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Why are enterprise resource planning systems indispensable to supply chain management?

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ABSTRACT

Supply chain design is becoming a core competency, and the enterprise resource planning (ERP) system is expected to be an integral component of supply chain management (SCM). Installing an ERP system is, however, expensive and risky. IT managers must decide how to use their limited resources and invest in the right product. Can an ERP system directly improve SCM competency? This study proposes a conceptual framework featuring the ERP benefits and SCM competencies, and examines the impacts of the former on the latter. The results confirm the operational, managerial, and strategic benefits of ERP for the SCM competencies, but not the IT infrastructure and organizational benefits as significant predictors of them. Moreover, more than 80% of respondents think it necessary to first adopt an ERP system as the backbone of company operations before deploying other enterprise systems (ES), such as the SCM system.

1. Introduction

The globalization of competition means that apart from ensuring their own successful operation, firms that hope to survive must establish highly responsive supply chains, with up-, mid-, and downstream partners. How to best improve corporate SCM capabilities in order to improve overall supply chain performance has therefore become an important issue in corporate management (Park et al., 2005; Whit et al., 2005). As Kuei et al. (2002) have pointed out, SCM is a network of autonomous or semi-autonomous business entities collectively responsible for procurement, manufacturing and distribution activities associated with one or more families of related products. Enterprises in the supply chain are likely to increase control over their suppliers and enhance their SCM competencies by gaining power from information. To meet these new challenges and the need for a competent supply chain, companies around the world have invested heavily in Information Technology (IT), and take advantage of IT systems to radically alter the conduct of business in both domestic and global markets. In particular, many firms have implemented company-wide systems called ERP systems, which are designed to integrate and optimize various business processes, such as order entry and production planning, across the entire firm (Mabert et al., 2001). This investment has also made possible the sharing of large amounts of information along the supply chain, and has enabled real-time collaboration between supply chain partners, providing organizations with forward visibility, thus improving inventory management and distribution. ERP, which allows for the transmission and processing of information necessary for synchronous decision making, can be viewed as an essential enabler of SCM competencies (Akkermans et al., 2003; Hsu et al., 2009; Sanders, 2007). Furthermore, many firms deploying ERP systems considered extending system scope mainly to integrate their suppliers, customers or both to the system, to provide additional e-commerce or e-business operations and to increase supply chain functionalities (Olhanger and Selldin, 2003).

When ERP systems are fully realized in a business organization, they can be expected to yield many benefits, such as reduction of cycle time, faster transactions, better financial management, the laying of the groundwork for e-commerce, linking the entire organization together seamlessly, providing instantaneous information, and making tacit knowledge explicit (Mabert et al., 2001; Davenport and Brooks, 2004; Shang and Seddon, 2000; Murphy and Simon, 2002; Al-Mashari et al., 2003). ERP can provide the digital nervous system and the backbone in an organization to respond swiftly to customers and suppliers (Cox et al., 2000; Mabert et al., 2001). As reported in Akkermans et al. (2003), ERP systems are widely believed to contribute to SCM in technical areas such as standardization, transparency and globalization. ERP systems are a leading tool for this purpose, and are always expected to be an integral component of SCM (Nah et al., 2001; Themistocleous

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et al., 2004). The potential benefits of an integrated ERP system are such that many organizations are willing to undertake the difficult process of conversion.

Adopting an integrated ERP system, however, has mixed results in terms of a firm's performance, and some academic research is much more suspicious of its benefits. First of all, implementing an ERP system is costly and risky; it requires a large amount of capital, and its inflexibility makes it often difficult to implement across all departments within a large corporation (Mabert et al., 2001). Some businesses have invested enormous sums of money in ERP or IT without positive results (Gupta and Kohli, 2006; Ehie and Madsen, 2005; Strassman, 1990).

Hitt et al. (2002), on the other hand, produced multiyear, multifirm ERP implementation and financial data that shows evidence of short-run gain during implementation, but a lack of post-implementation data at the time they conducted their study meant they were unable to estimate the long-run impact. Gattiker and Goodhue (2004) argued that high interdependence among organizational sub-units contributes to positive ERP-related effects because of ERPs facilitate coordination and information flows. When differentiation among sub-units is high, however, organizations may incur ERP-related compromise or design costs. A survey by Mabert et al. (2003a) found some improvements in managers' perceptions of performance, but that few firms had reduced direct operational costs. In addition, Hendricks et al. (2007) observed improvements only in profitability, not in stock returns. Data for improvements in profitability is also stronger in the case of early adopters of ERP systems. Although their results are not uniformly positive across the different enterprise systems (ES, including ERP, SCM, and CRM systems), they are encouraging in the sense that despite the high implementation costs, they do not find persistent evidence of negative performance associated with ES investments.

More recent evidence has, on the contrary, demonstrated large benefits and uncovered significant productivity gains from IT investments: for example, as reported in McAfee (2002), an in-depth case study of an ERP implementation and its effects on performance at a single firm. This longitudinal research presents initial evidence of a causal link between IT adoption and subsequent improvement in operational performance measures, as well as evidence of the timescale for these benefits. Hunton et al. (2002) experimentally tested the relationship between ERP and performance by presenting 63 certified analysts at a financial services firm with the hypothetical case of a company, and comparing these analysts' initial earning forecasts with their forecasts after they are told that the hypothetical firm has committed to investing in an ERP system. The results show that the revision in earnings is positive, thereby providing supports for the hypothesis that implementation of ERP systems has a positive effect on performance. Huang et al. (2007) proposed an integrated theoretical model that demonstrated that the company's implementation of ERP has a positive effect on the process capital of its Intellectual Capital (IC); the process capital then affects the customer capital, which ultimately translates into business performance.

Many academic researchers have contributed by confirming the relationship between SCM and firm performance (Du, 2007; Closs and Mollenkopf, 2004; Byrd and Davidson, 2003; Gunasekaran et al., 2004) or by confirming the relationship between ERP implementation and firm performance (Hendricks et al., 2007; Mabert et al., 2001, 2003a; McAfee, 2002; Hitt et al., 2002; Gupta and Kohli, 2006; Ehie and Madsen, 2005; Kalling, 2003). Moreover, determining how to integrate various ERP modules into SCM, for planning, control and execution of materials, resources and operations has recently become important (Koh et al., 2006; Samaranayake and Toncich, 2007; Ho, 2007). Research focusing on the relationship between ERP benefits and SCM competencies is limited and inconclusive (Hsu et al., 2009). Accordingly, the current research addresses this gap in the literature by analyzing the ERP benefits and SCM competencies. The evidence that the Taiwanese IT industry has had a highly successful growth experience with SCM competencies shows that it can be documented, and lessons can be learned.

This article focuses 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 SCM competencies. A conceptual research model is proposed. Third, the reasons for collecting data from Taiwanese IT firms through a survey and interviewing of experts are presented. And fourth, the overall proposed model is validated.

