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The Roles of Information Systems Integration in the Supply Chain Integration Context – Firm Perspective

by

Thawatchai Jitpaiboon

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T. S. Raghunathan

Advisor: Dr. T.S. Ragu-Nathan

Mark Vonderembse

Advisor: Dr. Mark Vonderembse

Graduate School

The University of Toledo

June 2005

UMI Number: 3188242

Committee Members,

Signature | Date of Signature

Christine Fox | 6/7/05

Dr. Christine Fox
Associate Professor of Educational Research and Measurement
College of Education
The University of Toledo

Janet L. Hartley | 6/6/05

Dr. Janet L. Hartley
Professor of Management
College of Business Administration
Bowling Green State University

B. Ragu-Nathan | 6/5/05

Dr. Bhanu Ragu-Nathan
Professor of Accounting
College of Business Administration
The University of Toledo

An Abstract of

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With advances in information technology (IT), information systems integration (ISI) and its role in an integrated supply chain have become important to executives and researchers. ISI represents the degree of cooperation in information system practices between business functions within a firm and between a firm and its trading partners. It has been documented that the introduction and utilization of ISI for supply chain management enhance the firms' competitiveness and growth. While many firms focus on achieving high levels of IT utilization, without high levels of ISI, supply chain members may not attain the full benefits of working within a supply chain.

The concept of ISI can be captured using two main sub-constructs (e.g., internal ISI and external ISI) and can be conceptualized at three levels – (1) Strategic, (2) Operational, and (3) Infrastructural. Studying the effects of ISI in these levels can help researchers and executives understand how ISI practices at different levels contribute to

overall supply chain effectiveness. The implications of such an understanding may bring significant benefits to both operations researchers and practitioners. Such benefits may include making better decisions about which IT to utilize, which information systems (IS) practices to emphasize, and what level of ISI to attain. From a practitioner's perspective, this research provides important guidelines so firms may better understand ISI issues and effectively implement IT.

This study proposes three significant contributions to supply chain management research. First, this study applies an information system perspective to study both causes and effects of supply chain integration. It proposes a theoretical framework that considers the role of ISI as a mediator between IT utilization and supply chain integration. Second, this study provides the inferences made from an instrument that is valid and reliable for the current study's context, which are beneficial for both practitioners and academicians. Third, it examines the effects of supply chain integration on a firm's operational performance; the effects of supply chain integration on a suppliers' operational performance, the effects of a suppliers' operational performance on a firm's operational performance, the effects of a suppliers' operational performance on a firm's overall performance, and the effects of a firm's operational performance on the firm's overall performance.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

A supply chain is a network of companies connected via a set of serial and parallel supplier-customer relationships from the first supplier to the final customer. A supply chain involves an interwoven coordination of logistics planning activities among supply chain members, which include all of the capabilities and functions required to design, fabricate, distribute, sell, support, use, and recycle or dispose of a product, as well as the associated information that flows up and down the chain (National research council, 2000). Supply chains are typically comprised of geographically dispersed facilities and capabilities, including sources of raw materials, product design and engineering organizations, manufacturing plants, distribution centers, retail outlets, and customers, as well as the transportation and communications links between them. As firms are continually participating in the global market to stay competitive, they are facing many challenges that include expanding global competition, advancing technology and innovation, increasing customer expectations, and growing supply chain complexity. These challenges are expected to continuously increase in intensity and complexity. To cope with these challenges, firms are applying advanced information technology (IT) to move toward ever-increasing supply chain integration in both inter- and intra-organizations.

An integrated supply chain is an association of customers and suppliers who work together to optimize their collective performance in the creation, distribution, and support of an end product. All supply chains are integrated to some extent by focusing and coordinating the relevant resources of each participant to optimize the overall performance of the chain. Therefore, supply chain integration is a continuous process that can be optimized when supply chain members work together to improve their relationships and when all participants are aware of key activities at all levels in the chain.

Information Technology (IT) is playing an increasingly critical role in the success or failure of the supply chain. IT ranks highly as the essential ingredient and backbone for the success of supply chain integration (Barut et al., 2002). IT has become one of the keys to operating success. It is impossible to achieve an effective supply chain without IT. Since suppliers are located all over the world, it is essential to integrate the activities both inside and outside of an organization. This requires an integrated information system (IS) for sharing information on various value-adding activities along the supply chain (Gunasekaran and Ngai, 2004; Gangopadhyay and Huang, 2004). As the concept of competing between supply chains grows more intense and widespread because of inevitable global competition, IT utilization has changed its role from back office and operational support to strategic imperative. Firms have started to utilize IT to directly influence the processes of comprising the value chain (Rushton and Oxley 1994; Williams et al., 1997). Increasingly, IT is used to facilitate internal coordination within a firm and enhance external integration with external constituencies (e.g., customers and suppliers) and also to enhance decision making among supply chain members. This phenomenon is evident by the increased usage of information systems for integration purposes; for instance, information systems infrastructure (e.g., data communication tools, network connection, standard data structure, and unified coding standards), information systems software (e.g., enterprise-wide information system such as SAP), and information systems applications (e.g., centralized database management systems, electronic data interchange (EDI), web-based or internet-base information systems). Although the advances in formation technologies are considered a key driver of supply chain integration; what is the best way to deploy these technologies and to coordinate supply chain-wide activities is still under research (Gangopadhyay and Haung, 2004).

This research is an attempt to study and understand the phenomenon by which IT has been used for integration purposes in the supply chain context and to examine how Information Systems Integration (ISI) relates to other factors (direct and indirect) at the organizational level. ISI is the degree of cooperation in information system practices between business functions within a firm and between the firm and its trading partners. ISI represents how top management perceives the extent of coordination on each IS activity, which the firm chooses to perform internally or to interact with its trading partners. At the functional level, ISI helps firms to use data from existing, heterogeneous, distributed sources by providing integration capabilities that support the illusion that a single integrated IS is being used in the supply chain. At the operational level, ISI offers supply chain members the possibility of increased productivity and customer responsiveness. ISI enhances the firm’s operational performance by integrating similar functions over different areas and by curtailing unnecessary activities, thus enhancing the firm’s capability to cope with sophisticated customer needs and to meet product quality standards, improve product quality, enhance productivity, increase equipment utilization, reduce space requirements, and expand logistics efficiency and flexibility (Bardi, Raghunathan, and Bagchi, 1994; Gross, 1984; Kaltwasser, 1990). At the strategic level, ISI helps businesses not only to automate their activities, but also to reshape and improve their business processes (Venkatraman, 1991).

In spite of a general understanding of the useful roles of ISI in enhancing firms' competitive position, the empirical investigation explaining both causes and impacts of ISI has been scarce in literature. The previous studies related to ISI have three major shortcomings. First, though there have been some studies discussing the issues of ISI, most of these studies are functionally focused and not in the supply chain context (Wyse and Higgins, 1993; Webber and Pliskin, 1996; Bhatt, 2000). The empirical investigation of the roles of ISI in the supply chain context and the establishment of an instrument to measure the concept of ISI are still lacking.

Second, although benefits of IT utilization in enhancing organizational performance are well documented in literature (Kim and Narasimhan, 2002; Rushton and Oxley, 1994; William et al., 1997; Bardi et al., 1994; Carter and Narasimhan, 1995; Gross 1984; Kaltwasser, 1990), the mechanism by which IT utilization enhances supply chain integration through ISI is not fully developed. Although some studies have pointed out that IT utilization can lead to productivity, performance, and differential and sustainable competitive advantages because it can strengthen linkages between functions within a firm and between firms (Hammer, 1990; Hammer & Champy, 1993; Davenport & Short, 1990; Venkatraman, 1994; Kim and Narasimhan, 2002; Narasimhan and Kim, 2001), empirical studies have not shown consistent results. In fact, several studies have shown that, in some instances, IT investment has had negative, dysfunctional effects on organizational productivity and performance (Hitt & Brynjolfsson, 1994; Roach, 1989; Weill, 1988).

Third, the study of both the causes and effects of ISI in the supply chain context at the organizational level is not fully developed and needs more attention from both practitioners and academicians.

Because the current literature still lacks a clear explanation of the role of ISI in enhancing the relationship between IT utilization and supply chain integration, this study seeks to provide three main contributions. First, a measurement of ISI is developed. Through an extensive literature review, the study identifies three levels of ISI (1) strategic integration, (2) operational integration, and (3) infrastructural integration, and two sub-constructs of ISI (1) Internal ISI (IISI) and (2) External ISI (EISI). This instrument is useful for both practitioners and academicians because it provides an appropriate set of ISI practices that firm can adopt to gain optimal benefits from integration of supply chain activities. Three dimensions of ISI guarantees that the implemented IS can be used to link all activities within and between firms.

Second, this study investigates the mediating role of ISI on the relationship between IT utilization and supply chain integration. According to the productivity paradox theory, the mediating role of ISI in ISI framework combined with the results from this study might be useful to explain the negative relationship between IT utilization and organizational performance found in previous studies (Hitt & Brynjolfsson, 1994; Roach, 1989; Weill, 1988; Dos Santos and Sussman, 2000). Small part-manufacturers, for instance, were forced by larger firms such as Ford and GM to implement IT projects such as EDI. However, the full benefits of technology utilization are hardly recognized due to the lack of systematic, hand-on practices which can help firms realize the potential benefits of IT. Without a higher level of ISI, benefits of supply chain integration may not be fully attained (Bhatt & Stump, 2001). ISI enhances the organizational capability to make decisions on which IT is to be utilized, which IS practices is to be emphasized, and on what levels of ISI to focus. From a practitioner's point of view, this research provides important guidelines for a firm to better understand ISI issues and to more effectively implement IT.

Third, this study proposes a theoretical framework to study causes and effects of ISI. This framework is tested using a large-scale survey methodology. The unit of analysis is at the organizational level and the targeted respondents are high level managers of manufacturing firms. The important relationships tested include: (1) direct impact of IT utilization on internal ISI; (2) direct impact of IT utilization on external ISI; (3) direct impact of internal ISI on external ISI; (4) direct impact of internal ISI on supply chain integration; (5) direct impact of external ISI on supply chain integration; (6) direct impact of supply chain integration on firm's operational performance; (7) direct impact of supply chain integration on suppliers' operational performance; (8) direct impact of suppliers' operational performance on firm's operational performance; (9) direct impact of suppliers' operational performance on firm's overall performance; and (10) direct impact of firm's operational performance on firm's overall performance.

Chapter 2 reviews the literature on theoretical foundation and constructs development. The overall framework that depicts the relationships between the constructs and the development of hypotheses are presented in Chapter 3. The research methodology for generating items for measurement instruments appears in Chapter 4. The large scale administration and instrument validation are coved in Chapter 5. Chapter 6 covers the structural equation modeling methodology for hypotheses testing and summary of results. Lastly, summary of the study, limitations, implications, and recommendations for future research are covered in Chapter 7.

CHAPTER 2: LITERATURE REVIEW

The globalization of markets and manufacturing has forced the management of supply chains to consider not only business processes in the traditional value chain, but also processes that penetrate networks of organizations. Thus, ISI research has turned from an intra-enterprise focus towards an inter-enterprise focus. Noori and Mavaddat (1998) discussed ISI as "enterprise-wide systems" which enable a much greater degree of integration through greater speed and flexibility in the way firms integrate their internal and external activities. A higher degree of ISI creates information visibility and captures the moments of information which enable collaborative members of the supply chain to manage their business processes better (Lummus and Vokkurka, 1999).

Despite the widely held belief that information technology (IT) is fundamental to a firm's survival and growth, scholars are still struggling to specify the underlying mechanisms linking IT to organizational performance (Bharadwaj, 2000). Anecdotal evidence and case studies have found that effective and efficient use of IT is a key factor differentiating successful firms from their less successful counterparts (Byrd and Marshall, 1997; Hammer, 1990; Hammer & Champy, 1993; Davenport & Short, 1990; Venkatraman, 1994). Although evidence from many case studies suggests that IT increases productivity and performance (Hammer, 1993; Hammer & Champy, 1993; Davenport & Short, 1990; Venkatraman, 1994), empirical evidence from large sample studies has not been as readily forthcoming. In fact, several studies have shown that, in some instances, IT investment has had negative, dysfunctional effects on organizational productivity and performance (Hitt & Brynjolfsson, 1994; Roach, 1989; Weill, 1988). There is evidence that many firms, concerned about falling behind on the technology curve, engage in high IT investments without deriving any benefits from IT (Nolan 1994). Despite the substantial investment in IT by corporations, direct linkage between technology utilization and increases in productivity and performance has been extremely elusive. Therefore, this study attempts to explain this missing link using the ISI concept.

2.1. ISI IN THEORY

The study of ISI started as early as 1985. Mudie and Schafer (1985) analyzed ISI in process terms, as they believed ISI should not only facilitate the process of development and use of data, applications, and other processing technology, but also should provide the flexibility to meet the future business demands in workstations, processing types, and applications. Wyse and Higgins (1993) defined ISI as the extent to which data and applications through different communication networks can be shared and accessed for organizational use. They defined ISI into two components: data integration and technical integration. Data integration refers to the relevancy of the information that is collected, processed, and disseminated throughout the firm. Technical integration concerns the physical or formal linkage of information systems and subsystems that are used by the firm.

Webber and Pliskin (1996) defined ISI in the merger or acquisition context as the extent of the integration of IS and data processing functions with financial systems, which are usually a critical component of the IS. The findings point to a positive relationship between ISI and effectiveness only when controlling IT intensity and organizational culture differences between the joining firms. Stylianou et al. (1996) also studied ISI framework in the merger and acquisition context conducted by the American Management Association (AMA). The framework examines the relationships between the measure of ISI success and the components that affect it. ISI success was measured using a multidimensional attribute as: 1) IS-assessment of the success of the integration process and integrated systems; 2) the ability to exploit to avoid opportunities arising from a merger; 3) the ability to avoid problems stemming from the merger; and 4) the end-user satisfaction with the integration process and integrated systems. Following this study, Robbies and Stylianou (1999) modified the ISI success measure to fit with the post-merger system integration context. The improved IS capability construct was added. They argued that the measure relating to improved IS capabilities that helped support the underlying motives for the merger is important and should be included.

Bhatt (2000) studied the relationship between ISI and business process improvement. He argued that, at a conceptual level, ISI can be viewed as data architectures, communication networks, and support firms. He used two aspects to measure the degree of ISI: Data integration and communication networks integration. The data integration was defined as the extent to which different firms can share a number of databases for coordinating their activities. Communication networks integration was defined as the extent to which different information systems can communicate with other wide information systems to coordinate present and future activities depending on network connectivity and network flexibility.

2.2. CONSTRUCTS OF ISI

Previous studies have discussed the role of ISI in tactical and operational perspectives suitable for the context of studies such as process development, financial research or merger and acquisition. Researchers mostly looked at only functional aspects of ISI, for instance, data integration and communication networks integration (Madnick, 1991; 1995; Wyse and Higgins, 1993; Bhatt, 2000; Wainwright and Waring, 2004; Themistocleous et al., 2004), the extent of IS and data processing functions and the extent of integration of financial systems (Webber and Pliskin, 1996), integration of heterogeneous information systems, databases, or application software, integration of different physical stages in business processes, and integration of subsystems into a well-coordinated network system (Sikora and Shaw, 1998; Cohen and Lee, 1988). None of the previous studies focused on ISI research at the strategic level. In addition, previous studies considered ISI as a success measure, not as a practice (Stylianou et al., 1996; Robbies and Stylianou, 1999).

In the inter-and intra-organizational supply chain context where integration of corporate entities can produce dynamic and synergistic opportunities, ISI should not only be viewed as traditional back office and processing support, but also as strategic support. Porter and Millar (1985) asserted that management of information systems can no longer be the only provision of functional activities such as accounting and record keeping. The use of advanced information systems in value chain activities allows companies to enhance competitive differentiation as well as attain cost leadership and sustainable competitive advantage (Kim and Narasimhan, 2002). McFarlan and McKenny (1984) showed in their information systems strategic grid that the role of IS should change from operational supporter to strategic enabler in order to form competitive success.

In this study, from a firm's perspective, ISI is the degree of cooperation between business functions within the firm (IISI) and between a firm and its trading partners (EISI) on an internally consistent set of strategic, operational, and infrastructural information systems practices using information systems (IS). ISI can be defined using two sub-constructs – IISI and EISI. Table 1 displays the IISI construct, its sub-constructs, and the construct definitions and Table 2 shows the EISI construct, its sub-constructs, and the construct definitions.

Constructs	Definitions	Literature
Internal Information Systems Integration (IISI)	The degree of cooperation between business functions within the firm on an internally consistent set of strategic, operational, and infrastructural information systems practices using information systems (IS).	Wainwright and Waring, 2004; Themistocleous et al., 2004; Koufteros, Vonderembse, and Jayaram, 2005; Fiderrio, 1989; McFarlan and McKenny, 1984; Gross, 1984; Porter and Millar, 1985; Madui and Schafer, 1985; Cohen and Lee, 1988; Earl, 1989; Kaltwasser, 1990; Madnick, 1991; Buck-lew et al., 1992; Wyse and Higgins, 1993; Stylianou et al., 1996; Webber and Pliskin, 1996; Sikora and Shaw, 1998; Robbies and Stylianou, 1999; Bhatt, 2000; Narasimhan and Kim, 2001; Numilaakso et al, 2002; Kim and Narasimhan, 2002;
Strategic information system integration	A set of strategic information system practices, which promote cooperation of various business functions within the firm.	McFarlan and McKenny, 1984; Earl, 1987; Earl, 1989; Chan et al., 1997; King and Teo, 1997
Operational information system integration	A set of operational information system practices, which promote cooperation of various business functions within the firm.	Buck-Lew et al., 1992; Narasimhan and Kim, 2001; Numilaakso et al, 2002; Kim and Narasimhan, 2002;
Infrastructural information system integration	A set of information system practices to facilitate information sharing and to coordinate work activities, which promote integration within firm.	Fiderrio, 1989; Madnick, 1991; 1995; Wyse and Higgins, 1993; Bhatt, 2000; Mudie and Schafer, 1985; Goodhue et al., 1992; Yates and Benjamin, 1991; Bhatt, 2002; Bhatt and Stump, 2001; Nurmilaakso et al.,2002;

Table 1: The IISI construct, its sub-constructs, and the construct definitions

Constructs		Definitions	Literature
External Information Systems Integration (EISI)		The degree of cooperation between a firm and its trading partners on an internally consistent set of strategic, operational, and infrastructural information systems practices using information systems (IS).	Wainwright and Waring, 2004; Themistocleous et al., 2004; Fiderrio, 1989; McFarlan and McKenny, 1984; Gross, 1984; Porter and Millar, 1985; Madui and Schafer, 1985; Cohen and Lee, 1988; Earl, 1989; Kaltwasser, 1990; Madnick, 1991; Buck-lew et al., 1992; Wyse and Higgins, 1993; Stylianou et al., 1996; Webber and Pliskin, 1996; Sikora and Shaw, 1998; Robbies and Stylianou, 1999; Bhatt, 2000; Narasimhan and Kim, 2001; Numilaakso et al, 2002; Kim and Narasimhan, 2002;
	Strategic information system integration	A set of strategic information system practices, which promote cooperation between a firm and its external constituencies such as customers and suppliers.	McFarlan and McKenny, 1984; Earl, 1987; Earl, 1989; Chan et al., 1997; King and Teo, 1997
	Operational information system integration	A set of operational information system practices, which promote cooperation between a firm and its external constituencies such as customers and suppliers.	Buck-Lew et al., 1992; Narasimhan and Kim, 2001; Numilaakso et al, 2002; Kim and Narasimhan, 2002;
	Infrastructural information system integration	A set of information system practices to facilitate information sharing and to coordinate work activities, which promote integration between a firm and its external constituencies such as customers and suppliers.	Fiderrio, 1989; Madnick, 1991; 1995; Wyse and Higgins, 1993; Bhatt, 2000; Mudie and Schafer, 1985; Goodhue et al., 1992; Yates and Benjamin, 1991; Bhatt, 2002; Bhatt and Stump, 2001; Nurmilaakso et al.,2002;

Table 2: The EISI construct, its sub-constructs, and the construct definitions

2.3. ISI FRAMEWORK AND ITS RELATED CONSTRUCTS

2.3.1. Information Technology Utilization

Previously, the introduction of IT was viewed as a back office support limited to the automation of clerical functions (Kim and Narasimhan, 2002). With the realization of global competition and advances in information technology, the utilization of IT can have a direct effect on value creation by integrating firm's supply chain activities resulting in higher quality products, enhanced productivity, efficient machine utilization, reduced space and increased logistics efficiency and flexibility (Gross, 1984; Kaltwasser, 1990; Kim and Narasimhan, 2002). Porter and Millar (1985) asserted that the utilization of IT has a significant influence on the relationships between value chain activities as well as on the physical aspects of individual value chain activities. IT provides competitiveness to firms such as: (a) creating value for customers; (b) creating value for companies; (c) optimizing or integrating value chains through IT to improve competitiveness; and (d) accommodating the creation of a new value chain. Earl (1989) asserted that IS must be considered as a strategic weapon. This view focuses the utilization of IS more in strategic and managerial activities than in operational areas. He classified the scope of IT into four categories: (1) IT used to automate or improve the physical aspects of every activity; (2) IT used to physically connect each value activity or to control the activities at the connecting point; (3) IS used to facilitate the implementation, support, and management of value activities, and (4) IS used to optimize or to adjust the connection of each value activity. Kyobe (2004) purported that strategic IT utilization plays a significant role in supporting the development and building of core and distinctive competencies which enable a firm to create a competitive advantage. Jane et al. (2004) argued that advances in information technology have been a primary enabler for firms' focus on Interorganizational business processes. Gangopaddyay and Hauang (2004), using simulation, claimed that the advances in formation technologies make information sharing possible, and these advances actually become a key driver of supply chain integration. However, what is the best way to deploy these technologies and to coordinate supply chain-wide activities is still under research.

This study adopts IT utilization from previous studies (Narasimhan and Kim, 2001; Kim and Narasimhan, 2002; Narasimhan and Kim, 2002). Narasimhan and Kim (2001) proposed measuring IT utilization using three sub-constructs. The three constructs include: (1) IS for infrastructural support (e.g., network plan and design system, accounting information system, and office information system); (2) IS for value creation management (e.g., production plan and process control system, sales and price management system, customer service and customer management system, and inventory and warehouse management system), and (3) IS for logistical operations (e.g., transportation management system, forecasting system, automatic ordering system, resource management system, and plant warehouse location selection system). They argued that the strategic utilization of IT has two major points in common. First, the role of IS must be raised from information processing to utilization of technology to change an existing value chain or create a new value chain. Second, IT should not only automate and improve the physical aspect of value activities, but also create and optimize the structural connection among supply chain activities. The IT utilization proposed by Narasimhan and Kim (2001) focuses only on physical and operational aspects of IS. Although these two points have significant implications for supply chain activities, these two points might not fully cover the concept of IT utilization in a supply chain integration context where strategic impacts of IT are far more important than operational and physical impacts. This study proposes to measure IT utilization using three sub-constructs: Strategic IT, Operational IT, and Infrastructural IT. Figure 2.1 shows the constructs and sub-constructs of IT utilization.

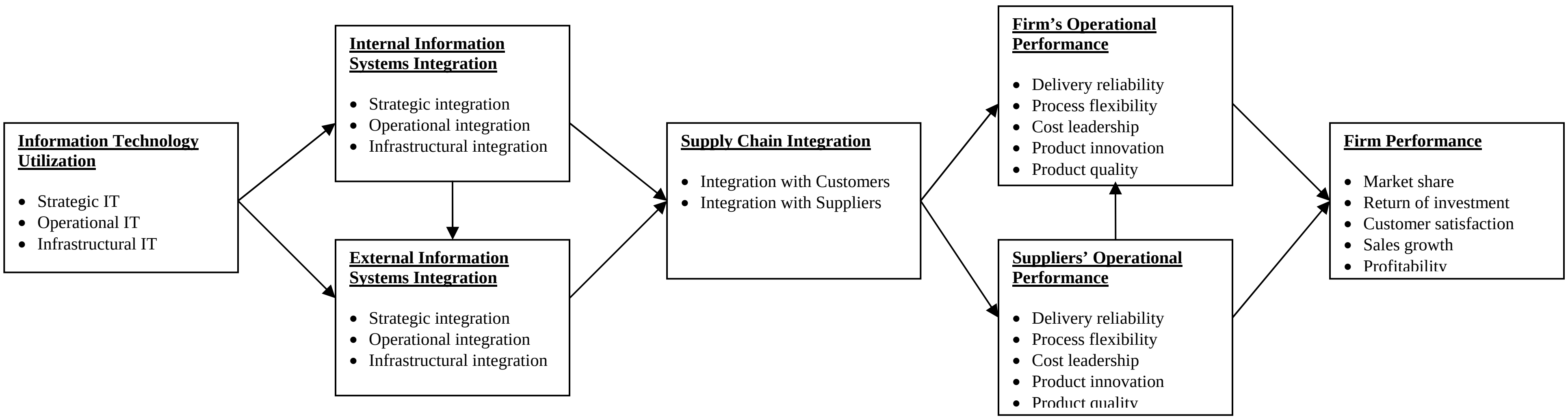


Figure 2.1: Theoretical framework for information systems integration

From a firm's perspective, IT utilization refers to ways that firms apply computer and information technology to support infrastructural and operational decision making and to assist in strategic decision planning. Table 3 shows the construct and sub-constructs of IT utilization.

Constructs		Definition	Literature
Information Technology (IT) Utilization		The way that firms apply computer and information technology to support infrastructural and operational decision making, and to assist in strategic decision planning.	Jane et al., 2004; Gangopadhyay and Huang, 2004; Gross, 1984; Porter and Millar,1985; Kaltwasser, 1990; Rushton and Oxley, 1994; Bardi, Raghunathan, and Bagchi, 1994; Raghunathan and Raghunathan, 1994; Carter and Narasimhan, 1995; Williams et al., 1997; Narasimhan and Kim, 2001; Kim and Narasimhan, 2002; Narasimhan & Kim,2002;
	Strategic IT	The extent to which your firm uses IT for formulating, justifying, and improving long-term business planning processes.	Kyobe, 2004; Chan et al, 1997; King and Teo, 1997;
	Operational IT	The extent to which your firm uses IT for monitoring, justifying, and improving daily operational decision processes.	Narasimhan and Kim, 2001; Kim and Narasimhan, 2002;
	Infrastructural IT	The extent to which your firm uses IT to facilitate information sharing and data communication, to recommend standards for IT architecture, to implement security, and to coordinate work activities within firm.	Narasimhan and Kim, 2001; Kim and Narasimhan, 2002;

Table 3: The IT utilization construct, its sub-constructs, and the construct definitions

2.3.2. Supply Chain Integration

Supply chain integration is defined as the extent to which a firm coordinates activities with suppliers and customers (Stock et al., 2000; Narasimhan and Jayaram, 1998; Wood, 1997; Li, 2002; Marquez et al., 2004). Supply chain integration links a firm with its customers, suppliers, and other channel members by integrating their relationships, activities, functions, processes and locations (Kim and Narasimhan, 2002). Having an integrated supply chain provides significant competitive advantage including the ability to outperform rivals on both price and delivery (Lee and Billington, 1995). The concept of supply chain integration was studied as early as 1989 by Bowersox. He argued that the process of supply chain integration should progress from the internal logistics integration to external integration with suppliers and customers. Both can be accomplished by the continuous automation and standardization of each internal logistics function and by efficient information sharing and strategic linkage with suppliers and customers. Stevens (1989), Byrne and Markham (1991), and Hewitt (1994) suggested that the development of internal supply chain integration should precede the external integration with suppliers and customers. Narasimhan and Kim (2002) examined the effect of chain integration on the relationship between diversification and performance. The supply chain integration instrument is comprised of three dimensions: (1) internal integration across the supply chain, (2) a company’s integration with customers, and (3) a company’s integration with suppliers. Frohlich and Westbrook (2002) and Frohlich (2002) studied the effect of web-based integration on demand chain management’s operational performance. In their study, web-based supply chain integration was measured by two constructs: (1) e-integration with suppliers and (2) e-integration with customers. This study adopts the concept of supply chain integration from previous research by using two sub-constructs to measure supply chain integration; Integration with suppliers and Integration with customers (Frohlich and Westbrook, 2002; Frohlich, 2002). Integration with customers involves determining customer requirements and tailoring internal activities to meet these requirements (Koufteros, Vonderembse, and Jayaram, 2005). As a firm gets to know its customers better and becomes committed to understanding and meeting their needs, a strong linkage is forged between the firm and its customers. Integration with customers ensures that the voice of the customer plays a vital role in the innovative process with in the organization. Integration with suppliers is characterized by a long-term commitment between the collaborators, and openness of communication, and mutual trust. Supplier partnering seeks to bring participants early in the product life cycle; thus entailing early supplier involvement in product design or the acquisition of access to superior supplier technological capabilities (Narasimhan and Das, 1999; Peterson et al., 2005). The internal supply chain integration is not included in the model because the concept is already captured in the ISI construct. Table 4 shows related literature on supply chain integration, its sub-constructs, and their definitions. Figure 2.1 shows the constructs and sub-constructs of supply chain integration.

Constructs		Definition	Literature
Supply Chain Integration		The extent to which a firm coordinates activities with suppliers and customers.	Peterson et al., 2005; Gunasekaran and Ngai, 2004; Bowersox, 1989; Stevens, 1989; Byrne and Markham, 1991; Lee and Billington, 1995; Hewitt, 1994; Clark and Hammond, 1997; Wood, 1997; Lummus et al., 1998; Stock et al., 2002; Narasimhan and Jayaram, 1998; Johnson, 1999; Frohlich and Westbrook, 2001; Ahmad and Schroeder, 2001;Kim and Narasimhan, 2002; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2002; Frohlich, 2002;
	External integration with suppliers	The degree of coordination between manufacturing firm and its upstream partners.	Peterson et al., 2005; Koufteros, Vonderembse, and Jayaram, 2005; Bowersox, 1989; Stevens, 1989; Byrne and Markham, 1991; Lee and Billington, 1995; Hewitt, 1994; Clark and Hammond, 1997; Wood, 1997; Lummus et al., 1998; Stock et al., 2002; Narasimhan and Jayaram, 1998; Johnson, 1999; Frohlich and Westbrook, 2001; Ahmad and Schroeder, 2001;Kim and Narasimhan, 2002; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2002; Frohlich, 2002;
	External integration with customers	The degree of coordination between manufacturing firm and its downstream customers.	Koufteros, Vonderembse, and Jayaram, 2005; Bowersox, 1989; Stevens, 1989; Byrne and Markham, 1991; Lee and Billington, 1995; Hewitt, 1994; Clark and Hammond, 1997; Wood, 1997; Lummus et al., 1998; Stock et al., 2002; Narasimhan and Jayaram, 1998; Johnson, 1999; Frohlich and Westbrook, 2001; Ahmad and Schroeder, 2001;Kim and Narasimhan, 2002; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2002; Frohlich, 2002;

Table 4: The supply chain integration construct, its sub-constructs, and the constructs definitions

2.4. PERFORMANCE INDICATORS

2.4.1. Firm's Operational Performance

Operational performance indicators are commonly used in the supply chain integration context to measure the effects of supply chain integration activities on the functional/operational outcomes. Considerable agreement exists among academics that the performance of manufacturing companies can be evaluated by one or more key competitive priorities (Wheelwright, 1984; Hayes and Wheelwright, 1984: Krajewski and Ritzman, 1996; Christiansen et al., 2003). Competitive priorities can be described in four major categories: (1) quality, (2) delivery, (3) cost, and (4) flexibility.

Many studies have reported the use of operational performance as one of the performance outcomes. For example, Frohlich and Westbrook (2002) studied the effects of the type of web-based demands and supply integration. They used operational performance as a dependent variable. The operational benefits of supply chain integration include faster delivery time, reduced transaction costs, greater profitability, and enhanced inventory turnover. The use of operational performance in supply chain integration context can also be found in terms of competitive capabilities. A significant body of prior empirical research indicates that capabilities such as quality, delivery, flexibility, and/or cost are positively related to supply chain integration (Khurana and Talbot, 1998; Kopczak, 1997; Roth, 1998). Rosenzweig et al. (2003) studies the effects of supply chain integration intensity using competitive capabilities: product quality, delivery reliability, process flexibility, and cost leadership. Table 4 shows the firm's operational performance construct, its literature review, and the construct definition. Figure 2.1 shows the constructs and sub-constructs of firm's operational performance.

Constructs	Definition	Literature
Firm's Operational Performance	The extent to which firms can achieve delivery reliability, process flexibility, cost reduction, product/process innovation, and product quality.	Koufteros, Vonderembse, and Jayaram, 2005; Christiansen et al., 2003; Kopczak, 1997; Khurana and Talbot, 1998; Roth, 1998; Frohlich, 2002; Frohlich and Westbrook, 2002; Rosenzweig et al., 2003; Wheelwright, 1984; Hayes and Wheelwright, 1984: Krajewski and Ritzman, 1996; Bardi, Raghunathan, and Bagchi, 1994; Gross, 1984; Kaltwasser, 1990

Table 5: The firm's operational performance construct and its definition

2.4.2. Suppliers' Operational Performance

Supplier performance is defined as the extent to which suppliers meet standards of product quality, delivery reliability, process flexibility, product innovation, and cost reduction. In the literature, supplier performance is considered one of the powerful determinants for the firm's operational success (Davis, 1993; Levy, 1997; Shin et al., 2000; Tan et al., 1998; Vonderembse and Tracey, 1999; Carr and Pearson, 1999). Beamon (1998) defined supplier performance as suppliers' consistency in delivering materials, components and products to manufacturing firms on time and in good condition. Poor vendor quality and delivery performance can result in higher inventory and backlog (Shin et al., 2000). Stevens (1990), Beamon (1998), and Gunasekaran et al. (2001) asserted that supplier performance is considered a very important dimension of supply chain performance because supplier involvement helps firms improve overall quality, reduce costs, and compete with competitors. Table 5 shows the supplier performance construct, its literature review, and the construct definition. Figure 2.1 shows the constructs and sub-constructs of suppliers' operational performance.

Constructs	Definition	Literature
Suppliers' Operational Performance	The extent of suppliers' consistency in delivering materials, components or products to manufacturing firm on time and in good condition	Koufteros, Vonderembse, and Jayaram, 2005; Christiansen et al., 2003; Beamon, 1998; Davis, 1993: Levy, 1997; Li, 2002; Shin et al., 2000; Tan et al., 1998; Vonderembse and Tracey, 1999; Carr and Person, 1999; Stevens, 1990; Gunasekaran et al., 2001.

Table 6: The suppliers' operational performance construct and its definition

Based on the extensive literature review, the concept of supplier performance can be measured using five sub-constructs: delivery reliability, delivery flexibility, cost leadership, innovation, and product quality.

2.4.3. Firm Performance

Firm performance refers to the ability of a firm to fulfill its market and financial goals (Yamin et al., 1999). There are many studies examining firm performance in the literature; however, this study focuses on the firm performance in the supply chain integration context. Wisner (2003) studies the effects of supply chain management strategy on firm performance. The firm performance can be measured by market share, return on assets, overall product quality, overall competitive position, and overall customer service level. Rosenzweig et al. (2003) used four items to measure business performance including pre-tax return on assets (ROA), percentage of revenues from new products, overall customer satisfaction ratings, and business unit's sales growth. Frohlich (2002) used two items to measure e-business performance: Annual percent of procurement using the Internet and annual percent of sales/turnover using the Internet. Narasimhan and Kim (2002) used sales growth and market share growth (ratio of the current level to three years ago), profitability, return on investment, return on assets, revenue growth, financial liquidity, and net profit to measure firm performance. Table 6 shows related literature on a firm performance construct and the construct definition. Figure 2.1 shows the constructs and sub-constructs of firm performance.

Constructs	**Definition**	**Literature**
Firm Performance	The ability of a firm to fulfill its market and financial goals.	Yamin et al., 1999; Frohlich, 2002; Narasimhan and Kim, 2002;Wisner, 2003; Rosenzweig et al, 2003;

Table 7: The firm performance construct and its definition

CHAPTER 3: THEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

When understanding the phenomenon of ISI, it is helpful to have a framework from which testable hypotheses can be drawn. A theoretical framework enables predictions to be made about the role of ISI in supply chain integration context. It enables observed business to be evaluated and therefore provides better explanations of the implications of ISI and their consequences.

3.1. THEORETICAL FRAMEWORK

To better understand the mediating role of ISI on the relationship between IT utilization and organizational performances, a framework is established that describes the causal relationships among IT utilization, internal ISI, external ISI, supply chain integration, suppliers' operational performance, firm's operational performance, and firm performance. The rationale underlying this research framework is straightforward. By considering the relationship of each pair of constructs carefully, Figure 3.1 depicts the proposed relationships among seven constructs discussed in Chapter 2. The numbers next to each arrow correspond to the 12 hypotheses to be developed later in this chapter. Table 7 shows the main constructs and their definitions in ISI framework. The following section will provide theoretical support for each hypothesis.

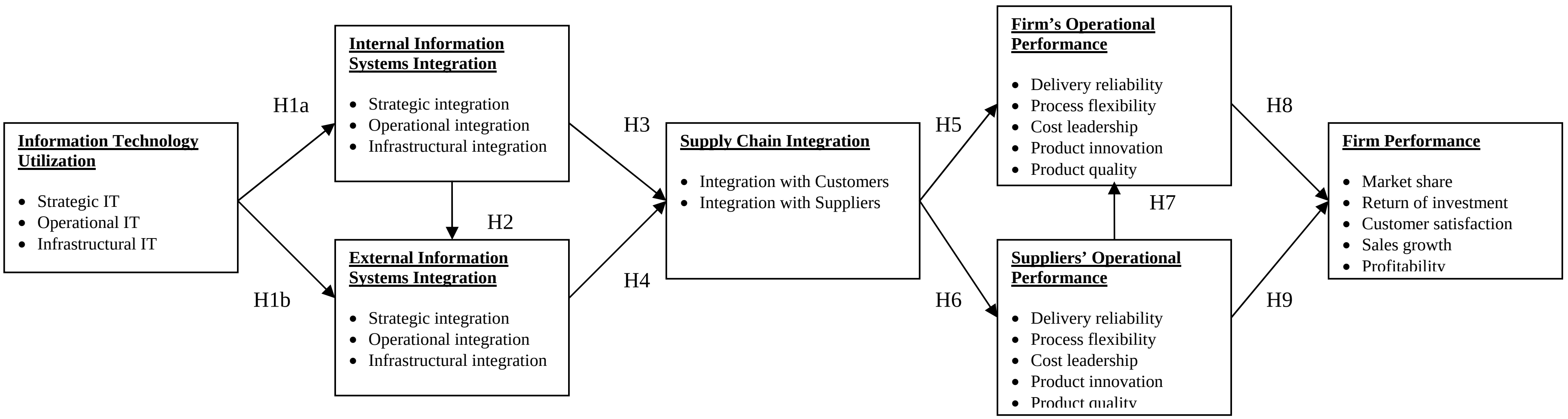


Figure 3.1: Theoretical framework for information systems integration

Constructs	Definition	Literature
Information Technology Utilization (ITU)	The way that firms apply computer and information technology to support infrastructural and operational decision making, and to assist in strategic decision planning.	Jane et al., 2004; Gangopadhyay and Huang, 2004; Gross, 1984; Porter and Millar,1985; Kaltwasser, 1990; Rushton and Oxley, 1994; Bardi, Raghunathan, and Bagchi, 1994; Raghunathan and Raghunathan, 1994; Carter and Narasimhan, 1995; Williams et al., 1997; Narasimhan and Kim, 2001; Kim and Narasimhan, 2002; Narasimhan & Kim,2002;
Internal Information Systems Integration (IISI)	The degree of cooperation between business functions within the firm on an internally consistent set of strategic, operational, and infrastructural information systems practices using information systems (IS).	Wainwright and Waring, 2004; Themistocleous et al., 2004; Koufteros, Vonderembse, and Jayaram, 2005; Fiderrio, 1989; McFarlan and McKenny, 1984; Gross, 1984; Porter and Millar, 1985; Madui and Schafer, 1985; Cohen and Lee, 1988; Earl, 1989; Kaltwasser, 1990; Madnick, 1991; Buck-lew et al., 1992; Wyse and Higgins, 1993; Stylianou et al., 1996; Webber and Pliskin, 1996; Sikora and Shaw, 1998; Robbins and Stylianou, 1999; Bhatt, 2000; Narasimhan and Kim, 2001; Numilaakso et al, 2002; Kim and Narasimhan, 2002;
External Information Systems Integration (EISI)	The degree of cooperation between a firm and its trading partners on an internally consistent set of strategic, operational, and infrastructural information systems practices using information systems (IS).	Wainwright and Waring, 2004; Themistocleous et al., 2004; Koufteros, Vonderembse, and Jayaram, 2005; Fiderrio, 1989; McFarlan and McKenny, 1984; Gross, 1984; Porter and Millar, 1985; Madui and Schafer, 1985; Cohen and Lee, 1988; Earl, 1989; Kaltwasser, 1990; Madnick, 1991; Buck-lew et al., 1992; Wyse and Higgins, 1993; Stylianou et al., 1996; Webber and Pliskin, 1996; Sikora and Shaw, 1998; Robbins and Stylianou, 1999; Bhatt, 2000; Narasimhan and Kim, 2001; Numilaakso et al, 2002; Kim and Narasimhan, 2002;
Supply Chain Integration (SCI)	The extent to which all activities with suppliers and all activities with customers are coordinated.	Peterson et al., 2005; Koufteros, Vonderembse, and Jayaram, 2005; Bowersox, 1989; Stevens, 1989; Byrne and Markham, 1991; Lee and Billington, 1992; Hewitt, 1994; Clark and Hammond, 1997; Wood, 1997; Lummus et al., 1998; Stock et al., 1998; Narasimhan and Jayaram, 1998; Johnson, 1999; Frohlich and Westbrook, 2001; Ahmad and Schroeder, 2001;Kim and Narasimhan, 2002; Narasimhan and Kim, 2002; Frohlich and Westbrook, 2002; Frohlich, 2002;
Suppliers' Operational Performance (SOP)	The extent to which suppliers meet delivery reliability, process flexibility, cost reduction, product/process innovation, and product quality.	Koufteros, Vonderembse, and Jayaram, 2005; Christiansen et al., 2003; Stevens, 1990; Alverez, 1994; Owen and Richmond, 1995; Beamon, 1998; Spekman et al., 1998; Beaman, 1999; Gunasekaran et al., 2001; Narasimhan and Kim, 2001; Li, 2002; Kim and Narasimhan, 2002;
Firm's Operational Performance (FOP)	The extent to which firms can achieve delivery reliability, process flexibility, cost reduction, product/process innovation, and product quality.	Koufteros, Vonderembse, and Jayaram, 2005; Christiansen et al., 2003; Kopczak, 1997; Khurana and Talbot, 1998; Roth, 1998; Frohlich, 2002; Frohlich and Westbrook, 2002; Rosenzweig et al., 2003;
Firm Performance (FP)	The ability of a firm to fulfill its market and financial goals.	Yamin et al., 1991; Frohlich, 2002; Narasimhan and Kim, 2002;Wisner, 2003; Rosenzweig et al, 2003;

Table 8: Construct definitions summary

3.2. IMPACTS OF IT UTILIZATION ON ISI (H1a and H1b)

In the inter-organizational supply chain context, not only does IT provide firms with the automation of clerical functions, but IT is also viewed as providing infrastructural and strategic support to the value chain. As firms move toward a highly integrated supply chain, the strategic usage of IT is much clearer and more compatible. As the trend moves toward globally competing between supply chains, supply chain members are much inclined to use IT to integrate similar functions spread over different areas, to communicate with each other, and to coordinate supply chain activities. The electronic inter-connectivity between two or more firms has become a competitive necessity to reduce cost and improve services (Bhatt, 2000).

The evidence explaining this phenomenon can be found in both conceptual and empirical research. Madnick (1991) and Boar (1993) stated that the level of extensive communication networks and inter-connectivity is raised because of the adoption of standards and integrated services digital networks (ISDN). Through the utilization of IT, companies have been able to integrate their internal functions as well as external activities, thus enhancing capability to cope with the sophisticated needs of customers and meeting the quality standards of products (Bardi et al., 1994, Carter and Narasimhan, 1995). Because the use of networks, shared databases, and other related information systems has been considered important for eliminating duplicate activities, preventing errors, reducing cycle time in product development, and improving inter-organizational communication, firms have not realized the benefits of ISI. Therefore,

H1a: The higher the extent of IT utilization, the higher the extent of IISI

H1b: The higher the extent of IT utilization, the higher the extent of EISI

3.3. IMPACTS OF IISI ON EISI (H2)

The development and evolvement of ISI can be explained using the supply chain integration theory. For example, Bowersox (1989) argued that the process integration should progress from the internal logistics integration to external integration with suppliers and customers. Both can be accomplished by the continuous automation and standardization of each internal logistics function and by efficient information sharing and strategic linkage with suppliers and customers. Stevens (1989), Byrne and Markham (1991), and Hewitt (1994) suggested that the development of internal supply chain integration should precede the external integration with suppliers and customers. This notion implies that, in order for IS to be integrated, ISI should happen in a sequential manner from internal integration to external integration. Firms with higher degree of internal ISI (i.e., firms with centralized databases, firms with enterprise-wide information systems) are more likely to integrate with their external partners because ISI processes take time, effort and capital investment. However, firms which have already set up internal systems have more chance to integrate with other firms that have compatibles systems.

In this study, IISI is characterized by internal cooperation between business functions. ISIS focuses on full system-visibility of internal supply chain activities including strategic, operational, and infrastructural IS practices. At this stage, all internal functions from raw material management through production, shipping, and sales are connected and integrated real-time. EISI, on the other hand, is characterized by an external cooperation between a firm and its trading partners. At this stage, full supply chain integration extending the scope of integration outside the company is accomplished. Therefore,

H2: The higher the extent of IISI, the higher the extent of EISI

3.4. IMPACTS OF ISI ON SUPPLY CHAIN INTEGRATION (H3 AND H4)

The sole purpose of ISI is to integrate diverse information system practices exercised by individual supply chain members and prioritize them into three levels of integration – strategic, operational, and infrastructural. ISI helps firms save costs by eliminating redundant logistic activities, unimportant information system practices, and unnecessary information system investments, which do not contribute to overall performance. With ISI, the proper architecture of hardware, software, networks, applications, and management practices must be integrated with the fabric of the firm, its business processes, and its organizational life (Bourdreau and Couillard, 1999).

Mudie and Schafer (1985) asserted that ISI should not only facilitate the process of developing and using data, applications, and other processing technology, but also should provide flexibility to meet the future business demands in workstations, processing types, and applications. In a merging and acquisition context, ISI is considered an important success factor when corporations seek to create synergistic effects by integrating two separate business entities in efforts to increase competitive advantages (Robbins and Stylianou, 1999; Stylianou et al., 1996). In the inter-organizational supply chain context, information technologies allow “multiple organizations to coordinate their activities in an effort to truly manage a supply chain” (Handfield and Nichols, 1999). ISI represents a set of consistent IS practices that supply chain members adopt and exercise to interact with each other. In this context, ISI can be both an internal focus and an external focus (IISI and EISI). A higher level of alignment in IS practices (internal and external) allows firms to stay competitive in a rapidly changing environment. Firms have to manage different components of technologies by integrating and coordinating them into a highly efficient, effective, and responsive system (Sikora and Shaw, 1998). With intensification of competition, firms begin to utilize information systems to directly influence the processes comprising the value chain (Rushton and Oxley, 1994; Williams et al., 1997). This study hypothesized that highly integrated information system practices (internal and external) help enhance cooperation and coordination between a firm and its external partners (e.g., suppliers and customers); therefore,

H3: The higher the extent of IISI, the higher the extent of supply chain integration

H4: The higher the extent of EISI, the higher the extent of supply chain integration

3.5. IMPACTS OF SUPPLY CHAIN INTEGRATION ON OPERATIONAL PERFORMANCE (H5 AND H6)

When sharing common objectives across the supply chain, firms become more cost effective, more efficient, more agile, more responsive to market and supply chain changes, and more innovative. Highly frequent information exchanges within and between firms in the production processes make the delivery process more stable and reliable. The supply chain management literature reports a number of studies on the operational performance benefits that firms derive from supply chain integration.

Armistead and Mapes (1993), for example, found that information exchanges among supply-chain entities lead to improved quality consistency, delivery lead time, ability to change volume quickly, and price. Successful integration (both internal and external) can provide good quality; accurate, useful and timely information; as well as create systems that operate efficiently by ensuring system availability, reliability, and responsiveness (Buck-lew et al., 1992). Ragatz et al. (1997) reported that effective integration of suppliers into project value/supply chains will be a key factor for some manufacturers in achieving the improvements necessary to remain competitive. Literature also provides evidence to support that supply chain integration can improve suppliers' operational activities. A case study by Carter and Ellram (1994) found that supplier involvement in product design has a positive impact on defect rate in the later manufacturing stage. Frequent communication between manufacturing firms and suppliers provides both parties the opportunities to access more efficient manufacturing processes, have higher product quality, implement more reliable logistical systems, reduce production cost, and devote more time on product design and innovation. Therefore,

H5: The higher the extent of supply chain integration, the higher the extent of a firm's operational performance

H6: The higher the extent of supply chain integration, the higher the extent of a suppliers' operational performance

3.6. IMPACTS OF SUPPLIERS' OPERATIONAL PERFORMANCE ON FIRM'S OPERATIONAL PERFORMANCE (H7)

Supplier performance is an inter-organizational performance measurement dealing with the evaluation of performance outside one's own organization. The relationship between suppliers' operational performance and firm's operational performance concerns both intra-organizational performance and inter-organizational performance. This study hypothesizes that, in the global supply chain environment, a firm's competitive position largely depends on its suppliers' abilities to respond to the firm's requirements. In giant industries such as automobile and computer, manufacturing firms mostly act as a central coordinator managing other logistic activities over the globe using advanced information technology. For example, Dell Computer manages all the transactions over the Internet, leaving the real operational activities in the hands of the suppliers. With this new way of doing business, supplier performance is crucial for the firm's survival and competitiveness.

