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Interorganizational System Characteristics and Supply Chain Integration: An Empirical Assessment*

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ABSTRACT

Some firms have gained significant benefits by effectively deploying interorganizational systems (IOS) to tightly couple operations with their supply chain partners. In contrast, other firms with IOS deployments have struggled to achieve this level of success. So it is not clear how such systems can be configured to promote idiosyncratic interorganizational processes that integrate the supply chains and facilitate successful outcomes. To shed further light on this issue, we draw from multiple theoretical perspectives to develop a comprehensive and unique conceptualization of IOS characteristics that goes beyond the limited treatment it has received in extant literature. Furthermore, we empirically examine the IOS configuration choices made by firms with different supply chain integration (SCI) profiles. Our results support the notion that successful firms sequence the configuration of IOS characteristics toward effectively developing and supporting their supply chain process capabilities. In particular, we found that firms at the lower end of SCI configure IOS features to support supplier evaluation and automatic alerts. As organizations move to the upper end of the SCI spectrum, greater attention is paid to features associated with systems integration, planning, and forecasting. Recommendations to managers and academics stemming from our study are provided, along with avenues for future research.

Subject Areas: Cluster Analysis, Electronic Integration, Interorganizational Systems, Supply Chain, and Survey.

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INTRODUCTION

Supply chain integration (SCI) has emerged as an important performance enhancing initiative that has gained wide acceptance among organizations. In this regard, a large number of studies have shown that developing idiosyncratic processes with supply chain partners provide distinctive advantages (Cachon & Fisher, 2000; Subramani, 2004; Villena, Gomez-Mejia, & Revilla, 2009; Narasimhan, Swink, & Viswanathan, 2010). Consequently, understanding the composition of SCI, and which factors facilitate it, have emerged as two important areas of investigation.

Interorganizational systems (IOS) act as facilitators of integration and development of unique processes across the supply chain. Firms have gained significant benefits by using various interorganizational information technology (IT) applications to collaborate with their suppliers (Songini, 2002; Wang & Wei, 2007). A major problem with prior studies on this topic is that the treatment of IOS has been done either at an aggregate level, or done inconsistently. Further, as supply chain management systems have matured, they have converged in functionality, raising questions regarding their distinctive contribution. This study consequently focuses on gaining a better understanding of the relationship between IOS and SCI by developing a nuanced conceptualization of the technological characteristics of IOS, and evaluating their utilization across dyadic linkages with varying SCI configurations.

There is broad substantiation for the importance of IOS in supporting various interorganizational activities and processes (Subramani, 2004; Malhotra, Gosain, & El Sawy, 2005; Kim, Umanath, & Kim, 2006; Rai, Patnayakuni, & Seth, 2006; Klein, Rai, & Straub, 2007). Electronic integration is one of the many impacts of using IOS (Malone, Yates, & Benjamin, 1987). Kambil and Short (1994) define such an integration as a strategic choice made by firms to transform a firm's business scope or business network by using IT to reengineer business processes and relationships. Subramanian and Shaw (2002) observe that various functionalities of Web-based systems can support search, processing, monitoring and control, and coordination activities. Zhu and Kraemer (2002, p. 279) propose that electronic commerce capabilities and system functionalities "may range from static information to online ordering and from digital product catalogs to integration with suppliers' databases." Virtual integration that captures the use of information systems (ISs) in facilitating common operations between supply chain partners and relationship specific customization of IT applications to promote strategic information flows are other interesting configurations proposed in literature (Wang & Wei, 2007; Klein et al., 2007). Research thus highlights the need for an explicit examination of IOS functionalities and an evaluation of their role within the supply chain context.

Despite considerable research on IOS, the conceptualization of IOS itself has received limited attention. Studies offer conceptual guidelines, but only a handful of studies have attempted to follow through and attempt empirical validation. The conceptualizations put forward in prior research treat IOS as a monolithic concept and do not explore its various components. Further, past conceptualizations either combine IOS with supporting processes or capture IOS through its impacts. This limits the ability to effectively evaluate the choices that an organization makes regarding the configuration of IOS characteristics needed to support SCI. It is also important to clearly distinguish between the IT artifact and the context in which it is used (Orlikowski & Iacono, 2001) to support supply chain processes. Our objectives are to expand understanding of various IOS characteristics, (often described as electronic integration) and examine how these characteristics vary across dyadic links between trading partners that depict different SCI profiles.

The study is organized as follows. The following section provides an extensive review of literature on IOS and their linkage with IOS constructs and SCI. Then we present our research methods and the associated analysis, followed by discussions of results and some concluding thoughts on implications of this study for practice and future research.

LITERATURE REVIEW

The evolution of electronic communication has opened up new ways for trading entities to interact. A core characteristic of this evolution is the adherence to object orientation that requires standardization across interfaces and protocols. While standardization of technologies on one hand may marginalize the unique benefits that can accrue to an entity; it also opens up the option of creating unique component combinations that can in a modular fashion support the configuration of unique interorganizational processes across supply chain partners. IOS as an IS shared across firms (Cash & Konsynski, 1985) can support governance structures by tightly coupling processes and allowing extensive exchange of information within the supply chain. In our effort to better understand the IOS phenomenon, it is important to first debate the appropriate approach toward evaluating it.

Burton-Jones and Straub (2006) propose that conceptualization and measurement of an IS requires an explicit assessment of the study context, which should drive its definition, conceptualization, and measurement. The core objective of our study is to assess the relationship between IOS and SCI. Achieving this objective requires a clear delineation between the IS and the processes that it supports. Traditional usage measures inherently blend IS features with the underlying processes. For example, if an organization is using IS to integrate design and manufacturing functions, the usage measurement approach presents the inquiry as the extent to which the organization is using IS to coordinate activities across design and manufacturing functions. Such an approach offers limited value because delineating the structure (integrated IS) and the process (coordination between the functions) is the key issue.

The approach that we take combines the configuration and plausible use of IOS functionalities (IOS characteristics) in capturing the IOS phenomenon. Such an approach is appropriate because it ties well with our study context that demands the segregation of IOS characteristics and the underlying processes they support. It also provides insights into managerial knowledge regarding the IOS functionalities in play at firms with different SCI profiles.

We review three streams of research that evaluate IOS in the supply chain context. The reasons for segmenting the research into three streams are twofold. First, these three streams have developed rather independently over time and evaluating them separately is important for a comprehensive coverage of the IOS phenomenon. Second, this approach offers the opportunity to synthesize overlapping areas and at the same time highlight the unique aspects brought forward by each stream.