2. Literature review

2.1. Supply chain management

The term "supply chain" is used in the present research in the spirit of the value chain concept. A supply chain is a dynamic process and involves the constant flow of information, materials, and funds across multiple functional areas both within and between chain members (Jain et al., 2009). "Supply chain management" as the integration of key business processes among a network of interdependent suppliers, manufacturers, distribution centers, and retailers in order to improve the flow of goods, services, and information from original suppliers to final customers, with the objectives of reducing system-wide costs while maintaining required service levels (Simchi-Levi et al., 2000). 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 marketplace.

2.2. Competencies of SCM

The literature on SCM is quite vast and dispersed across many areas. In recent years, supply chain design and its competencies and performance have received much attention from researchers and practitioners. From the RBV viewpoint, all firms have capabilities; however, a firm will usually focus on certain capabilities consistent with its strategy, and the firm's most important capabilities are called competencies (Barney, 1991). Accordingly, competencies emphasize technological and production expertise at a specific point along the value chain (Vickery et al., 1993). Closs and Mollenkopf (2004) proposed a framework that identifies six firm competencies critical for SCM and is based on the work of Bowersox et al. (1999). Each competency is composed of multiple underlying capabilities, which guide philosophies and processes to complete specific logistics and supply chain activities and to overcome obstacles that undermine both internal and external integration of value-added supply chain operations.

2.3. Enterprise resource planning

Different researchers have suggested different ways of defining ERP. 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 are improved considerably by incorporating best practices, so as to facilitate greater managerial control, speedy decision making and huge reduction of business operational cost. The definition of ERP used in the present research is as stated by Wallace and Kremzar (2001):

> "An enterprise-wide set of management tools that balances demand and supply, containing the ability to link customers

and suppliers into a complete supply chain, employing proven business processes for decision making, and providing high degrees of cross-functional integration among sales, marketing, manufacturing, operations, logistics, purchasing, finance, new product development, and human resources, thereby enabling people to run their business with high levels of customer service and productivity, and simultaneously lower costs and inventories; and providing the foundation for effective e-commerce."

2.4. ERP benefits

For years organizations have striven to realize the benefits of ERP, ES and IT investments. Integrated ERP systems affect all aspects of a business (Kalling, 2003; Hong and Kim, 2002). Dhillon (2005) claimed that real benefits reside not within the IT domain but, rather, in the changes in the organizational activities that the IT system has enabled.

Several researchers have classified the types of ERP benefits, and have indicated that some approaches may be appropriate techniques for evaluating the performance or benefits of ERP systems. Irani and Love (2001) proposed a framework for meeting the challenges associated with categorizing benefits that is based on the work of Harris (1996). Mabert et al. (2000) surveyed about 500 business executives, and revealed the following performance outcomes of ERP: quickened response time, increased interaction across the enterprise, improved order management, improved customer interaction, improved on-time delivery, improved supplier interaction, lowered inventory levels, improved cash management, and reduced direct operating costs. Stratman and Rothe (2002) defined eight theoretical ERP competency constructs. They argued that a firm's ERP competency must be used effectively in order to truly harness the capabilities of an ERP system for competitive advantage. Vemuri and Shailendra (2006) developed a set of initial measurement items for each ERP competency. Shang and Seddon (2000) classified the different types of ERP benefits into five groups as follows: IT infrastructure, operational, managerial, strategic and organizational benefits. Those studies have addressed the classification and content of ERP benefits. On the basis of the literature review presented above, we finally developed a framework consisting of five constructs and 32 measures. It is mainly based on the model of Shang and Seddon (2000), and merges the benefits and measures we have proposed (Table 1).

2.5. The impact of ERP on SCM

In the past decade, nearly all literature on ERP has focused on reasons for implementation and on the challenges of the implementation project itself. Several distinct research streams on ERP are observed in the recent literature. Although the initial focus of ERP was "within the organization," many organizations have addressed supply chain challenges with their ERP systems (Davenport and Brooks, 2004). Several studies have demonstrated a relationship between ERP benefits and SCM.

Although there is no analytical framework for measuring the impacts of ERP systems on SCM competencies, 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 covers all of the information systems, including ERP systems. Akkermans et al. (2003) studied the future impact of ERP systems on SCM. Their 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. Moreover, they identified key limitations of current ERP systems in providing effective SCM support. On the basis of the literature review presented above, we believe that the relationship between ERP and SCM suggested by the above-mentioned authors may be useful in the development of our research model and hypotheses.

3. The research model and hypotheses

Our research model is shown in Fig. 1. The definitions of various constructs in it are summarized in Table 1. In this study, the authors base the research model on selected literature on ERP and on SCM. The goal of our research is to examine in more detail ERP benefits' impact on SCM competency. Thus, our research model encompasses and relies on two areas: ERP benefits as referred to in the classification of ERP benefits, in Shang and Seddon (2000), and SCM competencies, based on the 21st Century Logistics framework as extended by Bowersox et al. (1999). The model includes five constructs for ERP benefits, namely: operational, managerial, strategic, IT infrastructure, and organizational benefits, and three constructs for SCM competencies, namely: operational, planning and control, and behavioral processes. Based on Shang and Seddon (2000) classification of ERP benefits, Stratman and Rothe (2002) competencies of ERP, and Vemuri and Shailendra (2006) measurement items, we conclude and hypothesize that ERP benefits are antecedents to improving SCM competencies after an ERP system is operational and functionally stable. Therefore, this model investigates the relationships between the benefits of ERP adoption and SCM competencies. A more detailed description of SCM competencies follows.

3.1. ERP benefits and the operational process of SCM

As Closs and Mollenkopf (2004) defined the operational process involves the processes that facilitate order fulfillment and replenishment across the supply chain. Effective order fulfillment requires coordination both within a firm and among supply chain partners. Within the operational process, firm competencies include customer integration, internal integration, and supplier integration.

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. Hsu et al. (2009) provide empirical support for the impact of operations capabilities on SCM practices. That result is consistent with resource-based and competency-based views of the firm. ERP is a suite of application modules that can link back-office to front-office operations, as well as internal and external supply chains. Since ERP systems can automate business processes and enable process changes, one would expect them to improve the SCM competencies in operational process and improve customer responsiveness and satisfaction (Venkatesh, 2006). Bowersox et al. (1999) and Vemuri and Shailendra (2006) have developed a set of scales to directly measure the SCM competencies and ERP benefits, and these form the basis of our measurement items and our hypothesis. Hence, in our model, the SCM competencies in operational process are driven by ERP benefits. In order to examine what categories of ERP benefits can predict SCM competency, the following research model and hypotheses are given:

Ha1: The operational benefits of ERP positively affect the operational process of SCM.

Hb1: The managerial benefits of ERP positively affect the operational process of SCM.

Table 1
The constructs of SCM competencies and ERP benefits.

