particular, Fine (1998) has pointed out that as the business environment changes, supply chain design is becoming a core competence. At the same time, another business-driven phenomenon, the adoption of enterprise resource planning (ERP), is sweeping across industry. Adoption of ERP systems may motivated by pressure from competitors, or by requests from partners or customers in the supply chain for linkage or system upgrades, or simply by the need to replace the legacy systems. When ERP systems are fully realized in a business organization, they can be expected to yield many benefits: reduction of cycle time; faster transactions; better financial management; the laying of the groundwork for e-commerce; and making tacit knowledge explicit. Since the potential benefits are large, many organizations are willing to undertake the difficult process of converting from whatever they currently use to an ERP system. Installing an ERP system is, however, an expensive and risky venture (Chen & Lin, 2009b; Markus & Yanis, 2000). Roach (1991) stated that although business was investing huge sums of money in IT, positive results could not yet be observed in the US economy. Strassman (1990) also failed to find positive returns from IT investments in his study of IT expenditures in the 1980s. Other researchers during this same time period found similar outcomes (Pentland, 1989). More recent,

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evidence, though, has, on the contrary, demonstrated large benefits from IT investments and uncovered significant productivity gains from IT. Other recent studies (Hitt & Brynjolffson, 1996; Mukhopadhyay, Kekre, & Kalathur, 1995) have argued persuasively that enough evidence has been gathered on the positive effects of IT to justify the conclusion that ERP investment does pay off.

As reported in Chang et al. (2008), while the external environments and alliance partnerships facing an enterprise are becoming more complex, executive should enhance efficiency and performance of supply chain management as well as to gain potential competitive advantages. Although many academic researchers have contributed by confirming the relationship between supply chain competences and enterprise performance or by confirming the relationship between ERP benefits and enterprise performance, determining just how the ERP system was expected to work as an integral component in supply chain management has been less studied and is not understood. Our research, therefore, focuses on the impact of ERP benefits on the firm competences of SCM, rather than on the relationship between ERP or SCM and enterprise performance. From the above historical perspective, and after reviewing the selected literature on ERP and supply chains, we first listen to practitioners. What do experts from business, who recently have been or are currently going through ERP or SCM systems implementations, think about the strengths and weaknesses of ERP with respect to enterprises and SCM? The present study is based on the Taiwanese IT industry for two reasons: First, it has achieved outstanding results over the past two decades (Chang and Yu, 2001, chap. 12). "Made by Taiwan" (Taiwan-made) IT products dominate the worldwide market in many categories. Most of them dominate over 50% of the worldwide market. Many scholars have conducted research into the SCM of firms in some developed countries (Benton & Maloni, 2005; Lim & Palvia, 2001). These studies cover many types of industry, such as the chemical, pharmaceutical, bioengineering, automobile, etc. They also include a wide range of high-technology firms. The IT industry in developing countries, such as Taiwan, China, and Korea, has not, however, been comprehensively studied. Second, in the IT industry, product life cycle is extremely short. Companies need to deliver new products before they have any market value. In the Taiwanese IT industry, the main type of business is original equipment manufacturing (OEM) and original design manufacturing (ODM). An OEM/ODM business is different from an own brand manufacturing (OBM) business in many aspects. With OBM, companies can entirely control their marketing activities. In the case of OEM/ODM, on the other hand, firms are not involved in their OEM/ODM customers' sales/marketing activities. Companies isolated from the customer base, still need to satisfy customer needs and to react to all the customer changes immediately. They are compelled to closely cooperate with all of the members on the supply chain so as to be able to react to any unexpected changes. To cope with the rapid changes in customer needs and the extremely short product life cycles, the cross-functional cooperation of information systems in the IT industry may be more important than those industries with a longer product life cycle. These two unique features – the rapid customer changes and short product life cycles – of the IT industry indeed encourage the companies to improve SCM competences and performance. There is much academic research and there are many empirical studies that show that firms with superior supply chain management competence have better performance (Byrd & Davidson, 2003; Closs & Mollenkopf, 2004; Gunasekaran, Patel, & McGaughey, 2004; Narasimhan & Kim, 2002); but how can ERP be expected to support or create firm competences in SCM? Are there any limitations to or weaknesses of the impact of SCM while companies are under going ERP implementation? The evidence that the Taiwanese IT industry has had a highly successful growth experience with SCM competences shows that it can be documented, and lessons can be learned.

This article sets the stage for recently completed research concentrating on SCM and ERP issues. First, definitions of those terms are provided, and compared with recent usage. Second, a review of past research on ERP and SCM is presented to illustrate the ERP benefits and supply chain competences. A conceptual research model is proposed. Third, data collected from Taiwanese IT firms through a survey and interviewing of experts is presented. The respondents to the survey were, primarily, chief information officers or IT industry related engineers or users and other top IT executives. And fourth, the confirmation of the overall proposed model is important because it provides empirical evidence that ERP impact on the supply chain did lead to better overall SCM competences. The results confirm that ERP provides benefits in the following areas lead to significant improvement in the firm competences of SCM: (1) operational benefits, relating to cost reduction, cycle time reduction, productivity improvement, quality improvement, and customer service improvement; (2) business process and management benefits, relating to better resource management, improved decision making and planning, and performance improvement; and (3) strategic IT planning benefits, involving building business flexibility, IT cost reduction, and increased IT infrastructure capability.

2. Literature review

2.1. Supply chain management and firm competences

Supply chain management (SCM) is a 21st century paradigm of IT infrastructure. It focuses on globalization and information management tools that integrate procurement, operations, and logistics from raw materials to customer satisfaction (Kovacs & Paganelli, 2003). Further, it increases manufacturing flexibility, transportation speed, and information availability, as well as management complexity. In recognition of these challenges, practicing managers and academic researchers have realized that SCM has been a major component of competitive strategy to enhance organizational productivity and profitability.

Not everyone, however, means the same thing by the term "supply chain." Generally, it has three levels. Some have restricted its meaning to apply to only the "relational" activities between a buyer and seller (Ellram, 1991). A second use of "supply chain" takes a broader view by including all "upstream" suppliers to a firm (Dobler & Burt, 1996). Yet a third view takes a "value chain" approach, in which all activities required to bring a product to the marketplace are considered part of the supply chain (Lee & Billington, 1993). Manufacturing and distribution functions are thus included as part of the flow of goods and services in the chain.

The definition of supply chain used in the present research follows the spirit of the value chain concept. The supply chain is the network of facilities and activities that performs the functions of product development, procurement of material from vendors, the movement of materials between facilities, the manufacturing of products, the distribution of finished goods to customers, and after-market support for sustainability. Such a holistic approach is consistent with the integrated way today's global business managers are planning and controlling the flow of goods and services to the market place.

The literature on SCM that deals with strategies and technologies for effectively managing a supply chain is quite vast. In recent years, the competences and performance of SCM have received much attention from researchers and practitioners. The relationship between firm competences and the impact on the performance of enterprise and supply chains has been remarkably

strong. According to Stalk, Evans, and Shulman (1992), competences emphasize technological and production expertise at a specific point along the value chain. Prahalad and Hamel (1990) characterize core competences as the collective learning of the organization, especially the knowledge of how to coordinate diverse production skills and integrate multiple streams of technologies. Accordingly, in our research we examined the company with powerful capability of supply chain management as the most important factors in the performance of supply chain management.