IOS Characteristics—Electronic Data Interchange (EDI) Systems Perspective

A large number of studies have focused on evaluating EDI systems and their strategic and operational impacts. EDI penetration (number of items traded through the EDI system), EDI embeddedness (extent of system integration), and intensity of EDI use (exchange of a wide range of documents such as request for quotes, purchase orders, paper drawings, and three-dimensional drawings) have been presented as different configurations of EDI systems (Bensaou & Venkatraman, 1995; Mukhopadhyay, Kekre, & Kalathur, 1995; Chatfield & Yetton, 2000). Massetti and Zmud (1996) propose that volume, breadth, diversity, and depth are four dimensions of EDI use. Truman (2000) suggests that integration of EDI systems with internal systems of the company is an important dimension of EDI use. Also, the extent to which item identification codes are consistent between the EDI systems of the two partner firms has been used to represent a high level of electronic integration (Mukhopadhyay & Kekre, 2002).

Table 1 summarizes key studies using the EDI perspective. It shows that cumulatively, systems integration (application integration) and data compatibility (consistent item identification codes) are the characteristics of EDI systems relevant to process integration among supply chain partners. However, contemporary IT systems are playing a pivotal role in enabling the concept of the "extended enterprise." Literature that examines IOS from this perspective is discussed next.

IOS Characteristics—Resource-Based Perspective

Research in the IS domain proposes IT infrastructure and system characteristics as critical organizational resources that cannot only enhance enterprise wide integration, but which can also be expanded to support the extended enterprise (Kayworth & Sambamurthy, 2000; Kumar, 2001). But building an integrated IT infrastructure takes time and effort, and involves experiential learning (Bhatt & Grover, 2005). IOS serve a similar purpose, but instead are used between two firms rather than departments or business units within a firm. Ross, Beath, and Goodhue (1996) argue that development of an IOS IT infrastructure that spans the entire value chain requires organizations to develop and perfect elaborate rules regarding distribution and management of hardware, software, and other support services. Thus, individual components that go into the infrastructure may be commodity-like, but the process of integrating the components to develop an infrastructure tailored to the strategic context of organizations is complex and imperfectly understood (Bharadwaj, 2000). Klein et al. (2007) stress the importance of IT customization in the supply chain context. They argue that configuring IT applications to be relationship-specific is critical in achieving higher levels of IT integration, which ultimately facilitates sharing of strategic information between trading entities.

Duncan (1995) proposes connectivity and compatibility as different aspects of the IT infrastructure. She defines connectivity (application integration) as the

Table 1: Characteristics of IOS.

Reference	Application Integration	Data Compatibility	Analytic Ability	Evaluation Ability	Alertness
Electronic Data Interchange (EDI) Perspective					
Saeed et al., 2005	System integration	Data flows			
Mukhopadhyay & Kekre, 2002		Item identification codes			
Truman, 2000	Interface integration				
Chatfield & Yetton, 2000	Integration of EDI with internal systems				
Massetti & Zmud, 1996	Depth	Depth			
Mukhopadhyay et al., 1995					
Bensaou & Venkatraman, 1995					
Interorganizational Systems Perspective					
Klein et al., 2007	IT customization	IT customization			
Rai et al., 2006	Cross functional SCM application integration	Data consistency			
Kim et al., 2006				Information transfer for monitoring	Information transfer for monitoring
Choudhary, 1997	System integration	Product code translation tables			Automatic alerts
Hess & Kraemer, 1994	End-to-end integration				
Clemons et al., 1993	Interconnected-ness	Integrated databases	Decision tools	Monitoring tools	
Malone et al., 1987	Separate, linked, & shared processes	Separate, linked, & shared processes			

Continued

Table 1: Continued

Reference	Application Integration	Data Compatibility	Analytic Ability	Evaluation Ability	Alertness
IOS Infrastructure Perspective					
Byrd & Turner, 2000	Connectivity	Compatibility			
Markus & Tanis, 2000	Integration of modules	Data sharing			
Duncan, 1995	Connectivity	Compatibility			
Operations Management (OM) Perspective					
Wang & Wei, 2007	Virtual integration				
Hill & Scudder, 2002	System integration				Exception handling features
Edwards et al., 2001	Application integration		Decision support tools	Decision support tools	
Narasimhan & Kim, 2001			Value creation management	Value creation management	
Zhao et al., 2001	Connectivity	Data sharing			

ability of any technology component to attach to any other technology component inside or outside the organization. Compatibility is the ability to share any type of data, and thus captures the competence of the system to support data compatibility. This stream of literature is summarized in Table 1, and highlights application integration and data compatibility as two key aspects.

IOS Characteristics—Operations Management Perspective

Research in the purchasing and operations management literature also provides interesting insights on IOS characteristics. Wang and Wei (2007) propose the concept of virtual integration, which captures the use of ISs in facilitating information visibility (i.e., orders, pricing, production planning, and inventory). On similar lines, Hill and Scudder (2002) stress that IOS facilitates frequent and automatic transfers of information required for high degrees of integration and coordination within the supply chain. They suggest that integration of the IOS with the internal systems of the firms and exception handling features are important characteristics of the IOS. Further, application integration and decision support tools are features of the IOS that support an extended enterprise (Edwards, Peters, & Sharman, 2001). Narasimhan and Kim (2001) propose ISs for infrastructural support (office automation and accounting systems), ISs for value creation management (systems supporting decision making and process control), and ISs for logistical operations (systems supporting transportation, forecasting, ordering, and warehousing) as three facets of IS utilization within the supply chain context. In general, research in the operations management domain summarized in Table 1 is consistent with other perspectives in highlighting the various integration features of the IOS. However, it brings out decision tools and event management features as distinct dimensions of the IOS.

IOS Characteristics—Synthesis of Different Perspectives

The broad concept of electronic integration has been discussed in various ways. Malone, Yates, & Benjamin (1987) define electronic interconnectedness as a progression from separate databases and processes to linked databases and processes that eventually evolve to shared databases and processes. Building on this work, Grover and Saeed (2007) capture electronic integration as sharing databases, applications, and files across trading entities. Clemons, Reddi, and Row (1993) emphasize interconnectedness of systems (application integration and data compatibility) and availability of analytical and performance evaluation tools as IOS characteristics that facilitate explicit coordination. A deeper assessment of the interconnectedness perspective shows that electronic integration captures the nature and direction of information exchange across trading entities (Saeed, Malhotra, & Grover, 2005).

Choudhury (1997) proposes a typology of IOS and stresses that electronic integration permits linked firms to jointly optimize the dyadic relationship. He also argues that it is important to look at the type of electronic integration rather than simply investigating whether such integration exists. Development of product code translation tables, automatic order alerts, and integration of systems that support boundary-spanning processes are presented as examples. Cumulatively, the EDI,

Table 2: Synthesis of research on IOS characteristics.