Constructs	Items and definitions	
Operational process	Firm has the competences to support customer requirements, and supplier integration links externally performed work into a seamless congruency with internal work processes	
SOP1	Relevancy	Maintenance and modification of customer focus to continuously match changing expectations
SOP2	Responsiveness	Accommodation of unique and/or unplanned customer requirements
SOP3	Cross-functional unification	Operations of potentially synergistic activities into manageable operational processes
SOP4	Standardization	Establishment of cross-functional policies and procedures to facilitate synchronous operations
SOP5	Operational fusion	Linkage of systems and operational interfaces to reduce duplication, redundancy, and dwell while maintaining operational synchronization
SOP6	Supplier management	Extended management to include hierarchical structure of suppliers' suppliers
Planning and control process	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	
SPCP1	Information management	Commitment and capability to facilitate supply chain resource allocation through seamless transactions across the total order-to-delivery cycle
SPCP2	Internal communication	Capability to exchange information across internal functional boundaries in a timely, responsive, and usable format
SPCP3	Connectivity	Capability to exchange information with external supply chain partners in a timely, responsive, and usable format
SPCP4	Collaborative forecasting and planning	Customer collaboration to develop shared visions and mutual commitment to jointly generated action plans
SPCP5	Functional assessment	The development of comprehensive functional performance measurement capability
SPCP6	Activity-based and total cost methodology	Adoption and commitment to activity-based costing, budgeting, and measurement of comprehensive identification of cost/revenue contribution of a specific entity such as a product
Behavioral process	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	
SBP1	Role specificity	Clarity concerning leadership process and establishment of shared versus individual enterprise responsibility
SBP2	Guidelines	Rules, policies, and procedures to facilitate inter-enterprise collaboration, leverage, and conflict resolution
SBP3	Information sharing	Willingness to exchange key technical , financial, operational, and strategic information
SBP4	Gain/risk sharing	Framework and willingness to apportion fair share reward and penalty
SBP5	Strategic alignment	Development of a common vision of the total value creation process and planning clarity concerning shared responsibility
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	
EOP1	Cost reduction	For better control of business operating expenses, decreased operations cost
EOP2	Cycle time reduction	Complex assortments, shorter cycle times, less inventory
EOP3	Productivity improvement	Power user involvement in user training for operational tasks
EOP4	Quality improvement	Improved quality management and control
EOP5	Customer service improvement	Meet customer needs proactively and more efficiently
EOP6	Error reduction	Less time and fewer errors in order process
Managerial benefits	Managerial 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	
EMNG1	Resource management	Tailoring products to meet specific needs of customer, and improving resource management to support customization
EMNG2	Decision making and planning	More effective decision making by workers
EMNG3	Performance improvement	Reduce cost, increase revenues, and improve market value
EMNG4	Partnership with customer and vendor	Management within and outside the firm's boundaries between groups
EMNG5	Scheduling	Allows users to generate supply chain schedules addressing customer needs
EMNG6	Quality management	Improved quality management and quality control
Strategic 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	
ESTG1	Worldwide expansion	Support for business growth
ESTG2	Business alliance	Support for business alliance
ESTG3	Business innovations	Building business innovations and absorb radical change routinely
ESTG4	Cost leadership	Building cost leadership by reduce inventory-carrying cost and lower labor cost
ESTG5	Product differentiation	Generate product differentiation including customization
ESTG6	External linkages	Building external linkages to have better connectivity with customer and supplier
IT infrastructure benefits	Involving building business flexibility, IT cost reduction, and increased IT infrastructure capability	
EIT1	Flexibility	Building business flexibility for current and future changes
EIT2	IT cost reduction	Reduction in cost of maintaining legacy systems
EIT3	Enabling e-commerce	Increased IT infrastructure capability
EIT4	Information management	Integrated and real time to effectively support information
EIT5	Improve IT architecture	Standardize procedures across different locations
EIT6	Single interface	Present a single interface to customer and consolidate multiple different systems of the same type
Organizational benefits	Relating to support organizational changes, facilitate business learning, empowering, and build common visions	
EOG1	Changing work patterns	Change management processes; breadth and broader horizon
EOG2	Organizational learning	Facilitating organizational learning and training for access of enterprise information
EOG3	Empowerment	Training for decision making skills and worker empowerment for taking actions
EOG4	Common vision	Building common vision
EOG5	employee morale	Better employee morale and satisfaction
EOG6	Behavior	Training for decision making skills

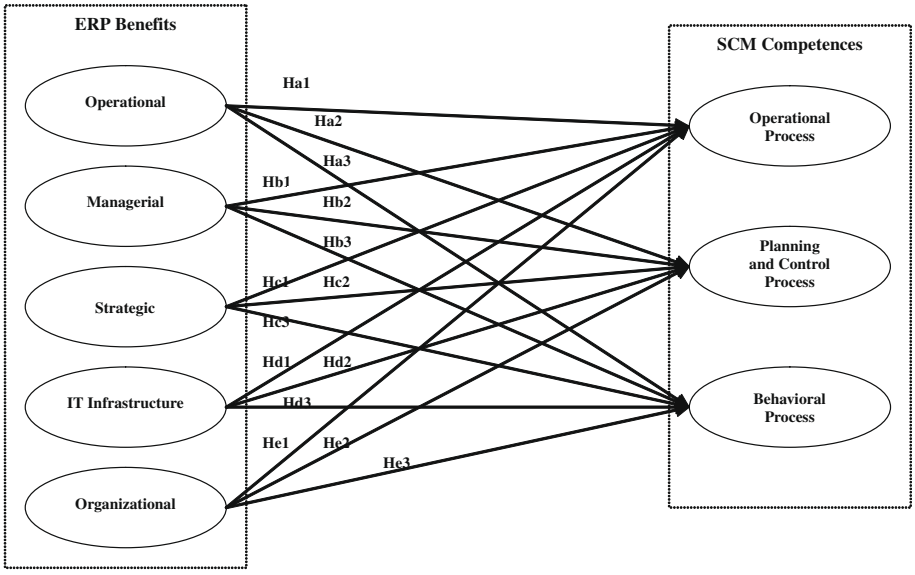

Fig. 1. The proposed conceptual model and research hypotheses.

Hc1: The strategic benefits of ERP positively affect the operational process of SCM.
Hd1: The IT infrastructure benefits of ERP positively affect the operational process of SCM.
He1: The organizational benefits of ERP positively affect the operational process of SCM.

3.2. ERP benefits and the planning and control process of SCM

The term "planning and control process" refers to the design, application, and coordination of information to enhance purchasing, manufacturing, customer order fulfillment, and resource planning. This competency includes access to databases that enable sharing of appropriate information among supply chain participants.

ERP systems are created by centralizing the database and building-in data analysis capabilities. These actions provide information benefits to process and resources management. When an ERP system is implemented, the advantage of business control process skills is demonstrated through an understanding of how the business operates and by 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, and waste or reject tracking, also meet the competencies needs of supply chains (Latamore, 1999). As reported in Bendoly and Jacobs (2005), that ERP software can be used to help firms create value, such as by eliminating information asymmetries, allowing simultaneous access to same data for planning and control, and providing on-time and real time information to jointly generated action plans.

Hence, the research contained in the above-mentioned literature and the classification of the ERP benefits of Shang and Seddon (2000) form the basis of our scale items and hypotheses. In our model, SCM competencies in the planning and control process are driven by ERP benefits. Therefore, the following research model and hypotheses are given:

Ha2: The operational benefits of ERP positively affect the Planning and Control Process of SCM.
Hb2: The managerial benefits of ERP positively affect the Planning and Control Process of SCM.
Hc2: The strategic benefits of ERP positively affect the Planning and Control Process of SCM.
Hd2: The IT infrastructure benefits of ERP positively affect the Planning and Control Process of SCM.
He2: The organizational benefits of ERP positively affect the Planning and Control Process of SCM.