In the literature, supplier performance is considered one of the determinant factors for the company's operational success (Monezka et al., 1983; Baxter et al., 1989; Ellram, 1991; Davis, 1993; Levy, 1997). Harley-Davidson has reported that supplier involvement has improved its overall quality, reduced costs, and helped Harley-Davidson compete against Japanese manufacturers. Integrated industrial relations between manufacturers and suppliers have also been cited as a crucial factor to the success of Japanese manufacturing firms implementing JIT (Hahn et al., 1983; Waters-Fuller, 1995). Vonderembse and Tracey (1999) empirically tested the relationship between supplier performance and manufacturing performance. The study stated that if supplier performance is highly correlated with manufacturing performance, a firm may be able to meet its manufacturing objectives with regard to production costs, work-in-process inventory levels, product quality, and on-time delivery to the final customers.

Based on extensive literature support, this study argues that supplier performance is most likely to bring operational benefits to the manufacturing firms; including reduction of inventory, delivery lead-time and supplier cost, and improvement of scheduling flexibility and quality. Therefore,

H7: The higher the extent of supplier performance, the higher the extent of a firm's operational performance

3.7. IMPACTS OF OPERATIONAL PERFORMANCE ON FIRM PERFORMANCE (H8 AND H9)

Both firm's and suppliers' operational performance; including delivery reliability, process flexibility, cost leadership, product/process innovation, and product quality, play a major role in many studies as an intermediate performance indicator. This capability will in turn influence a firms' overall performance (Mentzer et al., 2000). The operational performance provides necessary factors that impact organizational performances by ruling out other types of performance that are not related to supply chain activities. There are many studies supporting these relationships (Carr and Pearson, 1999; Frazier et al., 1988; Carr and Ittner, 1992; Tan et al., 1998). For example, Carr and Pearson (1999) investigated the impact of "strategic purchasing" and "buyer-supplier relationships" on the firm's financial performance". They found that strategically managed long-term relationships with key suppliers improve overall product quality, delivery, and process flexibility; and thus have a positive impact on the firm's financial performance. Based on extensive literature review, this study hypothesizes that,

H8: The higher the extent of a firm's operational performance, the higher the extent of firm performance.

H9: The higher the extent of a supplier's operational performance, the higher the extent of firm performance.

CHAPTER 4: INSTRUMENT DEVELOPMENT – ITEM GENERATION AND PILOT TEST

In this chapter, the instruments for this research are developed and tested. The instruments to measure include (1) IT utilization, (2) IISI, (3) EISI, (4) supply chain integration, (5) suppliers' operational performance, (6) firm's operational performance, and (7) firm performance. Instruments to measure firms' operational performance, suppliers' operational performance, and firm performance were adopted from previous studies (Tu, 1999; Li, 2002) with minor modifications. Since these three instruments have been tested in previous studies and were found to be valid and reliable, they were not tested again in the pilot study. Instead, they were re-validated in the large-scale analysis. The instruments to measure IT utilization, IISI, IISI, and supply chain integration were developed and pilot tested.

The development of the instruments for the four remaining constructs was carried out in three phases: (1) item generation, (2) pilot study, and (3) large-scale data analysis and instrument validation. First, as discussed in Chapter 2, an extensive and comprehensive literature review was conducted to identify the content domain of major constructs in the current research framework. Initial items and the definitions of each construct were generated from the literature review. The pilot study was conducted using the Q-sort method. Items placed in a common pool were subjected to three sorting rounds by the judges to establish which items should be in various categories. The objective of the Q-sort method is to pre-assess the convergent and discriminant validity of the scales by examining how the items were sorted into various construct categories. After that, analysis of inter-rater agreement about the items' placement identifies both bad items and weakness in the original definitions of the constructs. The third phase was large scale questionnaire administration (discussed in Chapter 5). Research hypotheses were then tested based on the large-scale data analysis.

4.1. ITEM GENERATION

Proper generation of measurement items of a construct determines the validity and reliability of empirical research. The basic requirement for a good measure is content validity, which means the measurement items contained in an instrument should cover the major content domain of a construct (Churchill, 1979). Content validity is usually achieved through comprehensive literature review and interviewing practitioners and academic experts. A list of initial items for each construct was generated based on a comprehensive review of relevant literature. The general literature bases for items in each construct are briefly discussed below.

The items for IT utilization (i.e., Strategic IT, Operational IT, and Infrastructural IT) were modified from previous studies (Narasimhan and Kim, 2001, 2002). The items for Information Systems Integration – IISI and EISI (i.e., Strategic IS Integration, Operational IS Integration, and Infrastructural IS Integration) were developed in this study. The items for Supply Chain Integration (i.e., Integration with Customers and Integration with Suppliers) were developed in this study. The items for Suppliers' Operational Performance (i.e., Delivery Reliability, Process Flexibility, Cost Leadership, Innovation, and Product Quality) and Firm's Operational Performance (i.e., Delivery

Reliability, Process Flexibility, Cost Leadership, Innovation, and Product Quality) were adopted with little modification from previous dissertations by Li (2002) and Tu (1999). Finally, the items for Firm Performance (i.e., Customer Retention Rate, Sales Growth, Market Share Growth, Return on Investment, Profit Margin, Production Throughput Time, New Product Development Cycle Time, and Overall Competition Position) were taken from previous dissertations (Li, 2002).

Once item pools were created, items for the various constructs were reviewed by five academicians and re-evaluated through structured interviews with two practitioners. The focus was to check the relevance of each construct's definition and the clarity of wordings of sample questionnaire items. Based on the feedback from academicians and practitioners, redundant and ambiguous items were either modified or eliminated. New items were added whenever deemed necessary. The result was the following number of items in each pool entering Q-sort analysis (see Appendix A). There were a total of 19 constructs and 170 items.

Information Technology Utilization	
Strategic Information Technology	13
Operational Information Technology	10
Infrastructural Information Technology	11
Internal Information System Integration	
Strategic Integration	9
Operational Integration	9
Infrastructural Integration – Data Integration	6
Infrastructural Integration – Network Connectivity	6
External Information System Integration	
Strategic Integration	10
Operational Integration	9
Infrastructural Integration – Data Integration	6
Infrastructural Integration – Network Connectivity	6
Supply Chain Integration	
Relationship with Customers	6

Relationship with Suppliers	5
Suppliers' Operational Performance	
Delivery Reliability	6
Process Flexibility	6
Cost Leadership	5
Innovation	5
Product Quality	6
Firm's Operational Performance	
Delivery Reliability	6
Process Flexibility	6
Cost Leadership	5
Innovation	5
Product Quality	6
Firm Performance	**8**
Total	**170**

4.2. PILOT STUDY

To further ensure the content validity, the measurement items generated from literature reviews were tested with manufacturing managers and operations managers in the Midwest region of U.S., faculty members who are familiar with operations management research at a large state university, and Ph.D. students who are specializing in operations management or manufacturing management.

The structured interview was conducted with two major steps. First, the definition of each research construct was presented to practitioners and some open-ended questions were asked to ensure the representation of questions/sub-dimensions for all constructs. In the second step, a "Q-Sort" methodology was conducted using two approaches (1) traditional paper based approach and (2) online approach. For the traditional approach, one 3" by 5" card was printed for each item generated from the literature review. The set of cards for each construct was then shuffled and given to the practitioners. The definitions of the entire construct and each of its sub-dimensions were also presented. The practitioners were asked to put each card under each of the sub-dimensions. Items considered not belonging to any of the existing dimensions were removed and new dimensions were suggested if applicable. If an item fell under a different dimension from previously conceived, questions were further examined for possible clarification. During the process, the practitioners could also suggest combining two possible overlapping dimensions. The interview results from all practitioners were then carefully analyzed and a common pattern of thinking was recognized, which formed the basis for further revision of measurement items and construct dimensions. For the online approach, a Q-Sort website was constructed to provide convenience for practitioners (e.g., time conflict or different locations). The detail of Q-Sort method is explained in the following subsection. A copy of the revised definitions and measurement items was then sent to faculty members to solicit their comments on the appropriateness of the measure. They had the opportunity to suggest "Keep", "Drop", and "Modify" each item. They could also suggest new construct dimensions if they felt that the existing dimensions did not cover the entire content domain. The instruments were then revised based on the comments.

4.3. SCALE DEVELOPMENT: THE Q-SORT METHOD

The basic procedure was to have a vice president of manufacturing, a manufacturing manager, a plant manager, a manufacturing director, a production manager, and/or a plant operations manager judge and sort the items from the first stage into separate sub-constructs, based on construct/sub-construct definitions. A group of potential judges was identified from local businesses. All of the potential participants were representatives of the population targeted for this study, and were considered knowledgeable in the manufacturing field, and with the required experience and position to assess the impact of information technology (IT) in their organization.

Based on the placements made by the judges, the items could then be examined. Inappropriately worded or ambiguous items could be eliminated or reworded. Two goals for this stage were to identify and modify any ambiguous items and to pre-assess the construct validity of the various scales being developed. First, judges sorted the various items into construct categories. This procedure is similar to the technique Davis (1989) used in assessing the coverage of the domains of his constructs. First, Davis asked judges to rank how well the items fit the construct definitions provided, and then asked the judges to sort items into construct categories. By comparing the categories developed, Davis was then able to assess the domain coverage of the particular construct. The second step in this research is similar to a procedure employed by Davis. An indicator of construct validity was the convergence and divergence of items within the categories. If an item was consistently placed within a particular category, then it was considered to demonstrate convergent validity with the related construct, and discriminant validity with the others.

4.3.1. Sorting Procedures

There were two approaches used to construct the Q-sort method. First, each item was printed on a 3 x 5 -inch index card. The cards were shuffled into random order for presentation to the judges. Each judge sorted the cards into categories. A “not applicable” category was included to ensure that the judges did not force any item into a particular category.

Second, the internet web-site was set up with potential items being shuffled randomly. Each judge was asked to sort each item into categories. A “not applicable” category was included to ensure that the judges did not force any item into a particular category. Figure 4.1 and Figure 4.2 shows the typical setting for the Internet Q-sort.

Figure 4.1: Q-sort login page

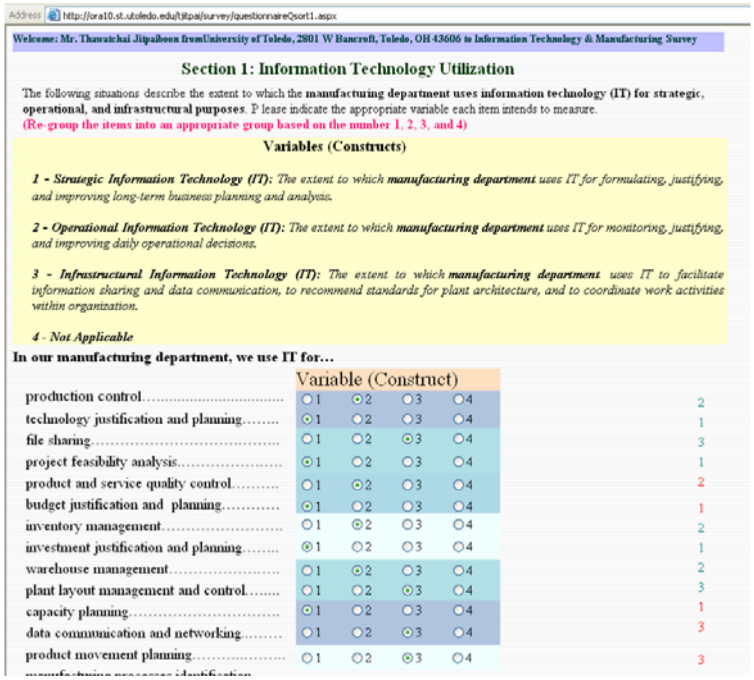


Figure 4.2: Q-sort page

During the three sorting rounds, eleven informants provided input (four academicians and seven practitioners); however, the results from only three different pairs of judges (six practitioners only) were used to estimate inter-rater reliability and item placement score. Each set of judges included appropriate job titles such as vice president of manufacturing, manufacturing manager, plant manager, manufacturing director, production manager, and/or plant operations manager. This ensures that a wide range of perceptions from the targeted population covers the whole domain of the study. Prior to sorting, the judges were briefed with a standard set of instructions that were previously tested with a separate judge to ensure comprehensiveness and comprehensibility. Judges were allowed to ask as many questions as necessary to ensure they understood the procedure.

4.3.2. Inter-rater reliabilities

Two different measures were made to assess the reliability of the sorting conducted by the judges. First, for each pair of judges in each sorting step, their level of agreement in categorizing items was measured using Cohen's Kappa (Cohen, 1960).

Second, an overall measure of both the reliability of the classification scheme and the validity of the items (Hit Ratio) was adopted from Moore and Benbasat, (1991). The method required analysis of how many items were placed by the panel of judges for each round within the target construct. In other words, because each item was included in the pool explicitly to measure a particular underlying construct, a measurement was taken of the overall frequency with which the judges placed items within the intended theoretical construct. The higher the percentage of items placed in the target construct, the higher the degree of inter-judge agreement across the panel must have occurred. Secondly, scales based on categories which have a high degree of correct placement of items within them can be considered to have a high degree of construct validity, with a high potential for good reliability scores. It must be emphasized that this procedure is more of a qualitative analysis than a rigorous quantitative procedure. There are no established guidelines for determining good levels of placement, but the matrix can be used to highlight any potential problems areas. Following is an example of how this measure would work. A description of the Cohen's Kappa (Cohen, 1960) and Moore and Benbasat's 'Hit Ratio" (Moore and Benbasat, 1991) is included in Appendix B.

4.3.2.1. Results of First Sort (see detailed results in Appendix B)

Five judges were involved in the first sorting round, two academicians and three practitioners. Only two practitioners were chosen in the estimation of agreement scores. In this round, the inter-judge raw agreement scores averaged 0.65 (Table 4.2), the initial overall placement ratio of items within the target constructs was 75 % (Table 4.3), and the Kappa scores averaged 0.62. Table 4.1 shows inputs used for calculating Cohen's Kappa coefficient. The calculations for the Cohen's Kappa coefficient are shown below.

$$k = \frac{N_i X_{ii} - \sum_i (X_{i+} X_{+i})}{N_i^2 - \sum_i (X_{i+} X_{+i})} = \frac{(98)(64) - 853}{(98^2) - 853} = 0.62$$

A summary of the first round inter-judge agreement indices is shown in Table 4.1 and Figure 4.4. Following the guidelines of Landis and Koch for interpreting the Kappa coefficient, the value of 0.62 indicates a moderate level of agreement beyond chance for the judges in the first round. This value is slightly lower than the value for raw agreement which is 0.65 (Table 4.2). The level of item placement ratios averaged 75% (Table 4.3 & 4.4). For instance, the lowest item placement ratio value was 44% for the External Operational Information Systems Integration construct, indicating a low degree of construct validity. On the other hand, two constructs (Relationship with Customers and Relationship with Suppliers) obtained a high placement ratio over 90%, indicating a high degree of construct validity.

In order to improve the Cohen's Kappa and other measures of agreement, an examination of the off-diagonal entries in the placement matrix (Table 4.3) was conducted. Tables 4.5 to 4.9 show the distribution of the agreement of measurement items. There are three possible explanations. The first explanation is that both judges agreed on a particular item but misplaced the item from the original construct intended to measure it. In such a case, the researcher would switch such items into the right construct before the next Q-sort round. The second explanation is that only one of the two judges correctly put the item into the right construct. In this situation, each item would be considered carefully to either be re-worded, re-grouped, deleted, or unchanged. Third, both judges correctly sorted the items into the right construct. In this case, no change was necessary.

4.3.2.2. Results of Second Sort (see detailed results in Appendix B)

Three practitioners were involved in the second sorting round. The second sorting round included the reworded items and two modified constructs. Infrastructural Information Systems Integration was changed into two new constructs – Data Integration and Network Connectivity. In this round the inter-judge raw agreement score average was 0.75 (Table 4.9), the initial overall placement ratio of items within the target constructs was 80 % (Table 4.10), and the Kappa score was 0.72.

The calculations for the Cohen's Kappa coefficient for the second sorting round are shown below.

$$k = \frac{N_i X_{ii} - \sum_i \left(X_{i+} X_{+i} \right)}{N_i^2 - \sum_i \left(X_{i+} X_{+i} \right)} = \frac{(98)(73) - 783}{(98^2) - 783} = 0.72$$

A summary of the second round inter-judge agreement indices is shown in the second column of Table 4.11. The value for the Kappa coefficient of 0.72 was higher than the value obtained in the first round, but still indicated a moderate level of agreement beyond chance for the judges in the second round. The level of item placement ratios averaged 80%. The lowest item placement ratio value was 58% for the Infrastructural IT construct, indicating a low degree of construct validity. Again several constructs (Operational IT, Internal Strategic Information Systems Integration, Relationship with Customers and Relationship with Suppliers) obtained over 90% item placement ratio, indicating a high degree of construct validity.

In order to further improve the Cohen's Kappa measure of agreement, an examination of the off-diagonal entries in the placement matrix (Table 4.10) was conducted. The results of the second round showed some improvements (Table 4.11). Four constructs including Infrastructural IT, Internal Infrastructural Information Systems Integration – Data Integration, Internal Infrastructural Information Systems Integration – Network Connectivity, and External Strategic Information Systems Integration showed worse inter-judge agreement ratios. These four constructs were the target for improvement on the following sorting round. Table 4.12 to 4.15 shows the results of the second sorting round.

4.3.2.3. Results of Third Sort (see detailed results in Appendix B)

As in the previous two sorting rounds, four judges participated in the third sorting round (two practitioners and two academicians), which included the reworded items and new added items. In the third round the inter-judge raw agreement scores averaged 0.91 (Table 4.16), the initial overall placement ratio of items within the target constructs was 93 % (Table 4.17), and the Kappa scores averaged 0.90.

The calculations for the Cohen's Kappa coefficient for the third sorting round are shown below.

$$k = \frac{N_i X_{ii} - \sum_i \left(X_{i+} X_{+i} \right)}{N_i^2 - \sum_i \left(X_{i+} X_{+i} \right)} = \frac{(96)(87) - 735}{(96^2) - 735} = 0.90$$

A summary of the third round inter-judge agreements indices is shown in the third column of Table 4.18. The value for the Kappa coefficient of 0.90 is significantly higher than the value obtained in the second round, and indicates an excellent level of agreement beyond chance. The level of item placement ratios averaged 93%. The lowest item placement ratio value was that of 75% (Internal and External Infrastructural Information Systems Integration - Network Connectivity construct) indicating a moderate to good degree of construct validity. The construct's Operational IT, Internal Strategic Information Systems Integration, Internal Operational Information Systems Integration, External Strategic Information Systems Integration, External Operational Information Systems Integration, Relationship with customers, and Relationship with suppliers obtained a 100% item placement ratio. This placement of items within the target construct shows that a high degree of construct validity and potential reliability were achieved.

The final refinement of the scales for the large scale survey was the slight modification of the third sorting round. The resultant measurement instrument from the three sorting rounds is shown in Appendix C. The number of items remaining for each construct after the third round of Q-sort was as follows:

Information Technology Utilization	
Strategic Information Technology	8
Operational Information Technology	11
Infrastructural Information Technology	7
Internal Information System Integration	
Strategic Integration	9
Operational Integration	8
Infrastructural Integration – Data Integration	6
Infrastructural Integration – Network Connectivity	7
External Information System Integration	
Strategic Integration	9
Operational Integration	8
Infrastructural Integration – Data Integration	6
Infrastructural Integration – Network Connectivity	6
Supply Chain Integration	
Relationship with Customers	6
Relationship with Suppliers	6
Suppliers' Operational Performance	
Delivery Reliability	6
Process Flexibility	6
Cost Leadership	5
Innovation	5
Product Quality	6
Firm's Operational Performance	
Delivery Reliability	6
Process Flexibility	6
Cost Leadership	5
Innovation	5
Product Quality	6
Firm Performance	**8**
Total	**161**

CHAPTER 5: INSTRUMENT DEVELOPMENT - LARGE-SCALE ADMINISTRATION AND INSTRUMENT VALIDATION

5.1. SAMPLING PLAN

5.1.1. Sampling plan and sampling design

A cross-sectional self-administered mail survey was conducted. This study aims to cover a wide variety of respondents from different tiers in supply chains (e.g., raw material suppliers, assemblers, manufacturers, wholesalers, component suppliers, sub-assemblers, distributors, and retailers) and from different major business areas (e.g., manufacturing, medicine, business service, public utility, transportation, petroleum, finance, mining, and construction).

Many options are available when developing sampling design. For example, convenient samples can be chosen if the sampling frame is not available or a population sample is hard to identify. Simple random sampling can be utilized when a population sample is unique and well identified. Stratified sampling can be used when the purpose of research is to find a unique phenomenon that confounds within each sample strata. Cluster sampling can be used when the population that is to be surveyed is physically or geographically separated or widely dispersed. According to the available sampling alternatives, this study chose a simple random sample for several reasons. First, there were many sampling frames available. There were many manufacturing associations that provided a list of manufacturing firms. Second, a simple random sample provides reliable and valid results. The purpose of this research is to explain relationships among variables.

The results should show both statistical and practical implications to the external population represented by the respondents.

5.1.2. Sampling frame options

One important success factor in an empirical study is the quality of respondents. The respondents are expected to have detailed knowledge on multiple topics covered in a survey. In the current study, the respondents are expected to have experience in different levels of IT utilization; which is used to enhance integration within their firm or with their trading partners. The respondents are also expected to be representatives of different geographical areas, industries, and firm sizes, so that the results can be highly generalized.

Many manufacturing associations provide lists of manufacturing firms, e.g. the Association of Purchasing and Inventory Control (APIC), the Society of Manufacturing Engineers (SME), the National Association of Purchasing Management (NAPM), the Council of Logistics Management (CLM), and so on. The criteria for choosing the optimal sampling frame depended on many factors such as past experience, cost, available information, experts' advice, data accuracy, and number of records. In this study, the sampling frame was obtained from the Society of Manufacturing Engineers (SME), an internationally known organization of manufacturing managers and engineers, with more than 120,000 active members world wide and in almost every industry. The list was obtained with a limited agreement and partial sponsorship by the SME (Appendix K).

5.1.3. Random sampling generation

Once the sampling frame was identified, the process of generating random samples was undertaken. The initial mailing list of 6,000 names was randomly selected from the SME United States membership database, which included 120,000 names using predetermined criteria. The criteria include states in the East North Central and West North Central regions, job functions, and SIC Codes. The states include OH, IN, MI, IA, WI, SD, ND, IL, MO, KS, NE, and MS. The job functions include manufacturing production, manufacturing engineering, and quality assurance/control. Priorities of members were then stratified in the following SIC classifications.

Food and kindred products.. SIC 20
Tobacco.. SIC 21
Textile mill products.. SIC 22
Apparel and other textile products.. SIC 23
Lumber and wood products .... SIC 24
Furniture and fixtures.. SIC 25
Paper and allied products.. SIC 26
Printing and publishing .... SIC 27
Chemical and allied products.. SIC 28
Petroleum and coal products... SIC 29
Rubber and plastic products.. SIC 30
Leather and leather products.. SIC 31
Stone, clay and glass products .... SIC 32
Primary metal industries .... SIC 33
Fabricated metal products... SIC 34
Industrial machinery and equipment, except electrical................ SIC 35
Electric and electronic equipment.. SIC 36
Transportation equipment .... SIC 37
Instruments and related products .... SIC 38

The SME provided the mailing list in an ASCII comma delimited format. The list includes the following fields: keyline (which can be translated into company size and 4 digit SIC code), person’s prefix name, person’s first name, person’s middle initial, person's last name, person' job title, company name, address line 1, address line 2, mail stop, city, state code, zip code, telephone number, and extension number. Table 5.1 shows codes used to translate a company size based on the number of employees.

Codes	Employee Sizes
0	1-19
1	20-49
2	50-99
3	100-249
4	250-499
5	500-999
6	1000-2499
7	2500+

Table 5.1: Number of Employees

5.2. LARGE SCALE DATA COLLECTION METHODOLOGY

This mailing list was then further refined through the following steps: 1) names were removed if they were without organization affiliations, or listed addresses that were home addresses. This was done in consideration of home privacy of respondents; 2) when multiple names from the same organization were given, the name of the person with the most relevant job title was retained and the others were removed; 3) obvious errors in names and mailing addresses were also corrected. These refinements resulted in a list of 4,000 names.

To ensure a reasonable response rate, five research schemes were administered. First, 4,000 questionnaires with cover letter, a fact sheet and a letter of endorsement of the SME indicating the purpose and significance of the study were mailed to the target respondents between November 8-12, 2004 (Appendix D, E, F, and K). In the cover letter, a web-address of the online version of the survey along with customized “username” and “password” was also provided for the respondents to reply electronically if desired. The online version of questionnaire is shown in Appendix G. Second, the 4,000 reminders stating the required due date and the lottery incentive were mailed after the Thanksgivings day, November 29, 2004 (Appendix J). Third, after the reminders were mailed, students were hired to make telephone calls to improve response rate (the calling drill included in the Appendix L). Table 5.2 shows the number of respondents and telephone calls made by state. The telephone calls were completed in only three states (OH, MI, and IA) because of time limit (Christmas holidays).

State	Number of Respondents	Number of Calls
OH	858	771
IN	407	24
MI	789	723
IA	115	105
WI	468	-
SD	29	-
ND	12	-
IL	712	-
MO	160	-
KS	81	-
NE	49	-
MN	320	-
Total	4,000	1,623

Table 5.2: Number of Respondents and Telephone Calls by State

Fifth, to improve the response rate, 2,000 questionnaires (the original mailing list excluding the bad addresses and returned surveys) with cover letter and 2,000 reminders were mailed to the target respondents on January 15, 2005 and February 10, 2005 respectively.

Of 4,000 mailed questionnaires, 579 did not reach the targeted respondents because of bad addresses. One hundred and eighty eight (188) questionnaires were undeliverable and 391 questionnaires were identified as incorrect addresses from the follow up phone calls. This number is expected to be higher if all calls are completed. The main reasons for undeliverable mail were; respondents not with the company, deceased, company out of business, or company moved. A large number of (235) respondent refused to participate in the survey. In addition, 14 questionnaires were returned empty. Therefore, the number of complete and usable responses was 220, representing a response rate of 6.91% (calculated as 220/(4000-579-235)).

Out of 220 respondents, the first wave produced 148 responses and the second generated 72 responses. Ninety three respondents (42%) were from the traditional mail and 127 respondents (58%) were from the on-line version of the survey.

5.3. SAMPLE CHARACTERISTICS OF THE RESPONDENTS

This section discusses sample characteristics of the respondents (job title, levels of education, years working and years with the organization), the SIC code, the size of organizations, the organizations (years of implementing SCM program, the number of product lines, the primary production system, employment size, annual sales, the percentage of electronic business transactions with customers and suppliers, and quantitative SCM measures), and the supply chains (horizontal structure, horizontal position of the organization in the supply chain, and channel structure).

5.3.1 Sample Characteristics of the Respondents (also see Table 5.3 Appendix M)

Job Title: 117 of the respondents (53.2%) are managers, while 16 or 7.3% state they are directors and 15 (6.8%) are titled CEO/president. Sixty of the respondents (27.3%) are supervisors and 10 (4.6%) are engineers, and 2 (0.9%) are identified as "other" category.

Job Function: The respondents were asked to mark all job functions that apply to their everyday tasks. Therefore, the results of this item are combinations of job function (one respondent can choose more than one job function). The majority of respondents (41.4%) chose manufacturing and production, 6.5% of the respondents chose corporate executive, and 6.1% purchasing, while 1.2% chose distribution, 2.3% chose transportation, and 6.1% chose sales. 13.4% are unidentified. The rest of respondents (23.0%) belong to the "other" category.

Level of Education: 10.5% of the respondents have finished high school, while 20% state they have completed two-year College and 31.8% have completed Bachelor's degrees. 16.4% have completed Mater's degrees and 1.4% are in a Doctoral level. 15.9% are unidentified. The rest of the respondents (4.1%) belong to the "other" category.

Years at the Organization: 7.3% of respondents indicate they have been with the organization less than 10 years, while 24.6% indicate having been at the organization between 4-10 years, and 18.6% of respondents state their years at the organization as between 10-15. 9.6% of respondents state that they have been with the organization between 15-20 years. The respondents with years at the organization more than 20 years account for 24.6% of the sample. 15.5% are unidentified.

Years Working: 0.5% of the respondents have been working less than 3 years. 7.3% of the respondents have been working between 4-10 years, while 12.7% state they have worked between 10-15 years and 10.9% have worked between 15-20 years. 53.2% have worked for more than 20 years. 15.5% are unidentified.

In short, more than 53% of the respondents are managers, have been working over 20 years, and/or function in the manufacturing and production area. CEO/presidents and directors were less likely to respond to the survey as indicated. This is represented by the low response rate compared to managers. The level of education and years of work at the current organization are randomly spread out, but the majority completed Bachelor's degree and have been working for the current organization for 4-20 years. Figures 5.3.1.1 to 5.3.1.5 (Appendix M) display the respondents by job titles, job functions, level of education, years worked at the organization, and years of working, respectively.

5.3.2. Sample Characteristics of Surveyed Organizations (also see Table 5.4 Appendix M)

Major Business: 79.6% of the respondents state that their business function is manufacturing, while 1% state that their main business is transportation and 1% is mining/construction/agriculture. 3.2% of the respondents are involved in other types of business and 15.5% are unidentified.

Major Industry: less than 1% of the organizations are in food and kindred products (SIC 20), tobacco (SIC 21), and furniture and fixtures industry (SIC 25). 1% of the organizations are in the leather and leather products industry (SIC 31). About 2.7% of the organizations are in the electric and electronic equipment industry (SIC 36) and 1.8%

in instruments and related products industry (SIC 38). About 2.7% of the organizations are from primary metal industries (SIC 33). About 7.7% of the organizations are from the rubber and plastic products industry (SIC 30). 27.3% of the organizations are in the fabricated metal products industry (SIC 34). 10.5% of the organizations are in the industrial machinery and equipment industry (SIC 35). 12.3% of the organizations are in the transportation equipment industry (SIC 37). 14.1% of the organizations are in the miscellaneous manufacturing industries (SIC 39). 18.6% are unidentified.

Primary Production System: Half of the organizations (50%) use make-to-order as their primary product system; while make-to-stock, engineer-to-order, and assemble-to-order account for 14.6%, 10%, and 9.1% respectively. 16.4% are unidentified.

Primary Manufacturing System: 9.5% of the organizations use continuous flow process as their primary manufacturing system; while 18% of the organizations use batch processing. 10.8% of the organizations use a flexible manufacturing system. 8.6% of the organizations use an assembly line. 19.8% of the organizations are a job shop. 4.1% of the organizations are a project system. 13.5% of the organizations are a manufacturing cell and 15.8% are unidentified.

Number of Employees: 10.9% of the organizations have fewer than 50 employees. 14.6% of the organizations have between 51 and 100 employees. 22.7% of the organizations have between 100 and 250 employees. 13.2% of the organizations have between 251 and 500 employees, and 6.4 % of the organizations have between 501 and 1000 employees. Organizations with more than 1000 employees account for 16.4% of the sample and the rest (15.9%) are unidentified.

Annual Sales: 9.1% of the organizations have sales volumes less than 5 million. 7.3% of the organizations have sales volumes between 5 and 10 million. 17.7% of the organizations have sales volumes between 10 and 25 million. 11.4% and 11.8% of the respondents have sales volumes between 25-50 million and between 50-100 million respectively. About 24.1% of the organizations have sales volumes more than 100 million. 18.6% of respondents could not identify their sales volumes.

In short, the majority of the surveyed organizations reported manufacturing as their business sector mainly in manufacturing fabricated metal products, and/or used a make-to-order production system. The number of employees and annual sales volumes are normally distributed among the surveyed organizations. Figure 5.3.2.1 to Figure 5.3.2.6 (Appendix M) display the surveyed organizations according to major business, major industry, primary business system, primary manufacturing system, number of employees, and annual sales, respectively.

5.3.3. Sample Characteristics of the Supply Chains (also see Table 5.5 Appendix M)

Organization's Involvement in "Supply Chain Integration": 29.6% of the respondents reported that their organization embarked upon a program aimed at implementing "Supply Chain Integration", while 53.6% of the respondents reported otherwise. 16.8% of the respondents are unidentified.

Electronic Business Transactions with Customers: 13.6% of the organizations state that they have done less than 10% of their business transactions electronically with customers, 17.7% of the organizations have done 10%-30% of their business transactions electronically with customers, and 20% of the organizations have done 30-50% of their business transactions with customers. 18.6% indicate 50%-80% of their business transactions are done electronically with customers and 11.8% indicate that more than 80% of their business transactions with customers are done electronically. 18.1% are unidentified.

Electronic Business Transactions with Suppliers: 19.1% of the organizations state that they have done less than 10% of their business transactions electronically with customers, 22.7% of the organizations have done 10%-30% of their business transactions electronically with customers, and 16.8% of the organizations have done 30-50% of their business transactions with customers. 17.3% indicate 50%-80% of their business transactions are done electronically with customers and 6.4% indicate that more than 80% of their business transactions with customers are done electronically. 17.7% are unidentified.

Comparing the electronic business transactions with suppliers and customers (see Figure 5.3.3.1), it can be seen that most of the business transactions with suppliers and customers are still done off-line in a traditional way. Organizations are more likely to conduct electronic business transactions with customers than with suppliers. About 12% of the organizations do more than 80% of their transactions with customers electronically, but only 6% of the organizations have done more than 80% of their business transactions with suppliers electronically. On the other hand, 14% of organizations conduct less than 10% of the transactions electronically with customers, but the number of the organizations that only do less than 10% of the transactions with suppliers is larger by 19%.

Horizontal Structure: horizontal structure refers to the number of tiers across the supply chain. The supply chain may be long, with numerous tiers, or short, with few tiers.

The results show that about half of supply chains (49%) have less than or equal to 3 tiers. 26% have 4 or 5 tiers across the supply chains. 4% have 6 or 7 tiers across the supply chains. Less than 1% have 8 to 10 tiers across the supply chains. 2% have more than 10 tiers across the supply chains. The rest (18%) are unidentified.

Horizontal Position of an Organization in the Supply Chain: A company can be positioned at or near the initial source of supply (raw material and component supplier), be at or near the ultimate customer (distributor/wholesaler/retailer), or somewhere between these end points of the supply chain (assembler and manufacturer). Among all surveyed organizations, manufacturers account for 54.1%, assemblers and sub-assemblers accounts for 9.5% and 4.6% respectively. In addition, 1.4% and 13.4% of respondents consider themselves raw materials suppliers and component suppliers correspondingly. Furthermore, distributors, wholesalers, and retailers account for 2.1%, 1.8%, and 0.7% respectively. 12.4% are unidentified. (Note: one company may occupy multiple positions and may represent multiple items, the calculation of the percentage is based on the total sample size of 283. Relating to the characteristics of supply chains, most surveyed organizations are manufacturers (also see Figure 5.3.3.1 to Figure 5.3.3.3 Appendix M).

5.3.4. Sample Characteristics of the Technology Applications

Organization's Information Technology Applications: 24.2% of the respondents reported that they use e-mail primarily for work, while 17.1% of the respondents reported using word processing. 21.4%, 17.1%, and 8.7% of the respondents use spread sheet, database, and programming tools respectively. 3.2% chose "other" category and 8.2% are unidentified.

Organization's Computer Applications: 26.1% of the respondents reported that they use main frame application as a main computing system, while 37.2% of the respondents reported using PC application. 36.7% use networked application as a main computing system.

5.4. TEST OF NON-RESPONSE BIAS

One concern of the survey is that information collected from respondents might have a non-response bias. Non-response bias can be estimated using the mean differences of some variables between the first wave response and the second wave response can be estimated by assuming that the second wave response is a non-response for the first wave.

Four thousand (4,000) surveys were sent out as the first wave. Out of this number, 220 surveys were received. Within this number, 148 responses were from the first wave and only 72 were from the second wave. Table 5.5 (Appendix M) shows the demographics of respondents by waves. The non-response bias can also be tested using an indirect approach by comparing variable means between those subjects who responded after the initial mailing (first wave) and those who responded to the second wave. Chi-square tests were used to make the comparisons. The results are shown in the last column of Table 5.6. We can see no significant difference in employment size, sales volume, production system, and respondent's job title between these two groups and we conclude non-response bias is not a cause for concern.

Variables	First-wave Frequency (%)	Second wave Expected Freq. (%)	Second wave Observed Freq. (%)	Chi-square Test
Number of Employees (220)				
1-50	24	8	0	χ^2=12.54 df=6 p>.05
51-100	18	10	14	
100-250	37	16	13	
251-500	19	9	10	
501-1000	8	5	6	
Over 1000	19	12	17	
Unidentified	23	11	12	
Sales Volume in millions of $ (220)				
<5	20	7	0	χ^2=10.78 df=6 p>.10
5 to <10	10	5	6	
10 to <25	28	13	11	
25 to <50	13	8	12	
50 to <100	20	9	6	
Over 100	33	17	20	
Unidentified	24	13	17	
Job Title (220)				
CEO/President/Vice President/Owner	13	5	2	χ^2=8.48 df=5 p>.10
Director	13	5	3	
Manager	82	38	35	
Supervisor	32	19	28	
Engineer	8	3	2	
Other	0	0	1	
Production System (220)				
Engineer to Order	16	7	6	χ^2=5.21 df=4 p>.10
Make to Order	77	36	33	
Assemble to Order	8	7	12	
Make to Stock	23	10	9	
Unidentified	24	12	12	

Table 5.6: Test of Non-Response Bias

The calculation formula $\chi^2 = \sum (f_e - f_o)^2 / f_e$

5.5. TEST OF RESPONSE BIAS

The response bias can also be tested based on the mean differences of some variables between the regular mail responses and the online responses. Out of 220 responses, 93 (42%) are from the regular mail and 127 (58%) are from the online survey. The response bias can be tested by comparing variable means between those subjects who responded online and those who responded using regular mail. Table 5.7 shows the non-response bias results. The results show that the means values of demographic variables (e.g., job title, level of education, years of work, years at a company, annual sales, and number of employees) are not significantly differently at the < 0.05 level. Thus, the results confirm that a regular mail survey and an online survey have no response bias.

Variables	Regular Mail (Means)	Online Mail (Means)	t - Differences	P - Value
Job Title	3.01	3.22	1.82	.07
Education	2.89	2.88	0.05	.96
Years of Work	4.18	4.39	1.37	.17
Years at Company	3.17	3.29	0.57	.57
Annual Sales	3.86	4.10	0.91	.37
Number of Employees	3.36	3.55	0.79	.43

Table 5.7: Test of Response Bias between an Online Survey and a Regular Mail

5.6. LARGE SCALE INSTRUMENT ASSESSMENT METHODOLOGY

Once the data was collected, the survey instrument used in the large-scale study was submitted to rigorous reliability and validity assessment using the 220 responses. The validity of a measurement concerns the "truth" of the measurement. The validity of a measurement procedure is the degree to which the measurement process measures the variable it claims to measure. The reliability of a measurement procedure is the stability or consistency of the measurement. If the same individuals are measured under the same conditions, a reliable measurement procedure will produce identical measurements. Although reliability and validity are both criteria for evaluating the quality of a measurement procedure, these two factors are partially related and partially independent. A measure cannot be valid unless it is reliable, but a measure can be reliable without being valid. As per the guidelines of Bagozzi (1980) and Bagozzi and Phillips (1982), the important properties for measurement to be reliable and valid include content validity, internal consistency of operationalization (unidimensionality and reliability), construct validity (discriminant and convergent) and predictive validity.

Content Validity

The content validity of measurement refers to the representativeness of item content domain. If the measures adequately cover the topics that have been defined as the relevant dimensions, then it can be concluded that an instrument has good content validity (Kerlinger, 1978). The evaluation of content validity is a rational judgmental process not open to numerical justification. Nunnally (1978) stated "*Content validity rests mainly on appeals to reason regarding the adequacy with which important content has been sampled and on the adequacy with which the content has been cast in the form of* *test items*." An instrument has content validity if there is a general agreement among the subjects and researchers that the measurement items that cover all important aspects of the variable being measured.

Content validity can be assessed by two important processes. First, a comprehensive review of the literature was conducted to make sure that measurement items were well covered the domain of the variable being measured (Nunnally, 1978). Second, a Q-sort method was conducted to clarify a description of the hypothesized constructs (Appendix B).

Unidimensionality and Reliability

The reliability (internal consistency) of the items comprising each dimension was examined using Cronbach's alpha. Following the guideline established by Nunnally (1978), an alpha score of higher than .70 is generally considered to be acceptable. To further ensure the unidimensionality of the measurement instrument, Item-total correlations have been used extensively for the development of unidimensional scales. Item-total correlation refers to a correlation of an item or indicator with the composite score of all the items or indicator with the composite score of all the items forming the same set. Item-total correlations less than 0.5 are usually candidates for elimination in further analysis. If all the items in a measure are drawn from the domain of a single construct, responses to those items should be highly intercorrelated (Churchill, 1979).

Convergent Validity

Convergent validity is defined as the extent to which the measurement items are converged into a theoretical construct. The traditional method employed for evaluation of construct validity of measurement scales is confirmatory factory analysis (CFA). In this study, one of the most widely used SEM software called AMOS was utilized. Using AMOS, it is possible to specify, test, and modify the measurement model. Model-data fit was evaluated based on multiple fit indexes. The overall model fit indexes include goodness of fit index (GFI), adjusted goodness of fit index (AGFI), and root mean square error of approximation (RMSEA). GFI indicates the relative amount of variance and covariance jointly explained by the model. The AGFI differs from GFI in that it adjusts for the number of degree of freedom in the model. Many researchers interpret these index scores (GFI, AGFI) in the range of .80-.89 as representing reasonable fit; scores of .90 or higher are considered as evidence of good fit (Joreskog and Sorbom, 1989). The RMSEA takes into account the error of approximation and is expressed per degree of freedom, thus making the index sensitive to the number of estimated parameters in the model; values less than 0.05 indicate good fit, values as high as 0.08 represent reasonable errors of approximation in the population (Browne & Cudeck, 1993), values ranging from 0.08 to 0.10 indicate mediocre fit, and those greater than 0.10 indicate poor fit (MacCallum et al, 1996).

Discriminant validity

Discriminant validity refers to the independence of the dimensions (Bagozzi and Phillips, 1982). Discriminant validity can be assessed using structural equation modeling methodology (Bagozzi and Phillips, 1982). It can be done by taking two constructs at a time. The constructs are considered to be distinct if the hypothesis that the two constructs together form a single construct is rejected. To test this hypothesis, a pair-wise comparison of models was performed by comparing the model with correlation constrained to one with an unconstrained model. A different between the χ^2 value (df = 1) of the two models that is significant at $p < 0.05$ level would indicate support for the discriminant validity criterion (Joreskog, 1971).

Another important aspect of discriminant validity is the validation of second-order construct. For example, information technology utilization is measured by strategic information technology, operational information technology and infrastructural information technology and each of these sub-constructs is measured by several indicators. The question here is “do these three sub-constructs form a high order construct (information technology utilization)?” T coefficient can be used to test for the existence of the single second-order construct that accounts for the variations in all its sub-constructs. The T coefficient is calculated as the following: suppose that model A (see Figure 5.6.1) represents four correlated first-order factors and model B (see Figure 5.6.2) hypothesizes the same four first-order factors and a single second-order factor. T coefficient is the ratio of chi-square of model A to the chi-square of model B which indicates the percentage of variation in the four first order factors in model A explained by the second-order factor in model B (Doll et al., 1995). Even though the fit index of model B is always a little “worse” than that of model A since more constraints have been added in the model B, a T coefficient higher than .80 may indicate the existence of a second-order construct since most of the variation shared by the first-order factors is explained by the single second-order factor.

Figure 5.6.1 (Model A)

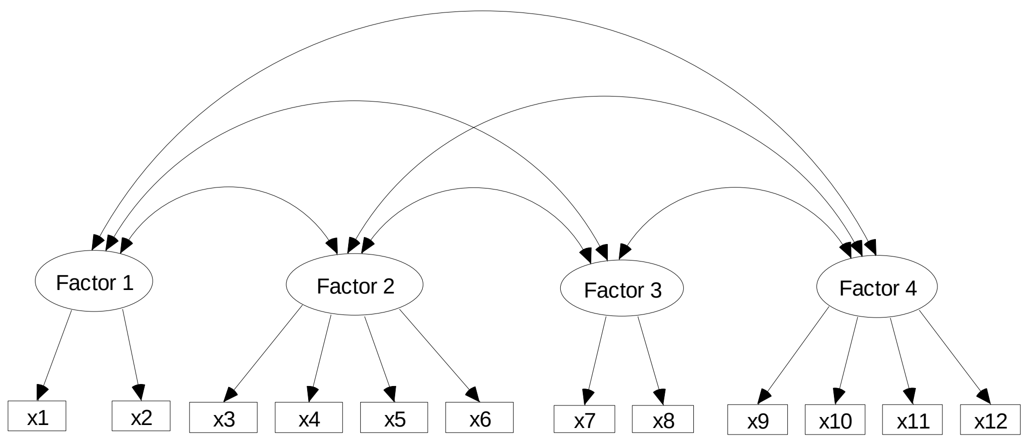
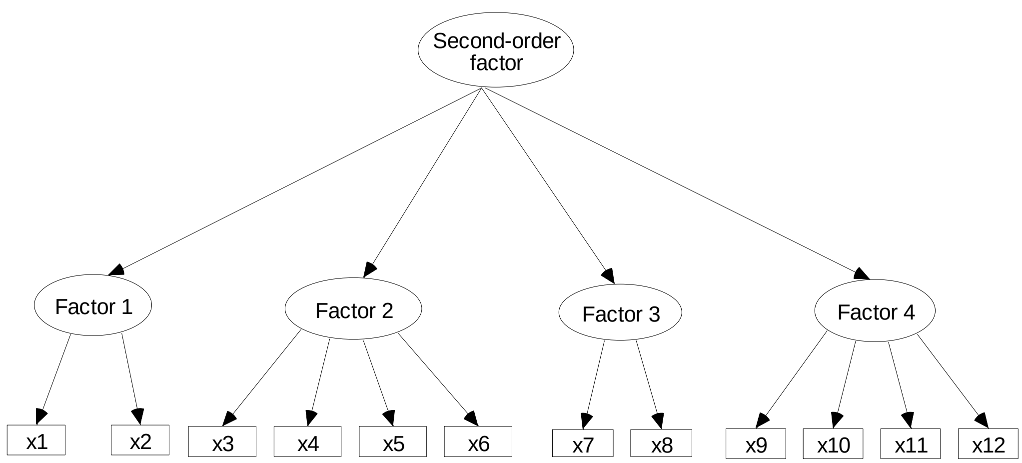


Figure 5.6.2 (Model B)



Predictive Validity

The predictive validity of the measures was also examined by linking the independents variables with their relevant dependent variables. To check for the predictive validity of the resulting measurement instrument, a composite score for each construct was calculated by taking the average of all remaining items in the construct. Pearson correlation coefficients among these composite construct measures were then calculated to determine the significance of hypothesized relationships.

5.7. LARGE-SCALE MEASUREMENT RESULTS

The following section presents the large-scale instrument validation results on each of the seven main constructs: Information Technology Utilization (ITU), Internal Information System Integration (IISI), External Information System Integration (EISI), Supply Chain Integration (SCI), Suppliers' Operational Performance (SOP), Firm's Operational Performance (FOP), and Firm Performance (FP). For each construct, the instrument assessment methodology described in the previous section was applied. In presenting the results of the large-scale study, the following acronyms were used to number the questionnaire items in each sub-construct.

ITU	**Information Technology Utilization**
SIT	Strategic Information Technology
OIT	Operational Information Technology
IIT	Infrastructural Information Technology
IISI	**Internal Information System Integration**
SISI-I	Strategic Information System Integration
OISI-I	Operational Information System Integration
ISID-I	Infrastructural Information System Integration – Data Integration
ISIN-I	Infrastructural Information System Integration – Network Connectivity
EISI	**External Information System Integration**
SISI-E	Strategic Information System Integration
OISI-E	Operational Information System Integration
ISID-E	Infrastructural Information System Integration – Data Integration
ISIN-E	Infrastructural Information System Integration – Network Connectivity
SCI	**Supply Chain Integration**
RC	Relationship with Customers
RS	Relationship with Suppliers
SOP	**Suppliers' Operational Performance**
DR-S	Delivery Reliability
PF-S	Process Flexibility
CL-S	Cost Leadership
IN-S	Innovation
PQ-S	Product Quality
FOP	**Firm's Operational Performance**
DR-F	Delivery Reliability
PF-F	Process Flexibility
CL-F	Cost Leadership
IN-F	Innovation
PQ-F	Product Quality
FP	**Firm Performance**

For each construct, the instrument assessment methodology described in the previous section will be applied, and tables will be provided to present the results: 1) The initial large-scale measurement items for the construct; 2) The dimension-level corrected item-total correlation (CITC) scores and Cronbach's alpha; 3) The convergent validity; and 4) The discriminant validity; and 5) The final set of measurement items for the construct (not provided if there is no change in items after instrument validation).