The 21st Century Logistics framework was developed at Michigan State University and introduced in 1999 (Bingi, Sharma, & Godla, 1999). The framework identifies six firm competences critical for logistics and supply chain management. Each competence is composed of multiple underlying capabilities, which guide philosophies and processes to complete specific logistics and supply chain activities. The competences leading to high supply chain performance can be grouped into operational, planning, and behavioral processes. A major challenge to empirically demonstrating the relationship concerns how to measure a firm's "success." Firm performance must certainly incorporate financial measures, but should also include broader measures. The 21st Century Logistics framework was developed using a measurement model that considers both firm and supply chain performance using 13 logistics and supply chain variables representing five key performance areas. These are customer service, cost management, quality, productivity, and asset management. Since this framework was introduced, many authors have applied the framework to international environments. For example, Carranza, Maltz, and Antun (2002) used the framework to discuss and compare the logistics strategy of Argentinian firms. Morash and Lynch (2002) investigated the relationship between public policy and supply chain capabilities and performance in three global regions: North America, Europe, and the Pacific Basin. This research made a contribution by confirming the relationship between supply chain management best practice and firm performance for the U.S. sample. And the results of the research suggest that the above six firm competences are reasonably robust across environments and confirm that firm competences do lead to improvement of the supply chain performance.

2.2. Enterprise resource planning and the benefits

The need for firm competences in supply chain management led to a significant development in information systems (IS). At the same time, one such information system, the enterprise resource planning (ERP) system, is sweeping across industry. An ERP system is an integrated enterprise computing system that is designed to automate the flow of material, information, and financial resources among all functions within an enterprise on a common database. Prior research suggests different ways of defining ERP: that is, from a business perspective, a technical perspective or a functional perspective. One way of looking at ERP is as a combination of business processes and information technology. Davenport (1998) proposed that implementing ERP systems brings many benefits to the organization, including reduction of cycle time, improving information flow, rapid generation of financial information, promotion of the E-business, and assistance in development of new organizational strategies. Koh, Gunasekaran, and Rajkumar (2007) suggest that the future will see a firm being increasingly core competence driven with increasing divestment of non-core activities. This would lead to a heightened supply chain, with a multitude of firms 'completing' the competence to provide the aforementioned goods and services. Furthermore, from a more strategic perspective, Chiplunkar, Deshmukh, and Chattopadhyay (2003) suggest as a benefit the capture of the complete business environment in a business process reengineering (BPR) project with the help of information technology, specifically supported by the system that improves the performance of the enterprise as a whole. From a technical perspective, ERP can be seen as the logical extension of the Material Requirement Planning (MRP) systems of 1970s and the Manufacturing Resource Planning (MRP II) systems of 1980s. The ERP was subsequently designed to overcome the operational problems that companies experienced with previous information systems. ERP systems should not be looked at simply as tools that have a fixed and measurable output, but rather as comprising a technological infrastructure designed to support the capability of all other tools and processes used by a firm. Functionally, an ERP system primarily supports the management and administration of the deployment of resources within a single organization. One significant feature of an ERP system is that core corporate activities, such as manufacturing, human resources, finance, and supply chain management, are automated and improved considerably by incorporating best practices, so as to facilitate greater managerial control, speedy decision making and huge reduction of business operational cost (Holland & Light, 1999). Most of the researchers agree that the task requires a mix of cross-functional strategic planning and enterprise-wide corporate diplomacy (Bingi et al., 1999). ERP is fundamentally tied to the integration, standardization, extension and assurance of future flexibility for corporate processes.

In the past decade, nearly all literature on ERP focused on reasons for implementation and on the challenges of the implementation project itself (Davenport, 1998). Recently, several distinct research streams on ERP are observed in the literature. Some researchers have turned their attention to the contribution of ERP systems to supply chain coordination, when the supply chain is composed of several legal entities, such as in virtual enterprises or in an international context. Akkermans, Bogerd, Yucesan, and van Wassenhove (2003) studied the future impact of ERP systems on supply chain management. One of their main findings is that the panel experts saw only a modest role for ERP in improving future supply chain effectiveness and a clear risk of ERP actually limiting progress in SCM: ERP was seen as offering a positive contribution to only four of the top 12 future supply chain issues. Moreover, they identified key limitations of current ERP systems in providing effective SCM support. The problem is that the first generation of ERP products has been designed to integrate the various operations of an individual firm, whereas in modern SCM, the unit of analysis has become a network of organizations, making these ERP products inadequate in the new economy. Kelle and Akbulut (2005) argue that even if ERP software provides different tools that can support supply chain integration, at the same time it has several features that prevent the integration with business partners. They based their analysis on the inventory management aspects of supply chain coordination, and their results can be used in enterprise software to measure the potential monetary value of policy coordination, to promote cooperation, and to minimize the total supply chain system cost. Moreover, several researchers have classified the types of ERP benefits, and have indicated that some approaches may be appropriate techniques for evaluating the performance of ERP systems. Markus and Tanis (2000) indicated that the balanced scorecard is such a technique. Chand and Hachey (Chand, Hachey, Hunton, Owhoso, & Vasudevan, 2005) derived a new ERP framework for evaluating the strategic impacts of ERP systems, and illustrate that an ERP system does indeed impact the business objectives of the firm. To evaluate the performance of ERP benefits, Zuboff (1985) notions suggest that the success of ERP implementations and operations depends on the firm's intention to use the ERP system to 'automate', 'informate' or 'transformate' the organization. Shang and Seddon (2000) classify the different types of ERP benefits into five groups as follows: IT infrastructure benefits, operational benefits, managerial benefits, strategic benefits and organizational benefits. Although there is no analytical framework for measuring the contributions and the impacts of ERP systems on

the firm competences of supply chain performance, Byrd and Davidson (2003) have examined how the antecedents, IT department technical quality, IT plan utilization, and top management of IT positively affected IT impact on the supply chain. Wade and Hulland (2004) provide an overview of the literature on IT-related resources and their impact on firm strategy and performance, where IT means all of the information systems, including ERP systems. Stratman and Rothe (2002) propose an integrated conceptual model of "ERP Competence," which they define as comprising several organizational aptitudes, including strategic planning, executive commitment, project management, IT skills, business process skills, ERP training, change readiness and learning. They argued that a firm's ERP competence must be used effectively in order to truly harness the capabilities of an ERP system for competitive advantage.

3. The research model and hypotheses

Our research model is shown in Fig. 1. The definitions of various constructs in the model are summarized in Table 1. In this study, the authors construct the research model based on reviewing the selected literature on ERP and on SCM. As discussed earlier, our research model encompasses and relies on two areas: firm competences in SCM, based on the 21st Century Logistics framework as extended by Bowersox, Closs, and Stank (1999), and ERP benefits as referred to in the classification of ERP benefits, in Shang and Seddon (2000) and Stratman and Rothe (2002). Although the 21st Century Logistics framework made a contribution by confirming the relationship between logistics best practice and firm performance for the U.S. sample, our research focus is on the impacts of organizational information systems on SCM competences. Thus, we select the firm competences of SCM that could be related to organizational information systems from the 21st Century Logistics framework in order to construct our research model. Also, for ERP benefits, we integrate them into three categories based on the above-mentioned literature. The model includes three constructs (Shang & Seddon, 2000) for ERP benefits, namely: operational, business process and management, and strategic IT planning benefits; and three constructs (Bowersox et al., 1999) for firm competences of SCM, namely: operational process integration, customer and relationship integration, and planning and control process integration. We also hypothesize ERP benefits as antecedents to improve firm competences in supply chain management after an ERP system is operational and functionally stable. Therefore, this model investigates the relationships between the benefits of ERP implementation and the impacts on the firm competences in supply chain management. A detailed description of six constructs of firm competences of SCM and ERP benefits follows:

3.1. The firm competences of SCM

To improve firm performance, a firm needs to enhance its competences in SCM. The 21st Century Logistics framework identifies six firm competences as critical for logistics and supply chain management. Each competence is composed of multiple underlying capabilities, which guide philosophies and processes to complete specific logistics and supply chain activities. Based on this framework and suggestions from experts who have recently gone or are currently going through ERP or SCM systems implementations in Taiwanese IT industry, we identify the firm competences that may be impacted by ERP benefits and may lead to high supply chain performance and group them into three constructs. These are operational process integration, customer and relationship integration, and planning and control process integration.