3.3. ERP benefits and the behavioral process of SCM

The term "behavioral process" refers to the behavior that fosters supply chain coordination. It includes relationship integration. Relationship integration is a competency that enables firms to share a mentality with customers and suppliers regarding interdependence and principles of collaboration.

Bendoly and Jacobs (2005) argued that ERP can be used to facilitate inter- and intra-organization communication and collaboration needs, laying the foundation for external integration. Stock et al. (2000) asserted that higher levels of external integration are characterized by activities in collaboration with those of its suppliers and customers, and by a greater blurring of organizational distinctions between the logistics activities of the firm and those of its suppliers and customers. Adopting ERP systems can mean capturing the benefits derived from facilitating business learning, and may support these goals. Segars et al. (1998) have developed a set of scales to capture the domain of ERP benefits, and these form the basis of our items and related hypotheses about the benefits of ERP. In our model, the SCM competencies in the behavioral process are driven by ERP benefits. Therefore, the following research model and hypotheses are given:

Ha3: The operational benefits of ERP positively affect the Behavioral Process of SCM.
Hb3: The managerial benefits of ERP positively affect the Behavioral Process of SCM.
Hc3: The strategic benefits of ERP positively affect the Behavioral Process of SCM.
Hd3: The IT infrastructure benefits of ERP positively affect the Behavioral Process of SCM.
He3: The organizational benefits of ERP positively affect the Behavioral Process of SCM.

4. Research design

4.1. Instrument design and refinement

To develop the research instrument, where possible measurement items are adapted from the literature. We identify the constructs of ERP benefits and SCM competencies that are hypothesized to be important antecedents of successfully creating SCM competencies. Our point of departure for construct definition and measurement item selection is a literature review encompassing the areas of ERP and SCM in strategic management, operations management, organizational behavior, and information technology. This is followed by site visits, interviews, and further literature reviews. In total, we visit three IT firms with operational ERP systems, where we gather first-hand knowledge about ERP systems at multiple levels in the organization, including users, IT technicians, engineers, production planners, supervisors, managers, and consultants. Visits are supplemented by structured and unstructured interviews with executives knowledgeable about ERP systems adoption practices and SCM practices. This process results in our research model, which identifies the constructs of ERP benefits, SCM competencies, and a set of initial measurement items. New measures are developed following standard psychometric scale development procedures (Boudreau et al., 2001). The domain of the relevant construct is initially specified, and the items are subsequently developed based on the conceptual definition. Based on the constructs, we develop a questionnaire draft. The backward translation method (with the material translated from English into Chinese, and back into English; versions compared; discrepancies resolved) is used to ensure consistency between the Chinese and the original English versions of the instrument (Mullen, 1995). The preliminary instrument is pilot tested and reviewed by IT managers from eight Taiwanese IT firms, doctoral students and EMBA students. The items are 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 (1979). 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) is used to collect most responses, while some questions involve absolute numbers, percentages or binary variables. The final questionnaire consists of 47 items (after dropping five that were suggested by experts) for eight constructs, and 10 questions pertaining to industry, number of employees, estimated revenue, type of ERP and SCM related software used, and the number of months and years since the ERP and SCM system initiatives.

4.2. Data collection

The present study is based on the Taiwanese IT industry, and mainly consists of electronics manufacturers and semiconductor-related manufacturers (see Table 2), for two reasons.

4.2.1. Taiwan is a major player in and contributor to the world IT industry

Taiwan has achieved outstanding results in IT over the past two decades (Chang and Yu, 2001). Taiwan-made IT products dominate the world market in many categories. The world market share exceeds 50%. The semiconductor manufacturing and electronics manufacturing industry (IT industry) especially have evolved to prominence in Taiwan's recent economic development. The country currently ranks third in computer manufacturing and fourth in the semiconductor industry (Foundry ranked No. 1; IC design ranked No. 2) in the world (ITIS Project, MOEA, 2008). Keeping pace with thaw in the political relations between Taiwan and China, Taiwan's IT industries have been playing a key role in that country — which, of course, has earned a reputation as "the world's workshop." For instance, Taiwan's leading notebook computer manufacturers — who have, at times, enjoyed a world market share in excess of 70% — began moving their production sites to China in 2001. All of Taiwan's notebook production lines have now been relocated to China. Most of China's share of the global notebook market can thus actually be attributed to the contributions by Taiwanese firms. In addition, the 2008 global IT industry competitiveness report issued by Britain's Economist Intelligence Unit (EIU)

Table 2
Demographic characteristics of the respondents.

	Percentage		Percentage
Type of industry		*Total assets (USD)*	
Computer manufacturers		<30,000,000	39.7
PC systems	35.5	30,000,000–100,000,000	37.9
Peripherals	8.4	100,000,001–200,000,000	8.1
Communications	3.5	200,000,001–300,000,000	2.8
Consumer electronics	7.0	>300,000,000	11.5
Computer components	7.0		
Semiconductors		*Annual turnover (USD)*	
Foundry	4.9	<30,000,000	8.5
IC design	9.8	30,000,000–150,000,000	62.9
Packaging and testing	5.9	150,000,001–300,000,000	13.9
Mask	1.0	300,000,001–900,000,000	7.7
Equipment/material	10.9	>900,000,000	7.0
Others	4.2		
IT strategy consultants	1.8		
		ERP system implementation (month)	
Job classification		<6	7.2
Top IT/ERP/SCM	27.1	7–12	42.2
Middle IT/ERP/SCM	55.4	13–24	29.9
Others	17.9	>24	20.7
Number of employee		*ERP system on line (year)*	
<100	12.3	<0.5	8.3
101–500	44.0	0.5–1	25.0
501–1000	18.5	1–2	23.2
1001–2000	14.7	>2	43.5
>2000	10.5		

ranked Taiwan sixth out of the 64 countries rated in terms of IT industry competitiveness, behind only the US, Japan, South Korea, Britain, and Australia. As for IT industry labor productivity, Taiwan leads the world, with output value of US$386,413 per IT industry employee. The industry's structure is the predominant reason for this high productivity (EIU, 2008).

4.2.2. Taiwan has delivered the best practices of SCM

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 respects. 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 end-customer base still need to satisfy customer needs and react to new ones immediately. They are compelled to closely cooperate with all of the members in the supply chain so as to be able to react to 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 in those industries with a longer product life cycle. In today's fast-changing business environment, the Taiwanese IT industry depends heavily on its highly-effective SCM to achieve superb performance. It is important to understand the supply chain network in Taiwan, since that supply chain network may influence organizational effectiveness. For instance, Foxconn, which is a contractor for such world-famous products as the iPod and iPhone, relies on the support of its ERP system (SAP) to perform varied, high-quality, low-cost production tasks. Foxconn is also the major supplier to leading brand name companies such as Cisco, Dell, HP, Nokia, Sony, etc. (Foxconn, 2008).