5.7.1. Information Technology Utilization

The Information Technology Utilization (ITU) construct was initially represented by three dimensions and 26 items, including Strategic Information Technology (SIT)(8 items), Operational Information Technology (OIT)(11 items), and Infrastructural Information Technology(IIT)(7 items).

Reliability and Unidimensionality Analysis The analysis began with purification using CITC analysis. An initial reliability analysis was done for each of the three Information Technology Utilization (ITU) dimensions. The Corrected Item-Total Correlation (CITC) scores for all items in SIT, OIT and IIT dimensions were above 0.50. The final Cronbach's Alpha scores were 0.89 for SIT, 0.91 for OIT, and 0.84 for IIT. The CITC for each item, its corresponding code name, and the reliability analysis results are shown in Table 5.7.1.1.

Coding	Items	CITC-1	CITC-2	α
Strategic Information Technology (SIT)				
SIT1	Long-term technology justification and planning.	.72		**α= .89**
SIT2	Budget justification and planning.	.63		
SIT3	Investment justification and planning.	.69		
SIT4	Long-term capacity planning.	.69		
SIT5	Long-term project planning.	.74		
SIT6	Project feasibility analysis.	.60		
SIT7	Competitor analysis.	.63		
SIT8	Industry analysis.	.61		
Operational Information Technology(OIT)				
OIT1	Daily production control.	.70		**α= .91**
OIT2	Daily product quality control.	.66		
OIT3	Daily products distribution management.	.79		
OIT4	Daily product movement planning.	.76		
OIT5	Daily customer analysis.	.71		
OIT6	Daily customer relationship management.	.68		
OIT7	Daily supplier relationship management.	.66		
OIT8	Daily inventory management.	.67		
OIT9	Daily material requirement planning.	.68		
OIT10	Daily warehouse/space management.	.58		
OIT11	Technology services and training	.50		

Table 5.7.1.1: Purification for Information Technology Utilization

Infrastructural Information Technology (IIT)				
IIT1	Setting up file sharing facilities.	.59		**α= .83**
IIT2	Setting up data communication facilities.	.54		
IIT3	Plant layout management and control.	.60		
IIT4	Floor plan management.	.59		
IIT5	Setting up advanced manufacturing technology.	.57		
IIT6	Setting up security services	.63		
IIT7	Setting up information disaster recovery system.	.51		

Table 5.7.1.1: Purification for Information Technology Utilization (continued)

Convergent Validity: In this step, the remaining 26 ITU items were then submitted to a measurement model analysis to check model fit indexes for each sub-construct (Table 5.7.1.2). The initial model fit indexes for SIT consist of GFI = .76, AGFI = .57 and RMSEA = .26. These indexes show nowhere near a reasonable fit; therefore, further model modification was proceeded based on modification indexes (MI). MI represents both measurement error correlations and item correlations (multicolinearity). MI shows evidence of misfit between the default model and the hypothesized model. MI is conceptualized as a chi-square statistic with one degree of freedom (Joreskog & Sorbom, 1989). Therefore, the threshold of MI is 4 chi-square statistics with significance at 0.05 level. High MI represents error covariances meaning that one item might share variance explained with another item (commonality) and thus they are redundant. The remedial action for error covariances is to delete such an item which has high error variance.

Based on the modification indexes, 4 items (SIT4, SIT6, SIT7, and SIT8) were dropped. The concepts of SIT4 – Long-term capacity planning and SIT6 – Project feasibility analysis are already covered in SIT5 – Long-term project planning and therefore were dropped. The concepts of SIT7 – Competitor analysis and SIT8 – Industry analysis are already covered in SIT3 – Investment justification and planning and therefore were dropped in the next phase. The new model fit indexes improved significantly to GFI = .99, AGFI = .97, and RMSEA = .05.

The initial model fit indexes for OIT consist of GFI = .81, AGFI = .71 and RMSEA = .15. These indexes show unreasonable fit; therefore, further model modification was proceeded to get rid of both measurement error correlations and item correlations (multicolinearity). Based on the modification indexes, six items (OIT3, OIT6, OIT7, OIT8, OIT10 and OIT11) were dropped. The concepts of OIT3 – Daily products distribution management, OIT8 – Daily inventory management, and OIT10 – Daily warehouse/space management are already covered in OIT1 – Daily production control and OIT4 – Daily product moving planning; therefore, they were dropped. The concepts of OIT6 – Daily customer relationship management and OIT7 – Daily supplier relationship management are already covered in OIT9 – Daily material requirement planning; therefore, they were dropped. OIT11 – Technology services and training seems to be irrelevant because of the low regression weight; therefore, it was dropped. The new model fit indexes improved significantly to GFI = .98, AGFI = .93, and RMSEA = .08.

The initial model fit indexes for IIT consist of GFI = .68, AGFI = .37 and RMSEA = .37. These indexes show unreasonable fit; therefore, further model modification was proceeded to improve model fit indexes. Based on the modification indexes, one item (IIT3, IIT4, and IIT6) were dropped. The concepts of IIT3 – Plant layout management and control and IIT4 – Floor plan management show low regression coefficients and are not really related to infrastructural information technology. Therefore, they were dropped. The concept of IIT6 – Setting up security service is already covered in IIT7 – Setting up information disaster recovery system and therefore; it was dropped in the further analysis. The new model fit indexes improved significantly to GFI = .99, AGFI = .93, and RMSEA = .09.

Coding	**Items**	**Initial Model Fit**	**Final Model Fit**
Strategic Information Technology (SIT)			
SIT1	Long-term technology justification and planning.	**GFI = .76** **AGFI = .57** **RMSEA = .26**	**GFI = .99** **AGFI = .97** **RMSEA = .05**
SIT2	Budget justification and planning.		
SIT3	Investment justification and planning.		
SIT4	Long-term capacity planning. *		
SIT5	Long-term project planning.		
SIT6	Project feasibility analysis. *		
SIT7	Competitor analysis. *		
SIT8	Industry analysis. *		
Operational Information Technology(OIT)			
OIT1	Daily production control.	**GFI = .71** **AGFI = .81**	**GFI = .98** **AGFI = .93**
OIT2	Daily product quality control.		
OIT3	Daily products distribution management. *		

OIT4	Daily product movement planning.	**RMSEA = .15**	**RMSEA = .08**
OIT5	Daily customer analysis.		
OIT6	Daily customer relationship management. *		
OIT7	Daily supplier relationship management. *		
OIT8	Daily inventory management. *		
OIT9	Daily material requirement planning.		
OIT10	Daily warehouse/space management. *		
OIT11	Technology services and training. *		
Infrastructural Information Technology (IIT)			
IIT1	Setting up file sharing facilities.	**GFI = .68**	**GFI = .99**
IIT2	Setting up data communication facilities.	**AGFI = .37**	**AGFI = .93**
IIT3	Plant layout management and control. *		
IIT4	Floor plan management. *	**RMSEA = .37**	**RMSEA = .09**
IIT5	Setting up advanced manufacturing technology.		
IIT6	Setting up security services. *		
IIT7	Setting up information disaster recovery system.		

***** Items were dropped from the initial model

Table 5.7.1.2: Model Fit Indexes for Information Technology Utilization

Discriminant validity: Table 5.7.1.3 shows the results from discriminant analysis. The differences between χ^2 values from every pairs are statistically significant at the $p < 0.0001$ level thus indicating high degree of discriminant validity among constructs.

Construct	SIT (χ^2)			OIT (χ^2)		
	Free	Fix	Dif.	Free	Fix	Dif.
SIT						
OIT	49.68	101.91	**52.23**			
IIT	40.41	89.34	**48.93**	54.04	99.16	**45.12**

Table 5.7.1.3: Pairwise comparison of χ^2 values for Information Technology Utilization

The final set of measurement items for the Information Technology Utilization construct are shown in Table 5.7.1.4.

Code Names	Measurement Items
Strategic Information Technology (SIT)	
SIT1	Long-term technology justification and planning.
SIT2	Budget justification and planning.
SIT3	Investment justification and planning.
SIT5	Long-term project planning.
Operational Information Technology(OIT)	
OIT1	Daily production control.
OIT2	Daily product quality control.
OIT4	Daily product movement planning.
OIT5	Daily customer analysis.
OIT9	Daily material requirement planning.
Infrastructural Information Technology (IIT)	
IIT1	Setting up file sharing facilities.
IIT2	Setting up data communication facilities.
IIT5	Setting up advanced manufacturing technology.
IIT7	Setting up information disaster recovery system.

Table 5.7.1.4: Information Technology Utilization - Final Construct Measurement Items

5.7.2. Internal Information System Integration (IISI)

The Internal Information System Integration (IISI) construct was initially represented by four dimensions and 30 items, including Strategic Information System Integration (SISI-I)(9 items), Operational Information System Integration (OISI-I)(8 items), Infrastructural Information System Integration – Data Integration (ISID-I) (6 items), and Infrastructural Information Integration – Network Connectivity (ISIN-I)(7 items).

Reliability and Unidimensionality Analysis The analysis began with purification using CITC analysis. An initial reliability analysis was done for each of the four Internal Information System Integration (IISI) dimensions. The Corrected Item-Total Correlation (CITC) scores for all items in SISI-I and ISIN-I dimensions were above 0.50. One item in OISI-I had CITC lower than 0.50 (OISI-I6) and therefore, this item will be dropped in the further analysis. ISID-I had one item whose CITC score was lower than 0.50 (ISID-I5). After a careful consideration, ISID-5 was dropped because doing so improves the overall consistency of the construct significantly. The final Cronbach's Alpha scores were 0.93 for SISI-I, 0.88 for OISI-I, 0.80 for ISID-I, and 0.94 for ISIN-I. The CITC for each item, its corresponding code name, and the reliability analysis results are shown in Table 5.7.2.1.

Coding	Items	CITC-1	CITC-2	α
Strategic Information System Integration (SISI-I)				
SISI-I1	Formulate long-term collaborative decision making.	.74		**α= .93**
SISI-I2	Justify long-term business plans.	.76		
SISI-I3	Analyze long-term business plans.	.82		
SISI-I4	Develop long-term business opportunities.	.80		
SISI-I5	Identify new markets	.71		
SISI-I6	Identify long-term technology justification and planning.	.75		
SISI-I7	Study strategies of competitors.	.63		
SISI-I8	Define long-term competitive positioning.	.73		
SISI-I9	Set long-term strategic goals.	.82		
Operational Information System Integration(OISI-I)				
OISI-I1	Adjust daily manufacturing processes.	.65	.69	α= **.88**
OISI-I2	Adjust daily product development processes.	.58	.57	
OISI-I3	Control daily product quality.	.68	.67	
OISI-I4	Manage daily order quality.	.76	.76	
OISI-I5	Exchange daily inventory information.	.67	.69	
OISI-I6	Select suppliers. *	.40		
OISI-I7	Manage daily logistical activities.	.63	.62	
OISI-I8	Establish daily product forecasts.	.65	.64	

Table 5.7.2.1: Purification for Internal Information System Integration

Infrastructural Information System Integration- Data Integration (ISID-I)				
ISID-I1	Use standard data definitions and codes.	.51	.51	**α= .80**
ISID-I2	Use standard information/data format.	.59	.68	
ISID-I3	Use standard presentation format.	.62	.68	
ISID-I4	Use centralized databases.	.59	.59	
ISID-I5	Use database synchronization system. *	.31		
ISID-I6	Integrate data and information.	.58	.48	
Infrastructural Information System Integration- Network Connectivity (ISIN-I)				
ISIN-I1	Use IS networks to communicate with other departments.	.83		**α= .94**
ISIN-I2	Use IS networks to connect to each other's database.	.75		
ISIN-I3	Use IS network applications.	.85		
ISIN-I4	Use IS networks to share information with other departments.	.88		
ISIN-I5	Use IS networks to connect to centralized databases.	.85		
ISIN-I6	Use IS networks to facilitate periodic interdepartmental meetings.	.69		
ISIN-I7	Use compatible network architectures.	.76		

* Item were dropped in the further analysis

Table 5.7.2.1: Purification for Internal Information System Integration (continued)

Convergent Validity: In this step, the remaining 28 IISI items were then submitted to a measurement model analysis to check model fit indexes for each sub-construct (Table 5.7.2.2). The initial model fit indexes for SISI-I consist of GFI = .72, AGFI = .54 and RMSEA = .24. These indexes show nowhere near a reasonable fit; therefore, further model modification was proceeded based on modification indexes (MI) for both measurement error correlations and item correlations (multicolinearity). Based on the modification indexes, four items (SISI-I2, SISI-I5, SISI-I7 and SISI-I8) were dropped. The concept of SISI-I2 – Justify long-term business plans was already covered in SISI-I3 – Analyze long-term business plans and was dropped. The concept of SISI-I5 – Identify new markets was also repeated in SISI-I4 – Develop long-term business opportunities. It was dropped in the later analysis. The concepts of SISI-I7 – Study strategies of competitors and SISI-I8 – Define long-term competitive positioning were already covered in SISI-I9 – Set long-term strategic goals; and therefore; were dropped in the further analysis. The new model fit indexes improved significantly to GFI = .98, AGFI = .94, and RMSEA = .07.

The initial model fit indexes for OISI-I consist of GFI = .92, AGFI = .89 and RMSEA = .09. These indexes showed a reasonable fit; however, further model modification was proceeded to achieve a perfect fit. Based on the modification indexes, one item (OISI-I2 – Adjust daily product development processes) was dropped because the concept was already covered in OISI-I1 – Adjust daily manufacturing processes. The new model fit indexes improved significantly to GFI = .97, AGFI = .94, and RMSEA = .07.

The initial model fit indexes for ISID-I consist of GFI = .88, AGFI = .72 and RMSEA = .20. These indexes showed unreasonable fit; therefore, further model modification was proceeded to achieve a perfect fit. Based on the modification indexes, one item (ISID-I4 – Use centralized databases) was dropped because the concept was already covered in ISID-I6 – Integrate data and information. The new model fit indexes improved significantly to GFI = .99, AGFI = .96, and RMSEA = .07.

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The initial model fit indexes for ISIN-I consist of GFI = .91, AGFI = .82 and RMSEA = .15. These indexes showed nowhere near a reasonable fit; therefore, further model modification was examined based on modification indexes (MI) for both measurement error correlations and item correlations (multicolinearity). Based on the modification indexes, two items (ISIN-I5, and ISIN-I6) were dropped. The concepts of ISIN-I5 – Use IS networks to connect to centralized databases and ISIN-I6 – Use IS networks to facilitate periodic interdepartmental meetings were already covered in ISIN-I1 – Use IS networks to communicate with other departments; therefore, there were dropped in the further analysis. The new model fit indexes improved significantly to GFI = .98, AGFI = .94, and RMSEA = .08.

Table 5.7.2.2: Model Fit Indexes for Internal Information System Integration

Coding	Items	Initial Model Fit	Final Model Fit
Strategic Information System Integration (SISI-I)			
SISI-I1	Formulate long-term collaborative decision making.	**GFI = .72** **AGFI = .54** **RMSEA = .24**	**GFI = .98** **AGFI = .94** **RMSEA = .07**
SISI-I2	Justify long-term business plans. *		
SISI-I3	Analyze long-term business plans.		
SISI-I4	Develop long-term business opportunities.		
SISI-I5	Identify new markets. *		
SISI-I6	Identify long-term technology justification and planning.		
SISI-I7	Study strategies of competitors. *		
SISI-I8	Define long-term competitive positioning. *		
SISI-I9	Set long-term strategic goals.		
Operational Information System Integration(OISI-I)			
OISI-I1	Adjust daily manufacturing processes.	**GFI = .92** **AGFI = .89** **RMSEA = .09**	**GFI = .97** **AGFI = .94** **RMSEA = .07**
OISI-I2	Adjust daily product development processes. *		
OISI-I3	Control daily product quality.		
OISI-I4	Manage daily order quality.		
OISI-I5	Exchange daily inventory information.		
OISI-I7	Manage daily logistical activities.		
OISI-I8	Establish daily product forecasts.		
Infrastructural Information System Integration- Data Integration (ISID-I)			
ISID-I1	Use standard data definitions and codes.	**GFI = .88** **AGFI = .72**	**GFI = .99** **AGFI = .96**
ISID-I2	Use standard information/data format.		

ISID-I3	Use standard presentation format.	**RMSEA = .20**	**RMSEA = .07**
ISID-I4	Use centralized databases. *		
ISID-I6	Integrate data and information.		
Infrastructural Information System Integration- Network Connectivity (ISIN-I)			
ISIN-I1	Use IS networks to communicate with other departments.	**GFI = .91** **AGFI = .82** **RMSEA = .15**	**GFI = .98** **AGFI = .94** **RMSEA = .08**
ISIN-I2	Use IS networks to connect to each other's database.		
ISIN-I3	Use IS network applications.		
ISIN-I4	Use IS networks to share information with other departments.		
ISIN-I5	Use IS networks to connect to centralized databases. *		
ISIN-I6	Use IS networks to facilitate periodic interdepartmental meetings. *		
ISIN-I7	Use compatible network architectures.		

***** Items were dropped from the initial model

Table 5.7.2.2: Model Fit Indexes for Internal Information System Integration (continued)

Discriminant validity: Table 5.7.2.3 shows the results from discriminant analysis. The differences between χ^2 values from every pairs are statistically significant at the $p < 0.0001$ level thus indicating high degree of discriminant validity among constructs. The results prove that the constructs are theoretically and statically different from each other as hypothesized in the measurement development section.

Construct	**SISI-I** (χ^2)			**OISI-I** (χ^2)			**ISID-I** (χ^2)		
	Free	Fix	Dif.	Free	Fix	Dif.	Free	Fix	Dif.
SISI-I									
OISI-I	103.71	175.81	**72.10**						
ISID-I	55.58	132.43	**76.85**	82.64	149.24	**66.60**			
ISIN-I	74.88	146.50	**71.62**	73.46	122.68	**49.22**	125.98	192.33	**66.35**

Table 5.7.2.3: Pairwise comparison of χ^2 values for Internal Information System Integration

The final set of measurement items for the Internal Information System Integration construct are shown in Table 5.7.2.4.

Code Names	Measurement Items
Strategic Information System Integration (SISI-I)	
SISI-I1	Formulate long-term collaborative decision making.
SISI-I3	Analyze long-term business plans.
SISI-I4	Develop long-term business opportunities.
SISI-I6	Identify long-term technology justification and planning.
SISI-I9	Set long-term strategic goals.
Operational Information System Integration(OISI-I)	
OISI-I1	Adjust daily manufacturing processes.
OISI-I3	Control daily product quality.
OISI-I4	Manage daily order quality.
OISI-I5	Exchange daily inventory information.
OISI-I7	Manage daily logistical activities.
OISI-I8	Establish daily product forecasts.
Infrastructural Information System Integration- Data Integration (ISID-I)	
ISID-I1	Use standard data definitions and codes.
ISID-I2	Use standard information/data format.
ISID-I3	Use standard presentation format.
ISID-I6	Integrate data and information.
Infrastructural Information System Integration- Network Connectivity (ISIN-I)	
ISIN-I1	Use IS networks to communicate with other departments.
ISIN-I2	Use IS networks to connect to each other’s database.
ISIN-I3	Use IS network applications.
ISIN-I4	Use IS networks to share information with other departments.
ISIN-I7	Use compatible network architectures

Table 5.7.2.4: Internal Information System Integration - Final Construct Measurement Items

5.7.3. External Information System Integration (EISI)

The External Information System Integration (EISI) construct was initially represented by four dimensions and 29 items, including Strategic Information System Integration (SISI-E)(9 items), Operational Information System Integration (OISI-E)(8 items), Infrastructural Information System Integration – Data Integration (ISID-E) (6 items), and Infrastructural Information Integration – Network Connectivity (ISIN-E)(6 items).

Reliability Analysis The analysis began with purification using CITC analysis. An initial reliability analysis was done for each of the four Internal Information System Integration (IISI) dimensions. The Corrected Item-Total Correlation (CITC) scores for all items in all dimensions above 0.60. The final Cronbach’s Alpha scores were 0.96 for SISI-E, 0.94 for OISI-E, 0.91 for ISID-E, and 0.95 for ISIN-E. The CITC for each item, its corresponding code name, and the reliability analysis results are shown in Table 5.7.3.1.

Table 5.7.3.1: Purification for External Information System Integration

Coding	Items	CITC-1	CITC-2	α
Strategic Information System Integration (SISI-E)				
SISI-E1	Formulate long-term collaborative decision making.	.81		**α= .97**
SISI-E2	Justify long-term business plans.	.89		
SISI-E3	Analyze long-term business plans.	.90		
SISI-E4	Develop long-term business opportunities.	.85		
SISI-E5	Identify new markets	.86		
SISI-E6	Identify long-term technology justification and planning.	.77		
SISI-E7	Study strategies of competitors.	.82		
SISI-E8	Define long-term competitive positioning.	.89		
SISI-E9	Set long-term strategic goals.	.86		
Operational Information System Integration(OISI-E)				
OISI-E1	Adjust daily manufacturing processes.	.79		α= .**93**
OISI-E2	Adjust daily product development processes.	.73		
OISI-E3	Control daily product quality.	.76		
OISI-E4	Manage daily order quality.	.83		
OISI-E5	Exchange daily inventory information.	.80		
OISI-E6	Select supplier	.70		
OISI-E7	Manage daily logistical activities.	.78		
OISI-E8	Establish daily product forecasts.	.70		
Infrastructural Information System Integration- Data Integration (ISID-E)				
ISID-E1	Use standard data definitions and codes.	.73		**α= .89**
ISID-E2	Use standard information/data format.	.69		
ISID-E3	Use standard presentation format.	.75		
ISID-E4	Use centralized databases.	.72		
ISID-E5	Use database synchronization system.	.61		

ISID-E6	Use compatible database systems.	.74		
Infrastructural Information System Integration- Network Connectivity (ISIN-E)				
ISIN-E1	Use IS networks to communicate with each other.	.82		**α= .93**
ISIN-E2	Use IS networks to connect to each other's database.	.82		
ISIN-E3	Use IS network applications.	.73		
ISIN-E4	Use IS networks to share information with each other.	.84		
ISIN-E5	Use IS networks to facilitate periodic meetings.	.79		
ISIN-E6	Use compatible network architectures.	.81		

Table 5.7.3.1: Purification for External Information System Integration (continued)

Convergent Validity: In this step, the remaining 29 EISI items were then submitted to a measurement model analysis to check model fit indexes for each sub-construct (Table 5.7.3.2). The initial model fit indexes for SISI-E consist of GFI = .81, AGFI = .67 and RMSEA = .18. These indexes showed unreasonable fit; therefore, further model modification was proceeded. Based on the modification indexes, three items (SISI-E5, SISI-E7 and SISI-E8) were dropped. SISI-E5 – Identify new markets was dropped because the concept is repeated in SISI-E4 – Develop long-term business opportunities. Items SISI-E7 – Study strategies of competitors and SISI-E8 – Define long-term competitive positioning were also dropped because the concepts were already covered in SISI-E2 – Justify long-term business plans. The new model fit indexes improved significantly to GFI = .98, AGFI = .90, and RMSEA = .10.

The initial model fit indexes for OISI-E consist of GFI = .94, AGFI = .89 and RMSEA = .10. These indexes show a reasonable; however, RMSEA is considered low and further model modification was necessary. Items OISI-E6 – Select supplier and OISI-E7 – Manage daily logistical activities were dropped because the concepts were already covered in OISI-E5 – Exchange daily inventory information. The final model fit indexes improved significantly to GFI = .98, AGFI = .95, and RMSEA = .05.

The initial model fit indexes for ISID-E were GFI = .77, AGFI = .45, and RMSEA = .30 and they showed unreasonable fit. Items ISID-E5 – Use database synchronization system and ISID-E6 – Use compatible database systems were dropped because the concepts were already covered in ISID-E4 – Use centralized databases. The final model fit indexes improved significantly to GFI = 1.00, AGFI = .99, and RMSEA = .00.

The initial model fit indexes for ISIN-E consist of GFI = .89, AGFI = .75 and RMSEA = .19. These indexes showed nowhere near a reasonable fit; therefore, further model modification was proceeded based on modification indexes (MI) for both measurement error correlations and item correlations (multicolinearity). Based on the modification indexes, two items (ISIN-E3 and ISIN-E6) were dropped. ISIN-E3 – Use IS network applications was dropped because the item was unclear and showed low regression weight. ISIN-E6 – Use compatible network architectures was dropped because it was repeated in ISIN-E2 – Use IS networks to connect to each other's database. The new model fit indexes improved significantly to GFI = .99, AGFI = .94, and RMSEA = .09.

Coding	Items	Initial Model Fit	Final Model Fit
Strategic Information System Integration (SISI-E)			
SISI-E1	Formulate long-term collaborative decision making.	**GFI = .81** **AGFI = .67** **RMSEA = .18**	**GFI = .98** **AGFI = .90** **RMSEA = .10**
SISI-E2	Justify long-term business plans.		
SISI-E3	Analyze long-term business plans.		
SISI-E4	Develop new business opportunities.		
SISI-E5	Identify new markets. *		
SISI-E6	Identify long-term technology justification and planning.		
SISI-E7	Study strategies of competitors. *		
SISI-E8	Define long-term competitive positioning.*		
SISI-E9	Set long-term strategic goals.		

* Items were dropped from the initial model

Table 5.7.3.2: Model Fit Indexes for External Information System Integration

Operational Information System Integration(OISI-E)			
OISI-E1	Adjust daily manufacturing processes.	**GFI = .94** **AGFI = .89** **RMSEA = .10**	**GFI = .98** **AGFI = .95** **RMSEA = .05**
OISI-E2	Adjust daily product development processes.		
OISI-E3	Control daily product quality.		
OISI-E4	Manage daily order quality.		
OISI-E5	Exchange daily inventory information.		
OISI-E6	Select supplier. *		
OISI-E7	Manage daily logistical activities. *		
OISI-E8	Establish daily product forecasts.		
Infrastructural Information System Integration- Data Integration (ISID-E)			
ISID-E1	Use standard data definitions and codes.	**GFI = .77** **AGFI = .45** **RMSEA = .30**	**GFI = 1.00** **AGFI = .99** **RMSEA = .00**
ISID-E2	Use standard information/data format.		
ISID-E3	Use standard presentation format.		
ISID-E4	Use centralized databases.		
ISID-E5	Use database synchronization system. *		
ISID-E6	Use compatible database systems. *		
Infrastructural Information System Integration- Network Connectivity (ISIN-E)			
ISIN-E1	Use IS networks to communicate with each other.	**GFI = .89** **AGFI = .75** **RMSEA = .19**	**GFI = .99** **AGFI = .94** **RMSEA = .09**
ISIN-E2	Use IS networks to connect to each other's database.		
ISIN-E3	Use IS network applications. *		
ISIN-E4	Use IS networks to share information with each other.		
ISIN-E5	Use IS networks to facilitate periodic meetings.		
ISIN-E6	Use compatible network architectures. *		

* Items were dropped from the initial model

Table 5.7.3.2: Model Fit Indexes for External Information System Integration (continued)

Discriminant validity: Table 5.7.3.3 shows the results from discriminant analysis. The differences between χ^2 values from every pairs are statistically significant at the $p < 0.0001$ level thus indicating high degree of discriminant validity among constructs. The results prove that the constructs are theoretically and statically different from each other as hypothesized in the measurement development section.

Construct	**SISI-E** (χ^2)			**OISI-E** (χ^2)			**ISID-E** (χ^2)		
	Free	Fix	Dif.	Free	Fix	Dif.	Free	Fix	Dif.
SISI-E									
OISI-E	109.71	153.69	**43.98**						
ISID-E	126.36	178.49	**52.13**	92.32	133.99	**41.67**			
ISIN-E	93.88	132.38	**38.50**	86.41	118.35	**31.94**	80.07	123.29	**43.22**

Table 5.7.3.3: Pairwise comparison of χ^2 values for External Information System Integration

The final set of measurement items for the External Information System Integration construct are shown in Table 5.7.3.3.

Code Names	Measurement Items
Strategic Information System Integration (SISI-E)	
SISI-E1	Formulate long-term collaborative decision making.
SISI-E2	Justify long-term business plans.
SISI-E3	Analyze long-term business plans.
SISI-E4	Develop new business opportunities.
SISI-E6	Identify long-term technology justification and planning.
SISI-E9	Set long-term strategic goals.
Operational Information System Integration(OISI-E)	
OISI-E1	Adjust daily manufacturing processes.
OISI-E2	Adjust daily product development processes.
OISI-E3	Control daily product quality.
OISI-E4	Manage daily order quality.
OISI-E5	Exchange daily inventory information.
OISI-E8	Establish daily product forecasts.
Infrastructural Information System Integration- Data Integration (ISID-E)	
ISID-E1	Use standard data definitions and codes
ISID-E2	Use standard information/data format.
ISID-E3	Use standard data presentation format.
ISID-E4	Use centralized databases.
Infrastructural Information System Integration- Network Connectivity (ISIN-E)	
ISIN-E1	Use IS networks to communicate with each other.
ISIN-E2	Use IS networks to connect to each other's databases.
ISIN-E4	Use IS networks to share information with each other.
ISIN-E5	Use IS networks to connect to facilitate periodic meeting.

Table 5.7.3.3: External Information System Integration – Final Construct Measurement Items

5.7.4. Supply Chain Integration (SCI)

The Supply Chain Integration (SCI) construct was initially represented by two dimensions and 12 items, including Relationship with Customers (RC)(6 items) and Relationship with Suppliers (RS)(6 items).

Reliability and Unidimensionality Analysis: The analysis began with purification using CITC analysis. An initial reliability analysis was done for each of the two Supply Chain Integration (SCI) dimensions. The Corrected Item-Total Correlation (CITC) scores for all items in all dimensions were above 0.50. The final Cronbach's Alpha scores were 0.83 for RC, and 0.90 for RS. The CITC for each item, its corresponding code name, and the reliability analysis results are shown in Table 5.7.4.1.

Coding	Items	CITC-1	CITC-2	α
Relationship with Customers (RC)				
RC1	The willingness of customers to share their market demands.	.61		**α= .83**
RC2	The participation level of customers in product development processes.	.62		
RC3	The participation level of customers in finished goods distribution processes.	.62		
RC4	The level of customer involvement in preparing business plans.	.60		
RC5	The extent of follow-up with customers for feedbacks.	.58		
RC6	The participation level of customers in manufacturing processes.	.60		
Relationship with Suppliers(RS)				
RS1	The participation level of suppliers in manufacturing processes.	.71		**α= .90**
RS2	The participation level of suppliers in production planning processes.	.81		
RS3	The participation level of suppliers in product development processes.	.71		
RS4	The level of customer involvement in logistics processes.	.76		
RS5	The level of cross-over of activities between our firm and our suppliers.	.73		
RS6	The level of supplier involvement in preparing our business plans	.71		

Table 5.7.4.1: Purification for Supply Chain Integration

Convergent Validity: In this step, the remaining 12 SCI items were then submitted to a measurement model analysis to check model fit indexes for each sub-construct (Table 5.7.4.2). The initial model fit indexes for RC consist of GFI = .95, AGFI = .89 and RMSEA = .11. These indexes showed a reasonable fit; therefore, further model modification was proceeded based on modification indexes (MI) for both measurement error correlations and item correlations (multicolinearity). Based on the modification indexes, one item (RC4 – The level of customer involvement in preparing business plans) was dropped because the concept was already covered in RC6 – The participation level of customers in manufacturing processes. The new model fit indexes improved significantly to GFI = .99, AGFI = .98, and RMSEA = .00.

The initial model fit indexes for RS consist of GFI = .93, AGFI = .84 and RMSEA = .13. These indexes showed a reasonable fit; however, further model modification was proceeded to achieve a perfect fit. Based on the modification indexes, one item (RS1 – The participation level of suppliers in manufacturing processes) was dropped because the concept was already covered in RS4 – The level of customer involvement in logistics processes. The new model fit indexes improved significantly to GFI = .97, AGFI = .93, and RMSEA = .09.

Coding	Items	Initial Model Fit	Final Model Fit
Relationship with Customers (RC)			
RC1	The willingness of customers to share their market demands.	**GFI = .95** **AGFI = .89** **RMSEA = .11**	**GFI = .99** **AGFI = .98** **RMSEA = .00**
RC2	The participation level of customers in product development processes.		
RC3	The participation level of customers in finished goods distribution processes.		
RC4	The level of customer involvement in preparing business plans. *		
RC5	The extent of follow-up with customers for feedbacks.		
RC6	The participation level of customers in manufacturing processes.		
Relationship with Suppliers(RS)			
RS1	The participation level of suppliers in manufacturing processes. *	**GFI = .93** **AGFI = .84** **RMSEA = .13**	**GFI = .97** **AGFI = .93** **RMSEA = .09**
RS2	The participation level of suppliers in production planning processes.		
RS3	The participation level of suppliers in product development processes.		
RS4	The level of customer involvement in logistics processes.		
RS5	The level of cross-over of activities between our firm and our suppliers.		
RS6	The level of supplier involvement in preparing our business plans		

* Items were dropped from the initial model

Table 5.7.4.2: Model Fit Indexes for Supply Chain Integration

Discriminant validity: Table 5.7.4.3 shows the results from discriminant analysis. The differences between χ^2 values from every pairs are statistically significant at the $p < 0.0001$ level thus indicating high degree of discriminant validity among constructs. The results prove that the constructs are theoretically and statically different from each other as hypothesized in the measurement development section.

Construct	**RC** (χ^2)		
	Free	Fix	Dif.
RC			
RS	87.12	129.31	**42.19**

Table 5.7.4.3: Pairwise comparison of χ^2 values for Supply Chain Integration

The final set of measurement items for the Supply Chain Integration construct are shown in Table 5.7.4.4.

Coding	Items
Relationship with Customers (RC)	
RC1	The willingness of customers to share their market demands.
RC2	The participation level of customers in product development processes.
RC3	The participation level of customers in finished goods distribution processes.
RC5	The extent of follow-up with customers for feedbacks.
RC6	The participation level of customers in manufacturing processes.
Relationship with Suppliers(RS)	
RS2	The participation level of suppliers in production planning processes.
RS3	The participation level of suppliers in product development processes.
RS4	The level of customer involvement in logistics processes.
RS5	The level of cross-over of activities between our firm and our suppliers.
RS6	The level of supplier involvement in preparing our business plans

Table 5.7.4.4: Supply Chain Integration – Final Construct Measurement Items

5.7.5. Suppliers' Operational Performance (SOP)

The Suppliers' Operational Performance (SOP) construct was initially represented by five dimensions and 28 items, including Delivery Reliability (DR-S)(6 items), Process Flexibility (PF-S)(6 items), Cost Leadership (CL-S)(5 items), Innovation (IN-S)(5 items), and Product Quality (PQ-S)(6 items).

Reliability Analysis The analysis began with purification using CITC analysis. An initial reliability analysis was done for each of the five Suppliers' Operational Performance (SOP) dimensions. The Corrected Item-Total Correlation (CITC) scores for all items in all dimensions above 0.50. The final Cronbach's Alpha scores were 0.89 for DR-S, 0.84 for PF-S, 0.90 for CL-S, 0.90 for IN-S, and 0.92 for PQ-S. The CITC for each item, its corresponding code name, and the reliability analysis results are shown in Table 5.7.5.1.

Table 5.7.5.1: Purification for Suppliers' Operational Performance

Coding	Items	CITC-1	CITC-2	α
Delivery reliability (DR-S)				
DR-S1	Deliver materials/components/products as promises.	.74		**α= .89**
DR-S2	Provide materials/components/products that are highly reliable.	.61		
DR-S3	Provide fast delivery.	.72		
DR-S4	Provide on-time delivery.	.81		
DR-S5	Provide reliable delivery.	.73		
DR-S6	Decrease manufacturing lead time.	.58		
Process flexibility (PF-S)				
PF-S1	Make rapid design changes.	.57		**α= .84**
PF-S2	Make rapid production volume changes.	.72		

PF-S3	Make rapid changeover between product lines.	.67		
PF-S4	Process both large and small orders.	.55		
PF-S5	Produce a variety of different products.	.56		
PF-S6	Increase capacity utilization.	.70		
Cost leadership (CL-S)				
CL-S1	Produce materials/components/products at low cost.	.61		**α= .90**
CL-S2	Reduce production cost.	.83		
CL-S3	Reduce inventory cost.	.77		
CL-S4	Reduce unit cost.	.84		
CL-S5	Increase labor productivity.	.69		
Innovation (IN-S)				
IN-S1	Develop new ways of customer service.	.71		**α= .90**
IN-S2	Develop new forms of shop floor management.	.77		
IN-S3	Develop new ways of supply chain management.	.85		
IN-S4	Develop new products and features.	.72		
IN-S5	Develop new process technologies.	.75		
Product quality (PQ-S)				
PQ-S1	Provide better product performance.	.76		**α= .92**
PQ-S2	Improve product durability.	.80		
PQ-S3	Provide product conformance to specifications.	.63		
PQ-S4	Improve product reliability.	.85		
PQ-S5	Reduce defective rate.	.82		
PQ-S6	Better product reputation.	.77		

Convergent Validity: In this step, 28 SOP items were then submitted to a measurement model analysis to check model fit indexes for each sub-construct (Table 5.7.5.2). The initial model fit indexes for CL-S shows a excellent fit; therefore, no further model modification was necessary.

The initial model fit indexes for DR-S consist of GFI = .95, AGFI = .89 and RMSEA = .11. These indexes showed a reasonable fit; however, further model modification was proceeded to achieve a perfect fit. Based on the modification indexes, one item (DR-S6 – Decrease manufacturing lead time) was dropped because the concept was already covered in DR-S1 – Deliver materials/components/production as promises. The new model fit indexes improved significantly to GFI = .98, AGFI = .93, and RMSEA = .09.

The initial model fit indexes for PF-S consist of GFI = .94, AGFI = .87, and RMSEA = .13. These indexes showed a reasonable fit; however, further model modification was proceeded to achieve a perfect fit. Based on the modification indexes, one item (PF-S5 – Produce a variety of different products) was dropped because the item showed low regression weight and high measurement error. The new model fit indexes improved significantly to GFI = .99, AGFI = .97, and RMSEA = .00.

The initial model fit indexes for IN-S consist of GFI = .96, AGFI = .88, and RMSEA = .13. These indexes showed a reasonable fit; however, further model modification was proceeded to achieve a perfect fit. Based on the modification indexes, one item (IN-S4 – Develop new products and features) was dropped because the item showed low regression weight and high measurement error. The new model fit indexes improved significantly to GFI = .98, AGFI = .92, and RMSEA = .11.

The initial model fit indexes for PQ-S consist of GFI = .86, AGFI = .69, and RMSEA = .21. These indexes showed a reasonable fit; however, further model modification was proceeded to achieve a perfect fit. Based on the modification indexes, two items (PQ-S2 – Improve product durability and PQ-S4 – Improve product reliability) were dropped because the items showed low regression weight and high measurement error. The new model fit indexes improved significantly to GFI = 1.00, AGFI = .98, and RMSEA = .02.

Table 5.7.5.2: Model Fit Indexes for Suppliers' Operational Performance

Coding	Items	Initial Model Fit	Final Model Fit
Delivery reliability (DR-S)			
DR-S1	Deliver materials/components/products as promises.	**GFI = .95** **AGFI = .89** **RMSEA = .11**	**GFI = .98** **AGFI = .93** **RMSEA = .09**
DR-S2	Provide materials/components/products that are highly reliable.		
DR-S3	Provide fast delivery.		
DR-S4	Provide on-time delivery.		
DR-S5	Provide reliable delivery.		
DR-S6	Decrease manufacturing lead time. *		
Process flexibility (PF-S)			
PF-S1	Make rapid design changes.	**GFI = .94** **AGFI = .87** **RMSEA = .13**	**GFI = .99** **AGFI = .97** **RMSEA = .00**
PF-S2	Make rapid production volume changes.		
PF-S3	Make rapid changeover between product lines.		
PF-S4	Process both large and small orders.		
PF-S5	Produce a variety of different products. *		
PF-S6	Increase capacity utilization.		
Cost leadership (CL-S)			
CL-S1	Produce materials/components/products at low cost.	**GFI = .97**	

CL-S2	Reduce production cost.	**AGFI = .91** **RMSEA = .10**	
CL-S3	Reduce inventory cost.		
CL-S4	Reduce unit cost.		
CL-S5	Increase labor productivity.		
Innovation (IN-S)			
IN-S1	Develop new ways of customer service.	**GFI = .96** **AGFI = .88** **RMSEA = .13**	**GFI = .98** **AGFI = .92** **RMSEA = .11**
IN-S2	Develop new forms of shop floor management.		
IN-S3	Develop new ways of supply chain management.		
IN-S4	Develop new products and features. *		
IN-S5	Develop new process technologies.		
Product quality (PQ-S)			
PQ-S1	Provide better product performance.	**GFI = .86** **AGFI = .69** **RMSEA = .21**	**GFI = 1.00** **AGFI = .98** **RMSEA = .02**
PQ-S2	Improve product durability. *		
PQ-S3	Provide product conformance to specifications.		
PQ-S4	Improve product reliability. *		
PQ-S5	Reduce defective rate.		
PQ-S6	Better product reputation.		

* Items were dropped from the initial model

Table 5.7.5.2: Model Fit Indexes for Suppliers' Operational Performance (continued)

Discriminant validity: Table 5.7.5.3 shows the results from discriminant analysis. The differences between χ^2 values from every pairs are statistically significant at the $p < 0.0001$ level thus indicating high degree of discriminant validity among constructs. The results prove that the constructs are theoretically and statically different from each other as hypothesized in the measurement development section.

Construct	DR-S (χ^2)			PF-S (χ^2)			CL-S (χ^2)			IN-S (χ^2)		
	Free	Fix	Dif.	Free	Fix	Dif.	Free	Fix	Dif.	Free	Fix	Dif.
DR-S												
PF-S	50.4	144.7	**94.3**									
CL-S	82.4	214.9	**132.5**	107.9	229.3	**121.4**						
IN-S	52.4	166.2	**113.8**	40.7	141.2	**100.5**	70.1	185.2	**115.1**			
PQ-S	46.4	153.0	**106.6**	39.8	162.3	**122.5**	53.7	188.9	**135.2**	59.5	160.6	**101.1**

Table 5.7.5.3: Pairwise comparison of χ^2 values for Supplier's Operational Performance

The final set of measurement items for the Suppliers' Operational Performance construct are shown in Table 5.7.5.4.

Coding	Items
Delivery reliability (DR-S)	
DR-S1	Deliver materials/components/products as promises.
DR-S2	Provide materials/components/products that are highly reliable.
DR-S3	Provide fast delivery.
DR-S4	Provide on-time delivery.
DR-S5	Provide reliable delivery.
Process flexibility (PF-S)	
PF-S1	Make rapid design changes.
PF-S2	Make rapid production volume changes.
PF-S3	Make rapid changeover between product lines.
PF-S4	Process both large and small orders.
PF-S6	Increase capacity utilization.
Cost leadership (CL-S)	
CL-S1	Produce materials/components/products at low cost.
CL-S2	Reduce production cost.
CL-S3	Reduce inventory cost.
CL-S4	Reduce unit cost.
CL-S5	Increase labor productivity.
Innovation (IN-S)	
IN-S1	Develop new ways of customer service.
IN-S2	Develop new forms of shop floor management.
IN-S3	Develop new ways of supply chain management.
IN-S5	Develop new process technologies.
Product quality (PQ-S)	
PQ-S1	Provide better product performance.
PQ-S3	Provide product conformance to specifications.
PQ-S5	Reduce defective rate.
PQ-S6	Better product reputation.

Table 5.7.5.4: Suppliers' Operational Performance – Final Construct Measurement Items

5.7.6. Firm's Operational Performance (FOP)

The Firm's Operational Performance (FOP) construct was initially represented by five dimensions and 28 items, including Delivery Reliability (DR-F)(6 items), Process Flexibility (PF-F)(6 items), Cost Leadership (CL-F)(5 items), Innovation (IN-F)(5 items), and Product Quality (PQ-F)(6 items).

Reliability and Unidimensionality Analysis: The analysis began with purification using CITC analysis. An initial reliability analysis was done for each of the five Firm's Operational Performance (FOP) dimensions. The Corrected Item-Total Correlation (CITC) scores for almost all the items were above 0.50. Two items show CITC a little lower than 0.50; therefore, these items will be kept for further analysis. The final Cronbach's Alpha scores were 0.87 for DR-F, 0.82 for PF-F, 0.87 for CL-F, 0.81 for IN-F, and 0.91 for PQ-F. The CITC for each item, its corresponding code name, and the reliability analysis results are shown in Table 5.7.6.1.

Table 5.7.6.1: Purification for Firm's Operational Performance

Coding	Items	CITC-1	CITC-2	α
Delivery reliability (DR-F)				
DR-F1	Deliver materials/components/ products as promises.	.60		**α= .87**
DR-F2	Provide materials/components/ products that are highly reliable.	.55		
DR-F3	Provide fast delivery.	.74		
DR-F4	Provide on-time delivery.	.80		
DR-F5	Provide reliable delivery.	.79		
DR-F6	Decrease manufacturing lead time.	.58		
Process flexibility (PF-F)				

PF-F1	Make rapid design changes.	.66		
PF-F2	Make rapid production volume changes.	.62		
PF-F3	Make rapid changeover between product lines.	.70		**α= .82**
PF-F4	Process both large and small orders.	.53		
PF-F5	Produce a variety of different products.	.52		
PF-F6	Increase capacity utilization.	.49	Keep	
	Cost leadership (CL-F)			
CL-F1	Produce materials/components/ products at low cost.	.42	Keep	
CL-F2	Reduce production cost.	.78		
CL-F3	Reduce inventory cost.	.73		**α= .87**
CL-F4	Reduce unit cost.	.83		
CL-F5	Increase labor productivity.	.71		
	Innovation (IN-F)			
IN-F1	Develop new ways of customer service.	.69		
IN-F2	Develop new forms of shop floor management.	.59		
IN-F3	Develop new ways of supply chain management.	.64		**α= .81**
IN-F4	Develop new products and features.	.55		
IN-F5	Develop new process technologies.	.55		
	Product quality (PQ-F)			
PQ-F1	Provide better product performance.	.82		
PQ-F2	Improve product durability.	.78		
PQ-F3	Provide product conformance to specifications.	.71		**α= .91**
PQ-F4	Improve product reliability.	.78		
PQ-F5	Reduce defective rate.	.70		
PQ-F6	Better product reputation.	.77		

Table 5.7.6.1: Purification for Firm's Operational Performance (continued)

Convergent Validity: In this step, the remaining 28 SOP items were then submitted to a measurement model analysis to check model fit indexes for each sub-construct (Table 5.7.6.2). The initial model fit indexes for PF-F and CL-F showed a reasonable fit; therefore, no further model modification was necessary.

The initial model fit indexes for DR-F consist of GFI = .92, AGFI = .81 and RMSEA = .17. These indexes showed an unreasonable fit; therefore, further model modification was proceeded to achieve a perfect fit. Based on the modification indexes, two items (DR-F2 and DR-F6) were dropped. DR-F2 – Provide materials/components/products that were highly reliable was dropped because the concept was already covered in DSR-F1 – Deliver materials/components/products as promises. DR-F6 – Decrease manufacturing lead time was also dropped because the concept was redundant with item DR-F3 – Provide fast delivery. The new model fit indexes improved significantly to GFI = 1.00, AGFI = .99, and RMSEA = .00.

The initial model fit indexes for IN-F consist of GFI = .93, AGFI = .79 and RMSEA = .18. These indexes showed a reasonable fit; however, further model modification was proceeded to achieve a perfect fit. Based on the modification indexes, one item (IN-F4 – Develop new products and features) was dropped because the item showed low regression weight. The new model fit indexes improved significantly to GFI = .98, AGFI = .90, and RMSEA = .13.

The initial model fit indexes for PQ-F consist of GFI = .93, AGFI = .83 and RMSEA = .15. These indexes showed a reasonable fit; however, further model modification was proceeded to achieve a perfect fit. Based on the modification indexes, two items (PQ-F2 and PQ-F5) were dropped. PQ-F2 – Improve product durability was also dropped because the concept was redundant with item PQ-F1 – Provide better product performance. PQ-F6 – Better product reputation was dropped because the item showed low regression weight and high measurement error. The new model fit indexes improved significantly to GFI = .98, AGFI = .94, and RMSEA = .08.