3.1.1. Operational process integration

As Bowersox et al. (1999) defined in the 21st Century Logistics framework, operations involve the processes that facilitate order fulfillment and replenishment across the supply chain. Effective order fulfilment requires coordination both within a firm and between supply chain partners. Within the operational process, the firm needs to build up its capabilities of internal integration and material and service supplier integration. If an enterprise on the critical path can reduce operation time effectively, the order fulfilment ability of the SCM may be increased (Chen & Huang, 2006). Successful internal integration centers on the ability to merge multiple operational activities into one synchronized, synergistic process that involves cross-functional planning, sourcing, manufacturing and delivery to achieve excellence throughout the enterprise. Successful external supply chain integration, however, is, to a significant degree, related to internal process integration. Nowadays, the IT industry is shifting from push methods driven by anticipated sales to pull methods that focus on delivering value to customers through rapid response to demand. To do this profitably, firms must strip redundancy and duplication of materials and effort from supply chain operations. The task is all the more challenging because it is not limited to

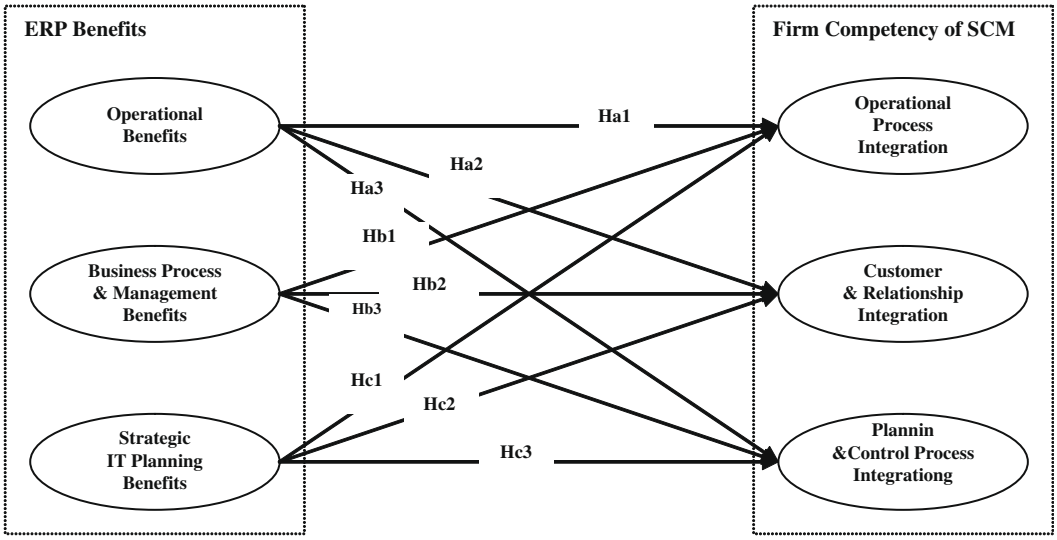

Fig. 1. The proposed conceptual model and research hypotheses.

Table 1
Definitions and constructs in the model.

Construct	Definitions	Key references
Operational benefits	The benefits of ERP systems that result from automating cross-functional processes, the use of data to better plan and manage production, manpower, inventory and physical resources, and from the monitoring and control of financial performance of products, customers, business lines and geographic areas	Shang and Seddon (2000), Stratman and Rothe (2002) and Vijay Vemuri and Palvis Shailendra (2006)
Business process and management benefits	Business process benefits are expected to improve the day-to-day business process (long-term impact), reflecting long-term benefits such as improved customer responsiveness, improved customer satisfaction, on-time delivery, and improved decision making	Shang and Seddon (2000), Stratman and Rothe (2002) and King and Teo (1996)
Strategic IT planning benefits	Focuses on the benefits that arise from the system's ability to support business growth, reduce the cost of maintaining legacy systems, and capture the benefits derived from facilitating business learning, empowerment of staff and higher employee morale and satisfaction	Shang and Seddon (2000), Fiedler et al. (1996), Kettinger et al. (1994), King and Teo (1996) and Segars et al. (1998)
Operational process integration	Firm has the competences to support customer requirements, and supplier integration links externally performed work into a seamless congruency with internal work processes	Bowersox et al. (1999)
Planning and control process integration	Planning and control process integration refers to information systems to support the wide variety of operational configurations needed to serve diverse market segments, and the capabilities to develop the measurement systems that facilitate segmental strategies and process	Bowersox et al. (1999)
Customer and relationship integration	Firm has the competences to build lasting distinctiveness with customers of choice; also refers to the ability to develop and maintain a shared mental framework with customers and suppliers regarding inter-enterprise dependency and principles of collaboration	Bowersox et al. (1999)

internal activities. It requires linking internal work processes with those of material and service providers. Thus, an important integration decision is how many material and service suppliers to include in synchronized operations. That is, integrating operations with material and service suppliers to form a seamless flow of internal and external work overcomes the financial barriers of vertical ownership while retaining many of the benefits. A successful SCM of operational process integration, cross-functional unification, standardization, simplification, compliance, structural adaptation, operational fusion, and supplier management capabilities must be developed.

3.1.2. Customer and relationship integration

The customer and relationship construct includes customer and relationship integration. Customer integration builds lasting distinctness with customers of choice. Relationship integration refers to the ability to develop and maintain a shared mental framework with customers and suppliers regarding inter-enterprise dependency and principles of collaboration (Bowersox et al., 1999). Quality relationships can improve trust among a firm's members, and further promote their attitude to and intentions of knowledge sharing in an organization. Extending the relations from simple buyer–supplier cooperation to a whole supply network form raw material suppliers to final customers provides several advantages that included for the buyers a large pool of suppliers, reduced transaction costs, market transparency, purchase transparency, lower prices, dynamic pricing models, control of maverick, buying, and lower inventory costs. For the suppliers the benefits among others are large pools of buyers, real time information, time to market, aggregation of small orders, efficient fund transfer (Kelle & Akbulut, 2005). The customer and relationship integration category is a competence that enables firms to build lasting distinctiveness with customers of choice and to share a mentality with customers and suppliers regarding interdependency and principles of collaboration. Six capabilities drive customer integration (Bowersox et al., 1999). The idea of segmental focus is that firms should identify core customers best suited to be their business clients, and then meet or exceed expectations by providing unique value-added services. Relevance requires firms to satisfy not only existing needs, but also those that may emerge. Responsiveness is the efficient and effective accommodation of unique customer requests. Flexibility is the capability to adapt to unexpected operational circumstances. Role specificity is the capability to clarify leadership processes and establish shared, as contrasted with individual, enterprise responsibility. Information sharing involves the willingness to exchange key technical, financial, operational and strategic information with others in the supply chain. Any firm seeking supply chain performance must demonstrate strong commitment to the customization required for effective customer and relationship integration. Bowersox et al. (1999) suggested, in the Supply Chain 2000 framework and assessment process, that the best way to start the search for integration gaps is by reviewing how a firm coordinates with customers and relationships (Bowersox et al., 1999). Thus, it is clear that consistent success ultimately depends on a firm's competence to create value for customers by providing products and services at prices that cover total cost and provide a profit to meet customers' needs.

3.1.3. Planning and control process integration

The planning and control process includes competences of technology and planning integration refers to information systems capable of supporting the wide variety of operational configurations needed and to the development of measurement systems that facilitate segmental strategies and processes to serve diverse market segments (Bowersox et al., 1999). Across the supply chain, information technology and measurement systems must facilitate planning and control of integrated operations. As Bowersox et al. (1999) explain in the 21st Century Logistics framework, success of technology and planning integration rests upon six capabilities: information management, internal communications, connectivity, collaborative forecasting and planning, and activity-based and total cost management. Information management focuses on supply chain resource allocation through seamless transactions across the total order-to-delivery cycle. Internal communication uses technological systems to exchange information across functional boundaries in a timely, responsive, and usable format. Connectivity extends internal communications capability to supply chain partners. Collaborative forecasting and planning involves customers and suppliers developing a shared vision supported by a mutual commitment to jointly generated action plans. Activity-based and total cost management uses activity-based costing, budgeting, and measurement to obtain a comprehensive picture of the cost/

revenue contribution of a specific customer or product. Operational excellence must be supplemented and supported by integrated planning and measurement competences. This process involves joining technologies to monitor, control, and facilitated overall supply chain performance.