Many scholars have conducted research into the SCM of firms in some developed countries (Benton and Maloni, 2005; Mabert et al., 2001; Lim and Palvia, 2001). These studies cover many types of industries, 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. The present study therefore presents the results of an empirical study of the impact of implementation of ERP on SCM competencies by IT manufacturers in Taiwan. Survey data is collected from a sample of Taiwanese IT companies listed in the Taiwan Stock Exchanges (TSE), mainly on electronics manufacturers (including: PC systems, peripherals, communications, consumer electronics, and computer components) and semiconductors-related manufacturers (including: foundry, IC design, packaging and testing, mask, and equipment/material provider), and screened according to whether they have operational ERP systems (see Table 2). Refined scales employing items drawn from constructs and measurement items referred to in the relevant literature are used to conduct empirical, confirmatory analyses. Each item's scale has measurement properties that fit into the commonly accepted guidelines for reliability and validity. The authors screen the candidates by accessing the database of the TSE and the companies' websites. Finally, 334 firms are included in the sample. For the respondents' convenience, the questionnaire is delivered to the presidents of the 334 firms in one of two forms: e-mail or regular mail. Along with the questionnaire, a personalized letter is sent to the president. It asks that he/she select the proper strategic business units (SBU) in his/her company and forward the questionnaire to the selected chief information officers, IT personnel, or operating managers who have implemented ERP systems. To encourage participation, all the informants are assured that their response will be kept confidential and will be shown only in an aggregated form. The authors also promise to give a copy of the results to all respondents. After several follow-up e-mails and phone calls, in all, 298 completed questionnaires were returned, of which 13 were invalid; 285 usable responses were received from 76 IT or ERP/SCM related managers, 158 lower-middle IT or ERP/SCM related managers and 51 others (who gave their job titles as "Director" or "Vice-President") employed by 138 companies. The valid responses include companies with a range of annual revenues from USD$10 millions to $800 millions, and workforces of 90 to 25000 employees. 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.

5. Analysis and results

5.1. The measurement model

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.

Second, multiple regression was conducted to verify the impacts of ERP benefits on SCM competencies. The measurement model was estimated using SPSS 14.0. The properties of the measurement model are summarized in Table 4.

Third, confirmatory factor analysis (CFA) was conducted to assess the measurement model; then, the structural relationships were examined. 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 AMOS 7.0.

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. Various reliability test results are shown in Table 4, which summarizes the item-to-total correlations and principal component scores for the sample. Item-to-total correlations exceed 0.30 (Dunn et al., 1994) in all cases. The principal component scores meet minimal levels of 0.30 and above in all cases (Hair et al., 1998). Thus, all of the scales reflect unidimensional characteristics. The Cronbach alpha ranges from .831 to .966 for the eight constructs, and are thus also satisfactory, as coefficient alphas meet or exceed 0.70 in all instances (Nunnally, 1978), indicating a high internal consistency. Except for one item in the behavioral process integration construct of SCM competencies, all the items were retained. The construct validity is also tested for convergent and discriminant validity. We assessed convergent validity by reviewing the t tests for the factor loadings and by examining composite reliability and average variance extracted from the measures (Hair et al., 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 4, our composite reliability values range from 0.925 to 0.992. For the average variance extracted by a measure, a score of 0.5 indicates acceptability (Fornell and Larcker, 1981). The average variances extracted by our measures range from 0.500 to 0.822, which are above or equal to the acceptability value. In addition, Table 5 exhibits the

Table 3
Exploratory factor analysis loading.

Construct	Items	1	2	3	4	5	6	7	8
Organizational benefits of ERP	EOG1	.907							
	EOG2	.910							
	EOG3	.912							
	EOG4	.866							
	EOG5	.811							
	EOG6	.779							
Strategic benefits of ERP	ESTG1		.780						
	ESTG2		.595						
	ESTG3		.804						
	ESTG4		.805						
	ESTG5		.767						
	ESTG6		.720						
IT infrastructure benefits of ERP	EIT1			.796					
	EIT2			.815					
	EIT3			.826					
	EIT4			.816					
	EIT5			.791					
	EIT6			.758					
Operational benefits of ERP	EOP1				.675				
	EOP2				.746				
	EOP3				.776				
	EOP4				.784				
	EOP5				.758				
	EOP6				.780				
Operational process of SCM	SOP1					.754			
	SOP2					.690			
	SOP3					.649			
	SOP4					.761			
	SOP5					.804			
	SOP6					.746			
Managerial benefits of ERP	EMNG1						.774		
	EMNG2						.756		
	EMNG3						.631		
	EMNG4						.716		
	EMNG5						.677		
	EMNG6						.691		
Planning and control process of SCM	SPCP1							.529	
	SPCP2							.568	
	SPCP3							.575	
	SPCP4							.675	
	SPCP5							.718	
	SPCP6							.726	
Behavioral process of SCM	SBP1								.688
	SBP2								.684
	SBP3								.643
	SBP4								.758
	SBP5								.700
Eigenvalues		18.244	5.649	2.543	2.486	1.684	1.676	1.440	1.130
% of Variance		38.817	12.018	5.412	5.290	3.584	3.567	3.063	2.404
Cumulative %		38.817	50.835	56.246	61.537	65.121	68.687	71.750	74.154

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 and Larcker, 1981) from each latent construct to the square of the correlation between this construct and every other construct, which has been used by some IS studies (Segars et al., 1998). The result, in Table 6, 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. Results of the structural model analysis

The structural model tested in the present study is shown in Fig. 1. This model was estimated using AMOS 7.0. The statistic of 2.073 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 (Browne and Cudeck, 1992). The parsimony-adjusted NFI of the revised model is 0.848, which is significantly above the suggested value of .60. Williams and Hazer (1986) indicate 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 50% of the variance in the operational process, 70% of the

Table 4
Summary of the measurement model.