Reference	Application Integration	Data Compatibility	Analytic Ability	Evaluation Ability	Alertness
Klein et al., 2007	X	X			
Rai et al., 2006	X	X			
Kim et al., 2006				X	X
Saeed et al., 2005	X	X			
Subramani, 2004	X		X		X
Mukhopadhyay & Kekre, 2002		X			
Christiaanse & Venkatraman, 2002			X	X	
Kraemer & Dedrick, 2002		X	X	X	X
Kumar, 2001			X	X	
Edwards et al., 2001	X		X	X	
Byrd & Turner, 2000	X	X			
Chatfield & Yetton, 2000	X				
Truman, 2000	X				
Choudhury, 1997	X	X			X
Vijayasarathy & Robey, 1997					
Bensaou, 1997					
Kumar & van Dissel, 1996		X			
Massetti & Zmud, 1996	X	X			
Duncan, 1995	X	X			
Riggins & Mukhopadhyay, 1994; Mukhopadhyay et al., 1995	X				
Clemons et al., 1993	X		X	X	
Malone et al., 1987	X	X			

IOS, and IT infrastructure literature streams point toward application integration and data compatibility (data conventions and formats) as distinct subcomponents of IOS. However, analytic ability of IOS (tools for decision making), evaluation ability of IOS (supplier evaluation tools), and alertness of IOS (tools for exception handling), are additional facets of the IOS that are emphasized in the context of interfirm process integration. Table 2 provides a synthesis of this comprehensive conceptualization of IOS.

IOS CONSTRUCTS

To enhance the validity of the categorization scheme that we developed based on the literature (Tables 1 and 2), we conducted a careful evaluation of the various software products being offered by commercial software vendors in this space (Appendix A). Appendix B presents actual examples of how three companies used their IOS, while Appendix C provides an illustrative overview of the fit between the categorization scheme and supply chain application suite from Manugistics. These appendices provide corroborating evidence on the validity of the various characteristics of IOS that were identified through our extensive review. We briefly elaborate next on the constructs that capture the IOS characteristics.

Application Integration

Application integration captures the extent to which the IOS applications are seamlessly assimilated in the supply chain. IOS consists of various components (ordering system, inventory system, warehousing system, etc.) that are automated representations of the business processes. It is imperative that these components are configured to recognize the dependencies between business processes, and are able to communicate with each other (Riggins & Mukhopadhyay, 1994; Truman, 2000; Klein et al., 2007). For example, an order by a customer triggers the sales process on the supplier's side. Subsequently, invoicing, inventory, and payment processes may also be invoked. These processes transform the data and pass it on to other processes for further transformation. Thus, the ordering system has to be programmed to interface with inventory and payment systems to manage process dependencies between them. Similarly, data transaction between the ordering system and the inventory system may involve accessing and updating different databases. Supply Chain Reference Model (SCOR) (www.supply-chain.org) and Rosettanet (www.rosettanet.org) are general standards that facilitate complete integration among the system components between collaborating firms.

Data Compatibility

We define data compatibility as the extent to which the IOS follows the same data formats, conventions, and metrics to be used by the firm and its supply chain partners. Companies may have different definitions for the same data elements and may also have different metric standards (Duncan, 1995; Truman, 2000; Ball, Ma, Raschid, & Zhao, 2001). These issues can be managed if standard industry conventions are prescribed, such as mapping or cross-referencing one company's products to the other's and aligning different units of measure. System-to-system exchange and updating of data in the databases can also be done by developing extensive conversion tables and routines.

Analytic Ability

Analytic ability is defined as the extent to which the IOS provides analytical tools to support decision making with respect to the supply chain functions. Eierman, Niederman, and Adams (1995) propose that decision support systems (DSS) characteristics can range from the ability to electronically extract information from databases to applying specific decision models to a particular situation. However, DSS characteristics have not received much attention in the domain of IOS, primarily because traditional IOS (i.e., EDI systems) were focused on data transmission and process execution. Advanced planning systems provide decision support such as forecasting, time series analysis, optimization techniques, and scenario-based planning (Kumar, 2001). Similarly, multicriterion decision making for procurement is proposed as an important feature of IOS (Geoffrion & Krishnan, 2001). The objective is to capture the variation in the sophistication of analytical tools. Systems with low analytic ability may provide rudimentary analysis support, such as extracting data based on certain parameters. Systems with high analytic ability may support statistical procedures, multidimensional view of data, higher-level supply chain maps, and simulation tools.

Evaluation Ability

Evaluation ability is defined as the extent to which the IOS provides tools that support the performance evaluation of suppliers and other members of the supply chain. Christiaanse and Venkatraman (2002) show that American Airlines uses SMARTS, a knowledge management system that utilizes data from the computer reservation system for monitoring distribution channel members. In the manufacturing sector, a system with features that can allow a firm to evaluate a supplier's performance can fulfill a similar purpose (Clemons et al., 1993). Firms need to consistently measure and monitor the relationships with their key suppliers to ensure smooth operations and shed light onto areas that are underperforming and need improvement.

Alertness

Alertness captures the extent to which the system is capable of detecting and reporting exceptions. Intelligence can be added to the system by specifying parameters that are constantly monitored by the system. For example, a system can be programmed to trigger orders to a supplier if the inventory falls below a certain level, or transmit alerts automatically (Choudhary, 1997) if the deviation between forecasts and actual status exceeds the established tolerance limit (Hill & Scudder, 2002).

SUPPLY CHAIN INTEGRATION

Firms can deploy IOS to support processes ranging from operational information exchange to pursuing strategic initiatives such as sharing ideas, identifying new market opportunities, and pursing a continuous improvement approach (Subramani, 2004; Rai et al., 2006; Wang & Wei, 2007; Klein et al., 2007). Performance gains in a supply chain can be achieved only when firms are willing to develop relationship specific processes and combine resources that are difficult to duplicate by other buyer–supplier combinations (Dyer & Singh, 1998). A critical issue to investigate is how IOS characteristics differ across dyadic links that show variation in integration of processes and routines in the supply chain. Assessment of this issue first requires a deeper understanding of the interfirm linkages, which we call SCI.

We adopt in this study a comprehensive three-dimensional conceptualization of SCI that includes strategic, operational, and financial integration (Saeed, 2004). We use this conceptualization because it synthesizes most of the prior SCI measurement approaches. Each dimension represents an organizational capability that facilitates the broader capability of SCI.

Strategic integration is defined as the extent to which members of the supply chain have developed joint knowledge sharing routines that facilitate use of innovative practices, sharing of new ideas, and working together in identifying and implementing improvement initiatives. Collaborative relationships exhibit knowledge sharing processes and promote leveraging of complementary resources (Bensaou & Venkatraman, 1995; Dyer & Singh, 1998; Modi & Mabert, 2007). Interaction involves actively sharing new ideas, jointly developing products, and working together toward identifying improvement initiatives.