Table 5.7.6.2: Model Fit Indexes for Firm's Operational Performance

Coding	Items	Initial Model Fit	Final Model Fit
Delivery reliability (DR-F)			
DR-F1	Deliver materials/components/products as promises.	**GFI = .92** **AGFI = .81** **RMSEA = .17**	**GFI = 1.00** **AGFI = .99** **RMSEA = .00**
DR-F2	Provide materials/components/products that are highly reliable. *		
DR-F3	Provide fast delivery.		
DR-F4	Provide on-time delivery.		
DR-F5	Provide reliable delivery.		
DR-F6	Decrease manufacturing lead time. *		
Process flexibility (PF-F)			
PF-F1	Make rapid design changes.	**GFI = .98** **AGFI = .96** **RMSEA = .03**	
PF-F2	Make rapid production volume changes.		
PF-F3	Make rapid changeover between product lines.		
PF-F4	Process both large and small orders.		
PF-F5	Produce a variety of different products.		
PF-F6	Increase capacity utilization		
Cost leadership (CL-F)			
CL-F1	Produce materials/components/ products at low cost.	**GFI = .98**	
CL-F2	Reduce production cost.		

CL-F3	Reduce inventory cost.	**AGFI = .95** **RMSEA = .07**	
CL-F4	Reduce unit cost.		
CL-F5	Increase labor productivity.		
Innovation (IN-F)			
IN-F1	Develop new ways of customer service.	**GFI = .93** **AGFI = .79** **RMSEA = .18**	**GFI = .98** **AGFI = .90** **RMSEA = .13**
IN-F2	Develop new forms of shop floor management.		
IN-F3	Develop new ways of supply chain management.		
IN-F4	Develop new products and features. *		
IN-F5	Develop new process technologies.		
Product quality (PQ-F)			
PQ-F1	Provide better product performance.	**GFI = .93** **AGFI = .83** **RMSEA = .15**	**GFI = .98** **AGFI = .94** **RMSEA = .08**
PQ-F2	Improve product durability. *		
PQ-F3	Provide product conformance to specifications.		
PQ-F4	Improve product reliability.		
PQ-F5	Reduce defective rate.		
PQ-F6	Better product reputation. *		

* Items were dropped from the initial model

Table 5.7.6.2: Model Fit Indexes for Firm's Operational Performance (continued)

Discriminant validity: Table 5.7.6.3 shows the results from discriminant analysis. The differences between χ^2 values from every pairs are statistically significant at the $p < 0.0001$ level thus indicating high degree of discriminant validity among constructs. The results prove that the constructs are theoretically and statically different from each other as hypothesized in the measurement development section.

Construct	DR-F (χ^2)			PF-F (χ^2)			CL-F (χ^2)			IN-F (χ^2)		
	Free	Fix	Dif.	Free	Fix	Dif.	Free	Fix	Dif.	Free	Fix	Dif.
DR-F												
PF-F	241.9	411.0	**169.1**									
CL-F	194.4	333.6	**139.2**	118.1	212.0	**93.9**						
IN-F	150.6	257.3	**106.7**	73.8	135.9	**62.1**	68.5	157.0	**88.5**			
Q-F	203.0	326.0	**123.0**	105.3	172.9	**67.6**	97.4	207.8	**110.4**	137.5	198.9	**61.4**

Table 5.7.6.3: Pairwise comparison of χ^2 values for Firm's Operational Performance

The final set of measurement items for the Firm's Operational Performance construct are shown in Table 5.7.6.4.

Coding	Items
Delivery reliability (DR-F)	
DR-F1	Deliver materials/components/products as promises.
DR-F3	Provide fast delivery.
DR-F4	Provide on-time delivery.
DR-F5	Provide reliable delivery.
Process flexibility (PF-F)	
PF-F1	Make rapid design changes.
PF-F2	Make rapid production volume changes.
PF-F3	Make rapid changeover between product lines.
PF-F4	Process both large and small orders.
PF-F5	Produce a variety of different products.
PF-F6	Increase capacity utilization.
Cost leadership (CL-F)	
CL-F1	Produce materials/components/products at low cost.
CL-F2	Reduce production cost.
CL-F3	Reduce inventory cost.
CL-F4	Reduce unit cost.
CL-F5	Increase labor productivity.
Innovation (IN-F)	
IN-F1	Develop new ways of customer service.
IN-F2	Develop new forms of shop floor management.
IN-F3	Develop new ways of supply chain management.
IN-F5	Develop new process technologies.
Product quality (PQ-F)	
PQ-F1	Provide better product performance.
PQ-F3	Provide product conformance to specifications.
PQ-F4	Improve product reliability.
PQ-F5	Reduce defective rate.

Table 5.7.6.4: Firm's Operational Performance – Final Construct Measurement Items

5.7.7. Firm Performance (FP)

The Firm Performance (FOP) construct was initially represented by one dimension and 8 items.

Reliability Analysis The analysis began with purification using CITC analysis. The Corrected Item-Total Correlation (CITC) scores for almost all the items above 0.50. Two items show CITC a little lower than 0.50; therefore, these items were kept for further analysis. The final Cronbach's Alpha score was 0.88 for FP. The CITC for each item, its corresponding code name, and the reliability analysis results are shown in Table 5.7.7.1.

Coding	Items	CITC-1	CITC-2	α
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy = 0.82				
FP1	Customer retention rate.	.53		**α= .86**
FP2	Sales growth.	.68		
FP3	Market share growth.	.66		
FP4	Return on investment.	.70		
FP5	Profit margin.	.65		
FP6	Production throughput time.	.49	Keep	
FP7	New product development cycle time.	.41	Keep	
FP8	Overall competitive position.	.80		

Table 5.7.7.1: Item Purification for Firm Performance

Measurement Model Analysis: In this step, the remaining 8 FP items were then submitted to a measurement model analysis to check model fit indexes for each sub-construct (Table 5.7.7.2). The initial model fit indexes for FP show less reasonable fit; therefore, further model modification was necessary. Based on the modification indexes, three items (FP3, FP5, and FP7) were dropped because the concepts are already covered in other items. The new model fit indexes improve significantly to GFI = .99, AGFI = .96, and RMSEA = .02.

Coding	Items	Initial Model Fit	Final Model Fit
FP1	Customer retention rate.	**GFI = .83** **AGFI = .69** **RMSEA = .19**	**GFI = .99** **AGFI = .96** **RMSEA = .05**
FP2	Sales growth.		
FP3	Market share growth. *		
FP4	Return on investment.		
FP5	Profit margin. *		
FP6	Production throughput time.		
FP7	New product development cycle time. *		
FP8	Overall competitive position.		

* Items were dropped from the initial model

Table 5.7.7.2: Model Fit Indexes for Firm Performance

The final set of measurement items for the Firm Performance construct are shown in table 5.7.7.3.

Coding	Items
FP1	Customer retention rate.
FP2	Sales growth.
FP4	Return on investment.
FP6	Production throughput times
FP8	Overall competitive position.

Table 5.7.7.3: Firm Performance – Final Construct

5.8. DISCRIMINANT VALIDITY (SECOND-ORDER CONSTRUCT)

The second-order factor is explaining the covariation among first-order factors in a more parsimonious way (i.e., one that requires fewer degrees of freedoms). Therefore, even when the higher-order model is able to explain the factor covariations, the goodness-of-fit of the higher order model can never be better than the corresponding first-order model (Segars and Grover, 1998). In this sense, the first-order model provides a target or optimum fit for the higher-order model. It has been suggested that the efficacy of second-order model be assessed through examination of target (T) coefficient (where T= χ^2 first-order model/χ^2 second-order model) (Marsh and Hocevar, 1985). The T coefficient .80 to 1.0 indicates the existence of a second-order construct since most of the variation shared by the first-order factors is explained by the single second-order factor. Table 5.8.1 shows the calculated target coefficient between the first-order model and the second-order model. This value suggests that the addition of the second-order model does not significant increase χ^2. Therefore, the second-order model represents a more parsimonious representation of observed covariances and it should be accepted over the first-order model as a “truer” representation of model structure. The results prove that the second-order constructs do really exist as hypothesized in the theory development section.

Construct	Model	Chi-Square (df)	Chi-Square/df	GFI	AGFI	RMSEA	T coefficient
ITU	First- Order	120.00 (62)	1.94	0.92	0.89	0.07	100.00%
	Second-Order	120.00 (62)	1.94	0.92	0.89	0.07	
IISI	First-Order	408.48 (164)	2.50	0.86	0.82	0.08	98.42%
	Second-Order	415.03 (166)	2.50	0.85	0.81	0.08	
EISI	First-Order	461.47 (164)	2.81	0.83	0.79	0.09	89.94%
	Second-Order	463.62 (166)	2.79	0.83	0.79	0.09	
Suppliers' Operational Performance	First-Order	429.27 (220)	1.95	0.86	0.83	0.07	94.93%
	Second-Order	452.19 (225)	2.01	0.86	0.83	0.07	
Firm's Operational Performance	First-Order	571.68 (220)	2.60	0.82	0.77	0.09	99.06%
	Second-Order	577.10 (225)	2.57	0.82	0.78	0.09	

Table 5.8.1: Goodness of Fit Indexes for First and Second Order Model

5.9. PREDICTIVE VALIDITY (CONSTRUCT-LEVEL CORRELATION ANALYSIS)

In order for measurement to be generalized, criterion-related validity or predictive validity must be performed by comparing the second-order factor models with one or more external variables (criterion) known or believed to measure the attribute. Criterion-related validity is characterized by prediction to an outside criterion and by checking a measuring instrument, either now or future, against some outcome or measure (Kerlinger, 1986). In this study, the criterion used to test the predictive validity is endogenous latent variable or a dependent variable.

To check for the predictive validity of the 10 hypotheses presented in Chapter 2, the Pearson correlation coefficients of the 10 hypothesized relationships were calculated using a composite score for each construct. The composite score was computed by taking the average score of all items in a specific construct. The results are presented in Table 5.9.1. As can be seen from the table, all correlations are significant at the 0.01 level. Thus, all hypothesized relationships of interest are statistically supported by the Pearson correlation. Further hypotheses testing using structural equation causal modeling were discussed in the next chapter.

Hypothesis	Independent Variable	Dependent Variable	Pearson Correlation
H1a	Information Technology Utilization (ITU)	Internal Information Systems Integration (IISI)	0.786**
H1b	Information Technology Utilization (ITU)	External Information Systems Integration (EISI)	0.685**
H2	Internal Information Systems Integration (IISI)	External Information Systems Integration (EISI)	0.809**
H3	Internal Information Systems Integration (IISI)	Supply Chain Integration (SCI)	0.453**
H4	External Information Systems Integration (EISI)	Supply Chain Integration (SCI)	0.539**
H5	Supply Chain Integration (SCI)	Suppliers' Operational Performance (SOP)	0.366**
H6	Supply Chain Integration (SCI)	Firm's Operational Performance (FOP)	0.386**
H7	Suppliers' Operational Performance (SOP)	Firm's Operational Performance (FOP)	0.491**
H8	Suppliers' Operational Performance (SOP)	Firm Performance (FP)	0.353**
H9	Firm's Operational Performance (FOP)	Firm Performance (FP)	0.573**
** Correlation is significant at the 0.01 level			

Table 5.9.1: Construct-Level Correlation Analysis Results

CHAPTER 6: STRUCTURAL EQUATION MODELING, HYPOTHESES TESTING, AND RECOMMENDATIONS FOR FUTURE RESEARCH

Although the bivariate correlations are statistically significant for all hypothesized relationships, it may not be true when all the relationships are put together in a multivariate complex model due to the interactions among variables. Since the measurement instruments for all seven major constructs in the current study have already been validated in Chapter 5, the hypotheses can be tested in a much more rigorous manner using the structural equation modeling (SEM) framework.

A major methodological breakthrough in the study of complex interrelations among variables has been the development and application of SEM (Joreskog, 1970). SEM is widely recognized as a powerful methodology for capturing and explicating complex multivariate relations in social science data. It represents the unification of two methodological traditions: factor analysis originating from psychology and psychometrics, and simultaneous equations (path analytic) modeling originating from econometrics (Kaplan and Elliot, 1997). Therefore, The standard SEM is composed of two parts – the *measurement model* (a sub-model in SEM that specifies the indicators of each construct and assesses the reliability of each construct for later use in estimating the causal relationships) and the *structural model* (The set of dependence relationships linking the model constructs). Since the measurement properties of each instrument in the current study has already been evaluated through comprehensive reliability analysis and factor analysis, the SEM model described in this chapter will focus on path analysis using the AMOS *structural model*. The significance of each path in the proposed structural model was tested and the overall goodness-of-fit of the entire structural equation model was assessed as well.

6.1. THE PROPOSED STRUCTURAL MODEL

The proposed structural model depicted in Figure 6.1 is a replicate of the theoretical framework presented in Figure 3.1. There are seven variables in the model: Information Technology Utilization (ITU), Internal Information System Integration (IISI), External Information System Integration (EISI), Supply Chain Integration (SCI), Suppliers' Operational Performance (SOP), Firm's Operational Performance (FOP), and Firm Performance. ITU is regarded as the independent (exogenous) variable, and all others are dependent (endogenous) variables.

The 10 hypotheses proposed in Chapter 3 are represented by the 10 causal relationships in the model. Hypothesis 1a is represented in Figure 6.1 by the relationship ITU → IISI; Hypothesis 1b is represented by the relationship ITU → EISI; Hypothesis 2 is represented by the relationship IISI → EISI; Hypothesis 3 is represented by the relationship IISI → SCI; Hypothesis 4 is represented by the relationship EISI → SCI; Hypothesis 5 is represented by the relationship SCI → FOP; Hypothesis 6 is represented by the relationship SCI → SOP; Hypothesis 7 is represented by the relationship SOP → FOP; Hypothesis 8 is represented by the relationship FOP → FP; Hypothesis 9 is represented by the relationship SOP → FP.

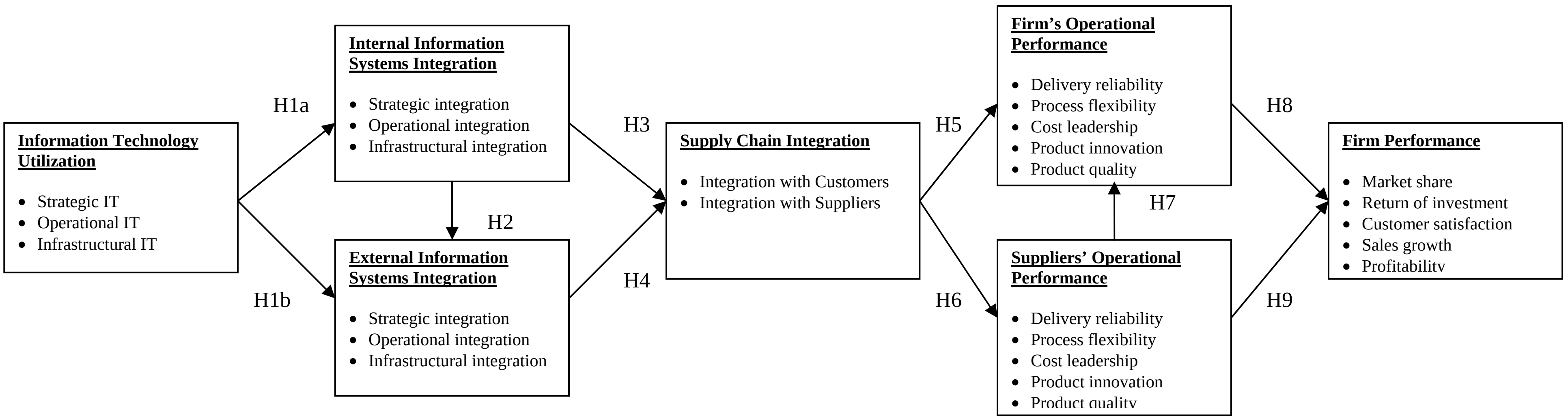


Figure 6.1: Theoretical framework for information systems integration

6.2. STRUCTURAL EQUATION MODELING METHODOLOGY

Before proceeding to the AMOS structural model testing of the hypotheses, the structural equation modeling methodology and some major model evaluation indices were discussed.

Unlike the traditional statistical methods that can examine only a single relationship at a time, the structural equation modeling (SEM) method greatly expanded the researchers' capability to study a set of interrelated relationships simultaneously. The first and most difficult steps in the SEM are to specify the two components: *Measurement Model* and *Structure Model.* It is difficult because SEM model specification must always be based on sound theory from existing literature. The need for theoretical justification in SEM is very important for the specification of dependence relationships, modifications to the proposed relationships, and many other aspects of model estimation (Hair, et al., 1992, pp. 434).

Once the measurement and structure models are specified, the researcher must choose a computer program for model estimation and evaluation. The most widely used program is AMOS 5 by James L. Arbuckle (1994-2003). There is no single statistical test that best describes the strength of a model. Instead, researchers have developed a number of goodness-of-fit measures to assess the results from three perspectives: 1) overall fit, 2) comparative fit to a base model, and 3) model parsimony. The AMOS algorithm provides several such statistics that can be used to evaluate the hypothesized model and also suggest ways in which the model might be modified given sufficient theoretical justification.

Overall Fit Measures.

The most fundamental measure of overall fit is the chi-square statistic (χ^2). Low values, which result in significance levels greater than 0.05, indicate that the actual and predicted input matrices are not statistically different, hence a good fit. However, the χ^2 measure is often criticized for its over-sensitivity to sample size, especially in cases where the sample size exceeds 200 respondents (Hair et al., 1992, pp. 490). As sample size increases, this measure has a greater tendency to indicate significant differences for equivalent models. Thus the current study does not use the χ^2 measure.

A second measure of overall fit is the **Goodness-of-fit index (GFI)** provided by AMOS. GFI represents the overall degree of fit (the squared residuals from prediction compared to the actual data), but is not adjusted for the degrees of freedom. GFI ranges in value from 0 (poor fit) to 1 (perfect fit). Generally, a GFI value of greater than 0.90 is considered as acceptable (Segars and Grover, 1993).

Another measure of overall fit is the **Root Mean Square Error of Approximation (RMSEA)**. The RMSEA takes into account the error of approximation and is expressed per degree of freedom, thus making the index sensitive to the number of estimated parameters in the model; values less than 0.05 indicate good fit, values as high as 0.08 represent reasonable errors of approximation in the population (Browne & Cudeck, 1993), values range from 0.08 to 0.10 indicate mediocre fit, and those greater than 0.10 indicate poor fit (MacCallum et al, 1996).

Comparative Fit Measures.

This class of measures compares the proposed model to some baseline model (null model) – some realistic model that all other models should be expected to exceed. In most cases, the null model is a single construct model with all indicators perfectly measuring the construct. One of the most popular measures of this kind is the **Normed Fit Index (NFI)**, which ranges from 0 (no fit at all) to 1 (perfect fit). A commonly recommended value is 0.90 or greater (Hair et al., 1992).

Parsimonious Fit Measures.

This type of measure relates the goodness-of-fit of the model to the number of estimated coefficients required to achieve this level of fit. The basic objective is to diagnose whether model fit has been achieved by "over-fitting" the data with too many coefficients. The most widely used measure of parsimonious fit is **Adjusted Goodness-of-Fit Index (AGFI)** provided by AMOS. AGFI is an extension of GFI but adjusted by the ratio of degrees of freedom for the proposed model to the degrees of freedom for the null model. A recommended acceptance value of AGFI is 0.80 or greater (Segars and Grover, 1993).

Modification Indices

The AMOS program also provides modification indices that suggest possible ways of improving model fit, such as uncovering new relationships among constructs. However, one has to bear in mind that the modifications must have sufficient theoretical justification.

Effect Size

Effect size is a name given to a family of indices that measure the magnitude of a treatment effect. Unlike significance tests, these indices are independent of sample size. Effect size is commonly used to compliment structural equation modeling (SEM) because SEM is a large-sample technique (e.g., 200 is the "floor" size of the sample; larger sample sizes are more appropriate). When the test of a relationship deals with a large-sample size, effect size helps researchers to differentiate between statistical significance and practical significance. In SEM, standardized structural or path coefficients are the effect sizes calculated by the model estimation program. Often these values are displayed above their respective arrows on the arrow diagram specifying a model. The interpretation is similar to regression: if a standardized structural coefficient is 2.0, then the latent dependent will increase by 2.0 standard units for each unit increase in the latent independent. In AMOS, the standardized structural coefficients are labeled "standardized regression weights", which are similar to the coefficients used to test the strength of relationships. Table 6.2.1 shows the recommended values of effect size by Cohen (1988 and 1990, p. 1309). The structural paths and loadings of substantial strength (as opposed to just statistically significant) should be at least 0.371 to be considered large indicating 13.8% of variance in the dependent variable that is accounted by the independent variable. Standardized paths should be at least 0.148 in order to be considered meaningful or medium effect. Meehl (1990) argues that anything lower may be due to what he has termed the crud factor where "everything correlates to some extent with everything else" (p. 204) because of "some complex unknown network of genetic and environmental factors" (p. 209). Paths of 0.10, for example, represent at best a one-percent explanation of variance and thus, portray mediocre relationship. In summary, the effect size of 0.371 or above is considered large, the effect size between 0.100 and 0.371 is considered medium, and the effect size of 0.1 or below is considered small.

Cohen's Standard	**r**	**r^2**
	.707	.500
	.689	.474
	.669	.448
	.648	.419
	.625	.390
	.600	.360
	.573	.329
	.545	.297
	.514	.265
	.482	.232
	.447	.200
	.410	.168
Large	.371	.138
	.330	.109
	.287	.083
Medium	.243	.059
	.196	.038
	.148	.022
Small	.100	.010
	.050	.002
	.000	.000

Table 6.2.1: The Relationship between r and r^2

6.3. STRUCTURAL MODEL TESTING RESULTS

The hypothesized relationships are now ready to be tested based on the structural model specified in Figure 6.1 and the model fit properties are evaluated using the fit statistics discussed above. The composite score computed for each construct at the end of Chapter 5 was used as input to the structural modeling process.

6.3.1. Initial Structural Modeling Results

Figure 6.2 displays the structural model and Figure 6.3 shows the path analysis resulting from the initial AMOS structural modeling analysis. More detailed results are presented in Table 6.3.1. Out of the 10 hypothesized relationships, 7 were found to be significantly supported. Hypotheses 1a, 2, 4, 5, 6, 7, and 8 all had a t-value of greater than 2.00, indicating the relationships are significant at the 0.001 level. The t-value for Hypotheses 1b, 3, and 9 are 0.48, 1.11, and 0.88 respectively, which are not significant at the 0.05 level. Therefore, all research hypotheses except Hypotheses 1b, 3, and 9 are supported by the AMOS structural modeling results. Out of the 7 supported relationships, 6 relationships had a large effect size and 1 relationship had a medium effect size. Thus, the effect size results confirm that the supported relationships have both statistical and practical significance, which is crucial in providing both theoretical and managerial implications. The initial model fit measures are: GFI = 0.96, RMSEA = 0.10, AGFI = 0.90. GFI was above the recommended minimum value of 0.90; AGFI was above the recommended minimum value of 0.80; only the RMSEA (0.10) was at the recommended 0.10 level. These results present an initial good fit of the proposed model to the data. The implications of the three insignificant relationships were discussed later in this chapter.

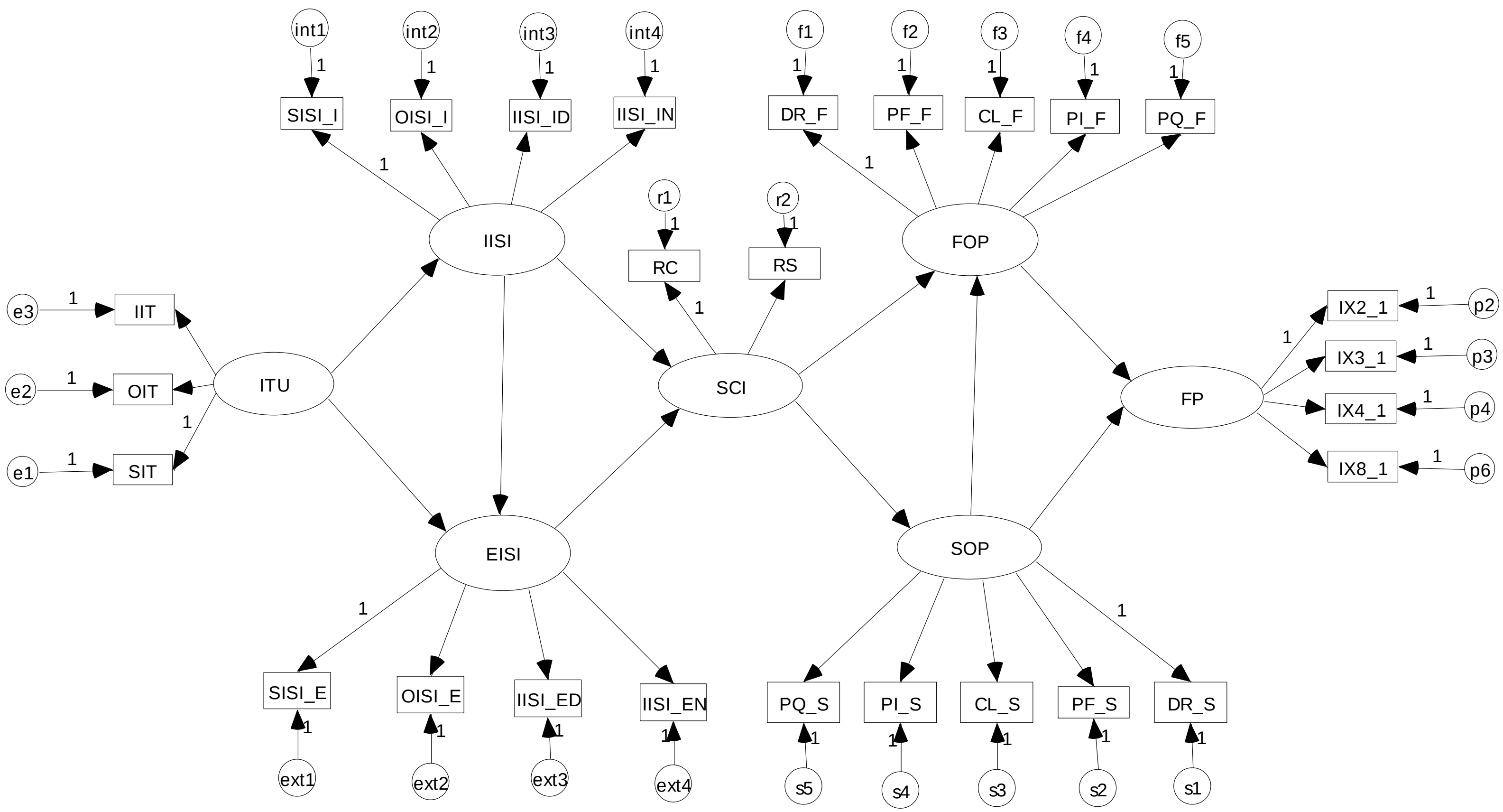
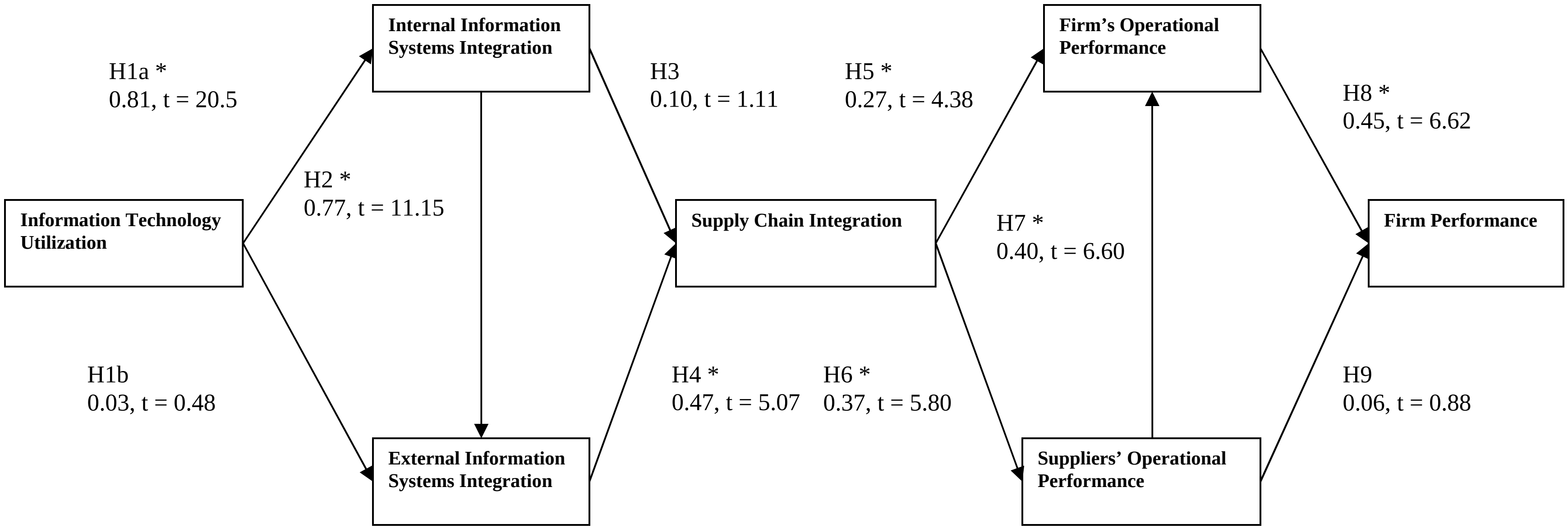


Figure 6.2: Structural Model for Information System Integration Framework

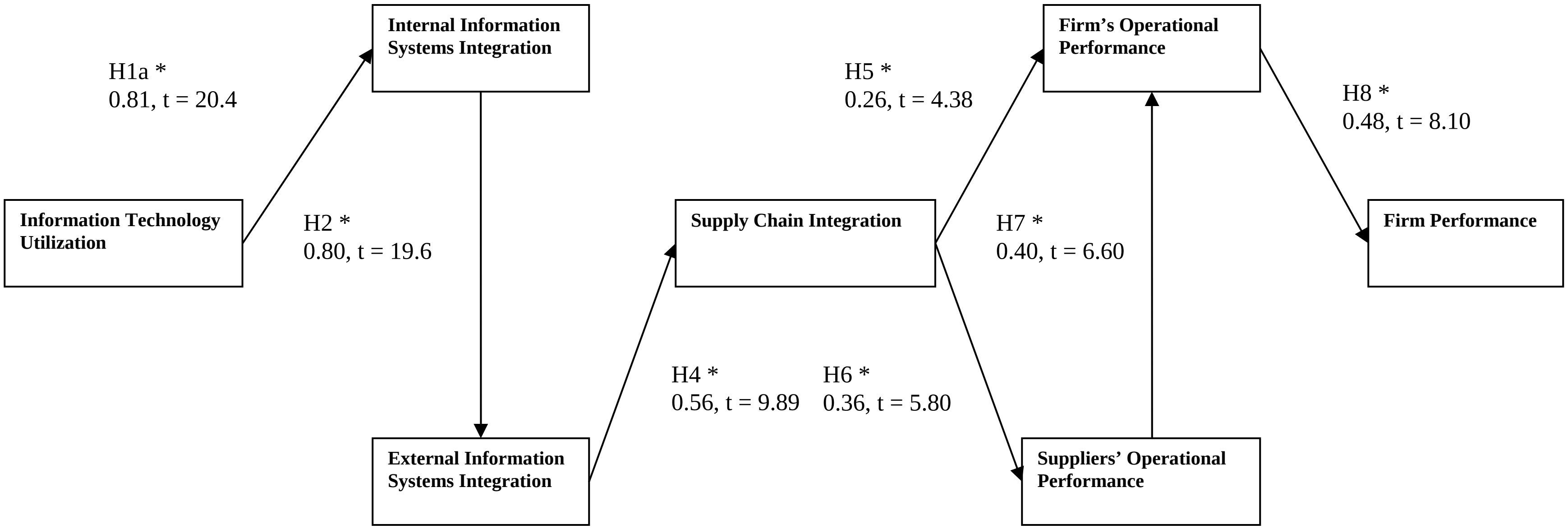


GFI = 0.96, AGFI = 0.90, and RMSEA = 0.10, * Significance at < 0.001

Figure 6.3: Path Analysis Results for Information System Integration Framework

Hypotheses	**Relationship**	**AMOS Coefficients**	**Effect Size**	**t-value**	**P**	**Support**
H1a	ITU → IISI	0.81	Large	20.50	***	Yes
H1b	ITU → EISI	0.03	Small	0.48	0.63	No
H2	IISI → EISI	0.77	Large	11.15	***	Yes
H3	IISI → SCI	0.10	Small	1.11	0.27	No
H4	EISI → SCI	0.47	Large	5.07	***	Yes
H5	SCI → FOP	0.27	Medium	4.38	***	Yes
H6	SCI → SOP	0.37	Large	5.80	***	Yes
H7	SOP → FOP	0.40	Large	6.60	***	Yes
H8	FOP → FP	0.45	Large	6.62	***	Yes
H9	SOP → FP	0.06	Small	0.88	0.38	No
GFI = 0.96 AGFI = 0.90 RMSEA = 0.10 *** P < 0.001						

Table 6.3.1: Initial AMOS Structural Modeling Results



GFI = 0.95, AGFI = 0.91, and RMSEA = 0.09 * Significance at < 0.001

Figure 6.4: Revised Path Analysis Results for Information System Integration Framework

6.3.2. Revised Structural Model

After revising the structural model by removing the three insignificant relationships (H1b, H3, and H9), the model was tested again using AMOS. The results are presented in Figure 6.4 and Table 6.3.2. All paths have a t-value of greater than 2.0 and significantly at the 0.001 level. Out of the 7 supported relationships, 5 relationships had a large effect size and 2 relationships had a medium effect size. Thus, the effect size results confirm that the supported relationships have both statistical and practical significance, which is crucial in providing both theoretical and managerial implications. The fit indexes of the revised indicate a good fit: GFI = 0.95 was greater than the minimum level 0.90 level; AGFI = 0.91 was above the minimum 0.80 level; and RMSEA = 0.09 level was lower than the recommended 0.10 level.

Hypotheses	Relationship	AMOS Coefficients	Effect Size	t-value	P	Support
H1a	ITU → IISI	0.81	Large	20.40	***	Yes
H2	IISI → EISI	0.80	Large	19.60	***	Yes
H4	EISI → SCI	0.56	Large	9.89	***	Yes
H5	SCI → FOP	0.26	Medium	4.38	***	Yes
H6	SCI → SOP	0.36	Medium	5.80	***	Yes
H7	SOP → FOP	0.40	Large	6.60	***	Yes
H8	FOP → FP	0.48	Large	8.10	***	Yes
GFI = 0.95 AGFI = 0.91 RMSEA = 0.09 *** P < 0.001						

Table 6.3.2: Revised Structural Modeling Results

6.4. DISCUSSIONS OF STRUCTURAL MODELING AND HYPOTHESES TESTING RESULTS

The previous sections reported the structural modeling and hypotheses testing results on the proposed model. To summarize, 6 of 10 hypothesized relationships (Hypotheses 1a, 2, 4, 6, 7, and 8) were significant at the 0.05 level, four hypotheses were not significantly supported (Hypotheses 1b, 3, 5, and 9), and the final AMOS structural model displayed very good fit to the data. Three new direct paths were found.

However, statistical significance and model fit are not the ultimate objectives of academic research. They are just the means to the end, which is to achieve better understanding of the subject under investigation, and discover new relationships. The results from the research will be of great value both to practitioners in terms of assisting their business decision making processes, and researchers in terms of providing some new instruments for further academic exploration. Therefore, the practical and theoretical implications of the results of each hypothesis are discussed as follows.

Hypothesis H1a: *The higher the extent of IT utilization, the higher the extent of IISI*

Hypothesis H1b: *The higher the extent of IT utilization, the higher the extent of EISI*

Hypothesis H1a was found to be significant and hypothesis H1b was found to be non-significant. This indicates that IT utilization has a direct positive influence on IISI but not EISI. The level of IT utilization represents the extent to which a firm applies computer and other information technologies to aid its internal activities. These internal activities include strategic level activities (e.g., strategic planning, investment planning, budget analysis), operational level activities (e.g., daily operations), and functional activities (e.g., infrastructural decisions). The extensive use of information technology can evolve into a high level of internal information system integration as employees in the organization use technology to communicate with each other. The evidence can be found in the adoption of standards and integrated services digital networks (ISDN), the Internet and World Wide Web technology, Electronic Data Interchange (EDI) and Electronic Commerce (EC), which raise the level of extensive communication networks and inter-connectivity. Through the utilization of IT, companies have been able to integrate their internal functions as well as external activities, thus enhancing capability to cope with the sophisticated needs of customers and meeting the quality standards of products (Bardi et al., 1994, Carter and Narasimhan, 1995). Because the use of networks, shared databases, and other related IS have been considered enormously important for eliminating duplicate activities, preventing errors, reducing cycle time in product development, and improving inter-organizational communication, firms realized the benefits of information system integration.

Hypothesis H2: *The higher the extent of IISI, the higher the extent of EISI.*

The hypothesis H2 was found to be significant. This indicates that IISI has a direct positive influence on EISI. Information System Integration (ISI) is characterized by degree of cooperation between business functions within a firm and between a firm and its trading partners on an internally consistent set of information system practices. Such practices consist of three levels. 1) At the infrastructural level, departments/firms can be connected through data integration activities (e.g., using standard data definitions and presentation formats) and network connectivity activities (e.g., using IS networks to communicate and facilitate join agreement). 2) At the operational level, departments/firms can use IS to facilitate joined daily activities (e.g., adjusting manufacturing process, controlling product quality, managing order fulfillment, and monitoring inventory level). 3) At the strategic level, departments/firms can interact with each other to agree on collaborative decisions (e.g., formulating and justifying long-term business plan, identifying future markets and new technologies, and studying competitors).

ISIS focuses on full system-visibility of internal supply chain activities including strategic, operational, and infrastructural IS practices. At this stage, all internal functions from raw material management through production, shipping, and sales are connected and integrated real-time. EISI, on the other hand, is characterized by external cooperation between a firm and its trading partners. At this stage, full supply chain integration extending the scope of integration outside the company is accomplished. The relationship between IISI and EISI was not clear in previous literature. However, this relationship can be explained using supply chain integration theory. For example, Bowersox (1989) argued that process integration should progress from internal logistics integration to external integration with suppliers and customers. Both can be accomplished by the continuous automation and standardization of each internal logistics function and by efficient information sharing and strategic linkage with suppliers and customers. Stevens (1989), Byrne and Markham (1991), and Hewitt (1994) suggested that the development of internal supply chain integration should precede the external integration with suppliers and customers.

Hypothesis H3: *The higher the extent of IISI, the higher the extent of supply chain integration*

Hypothesis H4: *The higher the extent of EISI, the higher the extent of supply chain integration*

The hypothesis H3 was found to be non-significant and the hypothesis H4 was found to be significant. This indicates that EISI has a direct positive influence on supply chain integration; however, IISI does not. The results suggest that a firm's internal information system integration does not affect the extent of supply chain integration directly but through external information system integration (EISI). This implies that it does not matter how well a firm can implement information systems internally, supply chain integration can only be improved if a firm uses information systems to interact with external partners.

Hypothesis H5: *The higher the extent of supply chain integration, the higher the extent of firm's operational performance*

Hypothesis H6: *The higher the extent of supply chain integration, the higher the extent of suppliers' operational performance*

The hypothesis H5 and H6 were found to be significant. This indicates that supply chain integration has a direct positive influence on a firm's operational performance and a suppliers' operational performance. A highly integrated supply chain has been reported to influence operational performance benefits in a number of studies (e.g., Armistead and

Mapes, 1993, Buck-lew et al., 1992). Ragatz et al. (1997) reported that effective integration of suppliers into project value/supply chains will be a key factor for some manufacturers in achieving the improvements necessary to remain competitive. Carter and Ellram (1994) found that supplier involvement in product design has a positive impact on defect rate in the later manufacturing stage. This finding empirically confirms the assertion in the literature that a high level of supply chain integration could provide an organization with competitive advantage. The successful supply chain implementation will improve the organization's performance on cost, quality, dependability, flexibility, and time-to-market, and give the organization a defensible position over its competitors through coordination of inter-organizational activities along the supply chain.

Hypothesis H7: *The higher the extent of supplier performance, the higher the extent of firm's operational performance*.

The hypothesis H7 was found to be significant. This indicates that supplier performance has a direct positive influence on a firm's operational performance. Suppliers and a firm form a cooperative relationship with each other. Firms depend on suppliers for a fast delivery of raw materials and parts, high quality of products, reliability and flexibility at reasonable costs. Suppliers also depend on firms for their generous volume at a reasonable price. It is a win-win situation. One way for a firm to improve its competitive priorities is to create a strategic alliance. A strategic alliance is an agreement with another firm that may take many forms such as collaborative effort, joint venture, and technology licensing.

Hypothesis H8: *The higher the extent of firm's operational performance, the higher the extent of firm performance*

Hypothesis H9: *The higher the extent of suppliers' operational performance, the higher the extent of firm performance*

The hypothesis H8 was found to be significant and the hypothesis H9 was found to be non-significant. This indicates that the firm's operational performance affects a firm performance directly, however; suppliers' operational performance does not have a direct positive influence on firm performance. Suppliers' operational performance might affect a firm performance indirectly through a firm's operational performance as evidence in hypothesis 6. This implies that suppliers and firms have to work together to improve their business processes in order to gain financial benefits. World class suppliers provide necessary factors to impact organizational performances but do not guarantee the success of a firm unless the firm strategically manages long-term relationships with key suppliers, improves overall product quality, delivery, process flexibility, and thus has a positive impact on the firm's financial performance.

6.5. STRUCTURAL EQUATION MODEL RESULTS – INDIRECT EFFECTS

Previous section (table 6.3.1) reports three of ten hypotheses were not significantly supported. The hypotheses include (1) the direct relationship between information technology utilization and external information systems integration, (2) the direct relationship between internal information systems integration and supply chain integration, and (3) the direct relationship between suppliers' operational performance and firm performance. As shown in table 6.5.1, these three relationships can be explained in the form of indirect effect.

The indirect impact of information technology utilization on external information systems integration is significant at $p < 0.001$ level and the indirect impact of internal information systems integration and supply chain integration is significant at $p < 0.01$ level. This result supports the claim mentioned earlier that information systems integration is a sequential process. The process starts within a firm by the firm integrating all its internal activities including infrastructural components (e.g., hardware, software, and standard), operational components (e.g., managing daily operations activities and exchanging information), and strategic components (e.g., justifying business plan, analyzing market position, and setting long term business goals). This process is crucial and a pre-requisite for the success of a supply chain integration because only external integration has a direct impact on supply chain integration. Even though information technology utilization does not impact external integration and supply chain integration directly, it does through internal integration as evident in the strong indirect relationship.

The results also provide managerial implications for top management. Top management involved in technology investments must set a high priority on the technologies that have potential revenues to both internal and external integration. Investing high capital on technologies geared toward internal integration alone; even though it sounds tempting, takes less time and is easy to measure benefits, and might satisfy many stakeholders - is not good for the organization in the long run. Integration projects should be viewed at the strategic level and provide long-term benefits (such as supply chain integration and supply chain performance). Therefore, technology investment strategy, internal information systems integration strategy, external information systems integration strategy, and corporate strategy should be viewed simultaneously - not a disposal of one another - when implementing technologies. All strategies must be aligned because each component is important for the success of the whole supply chain.

The results also show that the indirect impact of supplies' operational performance on firm performance is significant at $p < 0.01$ level. The results imply that firms must view suppliers as a strategic weapon; even though suppliers are a separate entity. Forming a close relationship with suppliers may bring many benefits to the firm including reduced product development time, improved transparent communication, focused efforts to core businesses, enhanced customer satisfaction, and increased operational and firm performance. Because of the inevitable global competition, many firms are interesting in forming a long-term relationship with their suppliers (e.g., Wal-Mart and P&G, Kodak and IBM, and etc.). By forming the strategic relationship, a firm's supply chain can compete with other supply chains.

Hypotheses	Relationship	Direct	Indirect	Total	T-Value of Indirect effect	P-Value of Indirect Effect
H1a	ITU → IISI	0.81	0.00	0.81	0.00	0.00
H1b	ITU → EISI	0.03	0.63	0.66	9.10	***
H2	IISI → EISI	0.77	0.00	0.77	0.00	0.00
H3	IISI → SCI	0.10	0.37	0.47	3.89	***
H4	EISI → SCI	0.47	0.00	0.47	0.00	0.00
H5	SCI → FOP	0.27	0.14	0.41	2.41	0.008
H6	SCI → SOP	0.37	0.00	0.37	0.00	0.00
H7	SOP → FOP	0.40	0.00	0.40	0.00	0.00
H8	FOP → FP	0.45	0.00	0.45	0.00	0.00
H9	SOP → FP	0.06	0.18	0.24	2.64	0.004

Table 6.5.1: Structural Modeling Results – Indirect Effects

6.6. MODIFIED STRUCTURAL EQUATION MODEL RESULTS

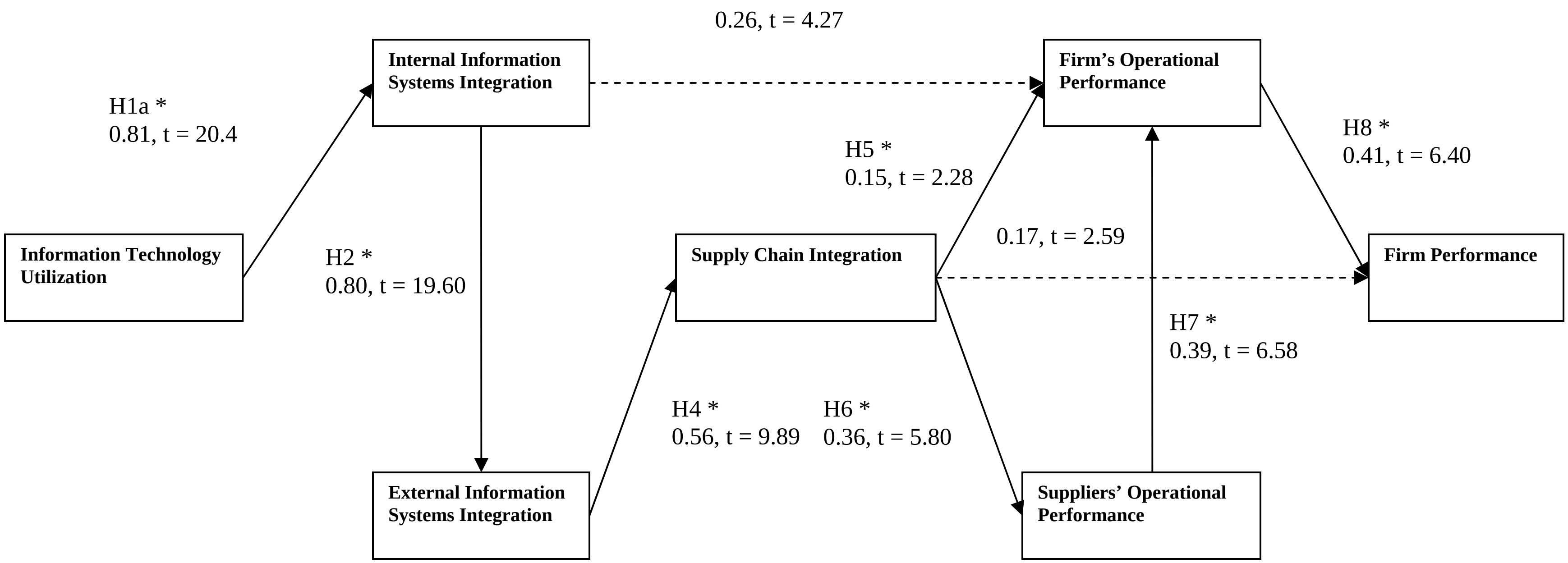
Although the model fit indices were generally acceptable in the revised model, there is still room for improvement to reach a higher standard of research. Especially the RMSEA was still high, though acceptable. This might indicate some other uncovered relationships in the model. After checking the modification indices provided by AMOS structural results, two interesting new paths not proposed in the original model were uncovered, which made perfect theoretical sense.

The two new discovered paths include: 1) the direct positive effects of Internal Information System Integration (IISI) on Firm’s Operational Performance (FOP), and 2) the direct positive effects of Supply Chain Integration (SCI) on Firm Performance (FP). These are very interesting and meaningful findings. After adding these two new paths, the structural model was estimated again using AMOS. The final results are presented in

Figure 6.5 and Table 6.6.1. All relationships show t-value greater than 2.0 and significant at the 0.05 level. Out of the 9 relationships, 5 relationships had a large effect size and 4 relationships had a medium effect size. Thus, the effect size results confirm that the supported relationships have both statistical and practical significance, which is crucial in providing both theoretical and managerial implications. The model fit indices were significantly improved. GFI = 0.98, AGFI = 0.96, and RMSEA = 0.03 were all significantly better than the suggested limits.