Construct	Indicator	Mean	Std. dev.	Principal components scores	Item-to total correlation	Standard loading	Cronbach alpha	Composite reliability	Average variance extracted estimates
Operational	EOP1	5.45	.607	.682	.762	.761	.954	.936	.775
	EOP2	5.69	.602	.824	.858	.903			
	EOP3	5.73	.638	.873	.895	.944			
	EOP4	5.71	.679	.903	.925	.964			
	EOP5	5.53	.653	.806	.848	.845			
	EOP6	5.53	.647	.812	.854	.848			
Management	EMNG1	5.63	.594	.820	.823	.893	.918	.925	.653
	EMNG2	5.62	.578	.802	.807	.881			
	EMNG3	5.21	.537	.579	.665	.669			
	EMNG4	5.63	.583	.756	.785	.849			
	EMNG5	5.36	.633	.692	.755	.754			
	EMNG6	5.32	.615	.720	.773	.778			
Strategic	ESTG1	5.27	.607	.777	.796	.906	.915	.992	.642
	ESTG2	5.49	.659	.544	.636	.628			
	ESTG3	5.22	.592	.801	.820	.922			
	ESTG4	5.22	.598	.772	.797	.826			
	ESTG5	5.21	.661	.736	.778	.783			
	ESTG6	5.37	.688	.641	.727	.700			
Organizational	EOG1	5.34	.627	.938	.944	.984	.966	.965	.822
	EOG2	5.35	.631	.934	.942	.988			
	EOG3	5.36	.632	.942	.948	.983			
	EOG4	5.35	.614	.847	.876	.893			
	EOG5	5.44	.661	.784	.839	.801			
	EOG6	5.52	.648	.745	.804	.763			
IT infrastructure	EIT1	5.66	.622	.742	.780	.867	.925	.928	.685
	EIT2	5.61	.660	.795	.824	.902			
	EIT3	5.35	.659	.778	.819	.813			
	EIT4	5.26	.683	.763	.809	.797			
	EIT5	5.01	.870	.694	.712	.702			
	EIT6	5.49	.715	.769	.808	.870			
Behavioral process	SBP1	4.79	.596	.635	.645	.740	.831	.958	.500
	SBP2	4.95	.612	.589	.607	.678			
	SBP3	4.85	.614	.533	.577	.639			
	SBP4	4.86	.616	.637	.654	.729			
	SBP5	4.76	.649	.680	.662	.734			
Operational process	SOP1	5.22	.552	.742	.790	.816	.924	.989	.672
	SOP2	5.19	.579	.696	.759	.807			
	SOP3	5.17	.633	.643	.721	.761			
	SOP4	5.22	.552	.728	.760	.797			
	SOP5	5.16	.585	.807	.834	.872			
	SOP6	5.18	.591	.779	.816	.860			
Control and planning process	SPCP1	5.20	.649	.642	.715	.777	.902	.984	.607
	SPCP2	5.16	.622	.639	.701	.748			
	SPCP3	5.29	.714	.619	.697	.749			
	SPCP4	5.29	.725	.695	.747	.782			
	SPCP5	5.33	.720	.764	.762	.807			
	SPCP6	5.42	.660	.753	.770	.810			

variance in the planning and control process, and 41% of the variance in the behavioral process. Most of the paths are significant and positive, supporting the corresponding hypotheses, except for the organizational process and IT infrastructure. Fig. 2 show the results, and illustrate that the SCM competencies in the operational process, the planning and control process and the behavioral process were positively influenced by ERP benefits. These results basically support all of our hypotheses. Table 7 also reports the results of all regression models (see supplementary material file — Results of Multiple Regression Analysis, Tables 7 and 9).

6. Analysis of results

The main objective of this study is to investigate the relationship between ERP benefits and SCM competencies. The findings show how ERP benefits impact on SCM competencies.

6.1. The impact on the operational process

There are six items in the operational process of the SCM construct (Table 1). The regression results strongly support the hypotheses Ha1, Hb1, Hc1 ($.20^{***}$,[1] $.32^{***}$, $.21^{***}$), and the SEM results (Fig. 2) — the hypotheses Ha1, Hb1, Hc1 — are also supported ($.12^{**}$,[2] $.34^{***}$, $.21^{***}$), demonstrating that SCM competencies in the operational process are positively impacted by operational, managerial, and strategic benefits of ERP (Table 7). Especially, the high beta coefficients of some items, such as relevance (SOP1, .30), responsiveness (SOP2, .33), and supplier management (SOP6, .34), mean that the construct of managerial ERP benefits is the dominant predictor for SCM competencies in the operational process. Besides, both regression and SEM results show that the impact of IT infrastructure and

[1] $***$: beta coefficient is significant at $p < .001$; $**$: $p < .01$; $*$: $p < .05$.
[2] $***$: path coefficient is significant at $p < .001$; $**$: $p < .01$; $*$: $p < .05$.

Table 5
Loadings of the measures.

Construct	Items	Standard loading	Standard error	*t*-value	Construct	Items	Standard loading	Standard error	*t*-value
Operational	EOP1	.761	.054	15.695	Organizational	EOG1	.984	.064	19.386
	EOP2	.903	.047	21.048		EOG2	.988	.065	19.483
	EOP3	.944	.048	23.065		EOG3	.983	.065	19.353
	EOP4	.964	.049	24.123		EOG4	.893	.065	17.027
	EOP5	.845	.054	18.636		EOG5	.801	.072	14.848
	EOP6	.848				EOG6	.763		
Management	EMNG1	.893	.065	16.937	Operational process	SOP1	.816		
	EMNG2	.881	.064	16.631		SOP2	.807	.066	15.795
	EMNG3	.669	.063	11.831		SOP3	.761	.074	14.533
	EMNG4	.849	.065	15.856		SOP4	.797	.063	15.508
	EMNG5	.754	.073	13.663		SOP5	.872	.064	17.680
	EMNG6	.778				SOP6	.860	.065	17.317
Strategic	ESTG1	.906			Planning and control process	SPCP1	.777		
	ESTG2	.628	.085	14.477		SPCP2	.748	.069	13.291
	ESTG3	.922	.077	10.172		SPCP3	.749	.080	13.312
	ESTG4	.826	.077	14.702		SPCP4	.782	.080	14.034
	ESTG5	.783	.084	13.266		SPCP5	.807	.079	14.572
	ESTG6	.700	.079	12.609		SPCP6	.810	.072	14.633
IT infrastructure	EIT1	.867			Behavioral process	SBP1	.740		
	EIT2	.902	.052	21.371		SBP2	.678	.089	10.563
	EIT3	.813	.056	17.578		SBP3	.639	.089	9.973
	EIT4	.797	.059	17.002		SBP4	.729	.090	11.331
	EIT5	.702	.081	13.922		SBP5	.734	.095	11.407
	EIT6	.870	.058	19.902					

Table 6
Comparison of AVE and squared roots correlations.

Var.	EOP	EMNG	ESTG	EIT	EOG	SOP	SPCP	SBP
EOP	**.801**							
EMNG	.215	**.901**						
ESTG	.604	.390	**.808**					
EIT	.524	.457	.610	**.880**				
EOG	.153	.520	.355	.546	**.828**			
SOP	.532	.235	.565	.503	.324	**.705**		
SPCP	.750	.266	.692	.662	.314	.526	**.779**	
SBP	.547	.381	.647	.565	.367	.442	.561	**.820**

The shaded numbers in the diagonal row are square roots of the average variance extracted.

Table 8
Fit indices of structural model.

X^2	2091
df	1009
X^2/df	2.073
Normed fit index (NFI)	.848
Tucker–Lewis index	.909
Comparative fit index (CFI)	.915
GFI	.756
RMR	.024
RMSEA	.061
Lower bound	.058
Upper bound	.065

organizational benefits (Hd1, He1) are not significant. Both results can be interpreted to mean that operational, managerial, and strategic benefits of ERP enhance SCM competencies in the operational process.