Operational integration captures the extent to which supply chain members link decisions at different stages of the supply chain by routinely coordinating various operational processes and activities through information sharing. Clemons, Reddi, and Row (1993) argue that the degree to which operational decisions are integrated between two economic entities is an important dimension of relational governance structure. Researchers propose the joint undertaking of planning and scheduling activities, joint ownership of the master production schedule, adherence to manufacturing plans, and visibility of information as operational depictions of integration (Cachon & Fisher, 2000; Wang & Wei, 2007).

Financial integration is defined as the extent to which supply chain partners jointly invest in projects of mutual interest. Stank, Keller, & Closs (2002) propose that the sharing of assets and technology is a critical aspect of close coupling among supply chain partners. Further, joint investments from supply chain members show a willingness to share risks, and can result in resource efficiencies and process improvements (Lockström, Schadel, Harrison, Möser, & Malhotra, 2010). Dyer and Singh (1998) argue that investment in relationship specific assets is an important aspect of idiosyncratic interfirm processes. Investments in joint R&D initiatives and new process development projects ensure alignment of expectations, and foster a greater understanding of how product and process interfaces can be streamlined.

IOS CHARACTERISTICS AND SUPPLY CHAIN INTEGRATION

IT systems can be configured to support repetitive tasks or unstructured tasks (Subramani, 2004). The choice is linked to the integration of operational and strategic interorganizational processes. Building on this work, Malhotra, Gosain, and El Sawy (2005) show that organizations with different collaboration capabilities depict variation in the configuration of IT systems in terms of storage, retrieval, manipulation, and interpretation of information related to the relationship with supply chain partners. Coordination theory (Malone & Crowston, 1993) provides further guidance on the role of IOS in managing process dependencies. It argues that IOS can be used to support process automation. However, it also suggests that IOS can be deployed to support new coordination configurations.

Coordination theory argues that selection of the IOS configuration dictates how process dependencies are managed. For example, automation of the ordering process can improve information flows and management of exceptions. Accumulation and assessment of information can help guide sourcing decisions, manage supplier evaluation, and indicate areas of opportunity or deficiency. Thus, according to coordination theory, choices that an organization makes in configuration of IOS shape the development of specific interfirm process capabilities. This concept is also visible in the shift by many firms from developing proprietary systems to configuring components to develop IOS architecture. Because they aim to develop specific process capabilities, organizations make deliberate decisions on selection and configuration of IT components. Thus, in examining how various facets of the IOS support integration across a multitude of interfirm processes, coordination theory provides a contingency lens. The choice of IOS features by a firm reflects its understanding of IOS characteristics and their linkage with supply chain processes.

We take an inductive approach toward evaluating this issue by examining the configurations of IOS in firms that are at different points in the SCI space, whereby the first step in achieving this objective is to understand SCI and identify variation in SCI across firms. This approach enables us to group firms into categories that show similar SCI profiles. Subsequently, we evaluate how IOS characteristics vary across these SCI profiles. We expect two interesting outcomes by following this approach. First, it enables us to gain insights into specific IOS characteristics that are emphasized across SCI profile groups at a granular level, an issue that prior studies have not adequately addressed. Second, comparison of IOS characteristics across SCI profiles can potentially provide a better understanding of the progression that firms follow in the development and deployment of their IOS features.

RESEARCH METHOD

This study takes a decidedly nuanced approach to IOS characteristics and SCI. Given the novel nature of the conceptualizations, there is an exploratory, theory-building undertone in this study and the development of its measures. It was therefore decided to initially conduct case-based detailed interviews at four firms to validate the conceptualization of IOS characteristics and refine the instrument. A structured protocol was followed in conducting the case studies, which included a process and a set of questions that were classified into different sections (e.g., business context, IOS applications, and SCI). The first two case studies included interviews with high-level managers in charge of both purchasing and IT. In the latter two firms, managers in charge of purchasing and supply chain were interviewed. After completion of the case studies, a larger scale data collection was completed through a survey.

Preliminary Case Studies for Validating Scale Development

An extensive literature review was conducted to cover the content domain of each IOS construct. The Delphi Study by Akkermans, Bogerd, Yucesan, and van Wassenhove (2003), along with panel discussions of industry experts conducted by *Business Week* and *CIO* magazine on concepts such as collaborative systems, integration, and visibility provided the insights into the content of the constructs. New items for the constructs were generated in most cases, and measurement items from previously validated scales were used when available. After item generation, a panel of judges consisting of four faculty members and seven PhD students participated in a Q-sort procedure (Moore & Benbasat, 1991). Overall, the accuracy of classification ranged from 86% to 100% for the IOS constructs. Based on these results and inputs provided by the judges, items were either modified or dropped. Measurement scales for SCI were adopted from Saeed (2004).

After initial purification of the items, the instrument was administered in person at four case study firms as described before. Along with gathering contextual and firm specific information at each site, the respondents were asked to fill out the instrument in the presence of the researchers and asked to follow a "think aloud" method where they vocalized any issues, ambiguities, or problems that they encountered (Fich-Benbunan, 2001). Appendix D provides brief information about the case study firms, their recommendations, and corresponding changes made to the instrument. The resulting final items for each scale and their literature sources are presented in Tables 3 and 4.

Unit of Analysis and Study Sample

The dyadic relationship between the buyer and supplier was selected as the unit of analysis. We asked the respondent to select an ongoing relationship with a supplier through which a particular component that is important to their production process is purchased. The respondents were instructed to answer the instrument questions with respect to that selected relationship and component only. Previous studies in this domain have used high-ranking purchase managers, logistics managers, IS directors, engineering executives, and manufacturing executives as key respondents (Bensaou, 1997; Narasimhan & Kim, 2001; Stank et al., 2002). Based on the insights gathered through case interviews, high-level purchase managers were deemed as the appropriate key respondents due to their ability to effectively respond to questions that involve multiple boundary spanning functions, IT, and relationship issues.

Multiple surveys were conducted to collect the data from firms in the manufacturing sector. The first wave involved sending mailings to 597 firms after accounting for undeliverable packets. These firms were randomly selected from the ELM Guide to North American Supplier Database. After mailing follow up reminder cards and placing phone calls to a random sample of 100 firms, 22 responses were received. In the second round, the survey was mailed to another 254 firms after accounting for bad addresses. The new list was randomly generated from the Dun and Bradstreet database. We received 31 responses from this mailing effort. The cumulative response rate was 6% for the 50 completed surveys received between the first and second samples (three responses were dropped due to incomplete data). Recently published studies show a similar trend in terms of response rate (Ray, Muhanna, & Barney, 2005; Banker, Bardhan, Chang, & Lin, 2006). Telephone follow up with nonrespondents revealed that the length of the study questionnaire and incorrect information about respondents in the databases contributed to the low response rate.