3.2. The ERP benefits

Markus and Tanis (2000) and Markus and Yanis (2000) identify various reasons that motivate organizations to implement ERP systems. They also suggest that there should be a connection between the reasons for adoption of ERP systems and the benefits. Shang and Seddon (2000) compiled an ERP benefits list from ERP vendor success stories published on the World Wide Web. Follow-up interviews and analysis led Shang and Seddon to classify the different types of ERP benefits into five categories. Stratman and Rothe (2002) identified eight theoretically important ERP competences and Vijay Vemuri and Palvis Shailendra (2006) developed a set of initial measurement items (see Appendix A) for each competences of ERP. Based on Shang and Seddon's classification of ERP benefits, Stratman and Roth's competences of ERP and Vemuri's measurement items, we must also heed the suggestions of experts who have recently been or are currently going through ERP or SCM systems implementations in Taiwanese IT industry. We conclude that ERP benefits may improve firm competences in SCM, and group those benefits into three constructs. There are operational benefits, business process and management benefits, and strategic IT planning benefits.

3.2.1. The operational benefits of ERP

Shang and Seddon (2000) determined that the operational benefits of an ERP system arise from automating cross-functional process. They encompass both efficiency-based and effectiveness-based performance improvements in order to capture the enterprise-wide business benefits. Those benefits are expected to improve day-to-day operations (short-term impact), which include improved inventory control, improved cash management, and reduction in operating costs (Stratman & Rothe, 2002). They will also lead to improvements in production, information and customer service quality. Byrne and Heavey (2006) has argued that an ERP system can improve information sharing between the supply chains echelons. Today's ERP solutions offer even more benefits. Many vendors have begun to enhance their offerings with extended supply chain applications in an effort to create a seamless, integrated information flow, from suppliers through manufacturing and distribution. ERP is a suite of application modules that can link back-office operations to front-office operations, as well as internal and external supply chains. Latamore (1999) has argued that a core ERP system for operational function must include applications for forecasting, production scheduling, material planning, inventory control, warehouse management, etc. Thus, comparing the firm competences of SCM with those operational benefits of ERP, it is not hard to find some correlation between the operational benefits of ERP and the firm competences of SCM. Vijay Vemuri and Palvis Shailendra (2006) have developed a set of scales to directly measure the operational benefits, and these form the basis of our measurement items and our hypothesis. Hence, in our model, the firm competences of SCM in operational process integration, customer and relationship integration, and planning and control process integration are driven by the operational benefits of ERP. Therefore, the following research model and hypotheses are given:

Ha1. The operational benefits of ERP positively affect firm competences of SCM in operational process integration.

Ha2. The operational benefits of ERP positively affect firm competences of SCM in customer and relationship integration.

Ha3. The operational benefits of ERP positively affect firm competences of SCM in planning and control process integration.

3.2.2. The business process and management benefits of ERP

The business process and management benefits arise from the use of databases to plan better and for better management of production, manpower, inventory and physical resources. Also, firms are getting benefits from monitoring and controlling of financial performance in the contexts of products, customers, business lines and geographic area (Shang & Seddon, 2000). Since ERP systems can automate business processes and enable process changes, one would expect them to offer all of the above types of benefits. Also, since process knowledge is dynamic, organizations may derive benefits from procedures and practices that continuously allow fundamental business processes to be improved in a systematic fashion. That is, business process and management benefits are expected to improve the day-to-day business process (long-term impact) which reflects long-term benefits. Those benefits include improving customer responsiveness, customer satisfaction, on-time delivery, and decision making (Karsak & Ozogul, 2009). They are provided by centralizing the database and built-in data analysis capabilities. Furthermore, ERP systems provide information benefits to process and resources management. Firms are likely to increase control over their suppliers by gaining power from information (Stratman & Rothe, 2002; King & Teo, 1996), and ERP applications, or similar integration solutions, are a leading tool for this purpose. By integrating computers and data communications into the business process, companies benefit from exchanging information electronically, in that they reduce paperwork, minimize cost and improve response time (Goutsos & Karacapilidis, 2003) When an ERP system is implemented, the advantage of business process skills is demonstrated by understanding of how the business operates, and the ability to predict the impact of a particular decision or action on the rest of the enterprise. At the same time, those benefits, such as production orders, capability planning, resource allocation, production tracking and reporting, inventory management, waste/reject tracking, etc., also meet the competences needs of supply chains (Latamore, 1999). Hence, the research contained in the above-mentioned literature and the classification of ERP benefits of Shang and Seddon (2000) form the basis of our scale items and hypothesis. In our model, firm competences of SCM in operational process integration, customer and relationship integration, and planning and control process integration are also driven by the business process and management benefits of ERP. Therefore, the following research model and hypotheses are given:

Hb1. The business process and management benefits of ERP positively affect firm competences of SCM in operational process integration.

Hb2. The business process and management benefits of ERP positively affect firm competences of SCM in customer and relationship integration.

Hb3. The business process and management benefits of ERP positively affect firm competences of SCM in planning and control process integration.

3.2.3. The strategic IT planning benefits of ERP

The strategic IT planning benefits of ERP are a consequence of the system's ability to support business growth, reduce the cost of maintaining legacy systems, and capture the benefits derived from facilitation business learning, empowerment of staff and higher levels of employee morale and satisfaction (2000). Strategic IT planning is an indication of an organization's competence

in matching IT capabilities with the changing, cross-functional business requirements of the enterprise. Several studies suggest that it is critical that a firm's information technology systems support the strategic goals of the firm (Fiedler, Grover, & Teng, 1996; Kettinger, Grover, Guha, & Segars, 1994). Strategic IT planning helps to ensure that IT development goals are aligned with the needs of the organization (King & Teo, 1996; Segars, Grover, & Teng, 1998). Dynamically changing business needs may require operations strategy planners to continually evaluate cross-functional business goals and define the information systems capabilities that are required to support these goals. Thus, a formal strategic IT planning process is posited to contribute to the quality of this ongoing activity, especially activity that can leverage supply chain processes to enhance performance need in each particular operating arena. Segars et al. (1998) have developed a set of scales to capture the domain of strategic IT planning, and these form the basis of our items and related hypotheses about the strategic IT planning benefits of ERP. In our model, the firm competences of SCM on operational process integration, customer and relationship integration, and planning and control process integration are driven by strategic IT planning benefits of the ERP system. Therefore, the following research model and hypotheses are given:

Hc1. The strategic IT planning benefits of ERP positively affect firm competences of SCM in operational process integration.
Hc2. The strategic IT planning benefits of ERP positively affect firm competences of SCM in customer and relationship integration.
Hc3. The strategic IT planning benefits of ERP positively affect firm competences of SCM in planning and control process integration.