Hypotheses	Relationship	Coefficients	Effect size	t-value	P	Support
H1a	ITU → IISI	0.81	Large	20.40	***	Yes
H2	IISI → EISI	0.80	Large	19.60	***	Yes
H4	EISI → SCI	0.56	Large	9.89	***	Yes
H5	SCI → FOP	0.15	Medium	2.28	0.02	Yes
H6	SCI → SOP	0.36	Medium	5.80	***	Yes
H7	SOP → FOP	0.39	Large	6.58	***	Yes
H8	FOP → FP	0.41	Large	6.40	***	Yes
New	IISI → FOP	0.26	Medium	4.27	***	Yes
New	SCI → FP	0.17	Medium	2.59	0.009	Yes
GFI = 0.98 AGFI = 0.96 RMSEA = 0.03 *** = P < 0.001						

Table 6.6.1: Final Structural Modeling Results



GFI = 0.98, AGFI = 0.96, and RMSEA = 0.03, * Significance at < 0.001

Figure 6.5: Final Path Analysis Results for Information System Integration Framework

6.7. DISCUSSION OF THE NEW PATHS

Path 1: *The direct influence of internal information systems integration on firm's operational performance.*

The results did not support the original hypothesis that internal information systems integration indirectly influences firm's operational performance through supply chain integration. However, the new direct relationship between internal information systems integration and firm's operational performance emerges. This new relationship actually makes theoretical and practical sense. The firm's operational performance relates to firm's competitive priorities (e.g., delivery reliability, process flexibility, cost leadership, product/process innovation, and product quality). From the results, the high level of firm's operational performance is dependent on the level of system integration within the firm. Firms that extensively use information systems to accommodate different level of activities (e.g., strategic, operational, and infrastructural) are more likely to accomplish their internal competitiveness; even though they do not involve much in supply chain activities. This explains why some companies do really well by themselves by implementing the right tools and practices but provide no value added to the overall supply chain.

Path 2: *The direct influence of supply chain integration on firm performance.*

The new relationship was not covered in the original hypothesis. It unsurprisingly provides both theoretical and practical sense as it relates to path 1 relationship. Path 1 shows that internal information system integration provides firm's internal advantages because it improves firm's operational performance; however, it might not provide ultimate benefits. As the new path shows the direct relationship between supply chain integration and firm performance, firms do not actually gain high level of performance unless they involve in supply chain integration activities. Supply chain integration activities may include involving customers and suppliers in the strategic and operational activities such as determining market demand, identifying product development process, enhancing logistics activities, and preparing strategic and business plans. Supply chain integration provides a means to an end for firms to improve their overall performance level.

6.8. SUMMARY OF RESULTS

Overall, the results indicate that higher levels of information technology utilization will lead to improved internal information systems integration, and improved internal information systems integration will enhance external information systems integration and firm's operational performance. The results also show that external information systems integration rather than internal information systems integration directly influences supply chain integration. In addition, firm performance is not only influenced directly by its operational performance and supply chain integration, but also indirectly by its suppliers' operational performance. Moreover, the findings reveal that effective supply chain integration will facilitate the firm's operational performance, the supplier's operational performance, and firm performance. However, the findings did not support the direct impact of information technology utilization on external information systems integrations, the direct impact of internal information systems integration on supply chain integration, and the direct impact of suppliers' operational performance on firm performance.

The next chapter will conclude with the limitations of the research, contributions, implications for managers, and recommendations for future research.

CHAPTER 7: SUMMARY, LIMITATIONS, IMPLICATIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH

This chapter provides (1) summary of research findings and major contributions, (2) implications for practitioners, (3) limitations of the research, and (4) recommendations for future research.

7.1. SUMMARY

The current research represents one of the first large-scale empirical efforts to systemically investigate the complex causal relationships between information systems integration and other related constructs such as information technology utilization, supply chain integration, firm's operational performance, suppliers' operational performance, and firm performance. It aims to answer the following important questions: 1) What are the key dimensions of information systems integration? 2) What are the key dimensions of information technology utilization? 3) What factors indirectly and directly affect operational performance and firm performance? 4) How are customers and suppliers involved in the process of supply chain integration? 5) What is the highest priority level of integration for firms to gain ultimate benefits from their supply chain?

As mentioned in the introduction, there is no clear definition of constructs and conceptual frameworks on information systems integration in the current literature and most empirical research mainly focuses on the physical aspects of information systems integration such as data integration and network connectivity within a merger and acquisition context. The few studies that have attempted to empirically study the concept of information systems integration are not clearly focused and mainly relate to infrastructural integration. The current study provides a complete set of measurements for information systems integration consisting of strategic integration, operational integration and infrastructural integration. The information systems integration framework developed here considers supply chain integration at the firm level. It represents top management's perception of the degree of involvement between a firm and its trading partners. Based on the data collected from 220 top managements and executives, the model was tested using structural equation modeling methodology. The study contributes to our understanding of information systems integration and supply chain research a number of ways.

First, this research provides a theoretical framework that identifies the detailed dimensions of information systems integration, information technology utilization, supply chain integration, firm's operational performance, suppliers' operational performance, and firm performance. This framework provides a foundation for future research. In the future, new constructs may be added to provide in-depth understanding of information systems integration theory.

Second, the study provides the inferences made from an instrument that is valid and reliable for the current study's context. The measurement instruments include four constructs: 1) information technology utilization, 2) internal information system integration, 3) external information system integration, and 4) supply chain integration. All the scales have been tested through rigorous statistical methodologies including pre-test, pilot-test using Q-sort method, confirmatory factor analysis, unidimensionality, reliability, and the validation of second-order construct. All the scales are shown to meet the requirements for reliability and validity and thus, can be used in future research. Such valid and reliable scales have been otherwise lacking in the literature. The development of these scales will greatly stimulate and facilitate theory development in this field.

Third, this study provides supporting evidence to the conceptual and prescriptive literature about previously inconclusive statements regarding the relationship between information technology utilization and performance. The results demonstrate that a higher level of information technology utilization will lead to a higher level of supply chain integration and firm performance through information systems integration. The results of this study further provide the empirical support that information systems integration acts as a bridge between the effective use of IT and the high level of coordination within the supply chain. It can be concluded that only information technologies used for integration purposes will provide sustainable competitive advantage for the organizations within the supply chain.

Fourth, the results highlight the critical role of customers and suppliers in facilitating supply chain integration. Effective relationships with customers and suppliers will directly lead to a higher level of supply chain integration and in turn lead to a higher level of operational performance for both firms and suppliers. Moreover, relationships with trading partners will directly and indirectly influence firm performance through firm’s and suppliers’ operational performance. This is a very valuable finding since partner relationships have received little attention by top management.

Fifth, this research reveals that the nature of the information systems integration process occurs in a sequential manner. The integration process starts with collaborating activities between departments such as collaborating and developing business plans, identifying new markets, adjusting manufacturing and logistics process, setting up network connectivity, and etc. Once the internal integration is firmly rooted, the process of external information systems integration is begun by involving their trading partners. Therefore, internal integration process is crucial and a pre-requisite for the success of a supply chain. The empirical findings from testing the influence of partner relationship attributes added significantly to the current body of knowledge in SCM field. It shows that the role of information systems integration in enhancing supply chain is strategic, operational, and infrastructural. Moreover, the indirect influence of IT use on supply chain integration demonstrates that the higher level of IT use alone will not necessarily result in the higher level of supply chain integration if not accompanied by other factors, such as internal information systems integration and external information systems integration.

7.2. IMPLICATIONS FOR PRACTITIONERS

The results of this study have several important implications for practitioners. First, as today's competition is moving from competing between firms to competing between supply chains, more organizations are increasingly adopting information technologies in the hope for improving operational and firm's performance. But there are doubts about the potential benefits from information technology utilization. The findings of this research assure the practitioners that information technology utilization is an effective way of competing and information systems integration implementation does have strong impacts on competitive advantage and organizational performance.

Second, the results of this study show that the information technology utilization affects the firm's internal information system integration directly; which in turn indirectly impacts the firm's external information system integration. This implies that the firm can only be integrated with its external partners through information technology when it is internally integrated and has an infrastructure in place. Without a high level of internal integration, the linkage with external partners will never work. Information technology alone does not guarantee external integration. This explains why several firms investing in high-tech do not successfully gain potential benefits from their investment. Technology is just a tool; it is not a solution. The implication to practitioners is clear; to achieve a high level of integration with suppliers and customers, internal integration is imperative and the process of integration is sequential from internal to external.

Third, the direct relationship between internal information systems integration and external information systems integration implies that, in order for information systems to be integrated; the process of integration occurs in a sequential manner from internal integration to external integration. Firms with high degree of internal integration (e.g., firms successfully implement enterprise-wide information systems such as SAP and MRP) are more likely to integrate with their external partners than firms with no internal integration system. Internal information systems integration projects are time consuming and capital intensive. Not all the firms implementing internal integration system can be successful. However, firms successfully implementing internal integration have more chances to integrate with other firms using existing compatible systems than the counter parts.

Fourth, the results indicate that internal information systems integration has an indirect impact on supply chain integration through external information systems integration. This implies that top management should devote much study to technology investment strategies because investing in the wrong technologies can become a competitive disadvantage. Top management should pay much attention, resources, and effort to invest in technologies that have value toward external integration, thus improving supply chain integration. As a firm is continuously competing not only with other firms but also with other value chains, investing in technologies geared toward external integration will improve the entire supply chain. The competitive advantages from improving supply chain integration include enhancing information flow and improving operational performance (e.g., cost leadership, product quality, delivery speed, process flexibility, and technology innovation) because logistics activities are much more transparent.

Fifth, the research identifies the key dimensions of information technology utilization. As hypothesized, the dimensions of information technology utilization include three sub-dimensions namely strategic IT, operational IT, and infrastructural IT. As identified in previous studies, information technology utilization provides both positive and negative impacts on a firm's outcomes because the full concept of information technology utilization has been poorly defined and utilized by many firms. In fact, many firms still tend to consider information technology utilization at the infrastructural and operational level, not at the strategic level. Even though firms have realized the importance of implementing the right information technology, they often do not know exactly what to implement, or just focus on part of technologies. The findings demonstrate to the practitioners that in order to gain full benefits, strategic information technologies should be set a high priority. This implies that investing in technologies that have strategic implications provides a building block for the supply chain integration success.

Sixth, the research identifies the key dimensions of information systems integration that a firm can adopt to interact with its trading partners. As hypothesized, the dimensions of information systems integration include two dimensions namely internal information systems integration and external information systems integration each with three sub-dimensions namely strategic, operational, and infrastructural information systems integration. These dimensions provide precise information to assist top management when implementing information systems. The findings demonstrate to the practitioners that, in order to gain overall benefits, top management should establish information system that best serve their internal firm needs before attempting external integration.

7.3. IMPLICATIONS FOR RESEARCHERS

First, the study provides the inferences made from an instrument that is valid and reliable for the current study's context for evaluating an organization's level of information technology utilization, information systems integration and supply chain integration, and tests these constructs with two performance outcomes namely operational performance and firm performance. Although several previous studies discussed the measurement of information technology utilization, they were either oriented toward infrastructural integration or operational integration such as network integration and data integration. The instruments developed in this research capture an important aspect of information system practices -strategic information systems integration. The new instruments provide better guideline for researchers in the SCM area; because, in the supply chain integration context, information technologies are intentionally designed to support coordination and enhance transparent information, and thus, can be considered strategic coalition tools. These measures are useful to researchers who are interested in evaluating causes and effects of information technologies to the overall supply chain.

Second, the findings identify the mediating role of information systems integration in facilitating supply chain coordination. This study takes a look at the supply chain integration at the firm level by measuring the degree of coordination between a firm and its trading partners (customers and suppliers). The concept of supply chain integration is difficult to measure; however, the level of coordination between a firm and its trading partners can be used as an indirect measure of this concept. This measure is useful to researchers who are interested in measuring the level of supply chain integration but cannot specify a sampling frame of the supply chain. Measuring supply chain integration at the firm level provides an alternative way to study supply chain outcomes.

Third, the study provides the inferences made from an instrument that is valid and reliable for the current study's context to measure the concept of information systems integration. With two sub-dimensions of information systems integration, the new instruments help expand research ideas for researchers who might adopt these measures to study the factors affecting information systems integration such as culture. These measures are also useful to researchers who are interested in studying the effects of information systems integration on other important management variables such as top management support and mass customization.

7.4. LIMITATIONS OF THE RESEARCH

While the current research made significant contributions from both a theoretical and practical point of view, it also has limitations, which are described below.

First, because of the limited number of observations (220), the revalidation of constructs was not carried out in this research. This needs to be addressed in future research. New mailing lists and research methods may be applied to improve the response rate.

Second, in this research, individual respondents (manufacturing managers and top management) in an organization were asked to respond to complex information systems integration issues, operational performance, and organizational performance dealing with all the participants along the supply chain, including upstream suppliers and downstream customers. However, no person in an organization is in charge of the entire supply chain: for example, manufacturing managers are mainly responsible for procuring raw materials and parts and managing production, and may not be in an appropriate position to answer the supplier/customer-related questions. The main area of manufacturing managers is production and they may not have thorough knowledge of their suppliers, customers, and firm performance. Therefore, the use of single respondent responses may generate some measurement inaccuracy.

Third, the response rate of 7%, even though comparable to similar studies, is considered low. A main important of the low response rate is the length of questionnaire. Because of the time constraint of top management, manufacturing managers and executives are unlikely to participate in the lengthy survey. This issue can be addressed in the future research by reducing the number of items in the questionnaire and concentrating the focus of the questionnaire to the areas requiring further clarification.

7.5. RECOMMENDATIONS FOR FUTURE RESEARCH

Definition and measurement items should be refined based on the results of the measurement model analysis. Future research should not only attempt to develop better definitions and sub-dimensions but also use the least amount of parsimony. Since the usefulness of a measurement scale comes from its generalizability, future research should revalidate measurement scales developed through this research by using the similar reference populations. Appendix N shows the recommended questionnaire items for the future research.

The following recommendations are proposed for future research.

Future research should conduct factorial invariance tests. Generalizability of measurement scales can further be supported by factorial invariance tests. Using the instruments developed in this research, one may test for factorial invariance across industries, across different organization size, and across organizations with different supply chain structure (such as supply chain length, organization's position in the supply chain, channel structure, and so on).

Future research should apply multiple methods to obtain data. The use of a single respondent to represent what are supposed to be intra/inter-organization wide variables may generate some inaccuracy and more than the usual amount of random error (Koufteros, 1995). Future research should seek to utilize multiple respondents from each participating organization as an effort to enhance reliability of research findings. Once a construct is measured with multiple methods, random error and method variance may be assessed using a multitrait-multimethod approach.

Future research should examine the hypothesized structural relationships across industries. Assuming an adequate sample size in each industry, structural analysis may be done by industry. This would reveal either industry-specific structural relationships or invariance of structural relationships across industries. The same hypothesized structural relationships across countries can also be tested in the future research. This will allow the comparison of Information System Integration between countries, the identification of country-specific ISI issues, and the generalization of common ITU facilitating factors and ISI practices across countries.

Future research should incorporate the factors inhibiting the implementation of ITU. Such issues as interdependence of the partners, channel conflict, power, and organizational/national culture have received attention in the literature. Studying the impacts of such inhibiting factors and solutions to reduce or even eliminate such negative influence on ISI practices are critical for further understanding ISI issues and improving overall firm performance. Future research should also explore the impact of such inhibiting factors on ISI practices and supply chain performance.

Future studies can also examine the proposed relationships by bringing some contextual variables into the model, such as organizational size and supply chain structure. For example, it will be intriguing to investigate how ISI practices differ across organization size. It will also be interesting to examine the impact of supply chain structure (supply chain length, organization's position in the supply chain, channel structure, and so on) on ISI practice and performance.

This study indicates that ITU plays an important role in implementing ISI practice and improving organizational performance. There are several issues regarding the success of IT implementations (such as trust, commitment, and shared vision). For example, how does one choose to implement a specific IT from many alternatives? What tools and procedures can be used to establish a successful IT implementation? What skills are necessary to develop commitment and credibility in the relationship between ITU and ISI? What is the role of top management in establishing a successful IT implementation? There may be addressed in future research.

In this study, composite measures are used to represent each construct, and only the structural model is tested using AMOS. However, the strength and nature of relationships among sub-constructs across variables may vary. For example, it is certain that ISI practices play critical roles in affecting operational performance and firm performance at the organizational level. More detailed questions can be raised, such as which ISI practice (i.e. strategic, operational, or infrastructural practices.) has more impact on performance, or which dimension of operational performance (i.e. process flexibility, product quality, cost, delivery speed, reliability) influences competitive advantage more. By assessing these relationships at the sub-construct level, one may explore numerous alternative models of structural relationships and make the findings more meaningful for decision makers.

Finally, future research can expand the current theoretical framework by integrating new constructs from other fields. For example, one might incorporate top management support and mass customization into the existing framework.

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APPENDIX A: Manufacturing and Information Technology Survey

Section 1: Information Technology Utilization The following situations describe the extent of information technology utilization in which **organizations adopt for strategic purposes, operational purposes, and infrastructural purposes**. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to you.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Strategic IT						
Our organization uses IT…						
for technology planning…………………………………………………………………	1	2	3	4	5	NA
for demand forecasting……………………………………………………………….	1	2	3	4	5	NA
for budget planning………………………………………………………………….	1	2	3	4	5	NA
for project planning………………………………………………………………….	1	2	3	4	5	NA
for investment planning………………………………………………………………..	1	2	3	4	5	NA
for technology justification………………………………………………………….	1	2	3	4	5	NA
for budget justification……………………..……………………................................	1	2	3	4	5	NA
for project feasibility analysis..…………………………………………………………	1	2	3	4	5	NA
for investment justification analysis..	1	2	3	4	5	NA
for market positioning analysis.…………..………………………..………………….	1	2	3	4	5	NA
for competitor analysis……...	1	2	3	4	5	NA
for customer analysis………………………………………………………………..	1	2	3	4	5	NA
for industry analysis…………………………………………………………………	1	2	3	4	5	NA
Operational IT						
Our organization uses IT…						
for production control…..	1	2	3	4	5	NA
for product and service quality control………………………………………………..	1	2	3	4	5	NA
for inventory management…………………………………………………………….	1	2	3	4	5	NA
for material requirement planning…………………………………………………..	1	2	3	4	5	NA
for warehouse management……………………………………………………………	1	2	3	4	5	NA
for sales management……………………………………………………………….	1	2	3	4	5	NA
for purchasing management...	1	2	3	4	5	NA
for customer relationship management…...	1	2	3	4	5	NA
for supplier management………………………………………………………………..	1	2	3	4	5	NA
for distribution management………………………………………………………….	1	2	3	4	5	NA
Infrastructural IT						
Our organization uses IT…						
for file sharing………………………….……………………………………………….	1	2	3	4	5	NA
for data communication…………………………..……………………………………..	1	2	3	4	5	NA
for network planning and design………………………………………………………	1	2	3	4	5	NA
for firm-wide communication network services………………………………………	1	2	3	4	5	NA
for firm-wide workstation networks management…………………………………….	1	2	3	4	5	NA
for recommending standards for IT architectures (e.g. hardware, operating systems)..	1	2	3	4	5	NA
for implementing security, disaster planning and recovery..….....................................	1	2	3	4	5	NA
for firm-wide messaging services.……………………….……………………………	1	2	3	4	5	NA
for technology education services (e.g. training)…………………………………..	1	2	3	4	5	NA
for multi-media operations and development (e.g. video-conferencing)………………	1	2	3	4	5	NA
for electronic linkages to suppliers or customers………………………………………	1	2	3	4	5	NA

Section 2: Information Systems Integration - Internal The following statements describe the extent to which **various business functions within the organization interact with each other** using information systems (IS). Please circle the appropriate number to indicate the extent of integration with each statement as it pertains to your organization.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Strategic Integration - Internal						
The use of Information Systems (IS) facilitates cooperation **of various business functions within the organization in…**						
formulating collaborative decision making……………………………………...	1	2	3	4	5	NA
justifying joint business plans…………………….....……………………………...	1	2	3	4	5	NA
analyzing the effectiveness of long-term business plans………………………….	1	2	3	4	5	NA
developing new business opportunities……………...…………………………….	1	2	3	4	5	NA
identifying new markets…………………………………………………………	1	2	3	4	5	NA
identifying new technologies………..………..…………………………………...	1	2	3	4	5	NA
studying competitors.……….……………………………………………………..	1	2	3	4	5	NA
defining firm's competitive position……………….………………………………	1	2	3	4	5	NA
setting firm's strategic goals………………..……………………………………...	1	2	3	4	5	NA
Operational Integration - Internal						
The use of Information Systems (IS) facilitates cooperation **of various business functions within the organization in…**						
establishing manufacturing processes…………….……………….……………	1	2	3	4	5	NA
developing product designs…………….………………………………………	1	2	3	4	5	NA
identifying product development processes.…….……………………………….	1	2	3	4	5	NA
managing order information………………….………………………………..	1	2	3	4	5	NA
exchanging inventory information….…….………………………………………	1	2	3	4	5	NA
selecting suppliers……..…..…………………….……………………………..	1	2	3	4	5	NA
managing logistical activities…………..………………………………………….	1	2	3	4	5	NA
establishing product forecasts…………………………..…………………………	1	2	3	4	5	NA
sharing functional knowledge………….……………………………………….	1	2	3	4	5	NA
Infrastructural Integration – Data Integration						
Various business functions within the organization…						
use standard data definitions and codes…………………………………………	1	2	3	4	5	NA
use standard data presentation format……………………………………………..	1	2	3	4	5	NA
use firm-wide databases (e.g. Oracle)…………………………………………….	1	2	3	4	5	NA
use database synchronization systems (e.g. Palm).……………………………….	1	2	3	4	5	NA
use firm-wide IS applications (e.g. Outlook, Lotus Note, SAP)…………………..	1	2	3	4	5	NA
have low degree of data redundancy……………………………………………	1	2	3	4	5	NA
Infrastructural Integration – Network Connectivity						
Various business functions within the organization….						
use IS networks to communicate with each other through ………………………...	1	2	3	4	5	NA
use IS networks to share information with each other……………………………..	1	2	3	4	5	NA
use IS networks to connect to centralized databases…………….…………………	1	2	3	4	5	NA
use IS networks to facilitate periodic interdepartmental meetings……...…………	1	2	3	4	5	NA
use compatible network architectures……………………………………………..	1	2	3	4	5	NA
use firm-wide workstation networks……………………………….……………	1	2	3	4	5	NA

Section 3: Information Systems Integration - External The following statements describe the extent to which **a firm interacts with its suppliers and customers using information systems (IS)**. Please circle the appropriate number to indicate the extent of integration with each statement as it pertains to your organization.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Strategic Integration - External						
The use of Information Systems (IS) facilitates cooperation **between our firm and our trading partners in…**						
formulating collaborative decision making………………………………	1	2	3	4	5	NA
justifying joint business plans……….………..………………………	1	2	3	4	5	NA
analyzing the effectiveness of long-term business plans…….………	1	2	3	4	5	NA
generating new products…….……………………………………………	1	2	3	4	5	NA
establishing new business opportunities…………………………………	1	2	3	4	5	NA
identifying new markets………………..…..………………………………	1	2	3	4	5	NA
identifying new technologies………………………………………………	1	2	3	4	5	NA
studying competitors………………………………………………………	1	2	3	4	5	NA
defining joint competitive position……………………..…………………	1	2	3	4	5	NA
setting joint strategic goals……………..………………………………..…	1	2	3	4	5	NA
Operational Integration - External						
The use of Information Systems (IS) facilitates cooperation **between our firm and our trading partners in…**						
establishing manufacturing processes…………..…………………………	1	2	3	4	5	NA
developing product designs………………………………………………	1	2	3	4	5	NA
designing product development processes…….………………………	1	2	3	4	5	NA
managing order information…………………………….…………………	1	2	3	4	5	NA
exchanging inventory information ………………………………………	1	2	3	4	5	NA
selecting raw materials and parts……………………………..………	1	2	3	4	5	NA
managing logistical activities……………………………………..………	1	2	3	4	5	NA
establishing product forecasts……………………….…………………	1	2	3	4	5	NA
sharing business knowledge……………………………………….……	1	2	3	4	5	NA
Infrastructural Integration – Data Integration						
Our firm and our trading partners…						
use standard data definitions and codes……………………………………	1	2	3	4	5	NA
use standard data presentation format…………………………………...	1	2	3	4	5	NA
use database synchronization systems…………………………..….	1	2	3	4	5	NA
use compatible database systems………………………………………	1	2	3	4	5	NA
use compatible IS applications………………..…………………..………	1	2	3	4	5	NA
have low degree of redundancy……………………………………………	1	2	3	4	5	NA
Infrastructural Integration – Network Connectivity						
Our firm and our trading partners…						
use IS networks to communicate with each other.. ………………………	1	2	3	4	5	NA
use IS networks to share information with each other……………………	1	2	3	4	5	NA
use IS networks to connect to each other's databases… …………………	1	2	3	4	5	NA
use IS networks to negotiate business issues (e.g. price)….………………	1	2	3	4	5	NA
use IS networks to facilitate periodic meeting…….………………………	1	2	3	4	5	NA
use compatible network architectures……………………………………..	1	2	3	4	5	NA

Section 4. The following statements describe the extent of supply chain integration **by which the organization interacts with external constituencies (e.g., customers and suppliers**. Please circle the appropriate number to indicate the extent on integration with each statement as it pertains to your organization.	Very Low	Low	Moderate	High	Very High	Not Applicable, or Do Not Know
Integration with suppliers						
The participation level of suppliers in manufacturing processes………	1	2	3	4	5	NA
The participation level of suppliers in production planning processes..	1	2	3	4	5	NA
The participation level of suppliers in product development processes..	1	2	3	4	5	NA
The participation level of suppliers in logistics processes……………	1	2	3	4	5	NA
The level of cross-over of activities between our firm and our suppliers…………………………………………………………….	1	2	3	4	5	NA
The level of supplier involvement in preparing our business plans……	1	2	3	4	5	NA
Integration with customers						
The willingness of customers to share their market demands..………..	1	2	3	4	5	NA
The participation level of customers in product development processes..	1	2	3	4	5	NA
The participation level of customers in finished goods distribution processes……………………………………………………………..	1	2	3	4	5	NA
The level of customer involvement in preparing business plans………	1	2	3	4	5	NA
The extent of follow-up with customers for feedbacks………..……….	1	2	3	4	5	NA

Section 5: Suppliers' and Firm's Operational Performance

The following statements describe typical **supplier and firm objectives**. Please circle the appropriate number that best indicates the level of your suppliers' and firm's attainment of each objective as applicable to your perception. Please respond to both sides as left side indicates the level of supplier's operational performance and right side indicates the level of firm's operational performance.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Supplier's Operational Performance						**Performance Dimensions**	**Firm's Operational Performance**					
						Delivery reliability						
1	2	3	4	5	NA	Deliver materials/components/products as promises……………	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide materials/components/products that are highly reliable...	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide fast delivery…………………………………………….	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide on-time delivery………….……………………………..	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide reliable delivery…………………………………………	1	2	3	4	5	NA
1	2	3	4	5	NA	Decrease manufacturing lead time……………………………..	1	2	3	4	5	NA
						Process flexibility						
1	2	3	4	5	NA	Make rapid design changes………………………..………..	1	2	3	4	5	NA
1	2	3	4	5	NA	Make rapid production volume changes…………..…………..	1	2	3	4	5	NA
1	2	3	4	5	NA	Make rapid changeover between product lines……………….	1	2	3	4	5	NA
1	2	3	4	5	NA	Process both large and small orders…………….………….	1	2	3	4	5	NA
1	2	3	4	5	NA	Produce a variety of different products………….……………	1	2	3	4	5	NA
1	2	3	4	5	NA	Increase capacity utilization……………………………………	1	2	3	4	5	NA
						Cost leadership						
1	2	3	4	5	NA	Produce materials/components/products at low cost………..	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce production cost……………………………………….	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce inventory cost……………..………………………….	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce unit cost………………………………………………	1	2	3	4	5	NA
1	2	3	4	5	NA	Increase labor productivity………………….…………………..	1	2	3	4	5	NA
						Innovation						
1	2	3	4	5	NA	Develop new ways of customer service………………………	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new forms of shop floor management………………	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new ways of supply chain management…………….	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new products and features…………………………..	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new process technologies……………………………	1	2	3	4	5	NA
						Product quality						
1	2	3	4	5	NA	Provide better product performance…………………………..	1	2	3	4	5	NA
1	2	3	4	5	NA	Improve product durability……………………………………	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide product conformance to specifications………………	1	2	3	4	5	NA
1	2	3	4	5	NA	Improve product reliability……….………………………..	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce defective rate…………….…………………………..	1	2	3	4	5	NA
1	2	3	4	5	NA	Better product reputation……………………………………..	1	2	3	4	5	NA

Section 6: Firm Performance The following statements measure **overall performance of your firm**. Please circle the appropriate number that best indicates the level of your firm's overall performance.	Significant Decrease	Decrease	Same as Before	Increase	Significant Increase	Not Applicable, or Do Not Know
Customer retention rate…………………………………………………	1	2	3	4	5	NA
Sales growth…………………………………………………………	1	2	3	4	5	NA
Market share growth……………………………………………………	1	2	3	4	5	NA
Return on investment……………………………………………………	1	2	3	4	5	NA
Profit margin……………………………………………………………	1	2	3	4	5	NA
Production throughput time……………………………………………	1	2	3	4	5	NA
New product development cycle time…………………………………	1	2	3	4	5	NA
Overall competitive position……………………………………………	1	2	3	4	5	NA

Section 7: Mass Customization Capability The following statements measure firm's **capability to customize products** inexpensively and quickly. Please circle the appropriate number that best indicates your perception of the relative capabilities of your firm as compared to the industry average.	Much Below Average	Below Average	About Average	Above Average	Much Above Average	Not Applicable, or Do Not Know
Our capability of customizing products at low cost is…………………..	1	2	3	4	5	NA
Our capability of customizing products on a large scale is………………	1	2	3	4	5	NA
Our capability of translating customer requirements into technical designs quickly is…………………………………………………….	1	2	3	4	5	NA
Our capability of adding product variety without increasing cost is……	1	2	3	4	5	NA
Our capability of customizing products while maintaining a large volume is…………………………………………………………………	1	2	3	4	5	NA
Our capability of setting up for a different product a low cost is………..	1	2	3	4	5	NA
Our capability of responding to customization requirements quickly is…	1	2	3	4	5	NA
Our capability of adding product variety without sacrificing overall production volume is….………………………………………………….	1	2	3	4	5	NA
Our capability of changeover to a different product quickly is…………	1	2	3	4	5	NA

APPENDIX B

COHEN'S KAPPA AND MORRE AND BENBASAT COEFFICIENT

The Q-sort method is an iterative process in which the degree of agreement between judges forms the basis of assessing construct validity and improving the reliability of the constructs. The method consists of two stages. In the first stage, two judges are requested to sort the questionnaire items according to different constructs, based on which the inter-judge agreement is measured. In the second stage, questionnaire items that were identified as being too ambiguous, as a result of the first stage, are reworded or deleted, in an effort to improve the agreement between the judges. The process is carried out repeatedly until a satisfactory level of agreement is reached.

The following example describes the theoretical basis for the Q-sort method and the two evaluation indices to measure inter-judge agreement level: Cohen's Kappa (Cohen, 1960) and Moore and Benbasat's 'Hit Ratio" (Moore and Benbasat, 1991).

Let us assume that two judges independently classified a set of N components as either acceptable or rejectable. After the work was finished the following table was constructed:

		Judge 1		
Judge 2		Acceptable	Rejectable	Totals
	Acceptable	X_{11}	X_{12}	X_{1+}
	Rejectable	X_{21}	X_{22}	X_{2+}
	Totals	X_{+1}	X_{+2}	N

Xij = the number of components in the i^{th} row and j^{th} column, for i,j = 1,2.

The above table can also be constructed using percentages by dividing each numerical entry by N. For the population of components, the table will look like:

Judge 1				
Judge 2		Acceptable	Rejectable	Totals
	Acceptable	P_{11}	P_{12}	P_{1+}
	Rejectable	P_{21}	P_{22}	P_{2+}
	Totals	P_{+1}	P_{+2}	100

Pij = the percentage of components in the i^{th} row and j^{th} column.

We will use this table of percentages to describe the Cohen's Kappa coefficient of agreement. The simplest measure of agreement is the proportion of components that were classified the same by both judges, i.e., $\Sigma_i P_{ii} = P_{11} + P_{22}$. However, Cohen suggested comparing the actual agreement, $\Sigma_i P_{ii}$, with the chance of agreement that would occur if the row and columns are independent, i.e., $\Sigma_i P_{i+}P_{+i}$. The difference between the actual and chance agreements, $\Sigma_i P_{ii} - \Sigma_i P_{i+}P_{+i}$, is the percent agreement above that which is due to chance. This difference can be standardized by dividing it by its maximum possible value, i.e., 100% - $\Sigma_i P_i + P_{+I} = 1 - \Sigma_i P_i + P_{+i}$. The ratio of these is denoted by the Greek letter kappa and is referred to as Cohen's kappa.

$$k = \frac{\Sigma_i P_{ii} - \Sigma_i (P_{i+} P_{+i})}{1 - \Sigma_i (P_{i+} P_{+i})}$$

Thus, Cohen's Kappa is a measure of agreement that can be interpreted as the proportion of joint judgment in which there is agreement after chance agreement is excluded. The three basic assumptions for this agreement coefficient are: 1) the units are independent, 2) the categories of the nominal scale are independents, mutually exclusive, and 3) the judges operate independently. For any problem in nominal scale agreement between two judges, there are only two relevant quantities:

p_o= the proportion of units in which the judges agreed

p_c= the proportion of units for which agreement is expected by chance

Like a correlation coefficient, k=1 for complete agreement between the two judges. If the observed agreement is greater than or equal to chance K <= 0. The minimum value of k occurs when ΣP_{ii} =0, i.e.,

$$\min(k) = \frac{-\Sigma_i(P_{i+}P_{+i})}{1-\Sigma_i(P_{i+}P_{+i})}$$

When sampling from a population where only the total N is fixed, the maximum likelihood estimate of k is achieved by substituting the sample proportions for those of the population. The formula for calculating the sample kappa (k) is:

$$k = \frac{N_i\,Xii - \Sigma_i(X_{i+}X_{+i})}{N^2 - \Sigma_i(X_{i+}X_{+i})}$$

For kappa, no general agreement exists with respect to required scores. However, recent studies have considered scores greater than 0.65 to be acceptable (e.g. Vessey, 1984; Jarvenpaa 1989; Solis-Galvan, 1998). Landis and Koch (1977) have provided a more detailed guideline to interpret kappa by associating different values of this index to the degree of agreement beyond chance. The following guideline is suggested:

Value of Kappa	Degree of Agreement Beyond Chance
.76 - 1.00	Excellent
.40 - .75	Fair to Good (Moderate)
.39 or less	Poor

A second overall measure of both the reliability of the classification scheme and the validity of the items was developed by Moore and Benbasat (1991). The method required analysis of how many items were placed by the panel of judges for each round within the target construct. In other words, because each item was included in the pool explicitly to measure a particular underlying construct, a measurement was taken of the overall frequency with which the judges placed items within the intended theoretical construct. The higher the percentage of items placed in the target construct, the higher the degree of inter-judge agreement across the panel that must have occurred.

Moreover, scales based on categories that have a high degree of correct placement of items within them can be considered to have a high degree of construct validity, with a high potential for good reliability scores. It must be emphasized that this procedure is more a qualitative analysis than a rigorous quantitative procedure. There are no established guidelines for determining good levels of placement, but the matrix can be used to highlight any potential problem areas. The following exemplifies how this measure works.

Item Placement Scores

CONSTRUCTS		ACTUAL						
		A	B	C	D	N/A	Total	% Hits
THEORETICAL	A	26	2	1	0	1	30	87
	B	8	18	4	0	0	30	60
	C	0	0	30	0	0	30	100
	D	0	1	0	28	1	30	93

Item Placements: 120 Hits: 102 Overall "Hit Ratio": 85%

The item placement ratio (the "Hit Ration") is an indicator of how many items were placed in the intended, or target, category by the judges. As an example of how this measure could be used, consider the simple case of four theoretical constructs with ten items developed for each construct. With a panel of three judges, a theoretical total of 30 placements could be made within each construct. Thereby, a theoretical versus actual matrix of item placements could be created as shown in the table above (including an ACTUAL "N/A: Not Applicable" column where judges could place items which they felt fit none of the categories).

Examination of the diagonal of the matrix shows that with a theoretical maximum of 120 target placements (four constructs at 30 placements per construct), a total of 102 "hits" were achieved, for an overall "hit ratio" of 85%. More important, an examination of each row shows how the items created to tap the particular constructs are actually being classified. For example, row C shows that all 30-item placements were within the target construct, but that in row B, only 60% (18/30) were within the target. In the latter case, 8 of the placements were made in construct A, which might indicate the items underlying these placements are not differentiated enough from the items created for construct A. This finding would lead one to have confidence in scale based on row C, but be hesitant about accepting any scale based on row B. In an examination of off-diagonal entries indicate how complex any construct might be. Actual constructs based on columns with a high number of entries in the off diagonal might be considered too ambiguous, so any consistent pattern of item misclassification should be examined.

Q-Sort Results for the First Sorting Round

	C11	C12	C13	C21	C22	C23	C31	C32	C33	C41	C42	NA	T	Xi+X+i
C11	7	5											12	96
C12	1	5	1										7	77
C13		1	6										7	49
C21				7	4								11	88
C22					4	1						1	6	66
C23				1	3	8							12	108
C31							9	7					16	192
C32							2	1					3	33
C33							1	3	6			2	12	72
C41										6			6	42
C42										1	5		6	30
NA												0	0	0
T	8	11	7	8	11	9	12	11	6	7	5	3	98	853

Table 4.1: Inputs for Cohen's Kappa coefficient

Table 4.2: Inter-judge Raw Agreement Scores: First Sorting Round

		Judge 1											
		C11	C12	C13	C21	C22	C23	C31	C32	C33	C41	C42	NA
Judge 2	C11	7	5										
	C12	1	5	1									
	C13		1	6									
	C21				7	4							
	C22					4	1						1
	C23				1	3	8						
	C31							9	7				
	C32							2	1				
	C33							1	3	6			2
	C41										6		
	C42										1	5	
	NA												0
Total items placement: 98					Number of Agreement: 64				Agreement Ratio: 0.65				

C11. Strategic IT
C12. Operational IT
C13. Infrastructural IT
C21. Internal Strategic Information Systems Integration
C22. Internal Operational Information Systems Integration
C23. Internal Infrastructural Information Systems Integration
C31. External Strategic Information Systems Integration
C32. External Operational Information Systems Integration
C33. External Infrastructural Information Systems Integration
C41. Relationship with customers
C42. Relationship with suppliers

Table 4.3: Items Placement Ratios: First Sorting Round

		ACTUAL CATEGORIES													
		C11	C12	C13	C21	C22	C23	C31	C32	C33	C41	C42	NA	T	TG%
THEORETICAL	C11	15	5											20	75
	C12	4	10	2										16	63
	C13	1	3	12										16	75
	C21				14	3	1							18	78
	C22				5	11	1						1	18	61
	C23					3	19							22	86
	C31							17	3					20	85
	C32							10	8					18	44
	C33							1	3	18			2	24	75
	C41										12			12	100
	C42										1	11		12	92
Total Items Placement: 196					Hits: 147					Overall Hit Ratio: 75 %					

C11. Strategic IT
C12. Operational IT
C13. Infrastructural IT
C21. Internal Strategic Information Systems Integration
C22. Internal Operational Information Systems Integration
C23. Internal Infrastructural Information Systems Integration
C31. External Strategic Information Systems Integration
C32. External Operational Information Systems Integration
C33. External Infrastructural Information Systems Integration
C41. Relationship with customers
C42. Relationship with suppliers

Table 4.4: Inter-Judge Agreements	
Agreement Measure	Round 1
Raw Agreement	.65
Cohen's Kappa	.49
Placement Ratio Summary	
Strategic IT	.75
Operational IT	.63
Infrastructural IT	.75
Internal Strategic Information Systems Integration	.78
Internal Operational Information Systems Integration	.61
Internal Infrastructural Information Systems Integration	.86
External Strategic Information Systems Integration.	.85
External Operational Information Systems Integration	.44
External Infrastructural Information Systems Integration	.75
Relationship with customers	1.00
Relationship with suppliers	.92
Average	.75

Table 4.5 to 4.8 show the Q-sort results from the first round.

Two misplaces ▪ One misplace ▪ or No misplace ▫

Section 1: Information Technology Utilization

The following situations describe the extent to which the **manufacturing department uses information technology (IT) for strategic, operational, and infrastructural purposes**. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.

technology justification and planning
budget justification and planning
investment justification and planning
capacity planning
manufacturing processes identification (continuous, job shop, batch, project and line).
project planning
project feasibility analysis
competitor analysis
customer analysis
industry analysis
production control
product and service quality control
inventory management
material requirement planning
warehouse management
customer relationship management
supplier relationship management
products distribution management
file sharing
data communication
plant layout management and control.
technology education services (e.g. training)
multi-media operations and development (e.g. CAD, CAM, Robots)
warehouse/space management
facility infrastructure design
product movement planning

Table 4.5: IT Utilization Construct

Section 2: Information Systems Integration - Internal

The following statements describe the extent to which the **manufacturing department collaborates with *other business functions*** by using information technology (IT). Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.

formulate collaborative decision making
justify business plans
analyze the effectiveness of business plans
develop new business opportunities
identify new markets
identify new technologies
study competitors
define competitive position
set strategic goals
establish manufacturing processes
develop product designs
identify product development processes
manage order information
exchange inventory information
select suppliers
manage logistical activities
establish product forecasts
share functional knowledge
use standard data definitions and codes
use standard data presentation format
use centralized databases (e.g. Oracle)
use database synchronization systems (e.g. Palm)
use enterprise-wide IS applications (e.g. Outlook, Lotus Note, SAP)
reduce information redundancy
use IS networks to communicate with each other
use IS networks to share information with each other
use IS networks to connect to centralized databases
use IS networks to facilitate periodic interdepartmental meetings
use compatible network architectures

Table 4.6: Internal Information Systems Integration Construct

Section 3: Information Systems Integration - External The following statements describe the extent to which the **manufacturing department collaborates with *its suppliers and customers* by using information technology (IT)**. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.
formulate collaborative decision making
justify business plans
analyze the effectiveness of business plans
generate new products
establish new business opportunities
identify new markets
identify new technologies
study competitors
define competitive position
set strategic goals
establish manufacturing processes
develop product designs
design product development processes
manage order information
exchange inventory information
select raw materials and parts
manage logistical activities
establish product forecasts
share business knowledge
use standard data definitions and codes
use standard data presentation format
use database synchronization systems
use compatible database systems
use compatible IS applications
reduce information redundancy
use IS networks to communicate with each other
use IS networks to share information with each other
use IS networks to connect to each other's databases
use IS networks to negotiate business issues (e.g. price)
use IS networks to facilitate periodic meeting
use compatible network architectures

Table 4.7: External Information Systems Integration Construct

Section 4: Relationship with Customers and Suppliers The following statements describe the extent to which the **manufacturing department interacts with *<u>its customers and suppliers</u>***. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.
The willingness of customers to share their market demands
The participation level of customers in product development processes
The participation level of customers in finished goods distribution processes
The level of customer involvement in preparing business plans
The extent of follow-up with customers for feedbacks
The participation level of customers in manufacturing processes
The participation level of suppliers in manufacturing processes
The participation level of suppliers in production planning processes
The participation level of suppliers in product development processes
The participation level of suppliers in logistics processes
The level of cross-over of activities between our firm and our suppliers
The level of supplier involvement in preparing our business plans

Table 4.8: Relationship with Customers and Suppliers

Q-Sort Results for the Second Sorting Round

Table 4.9: Inter-judge Raw Agreement Scores: Second Sorting Round

		Judge 1													
		C11	C12	C13	C21	C22	C23	C24	C31	C32	C33	C34	C41	C42	NA
Judge 2	C11	7		1											
	C12		11	2											
	C13	1		4											
	C21				8	1									
	C22				1	4	2	1							
	C23					1	4	2							
	C24						2	3							
	C31								5		1				
	C32								3	8	1				
	C33									1	5	3			
	C34								1		1	2			
	C41												6		
	C42													6	
	NA														0
Total items placement: 98					Number of Agreement: 73					Agreement Ratio: 0.75					

Table 4.10: Items Placement Ratios: Second Sorting Round

		ACTUAL CATEGORIES															
		C11	C12	C13	C21	C22	C23	C24	C31	C32	C33	C34	C41	C42	NA	T	TG%
THEORETICAL	C11	24	4	2												30	80
	C12		23	1												24	95
	C13	2	8	14												24	58
	C21				25	1	1									27	93
	C22				1	21	4	1								27	78
	C23					1	12	5								18	67
	C24						5	10								15	67
	C31								23	3	3	1				30	77
	C32									21	6					27	78
	C33									1	14	2			1	18	78
	C34									2	4	12				18	67
	C41												18			18	100
	C42												1	17		18	94
Total Items Placement: 294					Hits: 234					Overall Hit Ratio: 80 %							

C11. Strategic IT
C12. Operational IT
C13. Infrastructural IT
C21. Internal Strategic Information Systems Integration
C22. Internal Operational Information Systems Integration
C23. Internal Infrastructural Information Systems Integration - Data Integration
C24. Internal Infrastructural Information Systems Integration - Network Connectivity
C31. External Strategic Information Systems Integration
C32. External Operational Information Systems Integration
C33. External Infrastructural Information Systems Integration - Data Integration
C34. External Infrastructural Information Systems Integration - Network Connectivity
C41. Relationship with customers
C42. Relationship with suppliers

Table 4.11: Inter-Judge Agreements

Agreement Measure	Round 1	Round 2
Raw Agreement	.65	.75
Cohen's Kappa	.49	.72
Placement Ratio Summary		
Strategic IT	.75	.80
Operational IT	.63	.95
Infrastructural IT	.75	.58
Internal Strategic Information Systems Integration	.78	.93
Internal Operational Information Systems Integration	.61	.78
Internal Infrastructural Information Systems Integration – Data Integration	.86	.67
Internal Infrastructural Information Systems Integration – Network Connectivity		.67
External Strategic Information Systems Integration.	.85	.77
External Operational Information Systems Integration	.44	.78
External Infrastructural Information Systems Integration – Data Integration	.75	.78
External Infrastructural Information Systems Integration – Network Connectivity		.67
Integration with customers	1.00	1.00
Integration with suppliers	.92	.94
Average	75	.80

Table 4.12 to 4.15 show the Q-sort results from the second round.