The sales profile in Table 5 shows that the majority of the firms have sales of 500 million or less. The employee profile shows a similar trend, wherein, 57% of the firms have 500 or less employees. Although it seems that most firms fall in the small to medium size range, it should be noted that the data was collected at the

Table 3: Items for IOS characteristics.

Item No.	Application Integration Items	Source
AI 1	Supply chain planning applications used between the supplier and our firm (such as demand planning, production planning, distribution planning, etc.) are integrated.	Rai et al., 2006; Markus & Tanis, 2000; Edwards et al., 2001
AI 2	Supply chain execution applications used between the supplier and our firm (such as procurement, manufacturing, inventory, warehousing, sales, etc.) are integrated.	Rai et al., 2006; Truman, 2000; Markus & Tanis, 2000
Item No.	**Data Compatibility Items**	**Source**
DC 1	The data formats and standards used in the IT systems / IT applications of our firm and supplier S's firm are based on a common industry standard (for instance AIAG, etc.)	Duncan, 1995
DC 2	We have synchronized data formats and standards with supplier S.	Rai et al., 2006; Duncan, 1995
DC 3	Bar coding used by our firm and supplier S are compatible with each other.	Jayaram et al., 2000; Duncan, 1995
Item No.	**Analytic Ability Items**	**Source**
AA 1	The IT systems/IT applications offer various decision making tools (such as optimization, scenario analysis, etc.) for managing our relationship with supplier S.	Kumar, 2001; Geoffrion & Krishnan, 2001; Clemons et al., 1993
AA 2	The IT systems/IT applications offer various tools that can enable us to examine trends in the data for managing our interaction with supplier S.	Christiaanse & Venkatraman, 2002; Kumar, 2001
AA 3	The IT systems/IT applications offer various statistical tools for supporting our interactions with supplier S.	Kumar, 2001; Geoffrion & Krishnan, 2001
Item No.	**Alertness Items**	**Source**
AL 1	IT systems/IT applications based on preset levels can automatically detect and report deviations from plans to the concerned personnel in both firms.	Kraemer & Dedrick, 2002; Hill & Scudder, 2002
AL 2	IT systems/IT applications can notify the concerned personnel in both parties regarding events that may require adjustments.	Kraemer & Dedrick, 2002; Choudhary, 1997
AL 3	IT systems/IT applications can automatically prioritize exceptions based on preset criteria.	Kraemer & Dedrick, 2002
Item No.	**Evaluation Ability Items**	**Source**
	Please indicate the extent to which the IT systems/IT applications can be used to evaluate the following	
EA 1	Delivery criteria	Stump & Heide, 1996
EA 2	Quality criteria	Stump & Heide, 1996

Table 4: Items for supply chain integration.

Item No.	Strategic Integration
SI 1	My firm jointly works with supplier S to identify and implement continuous improvement initiatives.
SI 2	My firm shares new ideas with supplier S.
SI 3	My firm shares best practices with supplier S.
Item No.	**Operational Integration**
OI1	My firm routinely coordinates/shares production plans with supplier S.
OI2	My firm routinely exchanges demand forecasts with supplier S.
OI3	My firm routinely coordinates/shares information related to delivery activities (production schedules, delivery schedules, material releases, advanced shipment notices (ASN), etc.) with supplier S.
Item No.	**Financial Integration**
FII1	My firm shares research and development costs with supplier S.
FII2	My firm helps supplier S finance capital equipment.
FII3	My firm invests in process development with supplier S.

Table 5: Profile of the firms represented in the study.

Sales (in Millions)	Number of Firms	Number of Employees	Number of Firms	Designation	Number of Respondents
25 and less	31%	101–250	31%	Purchasing Director, Director Operations, VP Purchasing	27%
26–50	11%	251–500	26%	Purchasing Manager, Materials Manager, and Buyer	68%
51–100	11%	501–1000	21%	Others	5%
101–250	16%	1001–2500	10%		
251–500	27%	2501–5000	4%		
501–1000	2%	5000 and More	8%		
1001 and more	2%				

plant level (one plant per company), and that most of the plants were actually part of a larger firm. The analysis of key respondents showed that 27% were executives directly involved with managing the procurement function, whereas 68% occupied middle-level purchasing positions within their respective firms.

Nonresponse bias was examined in two ways. First, comparison between respondents and a randomly selected set of nonrespondents from the overall sample frame revealed there were no significant difference based on the number of employees. Second, comparisons between early and late respondents with regards to sales, number of employees, and the study variables showed that these groups were not different from each other on any of these variables at the 0.05 level of significance.

Construct Validity

We used the procedure proposed by Jarvis, Mackenzie, and Podsakoff (2003) to determine if a construct should be modeled as formative or reflective. In case of ambiguity, theoretical lenses and past research on the conceptualization and measurement of the construct were used to make the decision (Barclay, Thompson, & Higgins, 1995; Chin & Gopal, 1995; Hulland, 1999). Psychometric properties of the study scales are shown in Table 6. We first conducted factor analysis to assess uni-dimensionality, and then to assess reliability. Factor analysis for the IOS characteristics constructs was an iterative process, where certain items were dropped due to low loading or cross loading. In Table 6, the results for internal consistency (Fornell & Larcker, 1981) show that reliability for all the constructs is above the recommended guideline of 0.70 (Nunnally, 1978). The reliability values for formative constructs are not reported because their indicators may or may not be correlated with each other, thereby rendering reliability analysis irrelevant (Bollen & Lennox, 1991; Hulland, 1999).

In the case of reflective measures, loadings and composite reliability based on the PLS (inner model) were used to assess convergent validity, while the comparison between the square root of average variance extracted and correlations among constructs was employed to examine discriminant validity (Hulland, 1999). Researchers propose additional assessment guidelines in the case of PLS models. First, assessment of the magnitude (loadings higher than 0.55) and significance of the loadings of the items on the construct are recommended (Falk & Miller, 1992). It is also proposed that the average variance extracted (AVE) should exceed the threshold value of 0.50 (Barclay et al., 1995). Table 6 provides evidence that both these guidelines were met for the reflective constructs used in this study.