4. Research design

4.1. Instrument design and refinement

To develop the research instrument, where possible measurement items were adapted from the literature. We followed a two-stage normative process of scale development (Churchill, 1979). In the first stage, we identified the constructs of ERP benefits and SCM competences that were hypothesized to be important antecedents of successfully creating firm competences in SCM. Our point for construct definition and measurement item selection was a literature review encompassing the areas of ERP and SCM in strategic management, operations management, organizational behavior, and information technology. This was followed by iterations among site visits, interviews, and further literature reviews. In total, we visited one business that had operational ERP systems and another that had both ERP and SCM systems, where we gathered first-hand knowledge about ERP systems and SCM systems at multiple levels in the organization, including users, IT technicians, engineers, production planners, supervisors, managers, and consultants. Visits were supplemented by structured and unstructured interviews with executives knowledgeable about ERP and SCM systems and adoption practices. This process resulted in our research model, which identified the constructs of ERP benefits, SCM competences (see Fig. 1), and a set of initial measurement items. New measures were developed following standard psychometric scale development procedures (Boudreau, Gefen, & Straub, 2001). The domain of the relevant construct was initially specified, and the items were subsequently developed based on the conceptual definition. Based on the constructs, we developed a questionnaire draft. The backward translation method (with the material translated from English into Chinese, and back into English; versions compared; discrepancies resolved) was used to ensure consistency between the Chinese and the original English versions of the instrument (Mullen, 1995). The preliminary instrument was pilot tested and reviewed by IT managers from eight Taiwanese IT firms, doctoral students and EMBA students. The items were modified following a pre-test of the survey instrument with a sample of 15 experts, using the same data collection methods, following procedures recommended by Churchill (1997). The pre-tests indicate that the questionnaire is deemed appropriate to examine the relationship between ERP and SCM in Taiwanese IT firms. A seven-point Likert scale anchored at "strongly disagree" (1), "strongly agree" (7), and "neither agree nor disagree" (4) was used to collect most responses, while some questions involved absolute numbers, percentages or binary variables. The final questionnaire consisted of 35 items for six constructs, and 10 questions pertaining to industry, number of employees, estimated revenue, type of ERP/SCM related software used, and the number of months and years since the ERP/SCM system initiatives.

4.2. Data collection

In the second stage, survey data was collected from a sample of Taiwan IT companies listed in the Taiwan Stock Exchanges (TSE) and screened according to whether they had operational ERP systems or SCM systems or both. Empirical, confirmatory analyses were conducted using the items tapping into each of all the constructs and measurement items defined in stage 1 to produced refined scales. Each item's scale had measurement properties that fit into the commonly accepted guidelines for reliability and validity. The authors screened the candidates by accessing the database of the TSE and the companies' websites. Finally, 138 firms were included in the sample population. For the respondents' convenience, the questionnaire was delivered to the presidents of the 138 firms in one of two forms: e-mail and regular mail. Along with the questionnaire, a personalized letter was sent to the president. It asked that he/she select the proper strategic business units (SBU) in his/her company and forward the questionnaires to the selected IT/MIS managers. To encourage participation, all the informants were assured that their response would be kept confidential and would be shown only in an aggregated form. The authors also promised to give a copy of the results to all respondents. After several follow-up e-mails and phone calls, 285 usable responses were received from 76 IT/MIS managers, 158 senior engineers and 42 others employed by 138 companies. The total process of data collection started from Q1 2006 and ended in Q2 2007. Table 2 presents a summary of the demographic characteristics of the respondents.

Table 2
Demographic characteristics of the respondents.

	Number	Percentage (%)
Type of industry		
PC systems	101	35.5
Peripherals	24	8.4
Communications	10	3.5
Semiconductors	105	36.8
Consumer electronics	20	7.0
Components	20	7.0
Software	5	1.8
	285	100
Job classification		
Top IT/MIS manager	76	26.7
Lower-middle IT/MIS manager	158	55.4
Purchase related	12	4.2
Marketing related	39	13.7
	285	100

5. Data analysis

5.1. The measurement model

We propose a structural equation model (SEM) to analyze the relationship between ERP benefits evaluation factors and firm performance of SCM. Joreskig introduced the structural equation model in the early 1970s; it comprises two parts, the measurement model and the structural equation model. The measurement model specifies how latent variables or hypothetical constructs depend upon or are indicated by the observed variables. The model describes the measurement properties (reliabilities and validities) of the observed variables. The structural equation model specifies the causal relationships among the latent variables, describes the casual effects, and assigns the explained and unexplained variance (Joreskig & Sorbom, 1996a, 1996b). One of the unique characteristics of an SEM is its ability to provide parameter estimates for relationships among unobserved variables. Structural equation modeling resembles path analysis by providing parameter estimates of the direct and indirect links between observed variables (Joreskig & Sorbom, 1996a, 1996b). Fig. 1 illustrates the hypothesized model used in this work, which chooses the model components and the structural relationships among them, based on the above proposition.

Exploratory factor analysis (EFA) was first conducted to check whether the proposed factor structures are indeed consistent with the actual data. The factor structures suggested by the EFA match the one proposed in the research model. The various loadings are shown in Table 3. Next, confirmatory factor analysis (CFA) was conducted to check the reliability and validity of the measurement model. In this measurement model, no unidirectional path was specified between any latent variables. Instead, a covariance was estimated to connect each latent variable with every other latent variable. This measurement model was estimated using AMOS6.0. The properties of the measurement model are summarized in Table 4.

5.2. Instrument reliability and validity

To validate our measurement model, content validity, construct validity (including Cronbach alpha), convergent validity, and discriminant validity were assessed. Content validity was established by ensuring consistency between the measurement items and the extant literature. This was done by interviewing senior practitioners and pilot-testing the instrument. For the construct validity, the items were tested for scale reliability.

The Cronbach alpha ranges from .831 to .954 for the six constructs, indicating a high internal consistency. Except for one item in firm competences of SCM in the planning and control process integration construct, all the items were retained. Various reliability test results are shown in Table 5. The construct validity is also tested for convergent and discriminant validity. We assessed

Table 3
Results of exploratory factor analysis.

Construct	Components							
	Items	1	2	3	4	5	6	Communality
Operational benefits of ERP	EOP1	**.744**	.093	.186	.201	.207	.102	**.690**
	EOP2	**.788**	.228	.211	.233	.138	.168	**.819**
	EOP3	**.819**	.216	.155	.241	.186	.186	**.869**
	EOP4	**.843**	.222	.195	.224	.187	.143	**.905**
	EOP5	**.806**	.125	.228	.149	.212	.153	**.808**
	EOP6	**.833**	.183	.168	.154	.175	.085	**.818**
Strategic IT planning benefits of ERP	ESIP1	.134	**.784**	.154	.175	.193	.227	**.776**
	ESIP2	.276	**.595**	.167	.194	.179	.121	**.542**
	ESIP3	.168	**.802**	.170	.197	.205	.137	**.801**
	ESIP4	.105	**.789**	.189	.168	.230	.096	**.759**
	ESIP5	.144	**.752**	.210	.100	.290	.074	**.729**
	ESIP6	.189	**.713**	.133	.179	.128	.170	**.639**
Operational process integration of SCM	SOP1	.211	.135	**.759**	.196	.143	.207	**.740**
	SOP2	.187	.180	**.694**	.239	.103	.276	**.693**
	SOP3	.273	.180	**.663**	.216	.078	.204	**.641**
	SOP4	.194	.183	**.765**	.153	.106	.175	**.722**
	SOP5	.128	.240	**.807**	.191	.086	.187	**.805**
	SOP6	.176	.134	**.761**	.246	.196	.231	**.780**
Business process and management benefits of ERP	EBPM1	.199	.287	.200	**.781**	.076	.196	**.816**
	EBPM2	.128	.332	.223	**.757**	.145	.164	**.797**
	EBPM3	.184	.088	.242	**.655**	.191	.114	**.579**
	EBPM4	.280	.266	.160	**.721**	.180	.149	**.749**
	EBPM5	.262	.124	.194	**.709**	.233	.117	**.693**
	EBPM6	.212	.120	.262	**.712**	.263	.123	**.719**
Customer and relationship integration of SCM	SCR1	.198	.394	.176	.294	**.534**	.206	**.639**
	SCR2	.147	.447	.073	.227	**.577**	.170	**.640**
	SCR3	.245	.374	.092	.247	**.575**	.126	**.615**
	SCR4	.237	.325	.084	.212	**.679**	.141	**.695**
	SCR5	.286	.225	.238	.155	**.726**	.157	**.765**
	SCR6	.268	.222	.172	.220	**.728**	.152	**.752**
Planning and control process integration of SCM	SPC1	.184	.190	.108	.190	.197	**.692**	**.635**
	SPC2	.141	.105	.242	.123	.039	**.689**	**.581**
	SPC3	.087	.091	.265	.049	.154	**.651**	**.536**
	SPC4	.064	.132	.232	.124	.212	**.708**	**.638**
	SPC5	.157	.169	.140	.157	.016	**.755**	**.667**
Eigenvalues		15.773	2.544	2.380	1.739	1.476	1.139	
% of Variance		45.066	7.269	6.799	4.968	4.218	3.255	
Cumulative %		45.066	52.335	59.135	64.103	68.321	71.576	

Table 4
Summary of constructs.