Three misplaces | Two misplaces | One misplace | No misplace

Section 1: Information Technology Utilization The following situations describe the extent to which the **manufacturing department uses information technology (IT) for strategic, operational, and infrastructural purposes**. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.
Long-term technology justification and planning
Budget justification and planning
Investment justification and planning
Long-term capacity planning
Long-term manufacturing processes identification (continuous, job shop, batch, and line)
Long-term project planning
Project feasibility analysis
Competitor analysis
Customer analysis
Industry analysis
Daily production control
Daily product and service quality control
Daily inventory management
Daily material requirement planning
Daily warehouse management
Daily customer relationship management
Daily supplier relationship management
Daily products distribution management
Daily product movement planning
Daily warehouse/space management
File sharing
Data communication
Plant layout management and control
Technology education services (e.g. training)
Multi-media operations and development (e.g. CAD, CAM, Robots)
Facility infrastructure design

Table 4.12: IT Utilization Construct

Section 2: Information Systems Integration - Internal The following statements describe the extent to which the **manufacturing department collaborates with *other business functions*** by using information technology (IT). Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.
Formulate long-term collaborative decision making
Justify long-term business plans
Analyze the effectiveness of long-term business plans
Develop new business opportunities
Identify new markets
Identify long-term technology justification and planning
Study competitors
Define long-term competitive positioning
Set long-term strategic goals
Adjust daily manufacturing processes
Identify product development processes
Develop daily product designs
Manage daily order information
Exchange daily inventory information
Select suppliers
Manage daily logistical activities
Establish daily product forecasts
Share daily functional knowledge
Use standard data definitions and codes
Use standard data presentation format
Use centralized databases (e.g. Oracle)
Use database synchronization systems (e.g. Palm)
Use enterprise-wide IS applications (e.g. Outlook, Lotus Note, SAP)
Reduce data (information) redundancy
Use IS networks to communicate with each other
Use IS networks to share information with each other
Use IS networks to connect to centralized databases
Use IS networks to facilitate periodic interdepartmental meetings
Use compatible network architectures

Table 4.13: Internal Information Systems Integration

Section 3: Information Systems Integration - External The following statements describe the extent to which the **manufacturing department collaborates with *its suppliers and customers* by using information technology (IT)**. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.
Formulate long-term collaborative decision making
Justify long-term business plans
Analyze the effectiveness of long-term business plans
Generate new products
Establish new business opportunities
Identify new markets
Identify long-term technology justification and planning
Study competitors
Define long-term competitive positioning
Set strategic goals
Adjust daily manufacturing processes
Develop daily product designs
Identity product development processes
Manage daily order information
Exchange daily inventory information
Select raw materials and parts
Manage daily logistical activities
Establish daily product forecasts
Share daily business knowledge
Use standard data definitions and codes
Use standard data presentation format
Use database synchronization systems
Use compatible database systems
Use compatible IS applications
Reduce data (information) redundancy
Use IS networks to communicate with each other
Use IS networks to share information with each other
Use IS networks to connect to each other’s databases
Use IS networks to negotiate business issues (e.g. price)
Use IS networks to facilitate periodic meeting
Use compatible network architectures

Table 4.14: External Information Systems Integration

Section 4: Relationship with Customers and Suppliers The following statements describe the extent to which the **manufacturing department interacts with *its customers and suppliers***. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.
The willingness of customers to share their market demand
The participation level of customers in product development processes
The participation level of customers in finished goods distribution processes
The level of customer involvement in preparing business plans
The extent of follow-up with customers for feedbacks
The participation level of customers in manufacturing processes
The participation level of suppliers in manufacturing processes
The participation level of suppliers in production planning processes
The participation level of suppliers in product development processes
The participation level of suppliers in logistics processes
The level of cross-over of activities between our firm and our suppliers
The level of supplier involvement in preparing our business plans

Table 4.15: Relationship with Customers and Suppliers

Q-Sort Results for the Third Sorting Round

Table 4.16: Inter-judge Raw Agreement Scores: Third Sorting Round

		Judge 1													
		C11	C12	C13	C21	C22	C23	C24	C31	C32	C33	C34	C41	C42	NA
Judge 2	C11	7													
	C12		11												
	C13	2		6											
	C21				9										
	C22					8									
	C23						5	3							
	C24							4							
	C31								9						
	C32									7		1			
	C33										6	1			
	C34										2	3			
	C41												6		
	C42													6	
	NA														0
Total items placement: 96					Number of Agreement: 87					Agreement Ratio: 0.91					

Table 4.17: Items Placement Ratios: Third Sorting Round

THEORETICAL	ACTUAL CATEGORIES															
		C11	C12	C13	C21	C22	C23	C24	C31	C32	C33	C34	C41	C42	NA	T	TG%
	C11	14	2													16	88
	C12		20													20	100
	C13	2		14												16	88
	C21				18											18	100
	C22					16										16	100
	C23						10	2								12	83
	C24						3	9								12	75
	C31								18							18	100
	C32									16						16	100
	C33										11	1				12	92
	C34									1	2	9				12	75
	C41												12			12	100
	C42													12		12	100
Total Items Placement: 192					Hits: 179					Overall Hit Ratio: 93 %							

C11. Strategic IT
C12. Operational IT
C13. Infrastructural IT
C21. Internal Strategic Information Systems Integration
C22. Internal Operational Information Systems Integration
C23. Internal Infrastructural Information Systems Integration - Data Integration
C24. Internal Infrastructural Information Systems Integration - Network Connectivity
C31. External Strategic Information Systems Integration
C32. External Operational Information Systems Integration
C33. External Infrastructural Information Systems Integration - Data Integration
C34. External Infrastructural Information Systems Integration - Network Connectivity
C41. Relationship with customers
C42. Relationship with suppliers

Table 4.18: Inter-Judge Agreements

Agreement Measure	Round 1	Round 2	Round 3
Raw Agreement	.65	.75	.91
Cohen's Kappa	.49	.72	.90
Placement Ratio Summary			
Strategic IT	.75	.80	.88
Operational IT	.63	.95	1.00
Infrastructural IT	.75	.58	.88
Internal Strategic Information Systems Integration	.78	.93	1.00
Internal Operational Information Systems Integration	.61	.78	1.00
Internal Infrastructural Information Systems Integration – Data Integration	.86	.67	.83
Internal Infrastructural Information Systems Integration – Network Connectivity		.67	.75
External Strategic Information Systems Integration.	.85	.77	1.00
External Operational Information Systems Integration	.44	.78	1.00
External Infrastructural Information Systems Integration – Data Integration	.75	.78	.92
External Infrastructural Information Systems Integration – Network Connectivity		.67	.75
Integration with customers	1.00	1.00	1.00
Integration with suppliers	.92	.94	1.00
Average	75	.80	.93

The Cohen's Kappa coefficient can also be calculated using this web-site http://www.kokemus.kokugo.juen.ac.jp/service/kappa-e.html. The web-site shows the same results as calculated manually. Figure 4.3 shows the web-site inputs and Figure 4.4 shows the results.

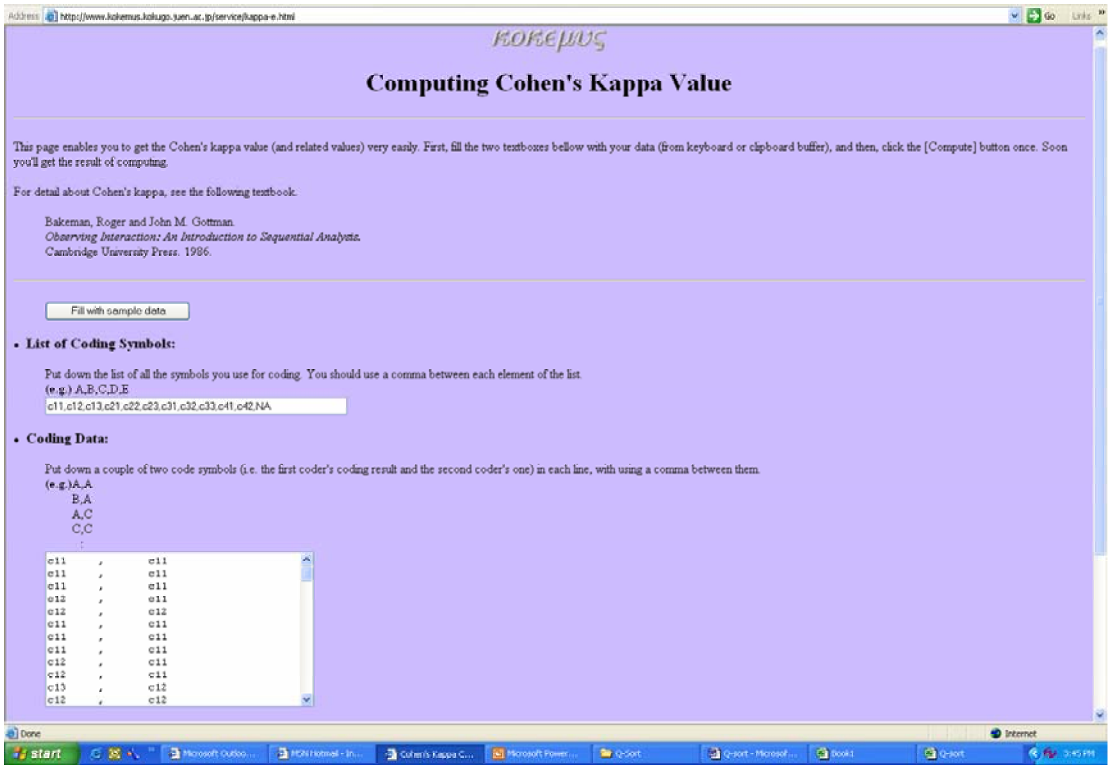


Figure 4.3: Web-site to Calculate Cohen's Kappa Coefficient

Figure 4.4: The Result of Computing Cohen's Kappa

2004/06/17 04:43 JST

Matrix: 12 x 12
Data : 98

	c11	c12	c13	c21	c22	c23	c31	c32	c33	c41	c42	NA	SUM
c11	7	1	0	0	0	0	0	0	0	0	0	0	8
c12	5	5	1	0	0	0	0	0	0	0	0	0	11
c13	0	1	6	0	0	0	0	0	0	0	0	0	7
c21	0	0	0	7	0	1	0	0	0	0	0	0	8
c22	0	0	0	4	4	3	0	0	0	0	0	0	11
c23	0	0	0	0	1	8	0	0	0	0	0	0	9
c31	0	0	0	0	0	0	9	2	1	0	0	0	12
c32	0	0	0	0	0	0	7	1	3	0	0	0	11
c33	0	0	0	0	0	0	0	0	6	0	0	0	6
c41	0	0	0	0	0	0	0	0	0	6	1	0	7
c42	0	0	0	0	0	0	0	0	0	0	5	0	5
NA	0	0	0	0	1	0	0	0	2	0	0	0	3
SUM	12	7	7	11	6	12	16	3	12	6	6	0	98

Kappa : 0.619243515026854

Po : 0.653061224489796
Pc : 0.088817159516868
Se : 0.052769721182628
Sk : 0.0310759818011669
Z : 19.9267562643379

Kappa: The value of kappa (Cohen's kappa).
Po : The proportion of agreement observed. (composite)
Pc : The proportion of agreement expected due to chance. (composite)
Se : The standard error of data.
Sk : The standard error for kappa.
Z : The associated score (kappa divided by its standard error).

APPENDIX C: THE FINAL VERSION OF QUESTIONNAIRE

Section 1: Information Technology Utilization The following situations describe the extent to which the **manufacturing department uses information technology (IT) for strategic, operational, and infrastructural purposes**. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
In our manufacturing department, we use IT for…						
Long-term technology justification and planning	1	2	3	4	5	NA
Budget justification and planning	1	2	3	4	5	NA
Investment justification and planning	1	2	3	4	5	NA
Long-term capacity planning	1	2	3	4	5	NA
Long-term project planning	1	2	3	4	5	NA
Project feasibility analysis	1	2	3	4	5	NA
Competitor analysis	1	2	3	4	5	NA
Industry analysis	1	2	3	4	5	NA
Daily production control	1	2	3	4	5	NA
Daily product quality control	1	2	3	4	5	NA
Daily products distribution management	1	2	3	4	5	NA
Daily product movement planning	1	2	3	4	5	NA
Daily customer analysis	1	2	3	4	5	NA
Daily customer relationship management	1	2	3	4	5	NA
Daily supplier relationship management	1	2	3	4	5	NA
Daily inventory management	1	2	3	4	5	NA
Daily material requirement planning	1	2	3	4	5	NA
Daily warehouse/space management	1	2	3	4	5	NA
Technology services and training	1	2	3	4	5	NA
Setting up file sharing facilities (e.g., network cable, telephone line, wireless network)	1	2	3	4	5	NA
Setting up data communication facilities (e.g., server, LAN, routers, disk/drive, network computers)	1	2	3	4	5	NA
Plant layout management and control (e.g., locations of machines/tools, line configuration, safety staircase)	1	2	3	4	5	NA
Floor plan management (e.g., material flow in/out plans, space management)	1	2	3	4	5	NA
Setting up advanced manufacturing technology (e.g., CAD/CAM, Robots, EDI)	1	2	3	4	5	NA
Setting up security services (e.g., control room, video camera, automatic door, intercom)	1	2	3	4	5	NA
Setting up information disaster recovery system (e.g., disk redundancy, backup facility)	1	2	3	4	5	NA

Section 2: Information Systems Integration - Internal The following statements describe the extent to which the **manufacturing department collaborates with *other business functions*** by using information technology (IT). Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
The use of Information Systems (IS) facilitates **manufacturing department and *<u>other business functions</u>* to work together to…**						
Formulate long-term collaborative decision making	1	2	3	4	5	NA
Justify long-term business plans	1	2	3	4	5	NA
Analyze long-term business plans	1	2	3	4	5	NA
Develop new business opportunities	1	2	3	4	5	NA
Identify new markets	1	2	3	4	5	NA
Identify long-term technology justification and planning	1	2	3	4	5	NA
Study strategies of competitor	1	2	3	4	5	NA
Define long-term competitive positioning	1	2	3	4	5	NA
Set long-term strategic goals	1	2	3	4	5	NA
Adjust daily manufacturing processes (e.g., change production schedule)	1	2	3	4	5	NA
Adjust daily product development processes (e.g., the adjustment of product designs)	1	2	3	4	5	NA
Control daily product quality	1	2	3	4	5	NA
Manage daily order quantity	1	2	3	4	5	NA
Exchange daily inventory information (e.g., daily line production)	1	2	3	4	5	NA
Select suppliers	1	2	3	4	5	NA
Manage daily logistical activities (e.g., shipment of product to warehouse)	1	2	3	4	5	NA
Establish daily product forecasts	1	2	3	4	5	NA
Use standard data definitions and codes (e.g., same terminology, abbreviation, term)	1	2	3	4	5	NA
Use standard information/data format (e.g., using Excel to report sales information)	1	2	3	4	5	NA
Use standard data presentation format	1	2	3	4	5	NA
Use central databases (e.g. Oracle, Excel, SQL Database, Fox Pro, Access)	1	2	3	4	5	NA
Use database synchronization systems (e.g. Palm)	1	2	3	4	5	NA
Integrate data and information	1	2	3	4	5	NA
Use IS networks to communicate with other departments	1	2	3	4	5	NA
Use IS networks to connect to each other's databases	1	2	3	4	5	NA
Use IS networks applications (e.g. Outlook, Lotus Note, SAP)	1	2	3	4	5	NA
Use IS networks to share information with other departments	1	2	3	4	5	NA
Use IS networks to connect to centralized databases	1	2	3	4	5	NA
Use IS networks to facilitate periodic interdepartmental meetings	1	2	3	4	5	NA
Use compatible network architectures	1	2	3	4	5	NA

Section 3: Information Systems Integration - External The following statements describe the extent to which the **manufacturing department collaborates with *its suppliers and customers* by using information technology (IT)**. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
The use of Information Systems (IS) facilitates **manufacturing department and *<u>its suppliers and customers</u>* to work together to…**						
Formulate long-term collaborative decision making	1	2	3	4	5	NA
Justify long-term business plans	1	2	3	4	5	NA
Analyze long-term business plans	1	2	3	4	5	NA
Develop new business opportunities	1	2	3	4	5	NA
Identify new markets	1	2	3	4	5	NA
Identify long-term technology justification and planning	1	2	3	4	5	NA
Study strategies of competitors	1	2	3	4	5	NA
Define long-term competitive positioning	1	2	3	4	5	NA
Set long-term strategic goals	1	2	3	4	5	NA
Adjust daily manufacturing processes (e.g., changing production schedule)	1	2	3	4	5	NA
Adjust daily product development processes (e.g., the adjustment of product designs)	1	2	3	4	5	NA
Control daily product quality	1	2	3	4	5	NA
Manage daily order quantity	1	2	3	4	5	NA
Exchange daily inventory information (e.g., daily line production)	1	2	3	4	5	NA
Select raw materials and parts	1	2	3	4	5	NA
Manage daily logistical activities (e.g., shipment of product)	1	2	3	4	5	NA
Establish daily product forecasts	1	2	3	4	5	NA
Use standard data definitions and codes (e.g., same terminology, abbreviation, term)	1	2	3	4	5	NA
Use standard information/data format (e.g., using Excel to report sales information)	1	2	3	4	5	NA
Use standard data presentation format	1	2	3	4	5	NA
Use central databases (e.g., Oracle, Excel, SQL Database, Access, Fox Pro)	1	2	3	4	5	NA
Use database synchronization systems (e.g., Palm)	1	2	3	4	5	NA
Use compatible database systems	1	2	3	4	5	NA
Use IS networks to communicate with each other	1	2	3	4	5	NA
Use IS networks to connect to each other's databases	1	2	3	4	5	NA
Use IS networks applications (e.g., Outlook, Lotus Note, SAP)	1	2	3	4	5	NA
Use IS networks to share information with each other	1	2	3	4	5	NA
Use IS networks to facilitate periodic meeting	1	2	3	4	5	NA
Use compatible network architectures	1	2	3	4	5	NA

APPENDIX D

COVER LETTER

October 10, 2005

XXX
YYYYY
ZZZZZZZ
1239 Portsmouth Drive
Howell, MI 48843

Dear XXX:

My name is Thawatchai Jitpaiboon. I am an Assistant Professor from the Miller College of Business, Department of Information Systems and Operations Management at Ball State University. This survey research is a partial fulfillment of requirements for the Doctor of Philosophy degree in Manufacturing Management from the University of Toledo. The purpose of the study is to examine the important roles of Information Technology (IT) in enhancing Supply Chain Integration for the manufacturing industry. This study provides guidelines to better implement and utilize technology, improve operational decision making processes, and enhance firm performance. The results from this study will be published in respected journals dedicated to manufacturing management, supply chain management, and operations management, which can be educational and useful for the manufacturing community.

I appreciate your valuable time to finish this questionnaire and return it using the enclosed pre-paid envelope by November 25, 2004. If you would like to complete this questionnaire online (more secure and speedy), you can do so by logging on to our secured web-site at http://tjitpaiboon.iweb.bsu.edu/.

Your username is "XXX" and your password is "bsu12017".

In addition, as a token of our appreciation for your help, **you can request the summary average of your firm's results compared to the industry, which will be sent to you free of charge**. Your confidentiality and anonymity are assured.

Again, please help us improve our manufacturing industry by expressing yourself in this questionnaire. Thank you for your cooperation. A business-reply envelope is enclosed for your use.

Sincerely,

Thawatchai Jitpaiboon
Assistant Professor
Department of Information Systems and Operations Management, WB224
Ball State University
Phone: 765-285-7048
Fax: 765-285-5308
Email: tjitpaiboon@bsu.edu

APPENDIX E

FACTS AND CHECKLIST

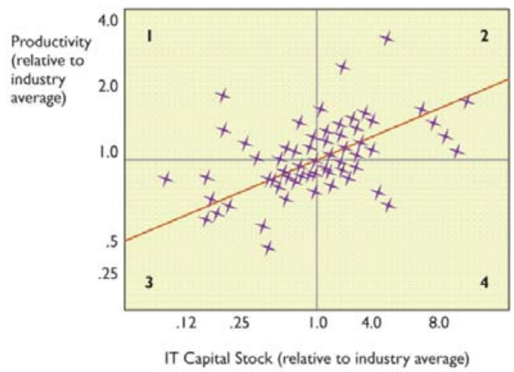
Facts

☑ Although, on average, IT investments produce returns far above expectation, a considerable number of firms still fall below the expected return on investment.

☑ Yes! This survey is partially supported by the Society of Manufacturing Engineers (SME) and the Miller College of Business, Ball State University.

☑ Yes! You can make a difference to our manufacturing society. By completing this survey, we can collaborate to improve IT investments in our manufacturing society.

☑ Yes! You can request a summary of your company's result relative to the industry average for **FREE**.



Source: Based on Erik Brynjolfsson and Lorin M. Hitt, "Beyond Computation: Information Technology, Organizational Transformation and Business Performance," Journal of Economic Perspectives 14, no. 4 (Fall 2000).

Checklist

✓ For accurately identifying the industry average, please read each question carefully and **COMPLETE ALL THE QUESTIONNAIRE ITEMS**. Some questions ask about your perceptions. Others ask about your company.

✓ Use the pre-stamped envelope to return the questionnaire.

✓ There is no reward worth more than the knowledge you gain from this research.

APPENDIX F

Manufacturing & Information Technology Survey

Thawatchai Jitpaiboon

Assistant Professor
Department of Information Systems and Operations Management
Miller College of Business
Ball State University
Muncie, IN 47306
Phone: 765-285-7048
Fax: 765-285-5308
Email: tjitpaiboon@bsu.edu

(Please feel free to contact anytime you need further clarification.)

GENERAL INSTRUCTIONS

This questionnaire is part of a study underway to document the importance of information technology (IT) in enhancing the integration of manufacturing enterprises. This study examines manufacturing managers' perception on how their information systems practices contribute to supply chain integration and performance. Such knowledge gaining from this research can help practitioners and researchers to focus on the most important information systems activities which help an organization to improve its competitive position.

The questionnaire is divided into nine sections. Each question requires that you choose the alternative that best fits your views on that topic. We estimate that it should take you about 20 to 30 minutes to complete this questionnaire. There are no right or wrong answers. We are interested only in your opinions. **The information provided by you will be treated in the strictest confidence. Your responses will be entered in a coded format and in no instance will a person ever be identified as having given a particular response.**

Thank you for your cooperation. We believe that, with your assistance, this study can help clarify a number of information systems issues in manufacturing that have only been addressed so far in theory. **Please seal your completed questionnaire in the enclosed envelope and return it the address provided below.**

Thank you very much for your help.

Thawatchai Jitpaiboon

Assistant Professor
Department of Information Systems and Operations Management
Miller College of Business
Ball State University
Muncie, IN 47306
Phone: 765-285-7048
Fax: 765-285-5308
Email: tjitpaiboon@bsu.edu

Section 1: Information Technology Utilization The following situations describe the extent to which the **manufacturing department uses information technology (IT) for strategic, operational, and infrastructural purposes**. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit. **In our manufacturing department, we use IT for…**	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Long-term technology justification and planning……………………..………………	1	2	3	4	5	NA
Budget justification and planning……………………………………………………	1	2	3	4	5	NA
Investment justification and planning………………………………………………	1	2	3	4	5	NA
Long-term capacity planning………………………………………………………	1	2	3	4	5	NA
Long-term project planning………………………..………………………………..	1	2	3	4	5	NA
Project feasibility analysis..……………………………………………………………..	1	2	3	4	5	NA
Competitor analysis……...	1	2	3	4	5	NA
Industry analysis………………………………………………………………………..	1	2	3	4	5	NA
Daily production control…..	1	2	3	4	5	NA
Daily product quality control……………………………………….……….……	1	2	3	4	5	NA
Daily products distribution management…..…………………………………………..	1	2	3	4	5	NA
Daily product movement planning………………..……………….……….……………	1	2	3	4	5	NA
Daily customer analysis…………..……………………………………………………	1	2	3	4	5	NA
Daily customer relationship management…...	1	2	3	4	5	NA
Daily supplier relationship management……………………………….……………	1	2	3	4	5	NA
Daily inventory management………………………………………………………..	1	2	3	4	5	NA
Daily material requirement planning……………………………….……….………..	1	2	3	4	5	NA
Daily warehouse/space management….……………………………………………….	1	2	3	4	5	NA
Technology services and training…………….………………………………………..	1	2	3	4	5	NA
Setting up file sharing facilities (e.g., network cable, telephone line, wireless network).	1	2	3	4	5	NA
Setting up data communication facilities (e.g., server, LAN, routers, disk/drive, network computers)………………………………………………………….………	1	2	3	4	5	NA
Plant layout management and control (e.g., locations of machines/tools, line configuration, safety staircase)………………………………………………………….	1	2	3	4	5	NA
Floor plan management (e.g., material flow in/out plans, space management)...............	1	2	3	4	5	NA
Setting up advanced manufacturing technology (e.g., CAD/CAM, Robots, EDI).........	1	2	3	4	5	NA
Setting up security services (e.g., control room, video camera, automatic door, intercom)………………………………………………………………………….	1	2	3	4	5	NA
Setting up information disaster recovery system (e.g., disk redundancy, backup facility)…………………………………………………………………………….	1	2	3	4	5	NA

Section 2: Information Systems Integration - Internal The following statements describe the extent to which the **manufacturing department collaborates with *other business functions (i.e., Sales, Marketing)*** by using information technology (IT). Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit. The use of Information Systems (IS) facilitates **manufacturing department and *<u>other internal business functions</u>* to work together to…**	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Formulate long-term collaborative decision making……………………………..…....……	1	2	3	4	5	NA
Justify long-term business plans…...……………...…………….………………………	1	2	3	4	5	NA
Analyze long-term business plans…..…………….………………………………………	1	2	3	4	5	NA
Develop long-term business opportunities.....…….………………………………..………..	1	2	3	4	5	NA
Identify new markets……...………………………………………………………………..	1	2	3	4	5	NA
Identify long-term technology justification and planning………………………………..	1	2	3	4	5	NA
Study strategies of competitors…………………….…………………………………..	1	2	3	4	5	NA
Define long-term competitive positioning...……………………………………………	1	2	3	4	5	NA
Set long-term strategic goals……...………...……………………...……………………	1	2	3	4	5	NA
Adjust daily manufacturing processes (e.g., changing production schedule)...…..………	1	2	3	4	5	NA
Adjust daily product development processes (e.g., adjusting product designs)………..	1	2	3	4	5	NA
Control daily product quality………... ………..…………………………………......	1	2	3	4	5	NA
Manage daily order quantity……………………..……………...………………………	1	2	3	4	5	NA
Exchange daily inventory information (e.g., daily line production)....………..….……….	1	2	3	4	5	NA
Select suppliers………...…...…………………….…………………….………….....……	1	2	3	4	5	NA
Manage daily logistical activities (e.g., shipping products to warehouse)……………....	1	2	3	4	5	NA
Establish daily product forecasts.…………………..……………….…………..………	1	2	3	4	5	NA
Use standard data definitions and codes (e.g., same terminology, abbreviation, jargon)...	1	2	3	4	5	NA
Use standard information/data format (e.g., using Excel to report sales information)……	1	2	3	4	5	NA
Use standard data presentation format………………………………………….………..	1	2	3	4	5	NA
Use centralized databases (e.g. Oracle, Excel, SQL Database, Fox Pro, Access)………	1	2	3	4	5	NA
Use database synchronization systems (e.g. Palm)………………………………...….…	1	2	3	4	5	NA
Integrate data and information……………………………..……………...…………	1	2	3	4	5	NA
Use IS networks to communicate with other departments...………………………..……	1	2	3	4	5	NA
Use IS networks to connect to each other's databases… ………………………....……	1	2	3	4	5	NA
Use IS networks applications (e.g. Outlook, Lotus Note, SAP)……………...…...………	1	2	3	4	5	NA
Use IS networks to share information with other departments…………………….……...…	1	2	3	4	5	NA
Use IS networks to connect to centralized databases………...……………….……….	1	2	3	4	5	NA
Use IS networks to facilitate periodic interdepartmental meetings……….……………....	1	2	3	4	5	NA
Use compatible network architectures……………………...…………………….….	1	2	3	4	5	NA

Section 3: Information Systems Integration - External

The following statements describe the extent to which the **manufacturing department collaborates with its suppliers and customers** by using information technology (IT). Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.

The use of Information Systems (IS) facilitates **manufacturing department and *<u>its suppliers and customers</u>* to work together to…**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Formulate long-term collaborative decision making…………..……………………..…..	1	2	3	4	5	NA
Justify long-term business plans ……………….…...………..………………….………..	1	2	3	4	5	NA
Analyze long-term business plans……………………….....……...….……..…………	1	2	3	4	5	NA
Develop new business opportunities.………………….………………………………	1	2	3	4	5	NA
Identify new markets….………………..…..…………..………………………………	1	2	3	4	5	NA
Identify long-term technology justification and planning.…………………………….	1	2	3	4	5	NA
Study strategies of competitors…...…………………………………………………	1	2	3	4	5	NA
Define long-term competitive positioning……..…………….……………….…………	1	2	3	4	5	NA
Set long-term strategic goals….……..………….…………………………………....…	1	2	3	4	5	NA
Adjust daily manufacturing processes (e.g., changing production schedule)…………	1	2	3	4	5	NA
Adjust daily product development processes (e.g., adjusting product designs)……...	1	2	3	4	5	NA
Control daily product quality…………..……..……………………………..…………	1	2	3	4	5	NA
Manage daily order quantity….…………………….…………………………………	1	2	3	4	5	NA
Exchange daily inventory information (e.g., daily line production)..………………….	1	2	3	4	5	NA
Select raw materials and parts…...…………………………..………………………..	1	2	3	4	5	NA
Manage daily logistical activities (e.g., shipping products)..……….….………………	1	2	3	4	5	NA
Establish daily product forecasts………………….………………………………..	1	2	3	4	5	NA
Use standard data definitions and codes (e.g., same terminology, abbreviation, jargon)…………………………………………………………………………	1	2	3	4	5	NA
Use standard information/data format (e.g., using Excel to report sales information)…………………………………………………………………..	1	2	3	4	5	NA
Use standard data presentation format…………………………...………….....…….	1	2	3	4	5	NA
Use central databases (e.g., Oracle, Excel, SQL Database, Access, Fox Pro)…………	1	2	3	4	5	NA
Use database synchronization systems (e.g., Palm)…………..……………………….	1	2	3	4	5	NA
Use compatible database systems……………………….……………….……………..	1	2	3	4	5	NA
Use IS networks to communicate with each other.. …………………………………	1	2	3	4	5	NA
Use IS networks to connect to each other's databases… ……………………………..	1	2	3	4	5	NA
Use IS networks applications (e.g., Outlook, Lotus Note, SAP)……………………..	1	2	3	4	5	NA
Use IS networks to share information with each other……………..………………....	1	2	3	4	5	NA
Use IS networks to facilitate periodic meeting…….……………………...…………	1	2	3	4	5	NA
Use compatible network architectures………………………………...……...……	1	2	3	4	5	NA

Section 4: Relationship with Customers and Suppliers The following statements describe the extent to which the **manufacturing department interacts with *<u>its customers and suppliers</u>***. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.	Very Low	Low	Moderate	High	Very High	Not Applicable, or Do Not Know
The willingness of customers to share their market demands..……………………..……	1	2	3	4	5	NA
The participation level of customers in product development processes............................	1	2	3	4	5	NA
The participation level of customers in finished goods distribution processes………..…	1	2	3	4	5	NA
The level of customer involvement in preparing business plans…………………………	1	2	3	4	5	NA
The extent of follow-up with customers for feedbacks……….…………………………	1	2	3	4	5	NA
The participation level of customers in manufacturing processes………………………	1	2	3	4	5	NA
The participation level of suppliers in manufacturing processes…………………………	1	2	3	4	5	NA
The participation level of suppliers in production planning processes..…………………	1	2	3	4	5	NA
The participation level of suppliers in product development processes.............................	1	2	3	4	5	NA
The participation level of suppliers in logistics processes……………..………...……	1	2	3	4	5	NA
The level of cross-over of activities between our firm and our suppliers…………………	1	2	3	4	5	NA
The level of supplier involvement in preparing our business plans………………………	1	2	3	4	5	NA

Section 5: Mass Customization Capability The following statements measure firm’s **capability to customize products** inexpensively and quickly. Please circle the appropriate number that best indicates your perception of the relative capabilities of your firm as compared to the industry average.	Very Low	Low	Moderate	High	Very High	Not Applicable, or Do Not Know
Our capability of customizing products at low cost is……………………………………	1	2	3	4	5	NA
Our capability of customizing products on a large scale is………………………………	1	2	3	4	5	NA
Our capability of translating customer requirements into technical designs quickly is…	1	2	3	4	5	NA
Our capability of adding product variety without increasing cost is………………………	1	2	3	4	5	NA
Our capability of customizing products while maintaining a large volume is…………….	1	2	3	4	5	NA
Our capability of setting up for a different product a low cost is……………..………..	1	2	3	4	5	NA
Our capability of responding to customization requirements quickly is……..……………	1	2	3	4	5	NA
Our capability of adding product variety without sacrificing overall production volume is……………………………………………………………………………………..	1	2	3	4	5	NA
Our capability of changeover to a different product quickly is……………………………	1	2	3	4	5	NA

Section 6: Suppliers' and Firm's Operational Performance

The following statements describe typical **operational performance objectives for firms and their suppliers**. Please circle the number that best indicates the level of your suppliers' and your firm's attainment of each objective. Please note that **left side** indicates the level of supplier's operational performance and **right side** indicates the level of firm's operational performance. ***Please fill in both sides of questionnaire items.***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Supplier						Performance Dimensions	**Firm**					
1	2	3	4	5	NA	Deliver materials/components/products as promises	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide materials/components/products that are highly reliable	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide fast delivery	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide on-time delivery	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide reliable delivery	1	2	3	4	5	NA
1	2	3	4	5	NA	Decrease manufacturing lead time	1	2	3	4	5	NA
1	2	3	4	5	NA	Make rapid design changes	1	2	3	4	5	NA
1	2	3	4	5	NA	Make rapid production volume changes	1	2	3	4	5	NA
1	2	3	4	5	NA	Make rapid changeover between product lines	1	2	3	4	5	NA
1	2	3	4	5	NA	Process both large and small orders	1	2	3	4	5	NA
1	2	3	4	5	NA	Produce a variety of different products	1	2	3	4	5	NA
1	2	3	4	5	NA	Increase capacity utilization	1	2	3	4	5	NA
1	2	3	4	5	NA	Produce materials/components/products at low cost	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce production cost	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce inventory cost	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce unit cost	1	2	3	4	5	NA
1	2	3	4	5	NA	Increase labor productivity	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new ways of customer service	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new forms of shop floor management	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new ways of supply chain management	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new products and features	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new process technologies	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide better product performance	1	2	3	4	5	NA
1	2	3	4	5	NA	Improve product durability	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide product conformance to specifications	1	2	3	4	5	NA
1	2	3	4	5	NA	Improve product reliability	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce defective rate	1	2	3	4	5	NA
1	2	3	4	5	NA	Better product reputation	1	2	3	4	5	NA

Section 7: Top Management Support for System Integration With regard to top management support for system integration, please circle the appropriate number that accurately reflects your firm's PRESENT conditions.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Top management is interested in our relationship with our trading partners ……………	1	2	3	4	5	NA
Top management supports our department with the resources we need …………………	1	2	3	4	5	NA
Top management regards our relationship with trading partners a high priority item ……	1	2	3	4	5	NA
Top management participates in integration with our trading partners……………………	1	2	3	4	5	NA
Top management considers the relationship between us and our trading partners to be important…………………………………………………………………………	1	2	3	4	5	NA
Top management encourages open communication with our trading partners……………	1	2	3	4	5	NA
Top management provides enough training on technology used to communicate with our trading partners…………………………………………………………………..	1	2	3	4	5	NA

Section 8: Firm Performance The following statements measure overall performance of your firm. Please circle the appropriate number that best indicates the level of your firm's overall performance.	Very Low	Low	Moderate	High	Very High	Not Applicable, or Do Not Know
Customer retention rate…………………………………………………………………	1	2	3	4	5	NA
Sales growth……………………………………………………………………………	1	2	3	4	5	NA
Market share growth……………………………………………………………………	1	2	3	4	5	NA
Return on investment…………………………………………………………………	1	2	3	4	5	NA
Profit margin……………………………………………………………………………	1	2	3	4	5	NA
Production throughput time……………………………………………………………	1	2	3	4	5	NA
New product development cycle time…………………………………………………	1	2	3	4	5	NA
Overall competitive position……………………………………………………………	1	2	3	4	5	NA

Section 9: Please provide the following information.

Personal information

1. Your job title:

☐ CEO/president ☐ Director

☐ Manager ☐ Other (Please indicate) ____________________

2. Your present job function (Mark all that apply)

☐ Corporate executive ☐ Purchasing ☐ Transportation

☐ Manufacturing production ☐ Distribution ☐ Sales ☐ Other (Please indicate) ________

3. Please indicate your level of education:

☐ High school ☐ Two-year college ☐ Bachelor's degree ☐ Master's degree

☐ Doctor's degree ☐ Other (please specify): ____________________________________

4. How many years have you been working? ___ <= 3; ___ 4-10; ___ 10-15; ___ 15-20; ___ > 20

5. How many years have you been working for your current organization?

___ <= 3; ___ 4-10; ___ 10-15; ___ 15-20; ___ > 20

6. On a scale of 1 to 10, please indicate your level of computer literacy:

Know nothing about computers ... Expert computer user

1----------2-----------3-----------4-----------5-----------6----------7---------8---------9--------10

7. Please indicate the perceived level of complexity of your routine computer-based tasks:

Not at all complex ... Moderately complex ... Extremely complex

1----------2-----------3-----------4-----------5-----------6----------7---------8---------9--------10

8. Please indicate your typical level of confidence in using an unfamiliar computer system:

Not at all confident ... Moderately confident ... Totally confident

1----------2-----------3-----------4-----------5-----------6----------7---------8---------9--------10

Business Information

1. Please indicate the category which best describes your major business (Please check the most appropriate one)

____	Manufacturing	____	Finance/insurance/real estate	____	Public utility
____	Medicine/Law/Education	____	Wholesale/retail trade	____	Transportation
____	Business service	____	Government local/state/federal	____	Petroleum
____	Communication	____	Mining/construction/agriculture	____	others

2. If you know your SIC code please insert it in [ ] the box :

Otherwise indicate the industry subdivision in which you operate, from the list below.
(Please circle ONE number only)

Food and kindred products (SIC 20) 01
Tobacco (SIC 21) 02
Textile mill products (SIC 22).......... 03
Apparel and other textile products (SIC 23).......... 04
Lumber and wood products (SIC 24). 05
Furniture and fixtures (SIC 25). 06
Paper and allied products (SIC 26).......... 07
Printing and publishing (SIC 27).......... 08
Chemical and allied products (SIC 28).......... 09
Petroleum and coal products (SIC 29).......... 10
Rubber and plastic products (SIC 30).......... 11
Leather and leather products (SIC 31).......... 12
Stone, clay and glass products (SIC 32) 13
Primary metal industries (SIC 33).......... 14
Fabricated metal products (SIC 34).......... 15
Industrial machinery and equipment, except electrical (SIC 35) 16
Electric and electronic equipment (SIC 36).......... 17
Transportation equipment (SIC 37).......... 18
Instruments and related products (SIC 38) 19
Miscellaneous manufacturing industries (SIC 39).......... 20
Other 21

3. Has your organization embarked upon an information system program(s) aimed specially at implementing "Supply Chain Integration"

_____ Yes _____ No

If your answer is Yes, how long? _____ years (Please indicate)

4. Your **primary** production system (Choose most appropriate one)

_____ Engineer to Order _____ Make to Order

_____ Assemble to Order _____ Make to Stock

5. Your **primary** manufacturing system (Choose most appropriate on)

_____ Continuous Flow Process _____ Assemble Line _____ Projects (one-of-a kind production)

_____ Batch Processing _____ Job Shop _____ Manufacturing Cells

_____ Flexible Manufacturing

6. Number of employees in your company:

_____	1 - 50	_____	51 - 100	_____	101 – 250
_____	251 – 500	_____	501 - 1000	_____	Over 1000

7. Average annual sales of your company in millions of $:

_____	Under 5	_____	5 to < 10	_____	10 to < 25
_____	25 to < 50	_____	50 to < 100	_____	Over 100

8. Please indicate the position of your company in the supply chain (Mark all that applies).

____	Raw material supplier	____	Component supplier	____	Wholesaler
____	Assembler	____	Sub-assembler	____	Retailer
____	Manufacturer	____	Distributor		

9. Please indicate the category that best describe your primary business:

____	Automotive or parts	____	Fabricated metal products	____	Electronics
____	Electrical equipment	____	Furniture and fixtures	____	Appliances
____	Rubber and plastic products	____	Industrial machinery and equipment	____	Others
____	Transportation equipment	____	Instruments and related products		

10. Please place check marks against one or more of the following technology applications you are primarily (heavily) using in your work.

☐ E-mail ☐ Word processing ☐ Spread sheet ☐ Database ☐ Programming tools
☐ Others (please specify) ____

11. What percentage of your business transactions with your customers is done electronically?

_____	Less than 10%	_____	10-30%	_____	30-50%
_____	50-80%	_____	More than 80%		

12. What percentage of your business transactions with your suppliers is done electronically?

_____	Less than 10%	_____	10-30%	_____	30-50%
_____	50-80%	_____	More than 80%		

13. Please indicate the number of tiers across your supply chain?

_____	<= 3	_____	4-5	_____	6-7
_____	8-10	_____	> 10		

14. What percentage of the computer applications that you are currently working with can be classified under each of the following three categories (Please fill in the percentages against each application so that the percentages add up to 100%):

_______% Main Frame Application ______% PC Application _______% Networked Application

We totally respect your privacy.
Please note that the information you provide below
will be used for academic purposes only.

Please complete the following details or attach your business card:

Your name: ____

Business Name: ____

Title: ____

Address: ____

____

City: __________________________ State: ___________________

Zip Code: _______________Phone: __________________________

Fax: _________________ Email: ____________________________

If you would like to receive the summarized version of your company's results compared to the industry, please specify the mode of receiving the information.

- ☐ Hard copy by regular mailing services
- ☐ Download from the internet (login and password)
- ☐ E-mail with attachment
- ☐ Other (Please indicate) ____________________

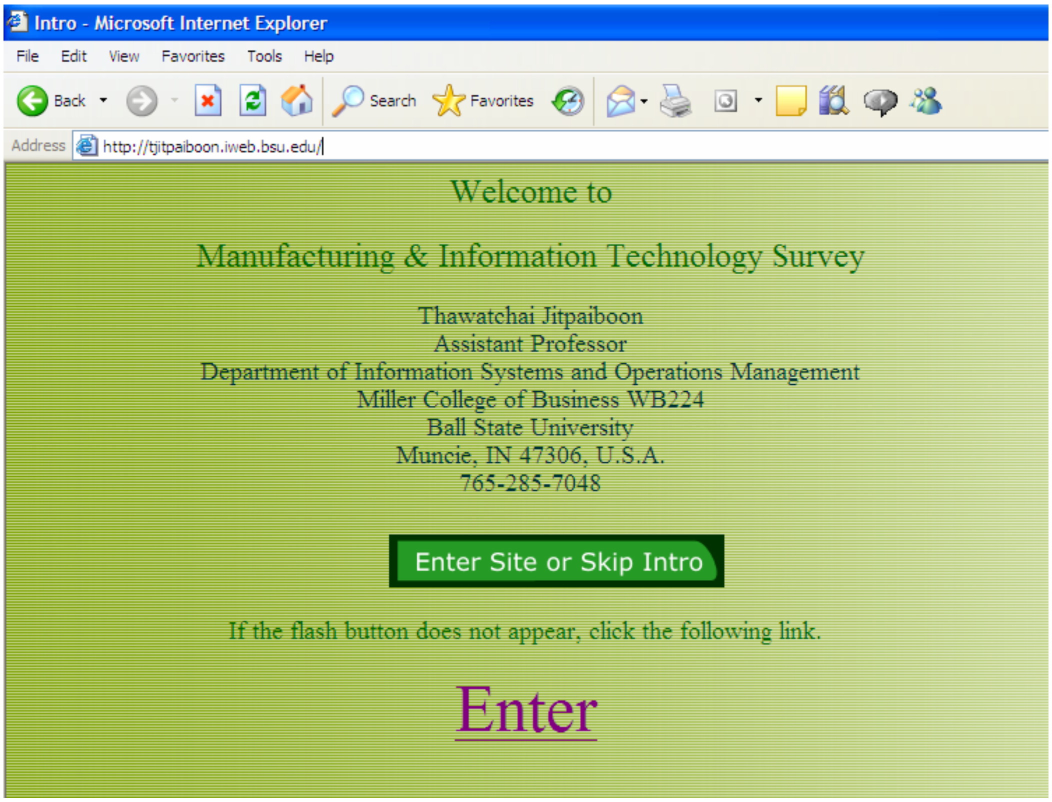
Thank you for your cooperation and response.

The author is currently working at Ball State University, the Miller College of Business, as an assistant professor of information systems and operations management.

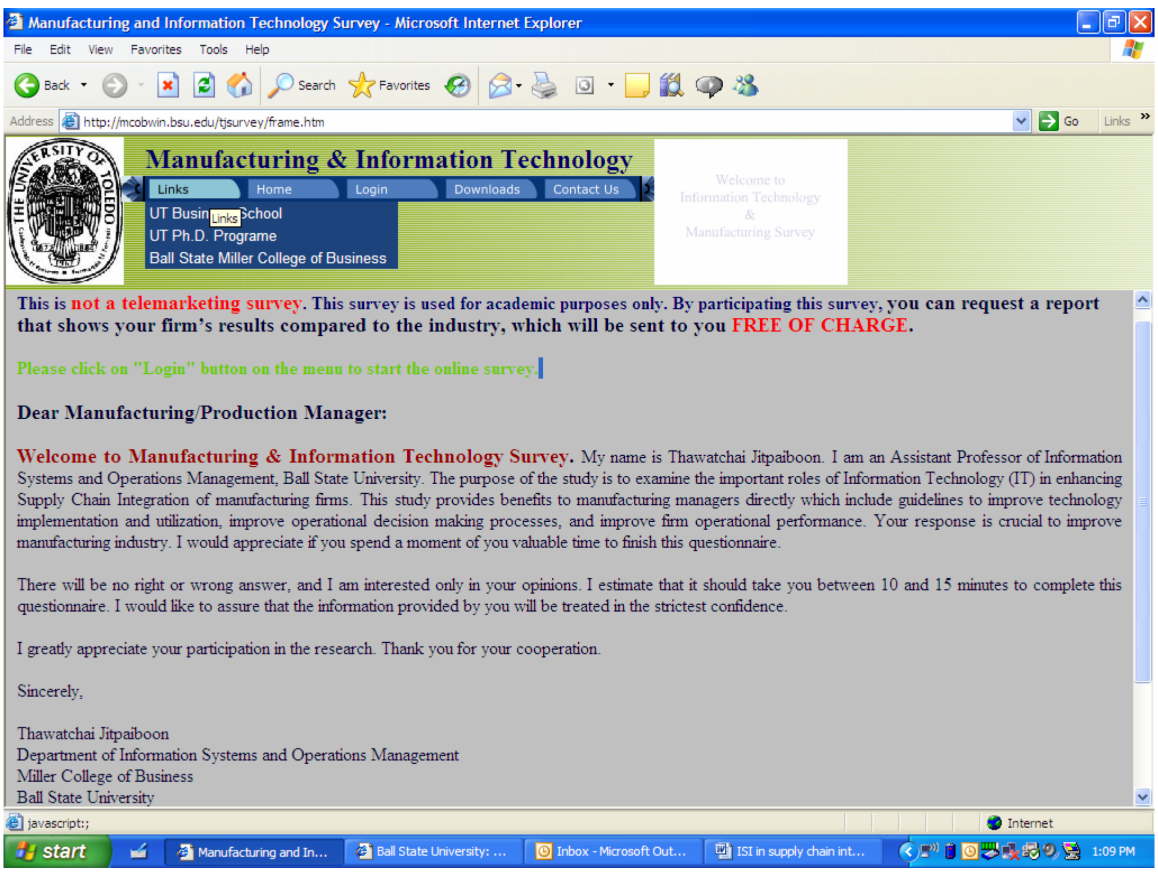
Miller
COLLEGE OF BUSINESS
Ball State University

APPENDIX G

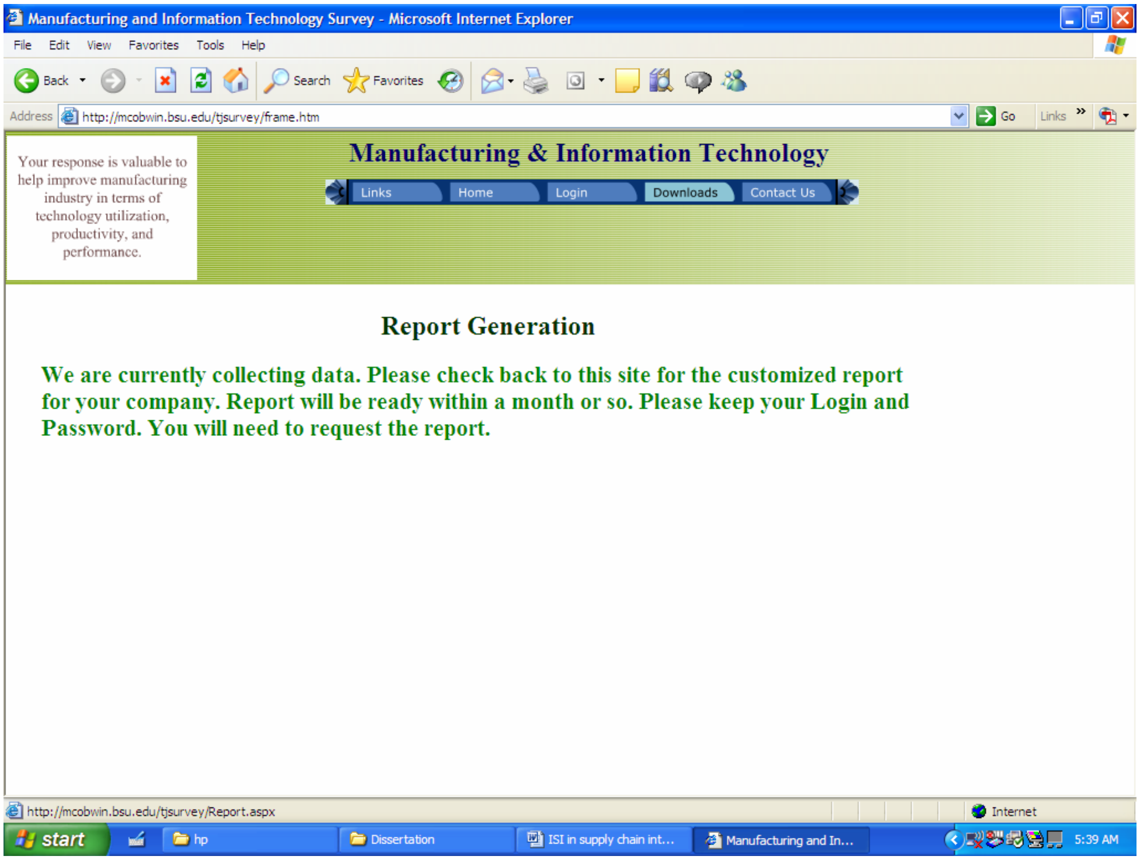
This appendix shows an online version of a survey and its functionality. The web-based survey starts with the welcome page as shown in the following:



Once the “Enter” button is clicked, the main survey page appears. The main page includes a cover letter explaining the purpose of a survey, approximate time to complete the survey, and contact information of a researcher. The top part of the main page is equipped with a pop-up menu. The menu consists of necessary links such as the University of Toledo, Business College home page, Ball State University, College of Business home page, and the University of Toledo, Ph.D. program home page. Menu bar can also direct the respondents to the “Log in” , “Downloads”, and “Contact Us” page.