6.2. The impact on the planning and control process

There are six items in the planning and control process of the SCM construct (Table 1). From the regression results (Table 7) it can be concluded that the hypotheses Ha2, Hb2, Hc2 are strongly supported ($.24^{***}$, $.24^{***}$, $.45^{***}$), and from the SEM results (Fig. 2), that the hypotheses Ha2, Hb2, Hc2 are also supported ($.25^{***}$, $.28^{***}$, $.48^{***}$), demonstrating that SCM competencies in the planning and control process are positively impacted by the operational, managerial, and strategic benefits of ERP. Especially, the strategic benefit of ERP is the most dominant predictor for SCM competencies in the planning and control process, because the beta coefficients of some items are high, such as information management (SPCP1, .41), internal communication (SPCP2, .50), connectivity (SPCP3, .38), collaborative forecasting and planning (SPCP4, .37), and functional assessment (SPCP5, .31). Just as with the construct of the operational process, both regression and SEM results show that the impact of IT infrastructure and organizational benefits (Hd2, He2) are not significant. Both results can be interpreted as indicating the operational, managerial, and strategic benefits of ERP enhanced SCM competencies in the planning and control process.

6.3. The impact on the behavioral process

There are five items in the behavioral process of the SCM construct (Table 1). The regression results (Table 7) support the hypotheses Hb3, Hc3 ($.26^{***}$, $.30^{***}$), and in the SEM results (Fig. 2), the hypotheses Hb3, Hc3 are also supported ($.19^{***}$, $.26^{***}$), demonstrating that the managerial and strategic benefits of ERP have the most impact on SCM competencies in

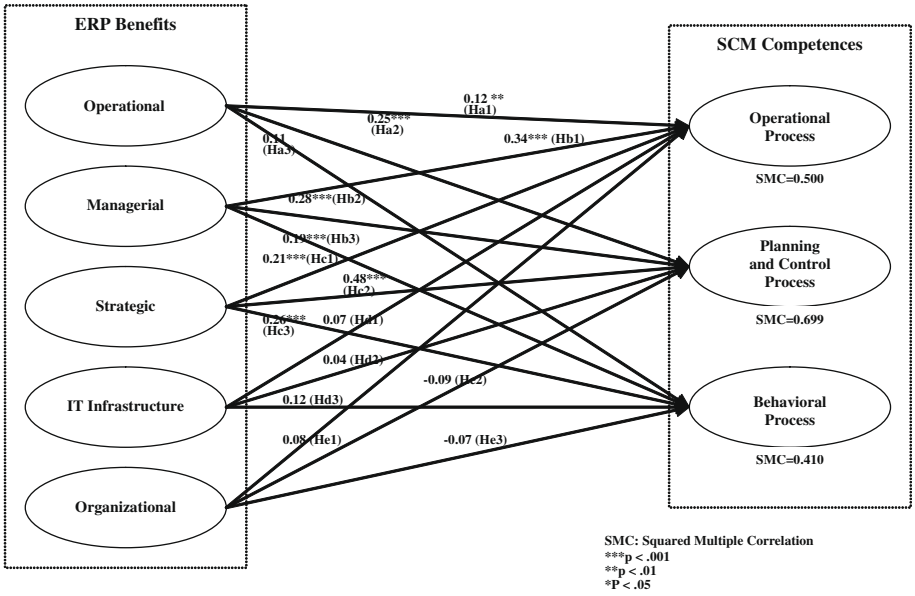

Fig. 2. Structural model results.

the behavioral process. Both regression and SEM results, however, indicate that the organizational benefit of ERP (He3) is not a significant predictor of the behavioral process.

7. Discussion and implications

The purpose of this paper was to propose and test a model of the relationship between the benefits to Taiwanese IT industries of their adoption of ERP systems and their impacts on SCM competencies. A number of important findings emerge that have both theoretical and managerial implications.

7.1. The operational, managerial, and strategic benefits are significant predictors for the SCM

A significant contribution of this study is the empirical test of theoretical assumptions in the extant literature of the influence of ERP benefits on SCM competencies. It confirms that of the five constructs of ERP benefits, the three that positively impact on SCM competencies are operational, managerial, and strategic benefits. This finding underscores the important role an ERP system plays in the functioning of supply chain organizations. The unequivocally positive results are not surprising, yet differ from those of most other studies, such as Hitt et al. (2002), Akkermans et al. (2003), Hendricks et al. (2007) and McAfee (2002). Three possible explanations for the remarkable finding are as follows.

7.1.1. Manpower and knowledge background of the Taiwanese IT industry

Much of Taiwanese IT firms' technology, and a considerable proportion of their knowledge, were transferred from the US (Chow et al., 2008). As we know, the United States and European countries have always been leaders in applying information systems. Moreover, a considerable number of Taiwanese IT firms' managers have been educated and worked in the US or Europe, and have obtained first-hand experience of using ERP systems or observed the adoption of these systems in the West. Accordingly, the experience and knowledge background of those managers may contribute to the adoption of ERP systems.

7.1.2. The center-to-satellite network structure of the Taiwanese IT industry

In terms of size, many of Taiwan's semiconductor manufacturers or electronics firms are large enterprises. TSMC, UMC, Foxconn, Acer, and ASUS are typical examples. Nevertheless, some Taiwanese IT firms are small and medium-size enterprises (SMEs). The scale of manufacturing SMEs in Taiwan is smaller than of those in the United States (US manufacturing SMEs typically have up to 1000 employees). No matter the size of those IT firms, their customers include such well-known large European and American companies as Intel, IBM, Apple, Dell, HP, Compaq, and Nokia. In contrast, the vast majority of the suppliers of those Taiwanese IT companies are SMEs. The manufacturing SMEs in Taiwan, however, have strong networks, and play an important role for much larger organizations within their multiple supply chains. Consequently, those SMEs operate in a satellite-type network structure around the larger Taiwanese IT companies. The success of the center-to-satellite network structure has greatly enhanced the competitiveness of Taiwanese IT manufacturers (Chen et al., 2008).

For large Taiwanese IT firms, ERP systems have been successfully used as the internal integration tool to centralize IS, which are often at multiple locations. In addition to internal process integration, the scope of systems integration has extended to collaborative supply chains partnerships, where suppliers are typically represented by SMEs. In order to facilitate information transmission and communication with partners, those SMEs (IT firms or upstream/downstream parts suppliers and satellite factories) have also adopted ERP systems or information systems. The systems thus satisfy the needs of large foreign customers to stay in close touch with their parts and components suppliers, and enhance overall supply chain performance. Furthermore, the government of Taiwan has systematically commissioned international firms to assist domestic manufacturers to adopt ERP systems. The MOEA's (Ministry of Economic Affairs, ROC) Project A is one such example. Satisfying the needs of customers and responding to the requirements of globalization and SCM thus inevitably becomes part of system specifications during the assessment, selection, and adoption stages. As a result, the enterprises in the supply chain not only have effective integrated processes within a business, but also have synchronization of the operations of all

partners in the supply chain. That is, ERP implementations in these Taiwanese companies have a significant impact on other companies, both large and small, within the global supply chain.