Construct name	Construct identifier	Initial number of items	Number of items carried forward to the analysis
Operational benefits of ERP	EOP	6	6
Business process and managerial benefits of ERP	EBPM	6	6
Strategic IT planning benefits of ERP	ESIP	6	6
Operational process integration of SCM	SOP	6	6
Customer and relationship integration of SCM	SCR	6	6
Planning and control process integration of SCM	SPC	6	5

Table 5
Summary of the measurement model.

Latent construct	Indicator	Mean	Std. Dev.	Item-to total correlation	Standard loading	Cronbach alpha	Composite reliability	Average variance extracted estimates
EOP	EOP1	5.45	.607	.762	.759	.954	.953	.774
	EOP2	5.69	.602	.858	.903			
	EOP3	5.73	.638	.895	.945			
	EOP4	5.71	.679	.925	.964			
	EOP5	5.53	.653	.848	.845			
	EOP6	5.53	.647	.854	.847			
EBPM	EBPM1	5.63	.594	.823	.895	.918	.918	.652
	EBPM2	5.62	.578	.807	.883			
	EBPM3	5.21	.537	.665	.666			
	EBPM4	5.63	.583	.785	.850			
	EBPM5	5.36	.633	.755	.751			
	EBPM6	5.32	.615	.773	.776			
ESIP	ESIP1	5.27	.607	.796	.905	.915	.914	.642
	ESIP2	5.49	.659	.636	.627			
	ESIP3	5.22	.592	.820	.922			
	ESIP4	5.22	.598	.797	.828			
	ESIP5	5.21	.661	.778	.784			
	ESIP6	5.37	.688	.727	.700			
SPC	SPC1	4.79	.596	.645	.741	.831	.831	.500
	SPC2	4.95	.612	.607	.676			
	SPC3	4.85	.614	.577	.639			
	SPC4	4.86	.616	.654	.727			
	SPC5	4.76	.649	.662	.738			
SOP	SOP1	5.22	.552	.790	.816	.924	.925	.672
	SOP2	5.19	.579	.759	.808			
	SOP3	5.17	.633	.721	.759			
	SOP4	5.22	.552	.760	.797			
	SOP5	5.16	.585	.834	.873			
	SOP6	5.18	.591	.816	.859			
SCR	SCR1	5.20	.649	.715	.778	.902	.903	.607
	SCR2	5.16	.622	.701	.748			
	SCR3	5.29	.714	.697	.749			
	SCR4	5.29	.725	.747	.783			
	SCR5	5.33	.720	.762	.806			
	SCR6	5.42	.660	.770	.810			

convergent validity by reviewing the t tests for the factor loadings and by examining composite reliability and average variance extracted from the measures (Hair, Anderson, Tatham, & Black, 1998). Although many studies have used 0.5 as the threshold reliability of the measures, 0.7 is a recommended value for a reliable construct (Chin, 1998). As shown in Table 5, our composite reliability values range from 0.831 to 0.953. For the average variance extracted by a measure, a score of 0.5 indicates acceptability (Fornell & Larcker, 1981). Table 5 shows that the average variances extracted by our measures range from 0.5 to 0.774, which are above or equal to the acceptability value. In addition, Table 6 exhibits the loadings of the measures in our research model. As expected, all measures are significant on their path loadings at the level of 0.01. Finally, we verified the discriminant validity of our instrument by comparing the average variance extracted (AVE) (Fornell & Larcker, 1981) of each latent construct to the square of correlation between this construct and every other construct, which has been used by some IS studies (Segars & Grover, 1998). The result in Table 7 confirms the discriminant validity: the square of the average variance extracted for each construct is greater than the levels of correlations involving the construct. The results of the inter-construct correlations also show that each construct shares larger variance with its own measures than with other measures.

5.3. The structural model

The structural model tested in the present study is shown in Fig. 1. This model was estimated using AMOS 6.0. The statistic of 2.097 is within the acceptable limit (Byrne, 1989). Several goodness of fit indices of the measurement model have been widely used in IS research and are presented in Table 8. The Tucker-Lewis index, also known as the non-normed fit index (NNFI), and the comparative fit index (CFI) are all above .90, suggesting a good fit between the structural model and the data. RMSEA is well below the suggested threshold value of 0.08 (Brwone & Cudeck, 1992). The parsimony-adjusted NFI of the revised model is 0.867, which

Table 6
Loadings of the measures.

Construct	Items	Standard loading	Standard error	*t*-Value	Construct	Items	Standard loading	Standard error	*t*-Value
Operational benefits of ERP	EOP1	.759	.054	15.658	Operational process integration of SCM	SOP1	.816		
	EOP2	.903	.048	20.847		SOP2	.808	.067	15.516
	EOP3	.945	.048	22.812		SOP3	.759	.074	14.489
	EOP4	.964	.050	24.007		SOP4	.797	.062	15.790
	EOP5	.845	.054	18.722		SOP5	.873	.066	17.269
	EOP6	.847				SOP6	.859	.066	17.130
Business process and management benefits of ERP	EBPM1	.895	.067	16.505	Customer and relationship integration of SCM	SCR1	.778		
	EBPM2	.883	.066	16.222		SCR2	.748	.069	13.339
	EBPM3	.666	.063	11.872		SCR3	.749	.080	13.178
	EBPM4	.850	.067	15.556		SCR4	.783	.080	14.020
	EBPM5	.751	.072	13.722		SCR5	.806	.080	14.405
	EBPM6	.776				SCR6	.810	.073	14.496
Strategic IT planning benefits of ERP	ESIP1	.905	.082	13.821	Planning and control process integration of SCM	SPC1	.741		
	ESIP2	.627	.083	10.278		SPC2	.676	.090	10.432
	ESIP3	.922	.081	14.020		SPC3	.639	.089	9.973
	ESIP4	.828	.077	13.294		SPC4	.727	.090	11.220
	ESIP5	.784	.085	12.722		SPC5	.738	.096	11.362
	ESIP6	.700							

Table 7
Comparison of AVE and squared correlations.

Var.	EOP	EBPM	ESIP	SOP	SCR	SPC
EOP	**.774**					
EBPM	.371	**.652**				
ESIP	.275	.365	**.642**			
SOP	.318	.410	.293	**.498**		
SCR	.438	.475	.558	.328	**.672**	
SPC	.249	.304	.272	.430	.340	**.607**

*AVE are on the diagonal; square correlations are off-diagonal.

is significantly above the suggested value of .60 (Williams & Hazer, 1986). Williams and Hazer (1986), indicating highly acceptable levels of parsimony and fit of the overall model. All of these fit indices are acceptable, suggesting that the overall structural model provides a good fit with the data. The results of estimating the structural model are presented in Fig. 2.

The squared multiple correlation (SMC) values, which are similar to in regression analysis, show that this model accounts for 47% of the variance in operational process integration, 70% of the variance in customer and relationship integration, and 40% of the variance in the planning and control process integration construct. All of the paths are significant and positive, supporting the corresponding hypotheses. These findings are discussed below. A summary of the hypotheses test results is provided in Table 9.

Fig. 2 and Table 9 show the results and illustrate that the firm competences of supply chain management on operational process, customer and relationship, and planning and control process integration were positively influenced by ERP benefits. These results basically support all of our hypotheses.

Table 8
Fit indices of structural model.

χ^2	1149
df	548
χ^2/df	2.097
Normed fit index (NFI)	.867
Tucker–Lewis index	.919
Comparative fit index (CFI)	.925
GFI	.802
RMR	.021
RMSEA	.062
Lower bound	.057
Upper bound	.067

6. Discussion of results

The main objective of this study is to investigate the relationship between ERP benefits and firm competences of SCM. The findings show how ERP benefits impact on firm competences of SCM. Based on these results, some interesting propositions are exhibited.