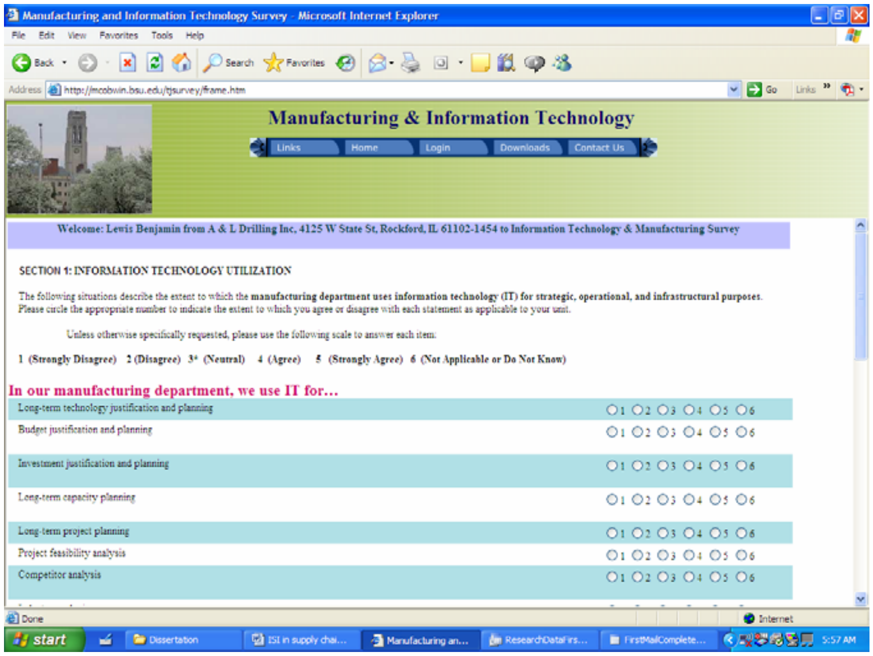


The “Downloads” page is used to provide summary reports for the respondents who request for the summary report. The page will be functional after data are completely analyzed.

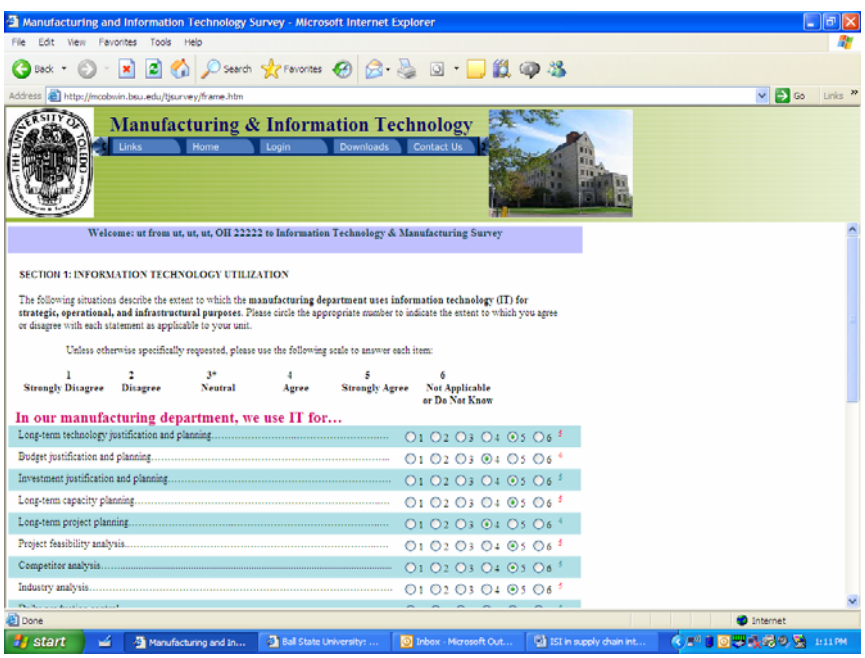


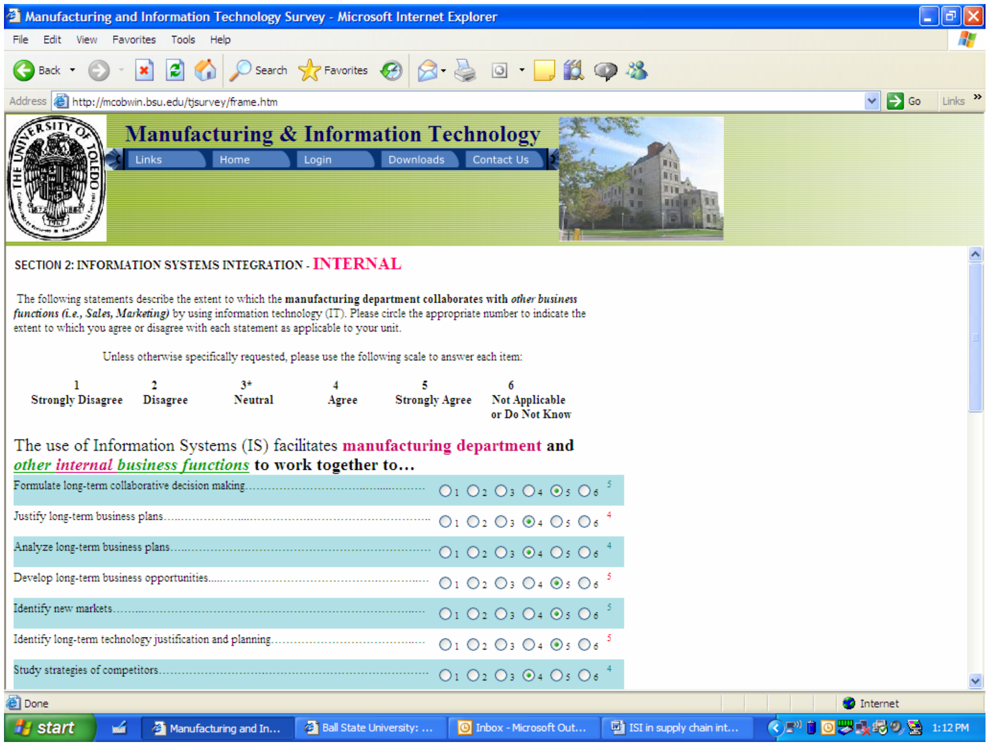
The “Login” page is used to provide a security access to the questionnaire. Only the respondents with the right username and password are able to log on to complete the survey.

After logging to the web site, the web site shows a customized welcome statement at the top part and a blank questionnaire at the bottom part.

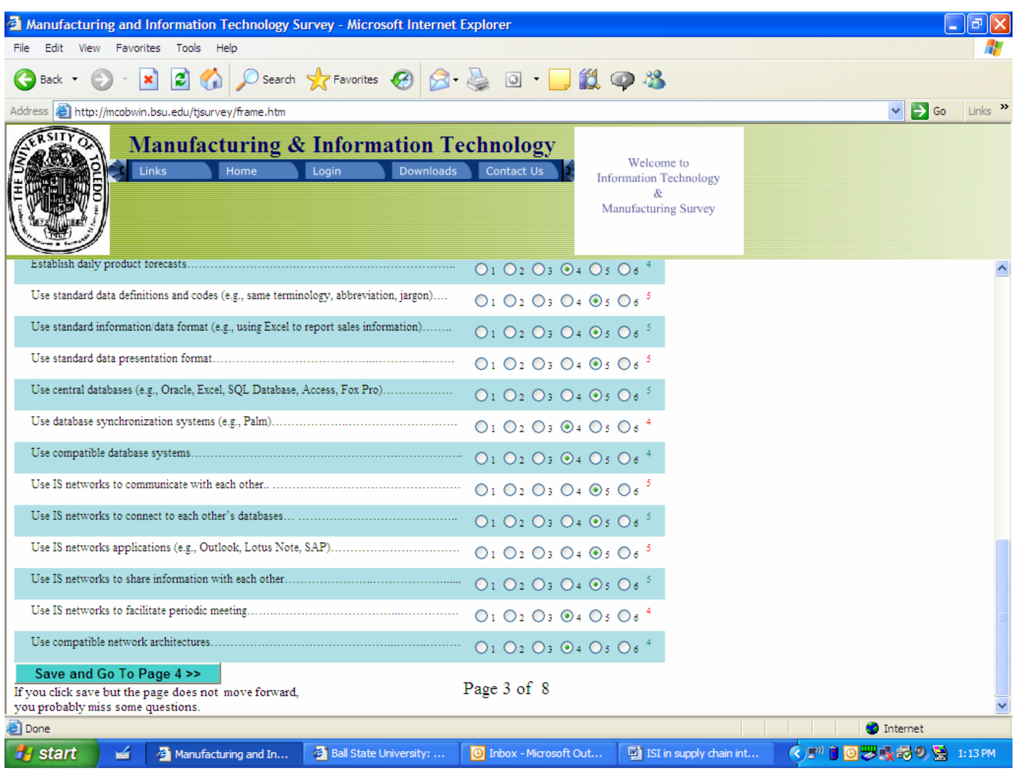


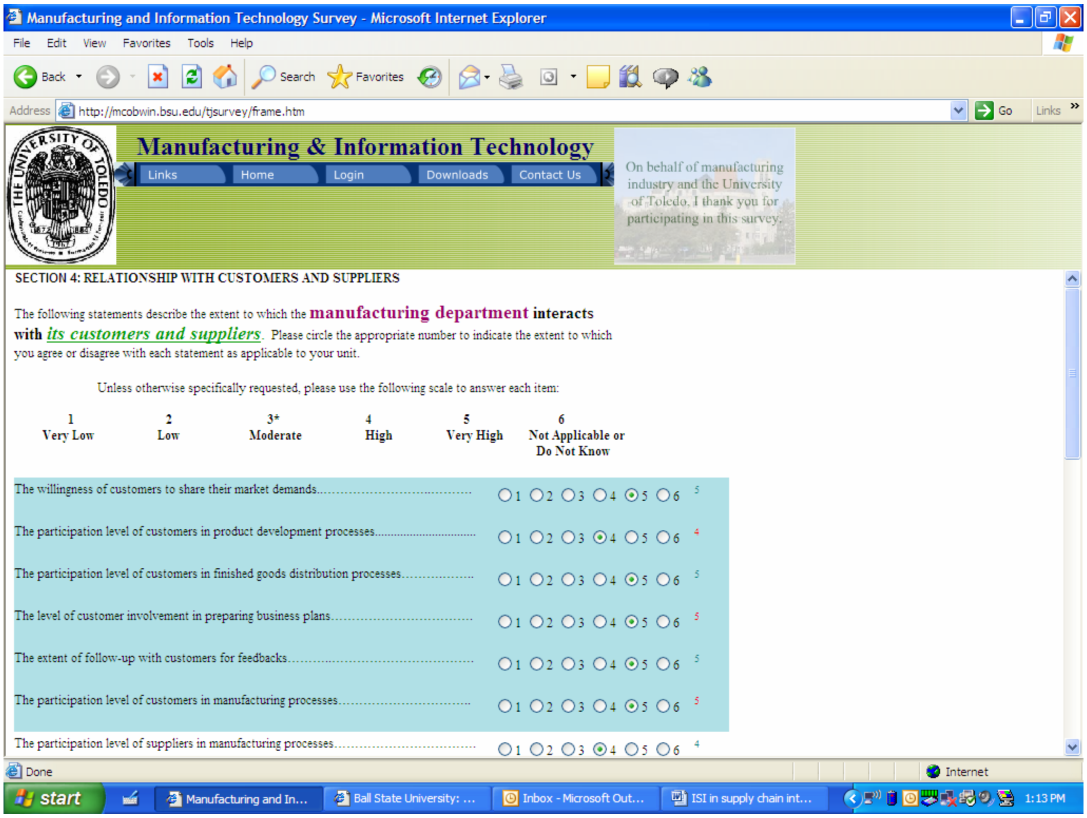
However, if the respondent logs on the second time, the web-page updates necessary information as previously chosen by the respondents. With this option, the respondents do not need to finish at one time.





The respondent can move from page to page by clicking on "Save and Go to Page #" button.




Manufacturing and Information Technology Survey - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://mcobwin.bsu.edu/tjsurvey/frame.htm
Manufacturing & Information Technology
Links Home Login Downloads Contact Us
On behalf of manufacturing industry and the University of Toledo, I thank you for participating in this survey.
SECTION 4: RELATIONSHIP WITH CUSTOMERS AND SUPPLIERS
The following statements describe the extent to which the manufacturing department interacts with its customers and suppliers. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.
Unless otherwise specifically requested, please use the following scale to answer each item:
1 Very Low
2 Low
3* Moderate
4 High
5 Very High
6 Not Applicable or Do Not Know
The willingness of customers to share their market demands.................. 1 2 3 4 5 6 — 5
The participation level of customers in product development processes.................. 1 2 3 4 5 6 — 4
The participation level of customers in finished goods distribution processes.................. 1 2 3 4 5 6 — 5
The level of customer involvement in preparing business plans.................. 1 2 3 4 5 6 — 5
The extent of follow-up with customers for feedbacks.................. 1 2 3 4 5 6 — 5
The participation level of customers in manufacturing processes.................. 1 2 3 4 5 6 — 5
The participation level of suppliers in manufacturing processes.................. 1 2 3 4 5 6 — 4
Done
Internet
start
Manufacturing and In...
Ball State University: ...
Inbox - Microsoft Out...
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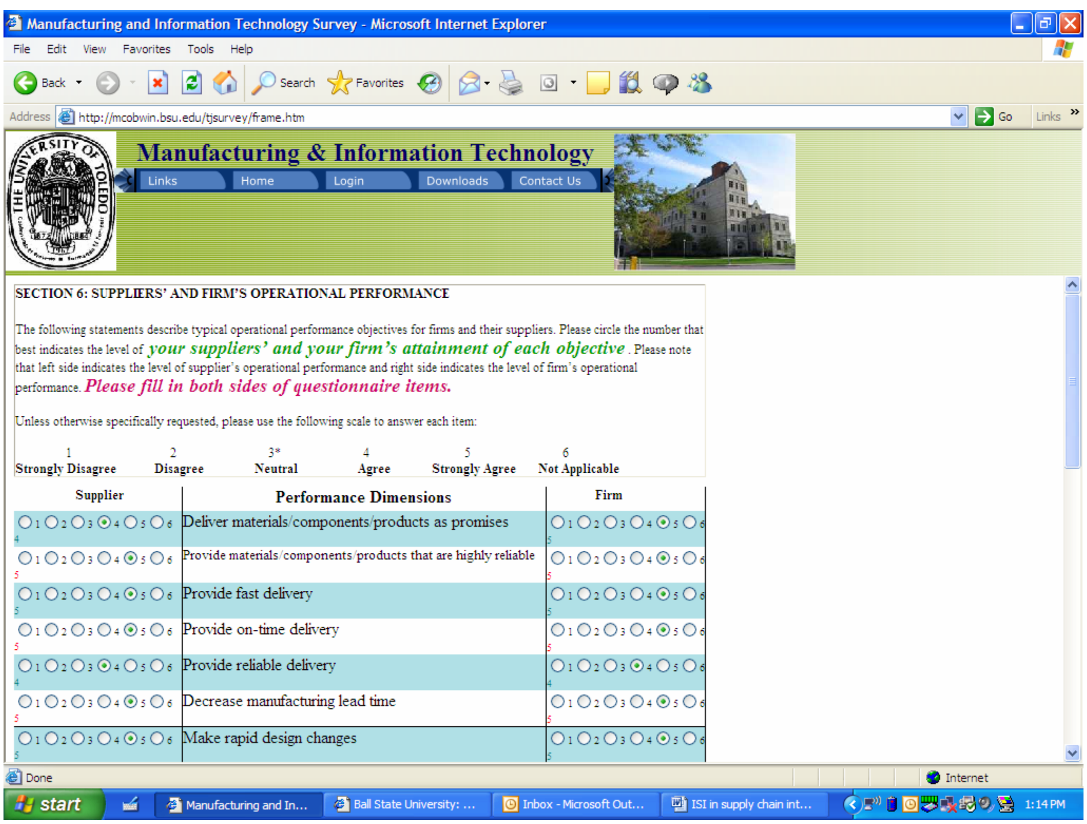
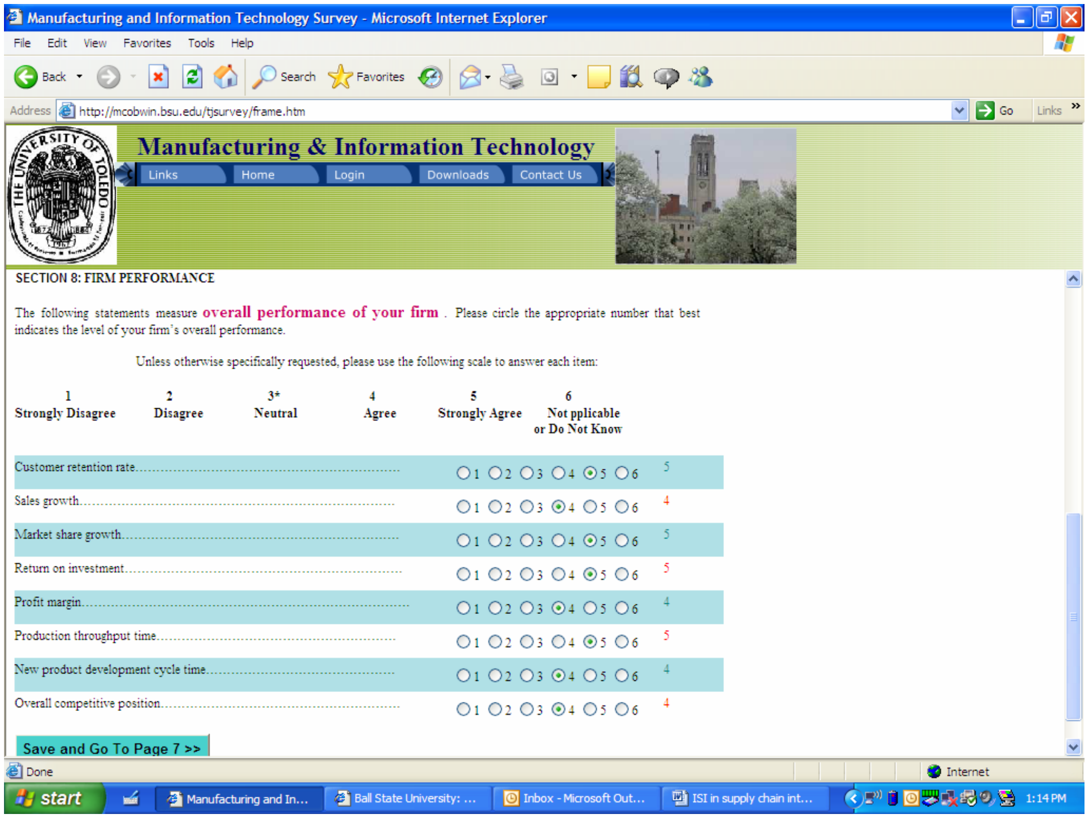
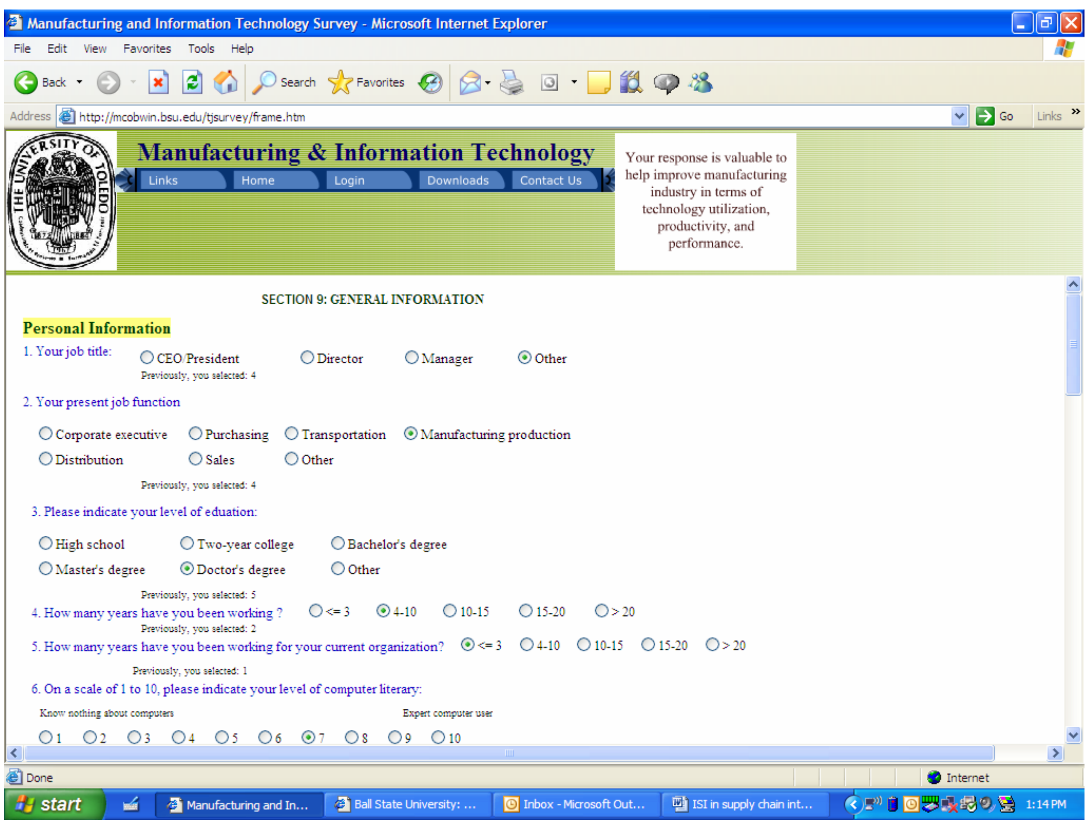
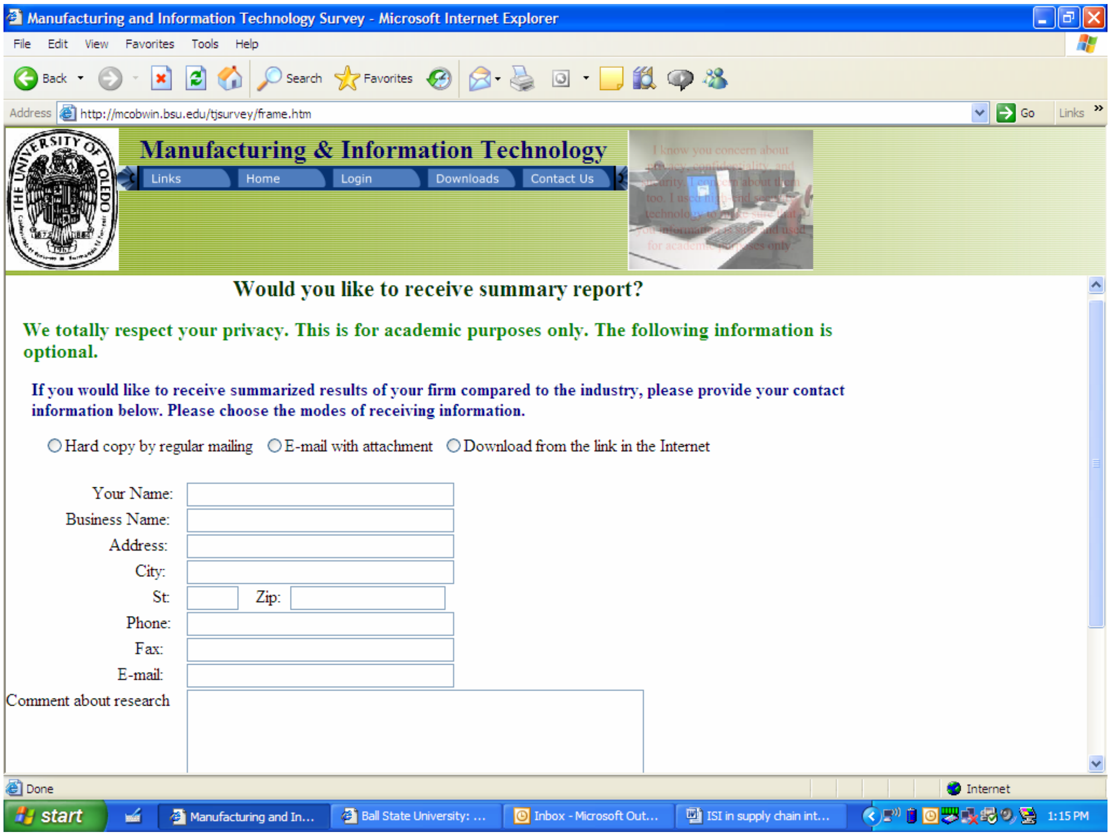

Manufacturing and Information Technology Survey - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://mcobwin.bsu.edu/tjsurvey/frame.htm
Manufacturing & Information Technology
Links Home Login Downloads Contact Us
SECTION 6: SUPPLIERS' AND FIRM'S OPERATIONAL PERFORMANCE
The following statements describe typical operational performance objectives for firms and their suppliers. Please circle the number that best indicates the level of your suppliers' and your firm's attainment of each objective. Please note that left side indicates the level of supplier's operational performance and right side indicates the level of firm's operational performance. Please fill in both sides of questionnaire items.
Unless otherwise specifically requested, please use the following scale to answer each item:
1 Strongly Disagree
2 Disagree
3* Neutral
4 Agree
5 Strongly Agree
6 Not Applicable
Supplier
Performance Dimensions
Firm
4 — Deliver materials/components/products as promises — 5
5 — Provide materials/components/products that are highly reliable — 5
5 — Provide fast delivery — 5
5 — Provide on-time delivery — 5
4 — Provide reliable delivery — 4
5 — Decrease manufacturing lead time — 5
5 — Make rapid design changes — 5
Done
Internet
start
Manufacturing and In...
Ball State University: ...
Inbox - Microsoft Out...
ISI in supply chain int...
1:14 PM


Manufacturing and Information Technology Survey - Microsoft Internet Explorer
http://mcobwin.bsu.edu/tjsurvey/frame.htm
Manufacturing & Information Technology
Links Home Login Downloads Contact Us
SECTION 8: FIRM PERFORMANCE
The following statements measure overall performance of your firm. Please circle the appropriate number that best indicates the level of your firm's overall performance.
Unless otherwise specifically requested, please use the following scale to answer each item:
1 Strongly Disagree
2 Disagree
3* Neutral
4 Agree
5 Strongly Agree
6 Not pplicable or Do Not Know
Customer retention rate 1 2 3 4 5 6 5
Sales growth 1 2 3 4 5 6 4
Market share growth 1 2 3 4 5 6 5
Return on investment 1 2 3 4 5 6 5
Profit margin 1 2 3 4 5 6 4
Production throughput time 1 2 3 4 5 6 5
New product development cycle time 1 2 3 4 5 6 4
Overall competitive position 1 2 3 4 5 6 4
Save and Go To Page 7 >>


Manufacturing and Information Technology Survey - Microsoft Internet Explorer
http://mcobwin.bsu.edu/tjsurvey/frame.htm
Manufacturing & Information Technology
Links Home Login Downloads Contact Us
Your response is valuable to help improve manufacturing industry in terms of technology utilization, productivity, and performance.
SECTION 9: GENERAL INFORMATION
Personal Information
1. Your job title: CEO/President Director Manager Other
Previously, you selected: 4
2. Your present job function
Corporate executive Purchasing Transportation Manufacturing production
Distribution Sales Other
Previously, you selected: 4
3. Please indicate your level of eduation:
High school Two-year college Bachelor's degree
Master's degree Doctor's degree Other
Previously, you selected: 5
4. How many years have you been working ? <= 3 4-10 10-15 15-20 > 20
Previously, you selected: 2
5. How many years have you been working for your current organization? <= 3 4-10 10-15 15-20 > 20
Previously, you selected: 1
6. On a scale of 1 to 10, please indicate your level of computer literary:
Know nothing about computers Expert computer user
1 2 3 4 5 6 7 8 9 10



This page provides the respondents' ability to request the summary report of a survey and shows modes of receiving information.

APPENDIX H

Miller
COLLEGE OF BUSINESS
Ball State University

Department of Information Systems and Operations Management
Miller College of Business
Ball State University
Muncie, IN 47306

XXX XXXXX
YYYY YYY
Howell, MI 48843

APPENDIX I

1-44200

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO . 307 MUNCIE, INDIANA

POSTAGE WILL BE PAID BY ADDRESSEE

Thawatchai Jitpaiboon
Department of Information Systems
and Operations Management
Miller College of Business, WB203
Ball State University
Muncie, IN 47306-9987

APPENDIX J

Miller
COLLEGE OF BUSINESS
Ball State University

October 10, 2005

Please participate in this survey to win $100 cash. You can also request the syndicated report for FREE.

XXXX
Manager
YYYY
ZZZZZZZZ
Comstock Park, MI 49321-8914

Dear XXX:

Approximately five weeks ago, I sent you a questionnaire survey of *Manufacturing and Information Technology*. You are one of the manufacturing managers carefully selected from SME membership to participate in this survey. Your response, therefore, is very valuable to this project.

Being that the holiday season is so busy for us all, you probably have not had time to complete the survey, or planned to complete it after the Thanksgiving. This is just a reminder to make sure that you have received the questionnaire. I hope that you are able to fill it out by **December 25, 2004**. If you have already completed and returned the survey, please disregard this letter.

In case you have not responded, **please** take a few minutes to fill out the previously sent questionnaire. In case you misplaced your original copy, please feel free to request a new one from the address provided below. You can also complete this survey on our secured web-site at **http://tjitpaiboon.iweb.bsu.edu/.**

Your username is "XXX" and your password is "**bsu1946**".

To encourage participation in this survey, I have arranged for **two lottery prizes worth $100 each**. To be included in the drawing, please return the survey before **December 25, 2004**. Won't you please complete your survey as soon as possible, so the odds of winning a prize are in your favor? In addition, **you can request a report that shows your firm's results compared to the industry, which will be sent to you FREE OF CHARGE**.

Thank you very much for your consideration.

Sincerely,

Thawatchai Jitpaiboon

Thawatchai Jitpaiboon
Assistant Professor
Department of Information Systems and Operations Management, WB224
Ball State University
Phone: 765-285-7048
Fax: 765-285-5308
Email: tjitpaiboon@bsu.edu

APPENDIX K

Society of Manufacturing Engineers

One SME Drive
P.O. Box 930
Dearborn, MI
48121-0930 USA
ph: (313) 271-1500
fax: (313) 425-3400

October 11, 2004

Thawatchai Jitpaiboon
Assistant Professor
ISOM Department
Miller College of Business
Ball State University
WB 100
Muncie, IN 47306

Dear Professor Jitpaiboon,

On behalf of SME, I am pleased to confirm our support for the survey entitled "Manufacturing & Information Technology Survey." We have provided you with a select mailing list of individuals for this research and we encourage them to participate in your survey.

The results of your study will be of interest to members of our Technical Community Network. They will be looking to identify opportunities to further enhance manufacturing through services and products of value to the manufacturing community.

SME's Technical Community Network represents key focus areas within the world of manufacturing. Community membership is free to all SME members. Each community provides its members with opportunities to participate in new events, training, technical reference information, publications, and services, along with the ability to guide the development and expansion of these resources. Additional information is available at: www.sme.org/communities.

We look forward to your successful results.

Sincerely,

Mark J. Stratton

Mark J. Stratton
Community Relations Manager
Education and Research Community

www.sme.org

APPENDIX L

CALLING SCRIPTS

Person Contacted:

1. Hi, this is -______________- calling from Ball State University. How are you?

2. I am calling to inquire whether or not you received the *Manufacturing and Information Technology* survey that we sent you in the mail a couple weeks ago, and to see if you had any questions about the survey.

3. We're doing follow up calls because you are one of the 500 manufacturing managers carefully selected from the Society of Manufacturing Engineers or SME membership to participate in this survey. Your response, therefore, is very valuable to this project.

4. We would like to know we can count on you. We would like to assure you that our survey is strictly for educational research purposes and has no marketing ties. All participants in the survey will receive a free syndicated report which shows **your firm's results compared to the industry, which will be sent to you FREE OF CHARGE**.

5. In addition, to encourage participation in this survey, I have arranged for **two lottery prizes worth $100 each**. To be included in the drawing, please return the survey before **December 25, 2004**. Won't you please complete your survey as soon as possible, so the odds of winning a prize are in your favor?

6. The author of the survey, Professor Chai, who has expertise in the field of Information Systems and Operations Management, would like to extend to you any consulting efforts that he and our department can offer to you in the future. His contact info is on the survey, if you have any interest in the matter or any questions about the survey.

7. With that being said, do you have any concerns or questions about the survey? (if so, contact Professor Chai) Have you had a chance to complete it yet?

8. We would like to know if there is any reason why you wouldn't be interested in participating in our study. -____________________-

9. OK, thank you for your time. Goodbye.

APPENDIX M: SAMPLE CHARACTERISTICS

Sample Characteristics of Respondents

1.	**Job Titles** (220)	
	CEO/President	6.82% (15)
	Director	7.27% (16)
	Manager	53.18% (117)
	Supervisor	27.27% (60)
	Engineer	4.55% (10)
	Other	0.91% (2)
2.	**Job Functions** (261)	
	Corporate Executive	6.51% (17)
	Purchasing	6.13% (16)
	Transportation	2.30% (6)
	Manufacturing Production	41.38% (108)
	Distribution	1.15% (3)
	Sales	6.13% (16)
	Unidentified	13.41% (35)
	Other	22.99% (60)
3.	**Level of Education** (220)	
	High School	10.45% (23)
	Two-year College	20.00% (44)
	Bachelor's Degree	31.82% (70)
	Master's Degree	16.36% (36)
	Doctor's Degree	1.36% (3)
	Unidentified	15.91% (35)
	Other	4.09% (9)
4.	**Years worked at the organization** (220)	
	<= 3	7.27% (16)
	4-10	24.55% (54)
	10-15	18.64% (41)
	15-20	9.55% (21)
	> 20	24.55% (54)
	Unidentified	15.45% (34)
5.	**Years of Working** (220)	
	<= 3	0.45% (1)
	4-10	7.27% (16)
	10-15	12.73% (28)
	15-20	10.91% (24)
	> 20	53.18% (117)
	Unidentified	15.45% (34)

Table 5.3: Characteristics of the Respondents

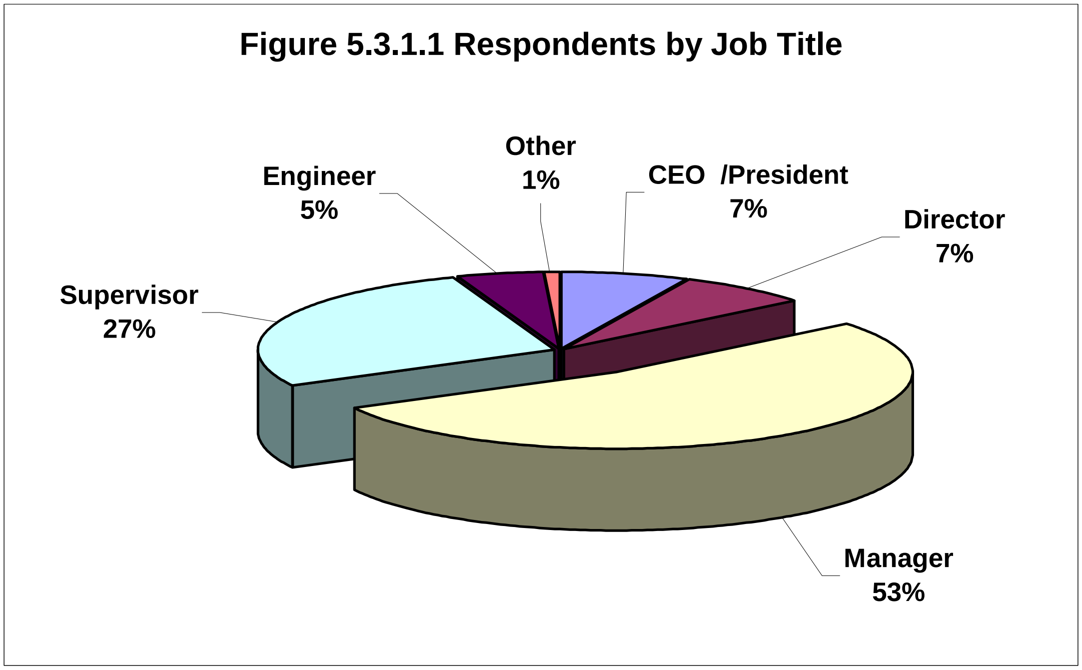


Figure 5.3.1.1 Respondents by Job Title
Other
1%
Engineer
5%
CEO /President
7%
Director
7%
Supervisor
27%
Manager
53%

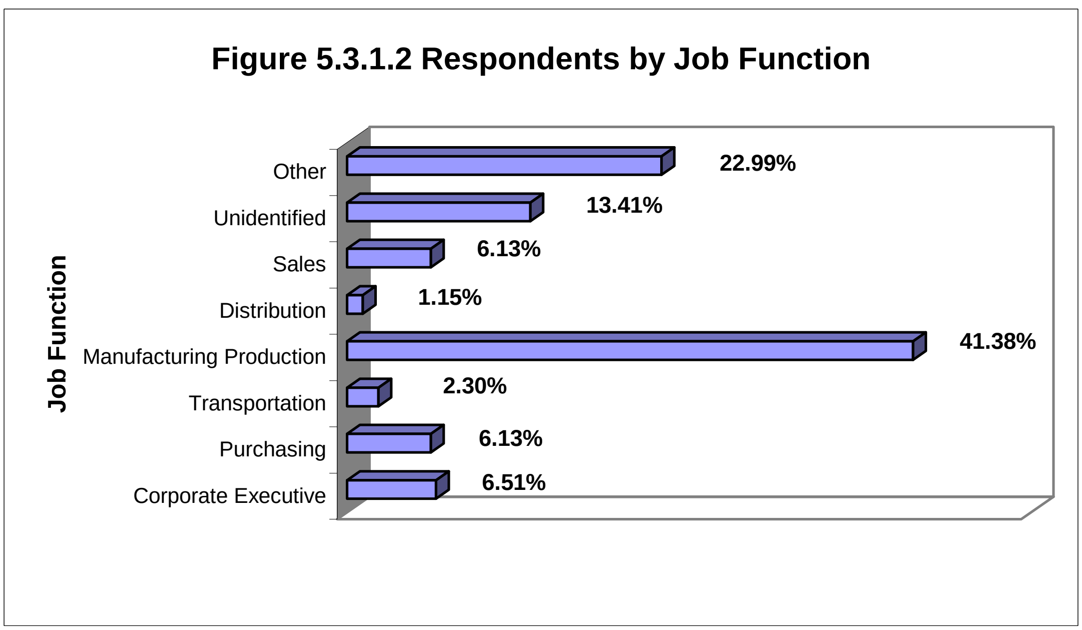


Figure 5.3.1.2 Respondents by Job Function
Job Function
Other
22.99%
Unidentified
13.41%
Sales
6.13%
Distribution
1.15%
Manufacturing Production
41.38%
Transportation
2.30%
Purchasing
6.13%
Corporate Executive
6.51%

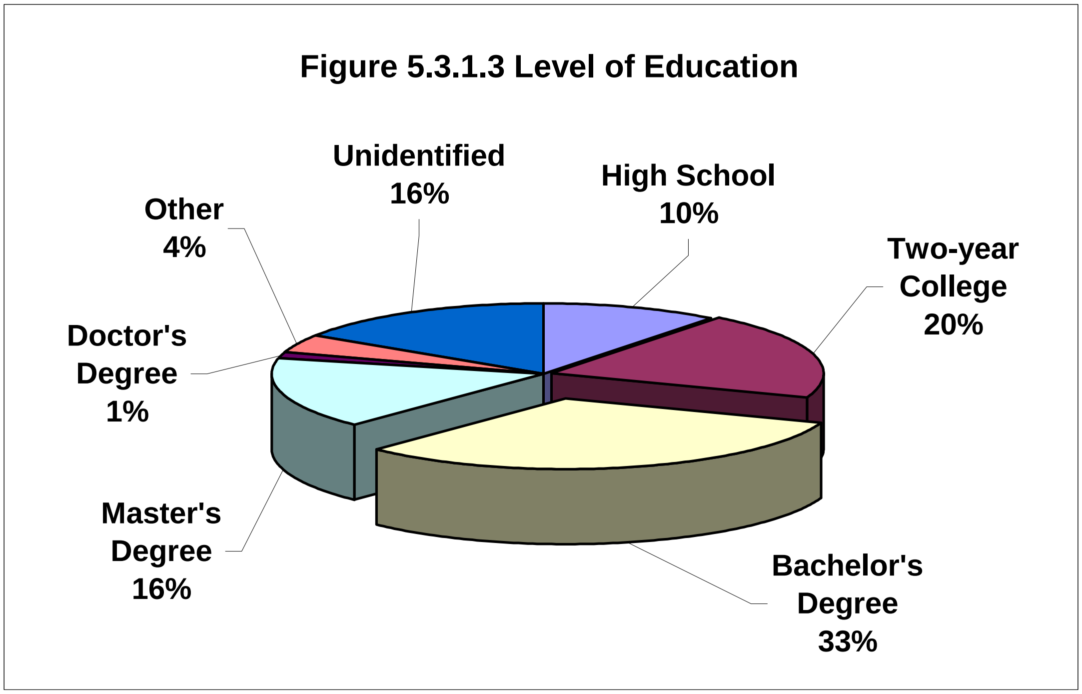


Figure 5.3.1.3 Level of Education
Unidentified 16%
High School 10%
Two-year College 20%
Other 4%
Doctor's Degree 1%
Master's Degree 16%
Bachelor's Degree 33%

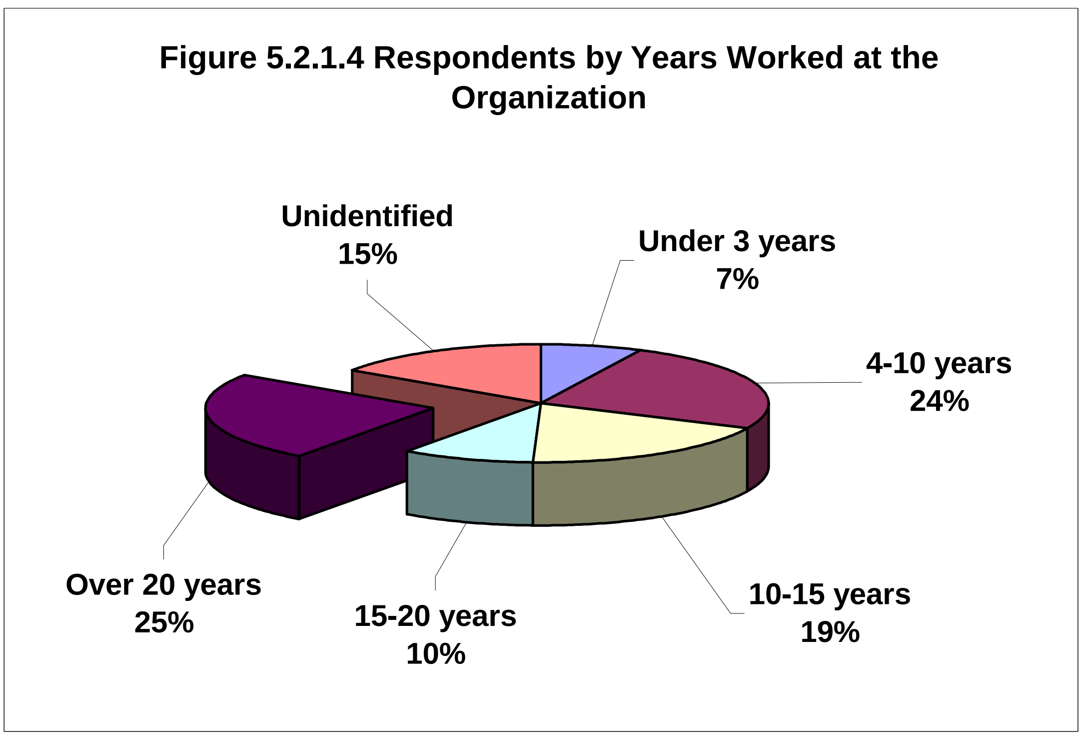


Figure 5.2.1.4 Respondents by Years Worked at the Organization
Unidentified 15%
Under 3 years 7%
4-10 years 24%
Over 20 years 25%
15-20 years 10%
10-15 years 19%

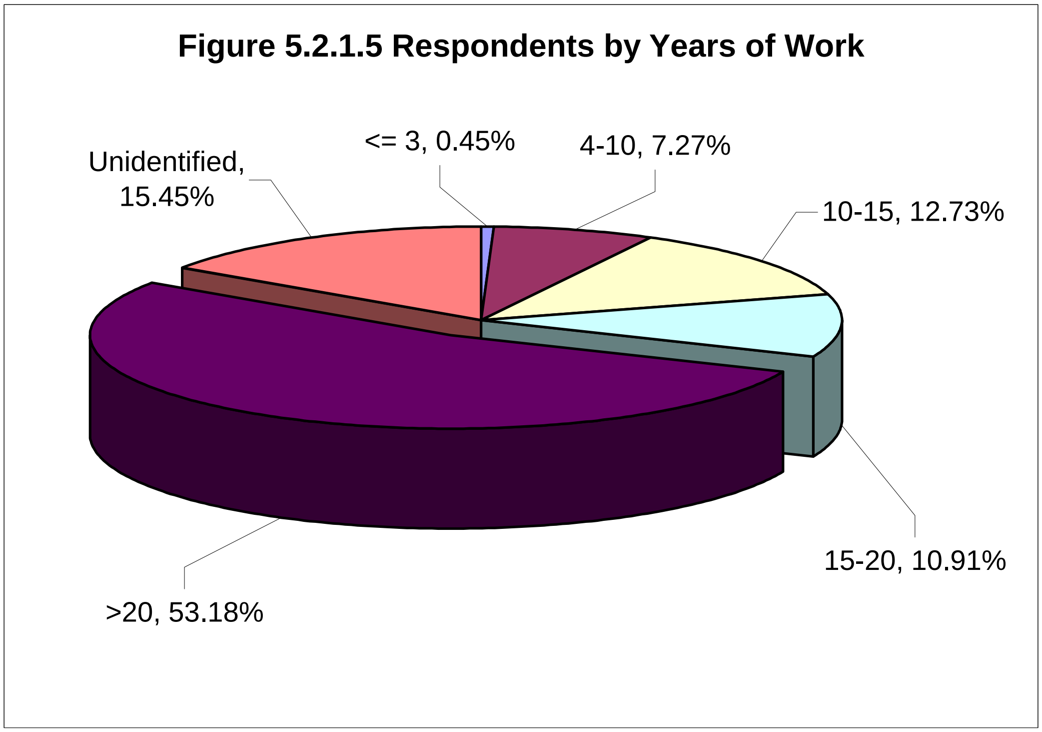


Figure 5.2.1.5 Respondents by Years of Work
Unidentified, 15.45%
<= 3, 0.45%
4-10, 7.27%
10-15, 12.73%
15-20, 10.91%
>20, 53.18%

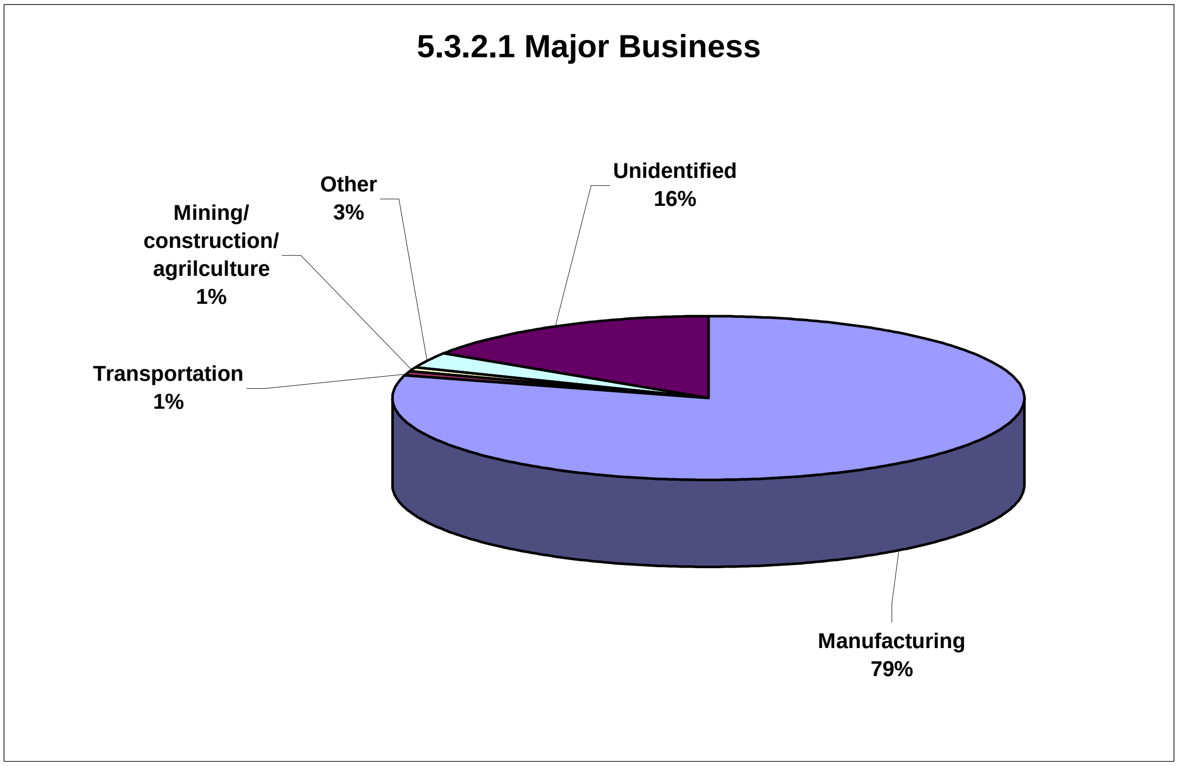
Sample Characteristics of Respondents' Organization