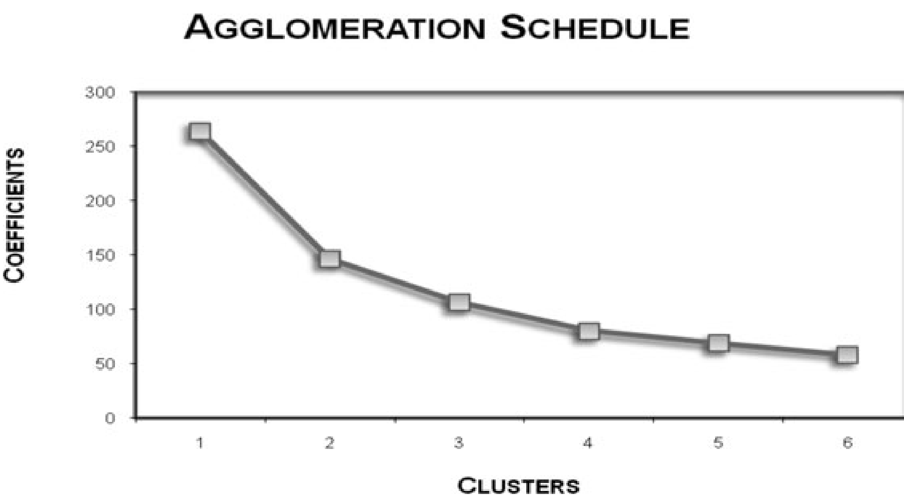
PLS provides weights instead of loadings for the formative measures. The significance of the weights can vouch for the convergent validity of formative constructs (Barclay et al., 1995). Table 6 shows that all weights are statistically significant. These weights can be converted into loadings for calculating AVE. This approach is consistent with traditional interpretation of canonical correlation results (Barclay et al., 1995). The analysis shows that the constructs exhibit satisfactory convergent validity. However, the traditional approach of assessing discriminant validity by comparing value for the square root of AVE with the variance shared between the construct and other constructs in the model is not appropriate for formative constructs.

Common method bias is an important issue in survey research that should be examined. Two sources for common method bias relevant to our study are bias due to the scale effect and bias due to the item context effect (Podsakoff, Mackenize, Lee, & Podsakoff, 2003). We conducted Harman's single factor test to evaluate these biases. The results of this test did not show that a single factor accounts for the majority of the covariance among the measures, thus indicating that common method bias does not impact the study results.

Table 6: Loadings and average variance extracted (PLS).

Latent Construct	Type	Indicators	Loading/ weights in ()	T-Values	Average Variance Extracted (Composite Reliability)
Application integration	Formative	Application integration 1	0.83 (0.69)	3.49	.59 (.74)
		Application integration 2	0.71 (0.15)	1.87	
Data compatibility	Reflective	Data compatibility 1	0.89	15.82	.75 (.90)
		Data compatibility 2	0.93	41.28	
		Data compatibility 3	0.76	8.56	
Alertness	Reflective	Alertness 1	0.91	23.39	.84 (.94)
		Alertness 2	0.92	26.10	
		Alertness 3	0.92	38.79	
Analytical ability	Reflective	Analytical ability 1	0.92	35.56	.89 (.96)
		Analytical ability 2	0.95	59.92	
		Analytical ability 3	0.95	40.07	
Evaluation ability	Formative	Evaluation ability 1	0.90 (0.59)	7.74	.77 (.87)
		Evaluation Ability 2	0.85 (0.46)	3.18	
Supply chain integration	Reflective	Strategic integration 1	0.78	7.33	.76 (.90)
		Strategic integration 2	0.90	26.15	
		Strategic integration 3	0.91	29.24	
		Operational integration 1	0.83	18.11	.75 (.90)
		Operational integration 2	0.88	16.73	
		Operational integration 3	0.89	25.76	
		Financial integration 1	0.75	7.95	
		Financial integration 2	0.89	23.67	
		Financial integration 3	0.88	24.84	.71 (.88)

Figure 1: Graph of error coefficients based on the agglomeration schedule.



RESULTS

The first step in determining our results was to construct the supply chain profiles. We followed the two step clustering process used by Malhotra, Gosain, and El Sawy (2005) to identify SCI groups. It is recommended that hierarchical and non-hierarchical techniques be used as complementary clustering methods (Sharma, 1996). The hierarchical approach offers the advantage that it does not require a priori knowledge of the number of clusters. However, once an observation is assigned to a cluster, it is not reassigned. This limitation is not present in nonhierarchical clustering. Thus, hierarchical clustering should be used first to identify the number of clusters. Those results can then be used to run nonhierarchical clustering analysis.

First, SCI groups were identified through the use of hierarchical clustering based on the three dimensions of SCI. Ward's method with squared Euclidean distance was used to perform the analysis. Ward's method forms clusters by maximizing the within group homogeneity. Further, Gong and Richman (1995) suggest that Ward's method provides robust results even with small sample sizes. Two heuristic-based techniques were used to identify the number of clusters. The first one involves examination of the agglomeration schedule, which provides information on the amount of error created when the groups are merged. A relatively large jump in the coefficient indicates that two dissimilar groups are being aggregated together. Figure 1 shows the plot of the error coefficients. A relatively large upturn in the error coefficient is visible when number of clusters is reduced from three to two, so the agglomeration table supports a three cluster solution. The second technique involved the examination of the dendogram, which provided further evidence supporting a three cluster solution.

At the next stage, a K-means nonhierarchical clustering technique was used by specifying the number of groups obtained from the earlier analysis. Further,

Table 7: Cluster analysis.

Dimensions	High Supply Chain Integration Group	Medium Supply Chain Integration Group	Low Supply Chain Integration Group
Strategic integration	5.92	4.96	3.14
Operational integration	6.47	5.53	4.22
Financial integration	5.02	2.17	2.89
Number of cases	16	22	12

Table 8: ANOVA test for differences in SCI dimensions across SCI groups.

	F Value	*p* Value	Power
Strategic integration	51.02	.00	1.00
Operational integration	36.98	.00	0.99
Financial integration	44.68	.00	0.99

Table 9: Difference in SCI dimensions across SCI groups (Tukey).

	Strategic Integration	Operational Integration	Financial Integration
High SCI group vs. low SCI group	2.78 (.00)	2.25 (.00)	2.13 (.00)
High SCI group vs. medium SCI group	0.96 (.00)	0.95 (.00)	2.85 (.00)
Medium SCI group vs. low SCI group (*p*-value)	1.82 (.00)	1.30 (.00)	−0.72 (.09)

the group centroids (means) for each dimension of SCI that were obtained from the results of hierarchical cluster analysis were used as initial cluster centers or starting seeds. The three groups identified through this two-step process were labeled as high SCI group, medium SCI group, and low SCI group (Table 7). The next step was to evaluate whether these SCI groups were distinctly different from each other on the SCI dimensions. We conducted an analysis of variance (ANOVA) test and multiple comparison procedure Tukey's test for this purpose. The results in Table 8 show that in general, the SCI groups are different across the SCI dimensions. The three SCI groups depict a significant increase in the SCI subdimensions from low SCI group to high SCI group (Table 9). The results show that companies in the high SCI group have significantly higher strategic, operational, and financial integration as compared to the low SCI group and the medium SCI group. The comparison across the low SCI group and the medium SCI group shows a significant increase in strategic and operational integration. Financial integration, however, was marginally higher for the low SCI group. Thus, companies in the medium SCI group have significantly higher strategic integration and operational integration as compared to companies in the low SCI group, but the companies in the two groups did not differ significantly across

Table 10: Correlation matrix with average variance extracted (diagonal).