6.1. ERP benefits contribute to firm competences of SCM in operational process

With all hypotheses supported, the empirical results provided strong overall validation for the research model. The hypotheses Ha1, Hb1, and Hc1 are strongly supported (0.23, 0.39, 0.30, $p < 0.001$), demonstrating that firm competences of SCM on operational process integration are positively impacted by operational, business process and management, and strategic IT Planning benefits of ERP. This result can be interpreted to mean that those items of constructs enhance firm competences of SCM in operational process integration. The goal of SCM on operational process integration is high-level basic service at the lowest total cost. Linking internally performed work into a seamless process supports customer requirements, and integrating operations with material and service suppliers to form a seamless flow of internal and external work overcomes the financial barriers of vertical ownership while retaining many of the benefits. The analysis of data results and our visits to businesses and plants brought out the fact that since the ERP system integrates disparate processes across the organization, the end result is more streamlined business processes, smooth and transparent flow of information, and linking of the flow of internal and external work. In the case company, the smooth and transparent flow of information improved on- time delivery and inventory management. The improvement has resulted in decreased costs. In short, the operational functions of

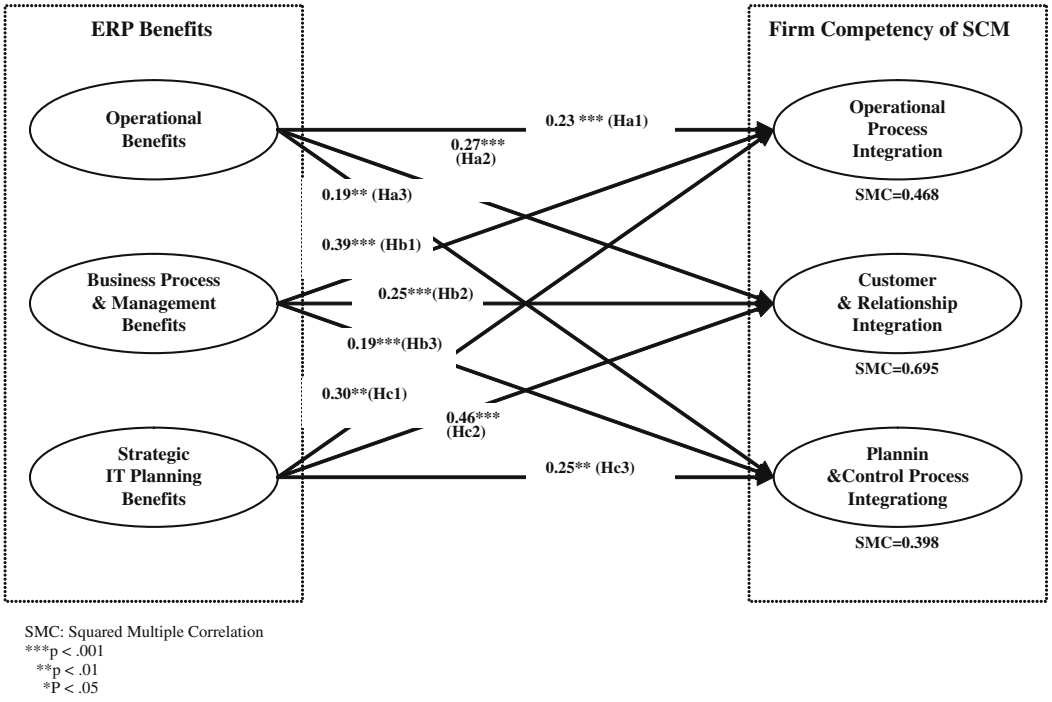

Fig. 2. Structural model results.

Table 9
Summary of the structural model.

Hypotheses	Path coefficient	Results
Ha1. The operational benefits of ERP positively affect firm competences of SCM in operational process integration.	.23	Supported
Hb1. The business process and management benefits of ERP positively affect firm competences of SCM in operational process integration.	.39	Supported
Hc1. The strategic IT planning benefits of ERP positively affect firm competences of SCM in operational process integration.	.30	Supported
Ha2. The operational benefits of ERP positively affect firm competences of SCM in customer and relationship integration.	.27	Supported
Hb2. The business process and management benefits of ERP positively affect firm competences of SCM in customer and relationship integration.	.25	Supported
Hc2. The strategic IT planning benefits of ERP positively affect firm competences of SCM in customer and relationship integration.	.46	Supported
Ha3. The operational benefits of ERP positively affect firm competences of SCM in planning and control process integration.	.19	Supported
Hb3. The business process and management benefits positively affect firm competences of SCM in planning and control process integration.	.19	Supported
Hc3. The strategic IT planning benefits of ERP positively affect firm competences of SCM in planning and control process integration.	.25	Supported

ERP benefit rationalized processes, standardization, rework and error reduction and cost reduction. Through those ERP benefits, firms can strip redundancy and duplication of materials from supply chain operations. The business process and management benefits of ERP include capabilities of customization and improved resource management, forecasting, and quality management improvement, which are the most important impact factors (path coefficient is .39) in improving operational process integration. ERP facilitates creating the capabilities of order fulfillment and replenishment across the supply chain. Furthermore, strategic IT planning has especially significant ERP benefits for firms with the ability to support business growth, reduce the cost of maintaining legacy systems, and capture the benefits derived from facilitation business learning, and for those firms' ability to make important integration decisions, because they now know how many material and service suppliers to include in synchronized operations.

6.2. ERP benefits contribute to firm competences of SCM in customer and relationship

Our analysis strongly supports hypotheses Ha2, Hb2, and Hc2 (0.27, 0.25, 0.46, $p < 0.001$), implying that three constructs of ERP benefits are important antecedents of developing firm competences of SCM in customer and relationship integration. Customer and relationship integration is a competence that enables firms to build lasting distinctiveness with customers of choice. It requires that firms assess their own strengths and weaknesses in service capability in terms of the needs and desires of top customers. The number of customers requiring services or service performance in which the firm is not strong increases the number of special requests outsourced to third-party providers. An ERP system can potentially improve transparency across the supply chain by removing information distortions and increasing the speed of information by reducing information delays (Akkermans et al., 2003). Hence, through the business process and management benefits of ERP, a firm has the ability to access correct and consistent data in a timely manner. Managers can easily get the integrated information to make decisions, and have efficient resource management and production control to meet customer needs. That is, out of ERP benefits firms create the competences of supply chain management in better resource management, better investment spending and higher quality decision making. Another area that has impacted customer satisfaction is quality control. Our visits to businesses and plants brought out the fact that in the old, legacy-based system, employees had to complete a multi-page form which was then sent to data processing, where it was subsequently subcontracted for data

entry. It would take four to five weeks to get the necessary reports and to conduct the root cause analyses. Today, quality control activities and related analyses are performed daily, so that customer's quality demands are better met. Furthermore, a segmental focus reflects the belief that all customers do not have the same service expectations, and do not necessarily want or deserve the same overall level of service. Firms need to have the competence of efficient and effective accommodation of unique customer requests. Customization means tailoring a product to meet the specific needs of an individual customer, and involves the delivery of a wide variety of customer-specific goods or services quickly, efficiently, and at low cost. Such integration competence provided by the ERP system would insure that the unique product ordered by the customer is properly translated into the appropriate production orders. Moreover, the sophistication of ERP systems makes it possible to construct catalogues containing a large number of standard end products. In short, the research results illustrate that the operational benefits of ERP can improve the response time, change the management process and meet customer needs proactively to improve customer satisfaction. The strategic IT planning benefits of ERP are the most important impact factors (path coefficient is .46) in improving firm competence of SCM in customer and relationship integration. Firms also have the ability to share information, such as key technical, financial, operational and strategic information, with others in the supply chain. Those ERP benefits can inspire firms to achieve the vision and create the measurement structures that will enable supply chain partners to share and reward risk and responsibility and to support business alliances.