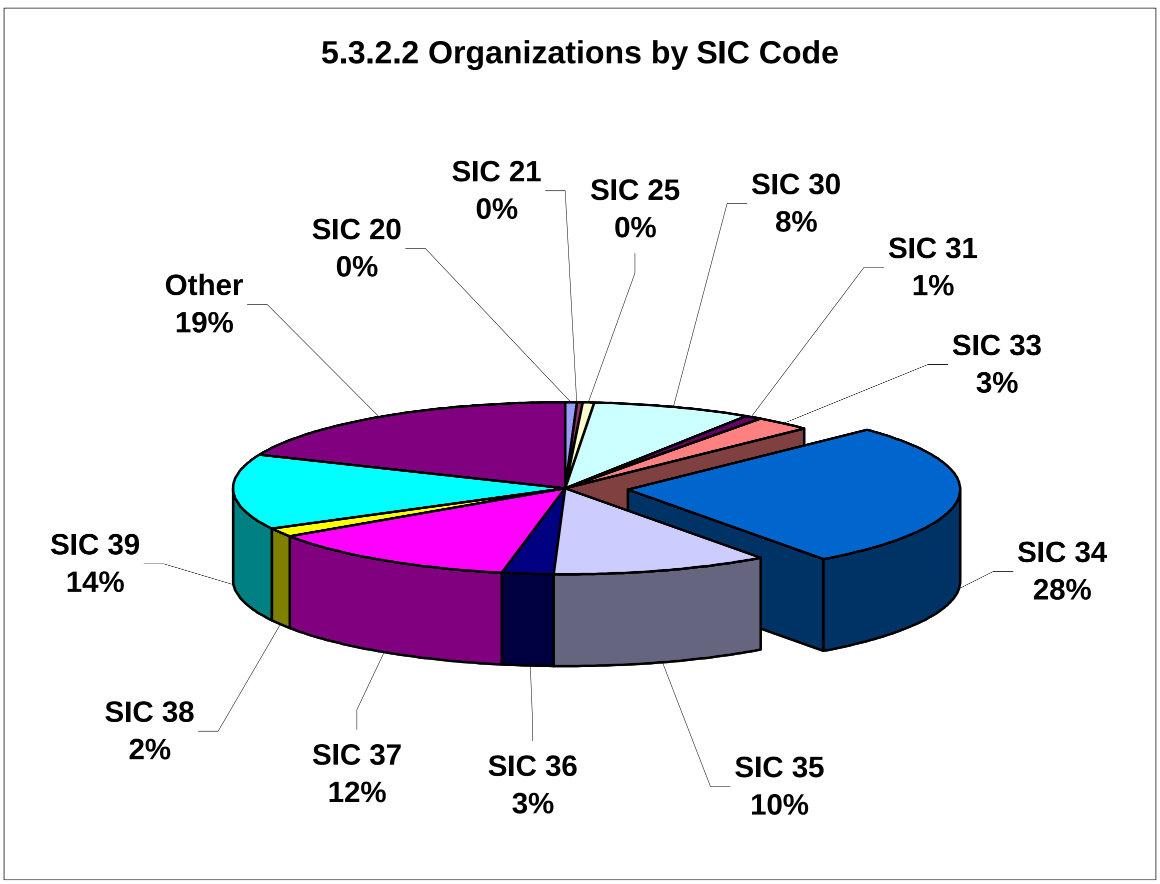
	Major business (220)	
	Manufacturing	79.55% (175)
	Transportation	0.91% (2)
	Mining/construction/agriculture	0.91% (2)
	Other	3.18% (7)
	Unidentified	15.45% (34)
2.	**Major industry** (220)	
	Food and kindred products (SIC 20)	0.45% (1)
	Tobacco (SIC 21)	0.45% (1)
	Furniture and fixtures (SIC 25)	0.45% (1)
	Rubber and plastic products (SIC 30)	7.73% (17)
	Leather and leather products (SIC 31)	0.91% (2)
	Primary metal industries (SIC 33)	2.73% (6)
	Fabricated metal products (SIC 34)	27.27% (60)
	Industrial machinery and equipment (SIC 35)	10.45% (23)
	Electric and electronic equipment (SIC 36)	2.73% (6)
	Transportation equipment (SIC 37)	12.27% (27)
	Instruments and related products (SIC 38)	1.82% (4)
	Miscellaneous manufacturing industries (SIC 39)	14.09 (31)
	Other	18.64% (41)
3.	**Primary production system** (220)	
	Engineer to Order	10.00% (22)
	Make to Order	50.00% (110)
	Assemble to Order	9.09% (20)
	Make to Stock	14.55% (32)
	Unidentified	16.36% (36)

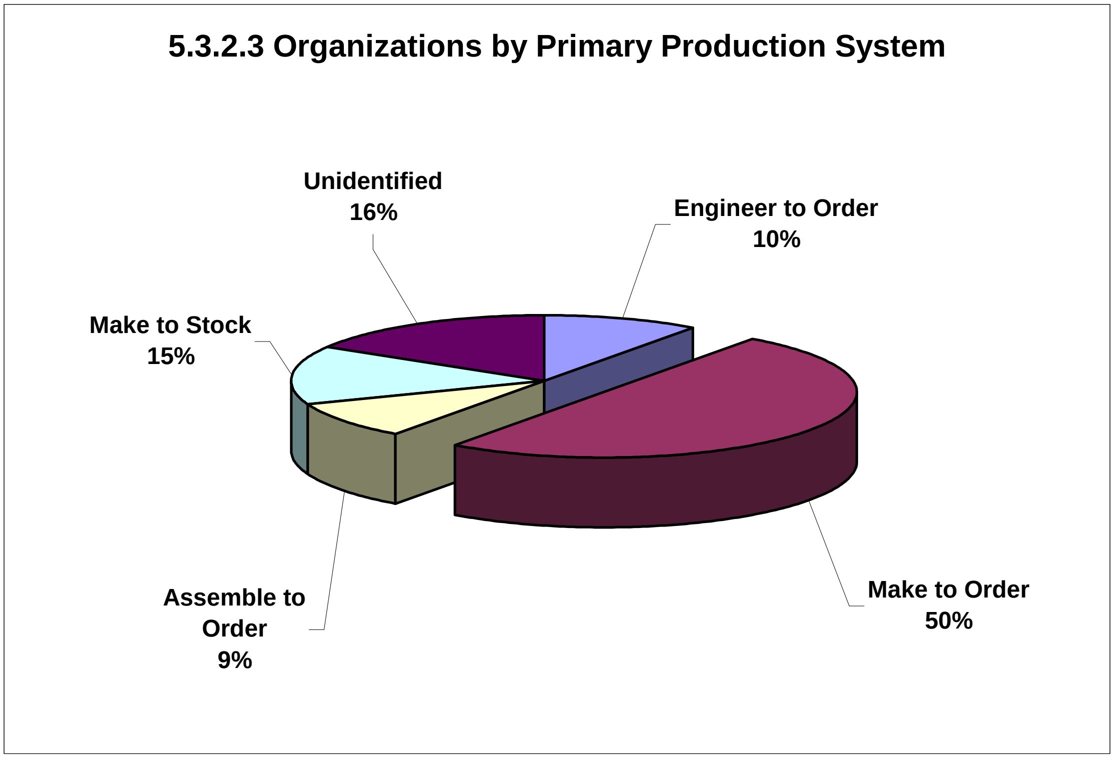
Table 5.4 Characteristics of the Surveyed Organizations

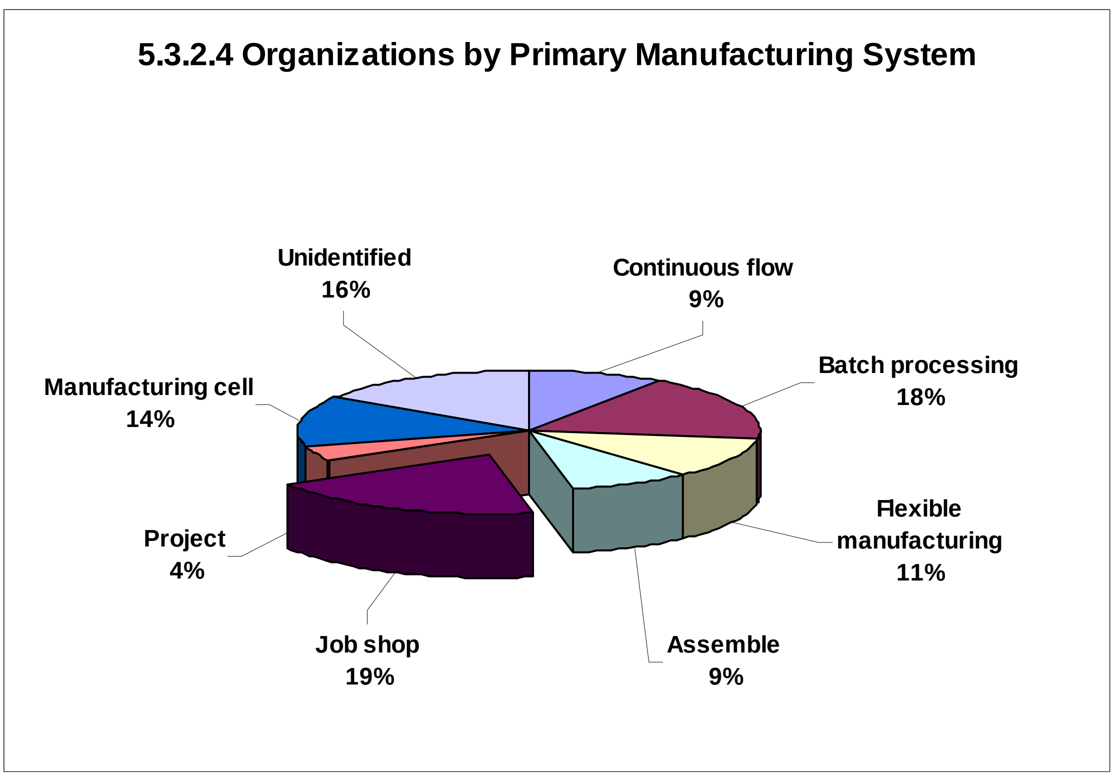
4.	**Primary manufacturing system** (220)	
	Continuous flow process	9.46% (21)
	Batch processing	18.02% (40)
	Flexible manufacturing	10.81% (24)
	Assemble line	8.56% (19)
	Job shop	19.82% (44)
	Project	4.05% (9)
	Manufacturing cell	13.51% (30)
	Unidentified	15.77 (35)
5.	**Number of employees** (220)	
	1-50	10.91% (24)
	51-100	14.55% (32)
	101-250	22.73% (50)
	251-500	13.18% (29)
	501-1000	6.36% (14)
	Over 1000	16.36% (36)
	Unidentified	15.91% (35)
6.	**Annual sales in millions of $** (220)	
	< 5	9.09% (20)
	5 to 10	7.27% (16)
	10 to <25	17.73% (39)
	25 to <50	11.36% (25)
	50 to <100	11.82% (26)
	>100	24.08% (53)
	Unidentified	18.64% (41)

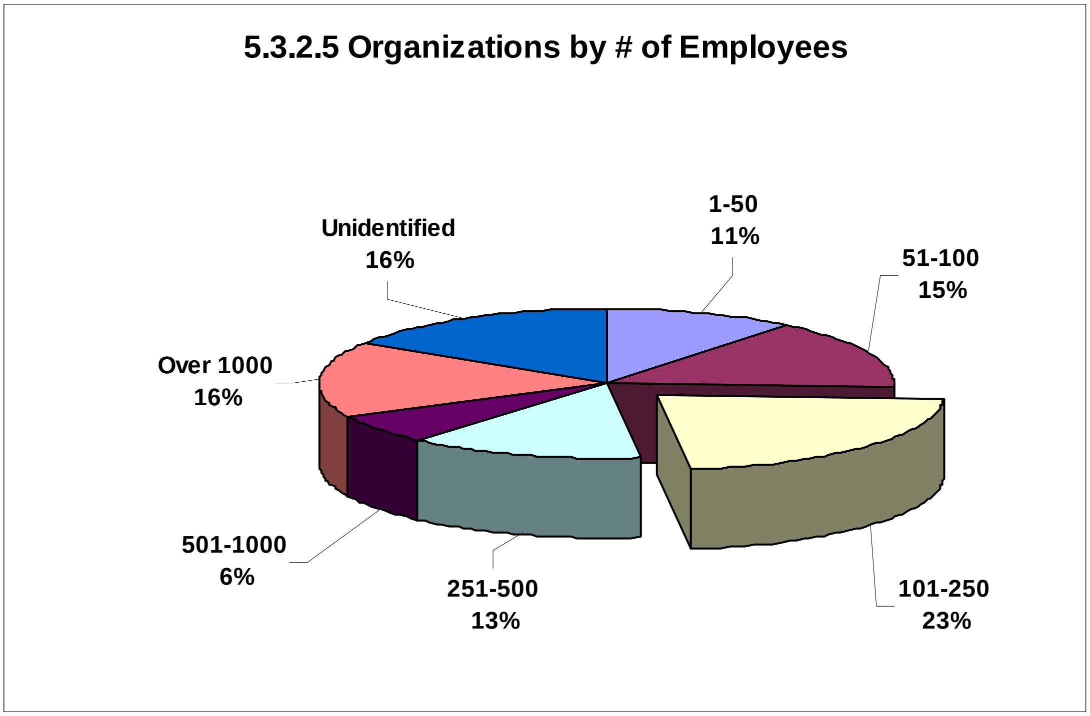
Table 5.4 Characteristics of the Surveyed Organizations (continued)

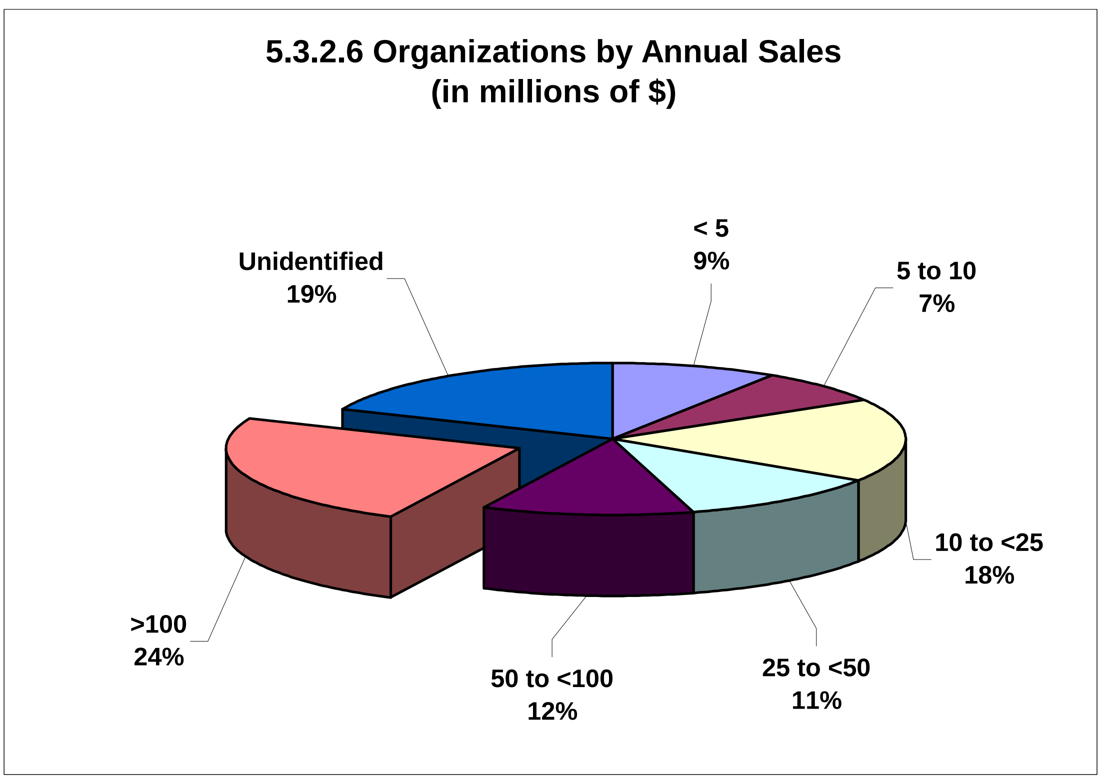

5.3.2.1 Major Business
Other 3%
Unidentified 16%
Mining/ construction/ agrilculture 1%
Transportation 1%
Manufacturing 79%


5.3.2.2 Organizations by SIC Code
SIC 21 0%
SIC 25 0%
SIC 30 8%
SIC 20 0%
SIC 31 1%
Other 19%
SIC 33 3%
SIC 39 14%
SIC 34 28%
SIC 38 2%
SIC 37 12%
SIC 36 3%
SIC 35 10%


5.3.2.3 Organizations by Primary Production System
Unidentified
16%
Engineer to Order
10%
Make to Stock
15%
Assemble to
Order
9%
Make to Order
50%


5.3.2.4 Organizations by Primary Manufacturing System
Unidentified
16%
Continuous flow
9%
Batch processing
18%
Manufacturing cell
14%
Flexible
manufacturing
11%
Project
4%
Job shop
19%
Assemble
9%

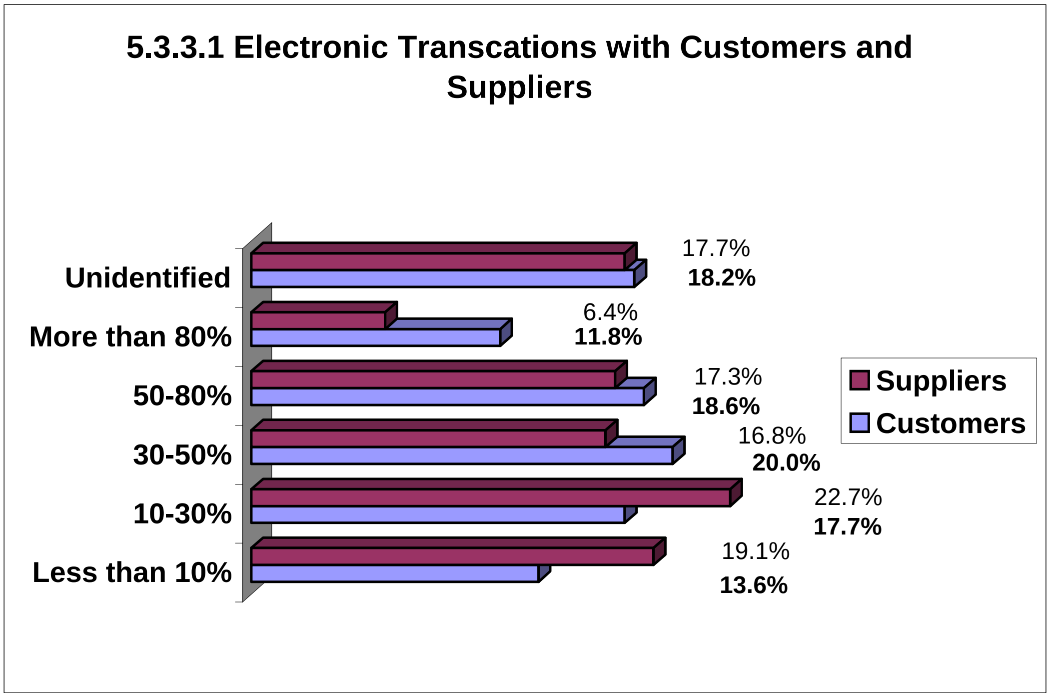

5.3.2.5 Organizations by # of Employees
Unidentified 16%
1-50 11%
51-100 15%
Over 1000 16%
501-1000 6%
251-500 13%
101-250 23%

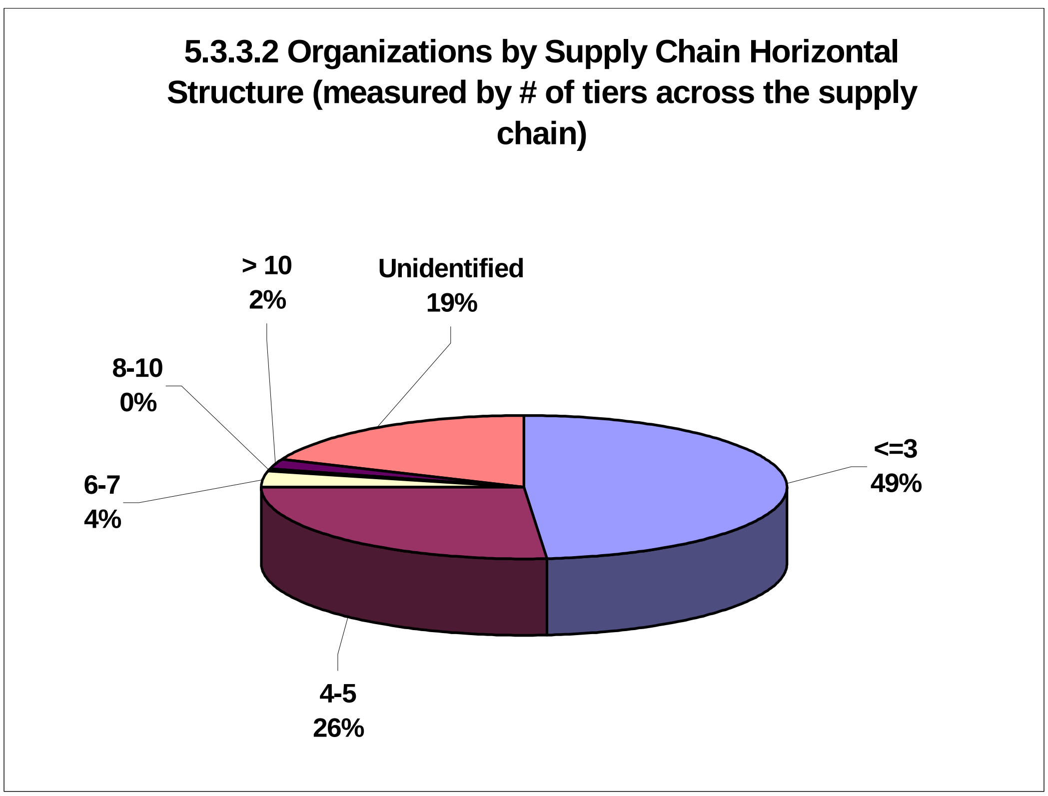

5.3.2.6 Organizations by Annual Sales (in millions of $)
Unidentified 19%
< 5 9%
5 to 10 7%
10 to <25 18%
>100 24%
50 to <100 12%
25 to <50 11%

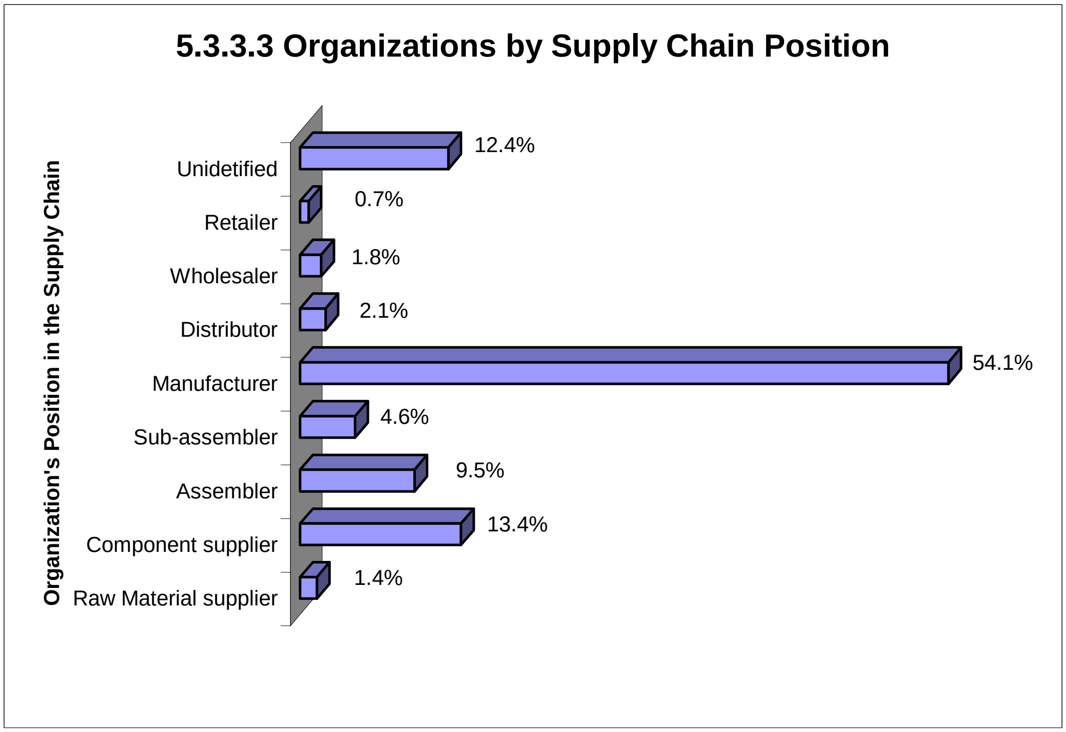
Characteristics of the Surveyed Organizations – Relationship with Customers and Suppliers

1.	**Organizations that have embarked upon a program aimed specially at implementing "Supply Chain Integration"** (220)	
	Yes:	29.55% (65)
	No:	53.64% (118)
	Unidentified	16.82% (37)
2.	**Percentage of business transactions with your customers done electronically** (220)	
	Less than 10%	13.64% (30)
	10-30%	17.73% (39)
	30-50%	20.00% (44)
	50-80%	18.64% (41)
	More than 80%	11.82% (26)
	Unidentified	18.18% (40)
3.	**Percentage of business transactions with your suppliers done electronically** (220)	
	Less than 10%	19.09% (42)
	10-30%	22.73% (50)
	30-50%	16.82% (37)
	50-80%	17.27% (38)
	More than 80%	6.36% (14)
	Unidentified	17.73% (39)
4.	**The number of tiers across your supply chain** (220)	
	<=3	48.64% (107)
	4-5	26.36% (58)
	6-7	3.64% (8)
	8-10	0.45% (1)
	>10	2.27% (5)
	Unidentified	18.06% (41)
5.	**Organization's position in the supply chain** (283)	
	Raw Material supplier	1.41% (4)
	Assembler	9.54% (27)
	Manufacturer	54.06% (153)
	Component supplier	13.43% (38)
	Sub-assembler	4.59% (13)
	Distributor	2.12% (6)
	Wholesaler	1.77% (5)
	Retailer	0.71% (2)
	Unidentified	12.37% (35)

Table 5.5 Characteristics of the Surveyed Organizations – Relationship with Customers and Suppliers


5.3.3.1 Electronic Transcations with Customers and Suppliers
Unidentified
More than 80%
50-80%
30-50%
10-30%
Less than 10%
17.7%
18.2%
6.4%
11.8%
17.3%
18.6%
16.8%
20.0%
22.7%
17.7%
19.1%
13.6%
Suppliers
Customers


5.3.3.2 Organizations by Supply Chain Horizontal Structure (measured by # of tiers across the supply chain)
> 10
2%
Unidentified
19%
8-10
0%
<=3
49%
6-7
4%
4-5
26%


5.3.3.3 Organizations by Supply Chain Position
Organization's Position in the Supply Chain
Unidetified
12.4%
Retailer
0.7%
Wholesaler
1.8%
Distributor
2.1%
Manufacturer
54.1%
Sub-assembler
4.6%
Assembler
9.5%
Component supplier
13.4%
Raw Material supplier
1.4%

APPENDIX N: THE QUESTIONNAIRE RECOMMENDED FOR FUTURE RESEARCH

Manufacturing & Information Technology Survey

Thawatchai Jitpaiboon

Assistant Professor
Department of Information Systems and Operations Management
Miller College of Business
Ball State University
Muncie, IN 47306
Phone: 765-285-7048
Fax: 765-285-5308
Email: tjitpaiboon@bsu.edu

(Please feel free to contact anytime you need further clarification.)

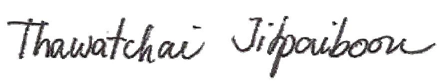
GENERAL INSTRUCTIONS

This questionnaire is part of a study underway to document the importance of information technology (IT) in enhancing the integration of manufacturing enterprises. This study examines manufacturing managers' perception on how their information systems practices contribute to supply chain integration and performance. Such knowledge gaining from this research can help practitioners and researchers to focus on the most important information systems activities which help an organization to improve its competitive position.

The questionnaire is divided into nine sections. Each question requires that you choose the alternative that best fits your views on that topic. We estimate that it should take you about 20 to 30 minutes to complete this questionnaire. There are no right or wrong answers. We are interested only in your opinions. **The information provided by you will be treated in the strictest confidence. Your responses will be entered in a coded format and in no instance will a person ever be identified as having given a particular response.**

Thank you for your cooperation. We believe that, with your assistance, this study can help clarify a number of information systems issues in manufacturing that have only been addressed so far in theory. **Please seal your completed questionnaire in the enclosed envelope and return it the address provided below.**

Thank you very much for your help.



Thawatchai Jitpaiboon

Assistant Professor
Department of Information Systems and Operations Management
Miller College of Business
Ball State University
Muncie, IN 47306
Phone: 765-285-7048
Fax: 765-285-5308
Email: tjitpaiboon@bsu.edu

Section 1: Information Technology Utilization The following situations describe the extent to which the **manufacturing department uses information technology (IT) for strategic, operational, and infrastructural purposes**. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit. **In our manufacturing department, we use IT for…**	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Long-term technology justification and planning……………………..……………..…	1	2	3	4	5	NA
Budget justification and planning…………………………………………………...	1	2	3	4	5	NA
Investment justification and planning……………………………………………….	1	2	3	4	5	NA
Long-term project planning………………………..……………………………..…	1	2	3	4	5	NA
Daily production control…..	1	2	3	4	5	NA
Daily product quality control………………………………………..……………	1	2	3	4	5	NA
Daily product movement planning………………..…………….…………………	1	2	3	4	5	NA
Daily customer analysis……………………………………………………………….	1	2	3	4	5	NA
Daily material requirement planning……………………….……….………….	1	2	3	4	5	NA
Setting up file sharing facilities (e.g., network cable, telephone line, wireless network)………………………………………………………………………………..	1	2	3	4	5	NA
Setting up data communication facilities (e.g., server, LAN, routers, disk/drive, network computers)………….………………………………………………………….	1	2	3	4	5	NA
Setting up advanced manufacturing technology (e.g., CAD/CAM, Robots, EDI)..........	1	2	3	4	5	NA
Setting up information disaster recovery system (e.g., disk redundancy, backup facility)…………………………………………………………………………………	1	2	3	4	5	NA

Section 2: Information Systems Integration - Internal The following statements describe the extent to which the **manufacturing department collaborates with *other business functions (i.e., Sales, Marketing)*** by using information technology (IT). Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit. The use of Information Systems (IS) facilitates **manufacturing department and *other internal business functions* to work together to…**	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Formulate long-term collaborative decision making…………………………..…....……	1	2	3	4	5	NA
Analyze long-term business plans…..…………….………………………………………	1	2	3	4	5	NA
Develop long-term business opportunities.....…….……………………………..………..	1	2	3	4	5	NA
Identify long-term technology justification and planning………………………………..	1	2	3	4	5	NA
Set long-term strategic goals……...………..……………………...……………………	1	2	3	4	5	NA
Adjust daily manufacturing processes (e.g., changing production schedule)...….………	1	2	3	4	5	NA
Control daily product quality………... ………..…..……………………………….....…	1	2	3	4	5	NA
Manage daily order quantity……………………..……………...…………………………	1	2	3	4	5	NA
Exchange daily inventory information (e.g., daily line production)....………...………….	1	2	3	4	5	NA
Manage daily logistical activities (e.g., shipping products to warehouse)………………	1	2	3	4	5	NA
Establish daily product forecasts.……………………..……………….………….………	1	2	3	4	5	NA
Use standard data definitions and codes (e.g., same terminology, abbreviation, jargon)...	1	2	3	4	5	NA
Use standard information/data format (e.g., using Excel to report sales information)……	1	2	3	4	5	NA
Use standard data presentation format………………………………………….………..	1	2	3	4	5	NA
Integrate data and information………………………………………………………..	1	2	3	4	5	NA
Use IS networks to communicate with other departments...…………………………..……	1	2	3	4	5	NA
Use IS networks to connect to each other's databases… …………………………...……	1	2	3	4	5	NA
Use IS networks applications (e.g. Outlook, Lotus Note, SAP)……………...….…..………	1	2	3	4	5	NA
Use IS networks to share information with other departments…………………….……...	1	2	3	4	5	NA
Use compatible network architectures……………………..…………………………..	1	2	3	4	5	NA

Section 3: Information Systems Integration - External The following statements describe the extent to which the **manufacturing department collaborates with its suppliers and customers** by using information technology (IT). Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit. The use of Information Systems (IS) facilitates **manufacturing department and *its suppliers and customers* to work together to…**	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Formulate long-term collaborative decision making……………..……………………..	1	2	3	4	5	NA
Justify long-term business plans ……………….…...………...…………………..……..…..	1	2	3	4	5	NA
Analyze long-term business plans……………………….....……...…….………………	1	2	3	4	5	NA
Develop new business opportunities.…………………..………………………………	1	2	3	4	5	NA
Identify long-term technology justification and planning……………………………..	1	2	3	4	5	NA
Set long-term strategic goals….……..………….…………………………………...…	1	2	3	4	5	NA
Adjust daily manufacturing processes (e.g., changing production schedule)…………	1	2	3	4	5	NA
Adjust daily product development processes (e.g., adjusting product designs)…..…...	1	2	3	4	5	NA
Control daily product quality………..…….………………………….…………...	1	2	3	4	5	NA
Manage daily order quantity…..…………………….………………………………	1	2	3	4	5	NA
Exchange daily inventory information (e.g., daily line production)..…………………	1	2	3	4	5	NA
Establish daily product forecasts…………………..………………………………..	1	2	3	4	5	NA
Use standard data definitions and codes (e.g., same terminology, abbreviation, jargon)……………………………………………………………………………..….	1	2	3	4	5	NA
Use standard information/data format (e.g., using Excel to report sales information)……………………………………………………………………..…...	1	2	3	4	5	NA
Use standard data presentation format…………………………...…………..…….	1	2	3	4	5	NA
Use central databases (e.g., Oracle, Excel, SQL Database, Access, Fox Pro)………	1	2	3	4	5	NA
Use IS networks to communicate with each other.. …………………………………	1	2	3	4	5	NA
Use IS networks to connect to each other's databases… ……………………………..	1	2	3	4	5	NA
Use IS networks to share information with each other…………..………………......	1	2	3	4	5	NA
Use IS networks to facilitate periodic meeting…….…………………...……………	1	2	3	4	5	NA

Section 4: Relationship with Customers and Suppliers The following statements describe the extent to which the **manufacturing department interacts with *its customers and suppliers***. Please circle the appropriate number to indicate the extent to which you agree or disagree with each statement as applicable to your unit.	Very Low	Low	Moderate	High	Very High	Not Applicable, or Do Not Know
The willingness of customers to share their market demands..…………………..…….	1	2	3	4	5	NA
The participation level of customers in finished goods distribution processes………..	1	2	3	4	5	NA
The participation level of customers in finished goods distribution processes……….	1	2	3	4	5	NA
The extent of follow-up with customers for feedbacks……………………………….	1	2	3	4	5	NA
The participation level of customers in manufacturing processes……………………..	1	2	3	4	5	NA
The participation level of suppliers in production planning processes..………………..	1	2	3	4	5	NA
The participation level of suppliers in product development processes.........................	1	2	3	4	5	NA
The participation level of suppliers in logistics processes………..………..………..	1	2	3	4	5	NA
The level of cross-over of activities between our firm and our suppliers………………	1	2	3	4	5	NA
The level of supplier involvement in preparing our business plans……………………	1	2	3	4	5	NA

Section 5: Mass Customization Capability The following statements measure firm's **capability to customize products** inexpensively and quickly. Please circle the appropriate number that best indicates your perception of the relative capabilities of your firm as compared to the industry average.	Very Low	Low	Moderate	High	Very High	Not Applicable, or Do Not Know
Our capability of customizing products at low cost is…………………………………	1	2	3	4	5	NA
Our capability of customizing products on a large scale is……………………………	1	2	3	4	5	NA
Our capability of translating customer requirements into technical designs quickly is.	1	2	3	4	5	NA
Our capability of adding product variety without increasing cost is…………………..	1	2	3	4	5	NA
Our capability of customizing products while maintaining a large volume is………..	1	2	3	4	5	NA
Our capability of setting up for a different product a low cost is………..…………	1	2	3	4	5	NA
Our capability of responding to customization requirements quickly is……..………..	1	2	3	4	5	NA
Our capability of adding product variety without sacrificing overall production volume is……………………………………………………………………….	1	2	3	4	5	NA
Our capability of changeover to a different product quickly is………………………...	1	2	3	4	5	NA

Section 6: Suppliers' and Firm's Operational Performance

The following statements describe typical **operational performance objectives for firms and their suppliers**. Please circle the number that best indicates the level of your suppliers' and your firm's attainment of each objective. Please note that **left side** indicates the level of supplier's operational performance and **right side** indicates the level of firm's operational performance. ***Please fill in both sides of questionnaire items.***

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Supplier						Performance Dimensions	**Firm**					
1	2	3	4	5	NA	Deliver materials/components/products as promises	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide fast delivery	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide on-time delivery	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide reliable delivery	1	2	3	4	5	NA
1	2	3	4	5	NA	Decrease manufacturing lead time	1	2	3	4	5	NA
1	2	3	4	5	NA	Make rapid production volume changes	1	2	3	4	5	NA
1	2	3	4	5	NA	Make rapid changeover between product lines	1	2	3	4	5	NA
1	2	3	4	5	NA	Process both large and small orders	1	2	3	4	5	NA
1	2	3	4	5	NA	Increase capacity utilization	1	2	3	4	5	NA
1	2	3	4	5	NA	Produce materials/components/products at low cost	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce production cost	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce inventory cost	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce unit cost	1	2	3	4	5	NA
1	2	3	4	5	NA	Increase labor productivity	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new ways of customer service	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new forms of shop floor management	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new ways of supply chain management	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new products and features	1	2	3	4	5	NA
1	2	3	4	5	NA	Develop new process technologies	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide better product performance	1	2	3	4	5	NA
1	2	3	4	5	NA	Provide product conformance to specifications	1	2	3	4	5	NA
1	2	3	4	5	NA	Reduce defective rate	1	2	3	4	5	NA
1	2	3	4	5	NA	Better product reputation	1	2	3	4	5	NA

Section 7: Top Management Support for System Integration With regard to top management support for system integration, please circle the appropriate number that accurately reflects your firm's PRESENT conditions.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable, or Do Not Know
Top management is interested in our relationship with our trading partners ………	1	2	3	4	5	NA
Top management supports our department with the resources we need ……………	1	2	3	4	5	NA
Top management regards our relationship with trading partners a high priority item .	1	2	3	4	5	NA
Top management participates in integration with our trading partners…………….	1	2	3	4	5	NA
Top management considers the relationship between us and our trading partners to be important………………………………………………………………………	1	2	3	4	5	NA
Top management encourages open communication with our trading partners…….	1	2	3	4	5	NA
Top management provides enough training on technology used to communicate with our trading partners……………………………………………………………..	1	2	3	4	5	NA

Section 8: Firm Performance The following statements measure overall performance of your firm. Please circle the appropriate number that best indicates the level of your firm's overall performance.	Very Low	Low	Moderate	High	Very High	Not Applicable, or Do Not Know
Customer retention rate………………………………………………………………	1	2	3	4	5	NA
Sales growth…………………………………………………………………………	1	2	3	4	5	NA
Return on investment………………………………………………………………..	1	2	3	4	5	NA
Production throughput time…………………………………………………………	1	2	3	4	5	NA
Overall competitive position……………………………………………………….	1	2	3	4	5	NA

Section 9: Please provide the following information.

Personal information

5. Your job title:

☐ CEO/president ☐ Director
☐ Manager ☐ Other (Please indicate) ______________________

6. Your present job function (Mark all that apply)

☐ Corporate executive ☐ Purchasing ☐ Transportation
☐ Manufacturing production ☐ Distribution ☐ Sales ☐ Other (Please indicate) ___________

7. Please indicate your level of education:

☐ High school ☐ Two-year college ☐ Bachelor's degree ☐ Master's degree
☐ Doctor's degree ☐ Other (please specify): _______________________________________

8. How many years have you been working? ___ <= 3; ___ 4-10; ___ 10-15; ___ 15-20; ___ > 20

9. How many years have you been working for your current organization?

___ <= 3; ___ 4-10; ___ 10-15; ___ 15-20; ___ > 20

10. On a scale of 1 to 10, please indicate your level of computer literacy:

Know nothing about computers — Expert computer user

1----------2-----------3-----------4-----------5-----------6----------7---------8---------9--------10

11. Please indicate the perceived level of complexity of your routine computer-based tasks:

Not at all complex — Moderately complex — Extremely complex

1----------2-----------3-----------4-----------5-----------6----------7---------8---------9--------10

12. Please indicate your typical level of confidence in using an unfamiliar computer system:

Not at all onfident — Moderately confident — Totally confident

1----------2-----------3-----------4-----------5-----------6----------7---------8---------9--------10

Business Information

2. Please indicate the category which best describes your major business (Please check the most appropriate one)

____ Manufacturing	____ Finance/insurance/real estate	____ Public utility
____ Medicine/Law/Education	____ Wholesale/retail trade	____ Transportation
____ Business service	____ Government local/state/federal	____ Petroleum
____ Communication	____ Mining/construction/agriculture	____ others

3. If you know your SIC code please insert it in [ ] the box :

Otherwise indicate the industry subdivision in which you operate, from the list below.
(Please circle ONE number only)

Food and kindred products (SIC 20) 01
Tobacco (SIC 21) 02
Textile mill products (SIC 22) 03
Apparel and other textile products (SIC 23) 04
Lumber and wood products (SIC 24). 05
Furniture and fixtures (SIC 25). 06
Paper and allied products (SIC 26) 07
Printing and publishing (SIC 27) 08
Chemical and allied products (SIC 28) 09
Petroleum and coal products (SIC 29) 10
Rubber and plastic products (SIC 30) 11
Leather and leather products (SIC 31) 12
Stone, clay and glass products (SIC 32) 13
Primary metal industries (SIC 33) 14
Fabricated metal products (SIC 34) 15
Industrial machinery and equipment, except electrical (SIC 35) 16
Electric and electronic equipment (SIC 36) 17
Transportation equipment (SIC 37) 18
Instruments and related products (SIC 38) 19
Miscellaneous manufacturing industries (SIC 39) 20
Other 21

6. Has your organization embarked upon an information system program(s) aimed specially at implementing "Supply Chain Integration"

_____ Yes _____ No

If your answer is Yes, how long? _____ years (Please indicate)

7. Your **primary** production system (Choose most appropriate one)

_____ Engineer to Order _____ Make to Order

_____ Assemble to Order _____ Make to Stock

8. Your **primary** manufacturing system (Choose most appropriate on)

_____ Continuous Flow Process _____ Assemble Line _____ Projects (one-of-a kind production)

_____ Batch Processing _____ Job Shop _____ Manufacturing Cells

_____ Flexible Manufacturing

7. Number of employees in your company:

_____	1 - 50	_____	51 - 100	_____	101 – 250
_____	251 – 500	_____	501 - 1000	_____	Over 1000

9. Average annual sales of your company in millions of $:

_____	Under 5	_____	5 to < 10	_____	10 to < 25
_____	25 to < 50	_____	50 to < 100	_____	Over 100

10. Please indicate the position of your company in the supply chain (Mark all that applies).

____	Raw material supplier	____	Component supplier	____	Wholesaler
____	Assembler	____	Sub-assembler	____	Retailer
____	Manufacturer	____	Distributor		

15. Please indicate the category that best describe your primary business:

____	Automotive or parts	____	Fabricated metal products	____	Electronics
____	Electrical equipment	____	Furniture and fixtures	____	Appliances
____	Rubber and plastic products	____	Industrial machinery and equipment	____	Others
____	Transportation equipment	____	Instruments and related products		

16. Please place check marks against one or more of the following technology applications you are primarily (heavily) using in your work.

☐ E-mail ☐ Word processing ☐ Spread sheet ☐ Database ☐ Programming tools
☐ Others (please specify) ____

17. What percentage of your business transactions with your <u>customers</u> is done electronically?

_____	Less than 10%	_____	10-30%	_____	30-50%
_____	50-80%	_____	More than 80%		

18. What percentage of your business transactions with your <u>suppliers</u> is done electronically?

_____	Less than 10%	_____	10-30%	_____	30-50%
_____	50-80%	_____	More than 80%		

19. Please indicate the number of tiers across your supply chain?

_____	<= 3	_____	4-5	_____	6-7
_____	8-10	_____	> 10		

20. What percentage of the computer applications that you are currently working with can be classified under each of the following three categories (Please fill in the percentages against each application so that the percentages add up to 100%):

_______% Main Frame Application ______% PC Application _______% Networked Application

We totally respect your privacy.
Please note that the information you provide below
will be used for academic purposes only.

Please complete the following details or attach your business card:

Your name: ____

Business Name: ____

Title: ____

Address: ____

____

City: ___________________________ State: ____________________

Zip Code: _______________Phone: ___________________________

Fax: _________________ Email: _____________________________

If you would like to receive the summarized version of your company's results compared to the industry, please specify the mode of receiving the information.

- ☐ Hard copy by regular mailing services
- ☐ Download from the internet (login and password)
- ☐ E-mail with attachment
- ☐ Other (Please indicate) ____________________

Thank you for your cooperation and response.

APPENDIX O

IRB FROM UNIVERSITY OF TOLEDO

THE UNIVERSITY OF TOLEDO

University Office of Research

Mail Stop 944
Toledo, Ohio 43606-3390
419.530.2844 Phone
419.530.2841 Fax
www.research.utoledo.edu

Human Subjects Research Committee

9-28-04

TO: **Thawatchai Jitpaiboon**

RE: Research Project# **204-190**
The roles of information systems integration in the supply chain integration context - firm persepctive

The University of Toledo Human Subjects Research Review Committee has completed its review of your project utilizing human subjects.

Your project has been approved as submitted, and you are authorized to use human subjects in that project until 9-28-05. At the end of that time, if your project is not complete, you must submit a request for an extension and a progress report in order to continue the project beyond that date. When your project has been completed, please fill out and send me the enclosed Certificate of Compliance.

This approval for the use of human subjects is contingent upon your following the research plan presented in your submitted proposal. You are not permitted to undertake any actions involving human subjects which are not a specific part of that proposal. If it becomes necessary to make changes, you may use those modifications only after you submit them for review and inclusion in your project file. Without such review, this authorization is void and you are not permitted to use human subjects in your research.

If any untoward incidents or unanticipated adverse reactions should develop in the course of your research on human subjects, you must suspend the project temporarily and notify me immediately.

Thank you very much for your cooperation. If you have any questions, please feel free to contact me at 419-530-1918.

Sincerely,

Gerald P. Sherman

Gerald P. Sherman, Chair

cc: Office of Research HSRC File
Dr. T.S. Ragu-Nathan, MS# 103

APPENDIX P

IRB FROM BALL STATE UNIVERSITY

BALL STATE UNIVERSITY

ACADEMIC AFFAIRS
OFFICE OF ACADEMIC RESEARCH AND SPONSORED PROGRAMS

Muncie, Indiana 47306-0155
Phone: 765-285-1600
Fax: 765-285-1624

INSTITUTIONAL REVIEW BOARD

TO: Thawatchai Jitpaiboon
Information Systems and Operations Management

FROM: Jerrell Cassady, Chair
Institutional Review Board

DATE: October 8, 2004

RE: Human Subjects Protocol – IRB # 05-87

The Institutional Review Board has recently approved your project titled *The Role of Information Systems Integration in the Supply Chain Integration Context- Firm Perspective* as originally submitted as an expedited study. Such approval is in force from October 7, 2004 to October 6, 2005.

Editorial note: We suggest that you remove page 12 of your materials and provide a disconnected process for the participants to access a summary of the research (separate email, posted to a website, etc announced in cover letter). Doing so removes identifying information from the study, and allows full anonymity. As such, we recommend removing the term "confidential" from the introductory letter. In the general instructions please change the pronoun from "we" to "I" to match the fact that you are the only listed individual.

It is the responsibility of the P.I. and/or faculty supervisor to inform the IRB:

- when the project is completed, or
- if the project is to be extended beyond the approved end date,
- if the project is modified,
- if the project encounters problems,
- if the project is discontinued.

Any of the above notifications should be addressed in writing to the Institutional Review Board, c/o the Office of Academic Research & Sponsored Programs (2100 Riverside Avenue). Please reference the above identification number in any communication to the IRB regarding this project. Be sure to allow sufficient time for extended approvals.