	Mean	*SD*	1	2	3	4	5	6	7
Application integration	4.29	1.67							
Data compatibility	4.54	1.73	.55**						
Alertness	3.91	1.85	.78**	.56**					
Analytical ability	3.77	1.67	.70**	.51**	.72**				
Evaluation ability	4.92	1.61	.62**	.34*	.62**	.71**			
Strategic integration	4.83	1.28	.45**	.25	.56**	.46**	.43**		
Operational integration	5.52	1.09	.43**	.13	.54**	.40*	.28*	.51**	
Financial integration	3.25	1.55	.25	.36*	.29**	.36**	.13	.34**	.44**

**p-value < .01 and *p-value < .05.

Table 11: Means for IOS characteristics across SCI groups.

Dimensions	High Supply Chain Integration Group	Medium Supply Chain Integration Group	Low Supply Chain Integration Group
Application integration	5.31	4.20	3.08
Data compatibility	5.60	4.08	3.97
Analysis ability	4.88	3.55	2.72
Alertness	5.15	3.80	2.44
Evaluation ability	5.47	5.14	3.79

Table 12: ANOVA test for differences in SCI dimensions across SCI groups.

Variables	*F* Value	*p* Value	Power
Application integration	7.86	.00	0.98
Data compatibility	5.26	.01	0.93
Analysis ability	7.75	.00	0.97
Alertness	10.20	.00	0.99
Evaluation ability	4.73	.01	0.95

financial integration dimension. The next step in the analysis was to evaluate the configuration of IOS characteristics across the three SCI groups.

The means and standard deviations for the constructs, along with construct correlations, are given in Table 10. The average values for IOS characteristics across the SCI groups are presented in Table 11. As before, comparisons of IOS characteristics across the three SCI groups were assessed through ANOVA and Tukey's multiple comparison procedure. The results show that all dimensions of IOS characteristics are significantly different across the high SCI group and the low SCI group (Tables 12 and Table 13). The power of the test reported in Table 12 shows that it is above the 0.80 threshold in all cases, thereby supporting the validity of the results. Firms in the high SCI group have significantly higher application integration, data compatibility, analytic ability, alertness, and evaluation ability as compared to the firms in the low SCI group. The high SCI group also has significantly higher data compatibility, analytic ability, and alertness as

Table 13: Difference in IOS characteristics across SCI groups (Tukey's Test).

Groups/ Variables	Application Integration	Data Compatibility	Analysis Ability	Alertness	Evaluation Ability
High SCI group vs. Low SCI group	2.23 (.00)	1.63 (.03)	2.15 (.00)	2.70 (.00)	1.68 (.01)
High SCI group vs. Medium SCI group	1.11 (.07)	1.53 (.02)	1.33 (.02)	1.34 (.03)	0.33 (.78)
Medium SCI group vs. Low SCI group	1.12 (.10)	0.10 (.98)	0.82 (.28)	1.36 (.05)	1.35 (.04)

compared to the medium SCI group (Table 13). However, significant difference across low SCI group and medium SCI groups was observed only in terms of evaluation ability and alertness. Overall, the results support the general thesis that firms with different SCI profiles tend to emphasize different IOS characteristics. However, the unique value of our results lies in providing an understanding of which specific IOS characteristics are emphasized by each SCI group, and how this emphasis is different across the SCI categories.

Our results show that all IOS characteristics are significantly different across the low SCI group and the high SCI group. Although an increase in values for application integration, data compatibility, and analytic ability is observed, the increase is not statistically significant across the low SCI group or the medium SCI group. Further, the difference across the high SCI group and the medium SCI group is not significant across application integration and evaluation ability. Thus, the variation in these aspects of IOS characteristics follows a different pattern. If it is assumed that firms progress from low SCI to high SCI, it can be argued that firms build on IOS dimensions as they move up the SCI scale. In some cases, the difference across IOS dimensions is significantly different across each of the SCI groups, whereas in other cases the differences become significantly clear across the companies at the extreme ends of the SCI space. For example, alertness shows a consistent increase across the three SCI groups. On the other hand, data compatibility and analytic ability are only significantly discernable across the high SCI group and the medium SCI group. Evaluation ability is significantly different across the low SCI group and the medium SCI group. But no significant improvements in evaluation ability are undertaken by firms in the medium SCI group as compared to firms in the high SCI group. Application integration shows a unique pattern wherein we see a progressive increase in values across the three groups. However, the difference is only significant across the low SCI group and the high SCI group. Thus, the results show an interesting pattern of IOS characteristics deployment across the SCI groups, which we elaborate on next.

DISCUSSION

We believe that the conceptualization and measurement approach presented in this study provides a deeper understanding of the IOS artifact than that understood in prior literature (Massetti & Zmud, 1996; Choudhary, 1997; Malhotra et al., 2005;

Rai et al., 2006; Klein et al., 2007; Wang & Wei, 2007), and subsequently takes a step forward in opening up the IT black box. Assessment of the IOS artifact in the supply chain context shows that firms at different levels of SCI depict variation in deployment of IOS characteristics. Significant differences in integration of supply chain applications and compatibility of data formats are visible across the low SCI group and the high SCI group. These IOS dimensions provide the infrastructure that firms leverage to streamline supply chain processes. For example, if a buyer is able to get an early commitment from the suppliers through the integrated system, the ability of the buyer to respond to its customers increases. The absence of IOS features related to system integration promotes manual data entry, which substantially affects data quality. Bad data quality actually reorients the firm toward fire fighting rather than managing the supply chain process and relationships. Application integration and data compatibility promote coordination of production and delivery schedules such that both organizations are working toward common goals.

We found significant differences in analytic ability, evaluation ability, and alertness across the low SCI group and the high SCI group (Table 13). However, all three IOS characteristics depicted a different pattern. Analytic ability shows variation across firms in the high SCI group and the medium SCI group. Buyers can leverage analytical features to conduct scenario analysis and develop effective plans for given parameters. Tools that enable firms to drill down into the data, examine trends, and run optimization scenarios cannot only enable coordination of joint activities, but also provide insights into areas of opportunities. Clemons, Reddi, and Row (1993) argue that decision support abilities of the IOS play an important role in facilitating operational integration and linking decisions across the supply chain. For example, production plans and capacity can be jointly developed and managed to streamline material flows. However, IOS features that support such initiatives are more prominent among firms that are higher on the SCI spectrum.