6.3. ERP benefits contribute to firm competences of SCM in planning and control process

The hypotheses Ha3, Hb3 and Hc3 are supported (0.19, 0.19, 0.25, $p < 0.01$), demonstrating that firm competences of SCM in planning and control process integration are positively impacted by operational, business process and management, and strategic IT planning benefits of ERP. This result can be interpreted as indicating that those items of constructs enhanced firm competences of SCM in planning and control process integration. Firm competences of SCM in planning and control process integration require information systems capability to support the wide variety of operational configurations needed to serve diverse market segments. Supply chain effectiveness depends on the exchange of timely and accurate information across customers, material and service suppliers, and internal functional areas. The case company indicated that ERP systems have benefits of error reduction and efficiency in the order processing and order fulfilment processes that touch the customer. ERP systems improved decisions in inventory management, and manpower planning in these processes contributed to cost reduction, and proactive and timely service to customers increased customer satisfaction. The cost reduction contributed to increased profits, increased customer satisfaction, and increased sales and market share. Those ERP benefits show the contributions of other streamlined processes to the achievement of strategic goals of SCM. The company also indicated that the cost of doing business was dramatically reduced once the ERP system was installed and functionally stable. The reduction of work stoppages and better data controls have improved corporate performance and promoted labor efficiencies. Simultaneously, the ability to make accurate commitments to trading partners and improve turn-around time has increased the after market business, thereby resulting in increased revenues. Furthermore, firm competences of SCM in activity-based and total cost methodology and comprehensive metrics are supported by operational benefits of ERP. Although firms are frequently frustrated by the inability of traditional measurement systems to monitor logistical processes that extend across functional and firm boundaries, through the ERP system firms can more easily have activity-based costing, budgeting, and measurement to obtain a comprehensive picture of the cost/revenue contribution of a specific customer or product. Thus, there are important operational benefits and business process and management benefits of ERP for establishing enterprises as well as for overall supply chain performance standards and measures.

Our discussions with experts indicated that for most Taiwanese IT companies, the initial decision to replace all of the legacy systems with an ERP system may be caused by competition in the markets, or requests from customers on the supply chain, or just the need to replace the legacy systems. One of the primarily reasons was based on a cost-benefit analysis for automation. In other words, the implementation objective of the ERP system was to automate the business, which was expected to lead to a lowered IT budget, increased efficiency of workers, reduced error rate and more timely availability of accurate and reliable information. Once managers and other users learned more about the new ERP system's capabilities, however, they recognized that improved information accessibility and visibility across the enterprise allowed them to make more effective operational, tactical and, in some cases, strategic decisions. This resulted in better manpower planning, enhanced inventory control, and radical improvement of on-time delivery of parts. Eventually, the consequential increase in customer satisfaction led to an unexpected change in business strategy, which was to increase the company's market share in the after market. The above discussion reveals the potential contributions of ERP benefits to the firm competences of SCM.

7. Conclusion and limitations

This paper provides empirical justification for a model that identifies three key constructs of ERP benefits and three key constructs of SCM competences. It confirms that all constructs of ERP benefits enhance firm competences of SCM. More specifically, there are 18 main items of ERP benefits that impact on 17 items of SCM competences. In view of this result, we can conclude that the confirmation of the overall proposed model was important because it provided empirical evidence that ERP benefits do really impact firm competences of SCM.

In considering the results of this study, although the validation of the variables that measure the ERP benefits and SCM competences came from the data of Taiwanese IT companies, the nature of the factors appeared to be universal, because Taiwanese IT companies have achieved outstanding results over the past two decades, and have the capabilities to cooperate with all of the members on the supply chain closely so as to be able to react to any unexpected changes. The validity and reliability of this measure were acceptable. The measure also took into account many different facets of the supply chain, from relationships with suppliers to relationships with customers and the activities in between.

The study developed measures for ERP benefits' impact on the SCM competences model. Although validity and reliability checks were performed on the measures, there is still room for improvement. If we can use more measures for firm competences drawn from the software or consultant companies in stead of self-reporting by the firms, the results will be more convincing. The limitation is that it seems most of the consultant companies did not keep records or did not trace back or evaluate the firm's performance after the project was finished. Furthermore, while the sample consisted of Taiwanese IT industry companies, it might be better to collect data from IT industry companies of other countries, such as Korea, Singapore, and China.

As the concept of SCM is complex and involves a network of companies all involved in the effort of producing and delivering a final product, its entire domain cannot be covered in just one study. Future research can expand the domain of SCM practice by considering additional constructs such as financial impact, comprehensive metrics, and JIT/lean capability, which were not included in this study.

Appendix A
ERP benefits and firm competences in SCM definitions

Items		Descriptions
Operational Benefits of ERP		
EOP1	Cycle time reduction	Complex assortments, shorter cycle times, less inventory
EOP2	Error reduction	Less time and fewer errors in order process
EOP3	Standardization	Establishment and standardization of cross-functional procedures to improve order-entry process and order-fulfillment process
EOP4	Operations cost	ERP allows for better control of business operating expenses, decreased operations cost
EOP5	Customer satisfaction	Meet customer needs proactively and more efficiently
EOP6	Flexibility	Improved engine repair scheduling and delivery to build business flexibility
Business process and management benefits of ERP		
EBPM1	Customization and resource management	Tailoring products to meet specific needs of customer, and improving resource management to support customization
EBPM2	Decision making	More effective decision making by workers
EBPM3	Linkage	The efficiency of the ERP entity's supplier network has been improved
EBPM4	Quality management	Improved quality management and quality control
EBPM5	Better forecasting;	To increase market share and improve market value
EBPM6	Scheduling	Allows users to generate supply chain schedules addressing customer needs
Strategic IT planning benefits of ERP		
ESIP1	Changes and planning	IT plans are redesigned as required to meet evolving conditions
ESIP2	Business innovations	Build business innovations and generate product differentiation
ESIP3	Business growth	Market share growth after firm using ERP?
ESIP4	Business alliance	Partnership with customers and supporting business alliance
ESIP5	IT infrastructure capability	IT cost reduction, and increased IT infrastructure capability to support business globalization
ESIP6	Information management	Integrated and real time to effectively support information
Operational process integration		
SOP1	Cross-functional unification	Operationalization of potentially synergistic activities into manageable operational processes
SOP2	Standardization	Establishment of cross-functional policies and procedures to facilitate synchronous operations
SOP3	Compliance	Adherence to established operational and administrative policies and procedures
SOP4	Structural adaptation	Extent to which the network structure and deployment of physical assets has been modified to facilitate integration
SOP5	Supplier management	Extended management to include hierarchical structure of suppliers' suppliers
SOP6	Operational fusion	Linkage of systems and operational interfaces to reduce duplication and redundancy, and dwell while maintaining operational synchronization
Customer and relationship integration		
SCR1	Segmental focus	Development of customer specific programs designed to generate maximum customer success
SCR2	Responsiveness	Accommodation of unique and/or unplanned customer requirements
SCR3	Relevancy	Maintenance and modification of customer focus to continuously match changing expectations
SCR4	Flexibility	Adaptation to unexpected operational circumstances
SCR5	Role specificity	Clarity concerning leadership process and establishment of shared versus individual enterprise responsibility
SCR6	Information sharing	Willingness to exchange key technical, financial, operational, and strategic information
Planning and control process integration		
SPC1	Information management	Commitment and capability to facilitate supply chain resource allocation through seamless transactions across the total order-to-delivery cycle
SPC2	Internal communication	Capability to exchange information across internal functional boundaries in a timely, responsive, and usable format
SPC3	Connectivity	Capability to exchange information with external supply chain partners in a timely, responsive, and usable format
SPC4	Collaborative forecasting and planning	Customer collaboration to develop shared visions and mutual commitment to jointly generated action plans
SPC5	Activity-based and total cost management	Adoption and commitment to activity-based costing, budgeting, and measurement of comprehensive identification of cost/revenue

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