7.1.3. Effectiveness of system adoption

The informatization of Taiwanese large and medium-size IT firms makes them a model for the country's other firms and industries. Although the adoption of ERP systems at big firms is a relatively large and complex undertaking, the adequate budgeting and relatively good consulting, talent, and technical support resources at such firms work to good effect (Chen et al., 2008). On the other hand, the experts consulted for this study mentioned that since many small firms previously were poorly informatized, they have little historical burden during the adoption process, making system adoption much simpler than at large firms. These small firms invariably embark on a full-scale upgrading campaign when they decide to deploy a new system, and can often rely on consulting and assistance from their larger customers. In other words, the less well established a firm is in IS/ES/ERP, the less it will be locked in into its existing information infrastructure, and the more beneficial will be its use of ERP. Another possible issue is that while early adopters may have received some competitive advantages, late ones generally have benefited from upgraded systems and a better implementation knowledge base (Mabert et al., 2003b). As Tarantilis et al. (2008) have pointed out, ERP systems may comprise from parts independent from each other, which will plug and operate like Lego bricks into enterprise systems in contrast to previous closed non-modular architecture. As a result, an enterprise will not have to acquire the whole enterprise software suite, but will be able to choose each module even from different vendors and create a unique, cost-efficient and tailor-made solution. For these reasons, small firms can also be affordable and achieve excellent IS/ES/ERP system effectiveness, which enables them to significantly enhance their SCM capabilities. As reported in Mabert et al. (2003b), companies of different sizes approach ERP implementations differently across a range of issues. The benefits differ by company size. Larger companies report improvements in financial measures, whereas smaller companies report better performance in manufacturing and logistics.

To sum up, the comments from the follow-up interviews and the analysis of data brought out the fact that the operational cost was reduced for those Taiwanese IT firms that adopted an ERP system, probably because of the process improvement, which in turn is a result of better information flow among all of the entities in the supply chain. Better information flow leads to cycle time reduction, since, apart from the internal functions improvements, the supply chain will be better equipped to answer customers' real-time demands. Answering real-time demands in turn leads to an overall increase of productivity, and of product and delivery quality. Furthermore, such firms strip redundancy and duplication of materials from supply chain operations. The managerial benefits of ERP, which include better resource management and improved decision making and planning, performance improvement, partnership management, scheduling, and quality management, are (with a path coefficient of .34) the most important factors impacting the operational process of SCM. For example, they now know how many material and service suppliers to include in synchronized operations. Moreover, strategic benefits of ERP, which include building external linkages and extending the value chain, improve those firms' ability to make important integration decisions.

7.2. The IT infrastructural and organizational benefits are not significant predictors of SCM

Another important finding is that IT infrastructural and organizational benefits of ERP do not directly impact SCM competencies. The comments from the follow-up interviews suggest two possible explanations for this finding.

7.2.1. The need for flexible management and further system modifications

According to a prominent consulting company that responded to this study, Taiwanese IT firms' internal operations were sometimes excessively flexible during that time when their level of informatization was still low. While flexible management may have led to administrative complexity, it may also have enabled these firms to satisfy their customers' varied needs. For instance, Taiwan's Notebook PC manufacturers have had to flexibly adjust or even eliminate many relevant time-consuming management steps in order to fulfill such nearly-impossible customer demands as Dell's 973 and 982 shipment policies (973 requires shipment of 97% of orders within three days; the current 982 policy requires shipment of 98% of orders within two days). It has often been necessary to flexibly schedule employee overtime in order to fill orders on time. While this flexible approach to management has certainly resolved many short-term problems in the face of growing competition and increasingly exacting demands, it is gradually cracking under the burden it must withstand.

As reported in Bennett and Smith (2004), although over 95% of SMEs use external advice, some owners strongly believe they know their business very well. This makes them very skeptical about new advice from external sources. Because the integrative design of ERP systems increases the complexity involved in source code modifications, however, most companies significantly underestimate the effort required for modifications. Modifications not only lead to increased costs and implementation times; they also make further upgrades of the system difficult (Mabert et al., 2003a,b).

This study's analysis of IT infrastructure and organizational performance makes it clear that these two benefits of ERP do not have positive impacts on corporate SCM competencies, and some items may even have a negative effect on SCM. While this finding is somewhat at odds with the results presented in the literature review, it is not surprising. As some studies in the literature have noted, organizational collaboration and information sharing, in turn, are expected to improve organizational performance. The complexity of organizational collaboration and investing in information technologies may facilitate it (Sanders, 2007). Insufficient managerial capabilities, strategic change and complexity, and excessively flexible operating control procedures may, however, cause management complexity and wasted time at SMEs (Bennett and Smith, 2004; Riemenschneider et al., 2003). In addition, the initial confusion that ensues after a new system's adoption may temporarily obscure many of the system's benefits. The literature includes suggestions that the time factor be taken into consideration when assessing the effect of ERP system adoption on corporate performance (Hendricks et al., 2007; Hitt et al., 2002; McAfee, 2002; Mabert et al., 2003a).

7.2.2. The impact of the Chinese market

It deserves to be mentioned that as SMEs globalize, Taiwanese SMEs unite against foreign competitors, and have made aggressive outbound investments in Southeast Asia and China. As the roles of Asian nations in the world economy grow, especially those of China and the other BRIC countries (Brazil, Russia and India), the substantial impact of Taiwan's SMEs on the Pacific region is increasing (Chen et al., 2008). Taiwanese IT firms also have moved most if not all of their production sites to China. Nevertheless, as many multinational firms have noted, many systems in the newly-opened China market are either ineffective or at variance with international practice. The best-known examples involve China's tax procedures. Firms with plants in China that

wish to use the same information system or ERP system to handle tax matters often encounter the dilemma of contradictory specifications.

The differences between the data from Western countries and Taiwanese data suggest different managerial perceptions of how ERP benefits impact SCM competencies or firm performance. More important, they suggest that perceptions of how these components influence SCM competencies may be affected by different world-views and, perhaps, international cultural differences. Thus, the association between supply chain components and organizational performance may differ according to place. As a result, in view of the legal system, organizational culture, and habits prevailing in China, it is not surprising that ERP-based IT infrastructure and organization have little short-term positive effect on SCM competencies.

Last, this study found that three of the five benefits of ERP have a positive impact on SCM competencies, while the remaining two benefits have no positive effect. When the study questionnaire asked whether it would be feasible for a firm to adopt a specialized SCM system in order to improve supply chain management instead of first adopting an ERP system, however, more than 80% of respondents felt that it was necessary to first adopt an ERP system to serve as a corporate information framework before the deployment of other corporate information systems (such as an SCM system) could achieve the desired effect. Accordingly, our research result is also consistent with the literature (Mabert et al., 2001), and supports the finding that the ERP system can successfully become the backbone of company operations in the new economy. It is neither a myth nor merely imitative behavior. The immediate and current issue for IT managers is less whether to adopt an ERP system and more how to best plan that adoption so that firm and supply chain performance are enhanced.

8. Limitation and future research

The study developed ways of measuring ERP benefits' impact on the SCM competencies model. Although validity and reliability checks were performed on the measurements, if we can use more measurements for firm competencies drawn from the ERP software or consultant companies, instead of self-reporting by the firms, the results will be more convincing. The limitation is that it seems that most of the consultant companies either did not keep records or did not trace back or evaluate the firm's performance after the project was finished.

Future research based on the results of this study could perform a comparative analysis of the effect on performance of adoption of an ERP system alone, adoption of an SCM system alone, and simultaneous adoption of both system types. 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.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ejor.2009.07.003.

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