Except for the medium SCI group and the high SCI group, evaluation ability was found to differ across all groups. As firms start to scale the SCI ladder, the initial steps involve putting in place IOS characteristics that increase their capability to effectively evaluate supplier performance. Evaluation ability of the IOS enables the firm to consistently monitor and evaluate performance in areas such as cost, delivery, conformance to product specifications, and compliance with standards. Thus, features associated with tracking supplier performance can be used to identify problematic areas that can potentially escalate in the future. Finally, alertness is the only IOS characteristic that was different across all SCI groups. Alertness features enable the firms to proactively detect and report exceptions to the concerned parties so that immediate action can be taken to manage them. Automatic alert features enable the firms to stay on top of issues and proactively manage exceptions. Thus, exception handling features and supplier evaluation features can enable firms to quickly recognize issues that need to be addressed and develop an effective organizational response mechanism (Kambil & Short, 1994; Bensaou & Venkataraman, 1995).

What is the progression that firms go through in terms of configuring the various IOS characteristics? An important aspect that has not been adequately addressed in literature is the sequence of ISs selection and implementation in the supply chain context. ISs decisions traditionally are made in a vacuum. Few firms engage in a systematic assessment of the sequence of ISs projects. Our study provides initial guidance on this issue in the context of IOS through an inductive assessment of choices that organizations have made.

Configuring an integrated IOS is actually a process that organizations pursue on a continuous basis. Our results show that progressing toward an integrated IOS requires long-term commitment. The process starts with integrating systems across the supply chain and then progressing to adoption of common data conventions ideally based on an industry standard. Consequently, the improvements in SCI through application integration and data compatibility show an incremental approach. Firms in the lower SCI space invest in application integration, while firms in the higher SCI space sustain the emphasis on application integration and supplement it with data compatibility. This assertion is supported by the increase in application integration across the three SCI groups, while the differences in data compatibility are only significantly visible across firms at the higher end of the SCI space.

Alertness, evaluation ability, and analytic ability show a different sequence as outlined earlier. It seems that firms at the lower end of the SCI space initially configure IOS characteristics that assist them in better monitoring their supplier's performance and automate detection of exceptions to reduce the resources expended on fire fighting and responding to exceptions related to supply chain processes. As the firms move to the higher end of the SCI space, the investment in alertness features is sustained along with pursuit of new initiatives related to analytic ability. However, the emphasis on evaluation ability drops off at this stage.

Overall the results show that initial investments of the firms go into configuring those IOS characteristics that will help in evaluating, monitoring, and streamlining links with the business partners along with working on IOS characteristics associated with system integration. As firms move into the higher end of the SCI space, they put more emphasis on IOS characteristics that support data compatibility and planning and forecasting capabilities. The sequencing is intuitive because configuring the IOS with planning and forecasting features may be ineffective without first putting in place effective monitoring and exception handling features.

To gain further insights into the role of IOS characteristics in the context of SCI groups, we conducted multigroup discriminant analysis (MDA). The objective of this analysis was to gain better understanding of how IOS characteristics jointly differentiate across the SCI groups. Analysis grouped the IOS characteristics into two distinct discriminant functions based on a rotated factor structure using Varimax rotation. It is important to note that the aggregation of the IOS characteristics is mainly driven by the extent to which the factors distinguish between the SCI groups rather than how these characteristics can be conceptually grouped together. Table 14 shows that application integration, alertness, and evaluation ability were grouped together, whereas data compatibility and analytic ability were grouped into a separate discriminant function. We call these functions "evaluation support" and "planning support," respectively. The plot of the group centroids for the functions shows that the value for evaluation support increases sharply when comparing the low SCI group and the medium SCI group (Table 15 and Figure 2), but the

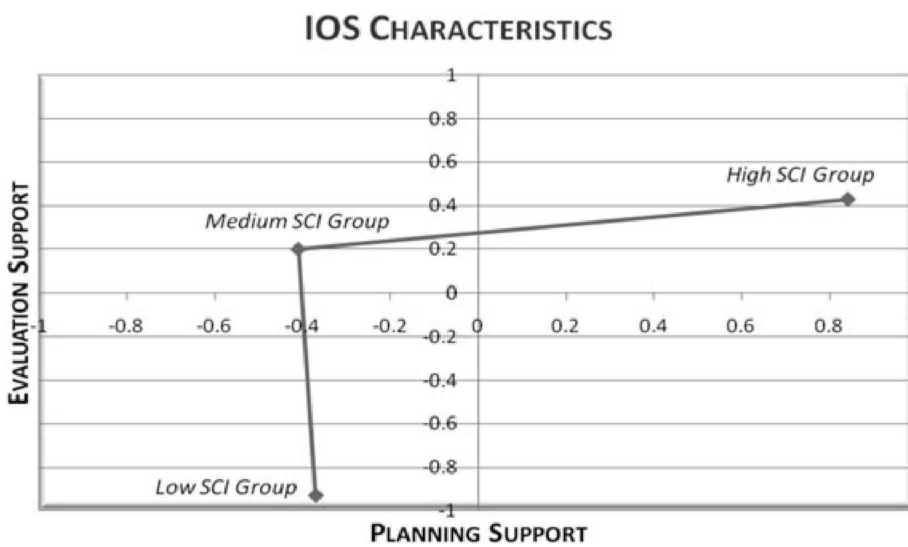
Table 14: Rotated structure matrix.

IOS Characteristics/ Discriminant Functions	Function 1	Function 2
Evaluation ability	.03	.80(∗)
Alertness	.54	.79(*)
Application integration	.47	.69(*)
Analysis ability	.62(*)	.52
Data compatibility	.75(*)	.09

Table 15: Discriminant functions at group centroids.

SCI Groups/ Discriminant Functions	Function 1	Function 2
High SCI group	.84	.43
Medium SCI group	−.41	.20
Low SCI group	−.37	−.93

Figure 2: Plot of discriminant functions at group centroids.



value for planning support drops marginally. On the contrary, when comparing the medium SCI group and the high SCI group, the value for planning support goes up sharply. These results further support the sequencing argument and confirm that firms in the low and medium SCI groups invest in integrating the IOS and deploying IOS with alertness and evaluation ability features. Firms in the high SCI group show sustained commitment to features related to system integration and alertness, along with a renewed focus on standardizing data conventions and emphasis on features that support planning and optimization. Overall, organizations are faced with a multitude of options in how they can configure IOS. Our results show that the choices firms make reflect the type of interfirm process capabilities they intend to develop, and successful firms depict a better understanding of the sequence in which IOS characteristics need to be configured to support interfirm process capabilities.

CONCLUSION AND IMPLICATIONS FOR RESEARCH AND PRACTICE

This study has broken significant new ground, albeit with the limitation of a relatively small sample size. In order to address this concern, we adopted appropriate statistical techniques and evaluated the data using parametric analysis as well as nonparametric analysis (which was done to check the validity of the results and is not reported in the study). Interestingly, we found the results to be consistent across both statistical techniques. We also recognize the consequences of selecting IOS characteristics rather than IOS usage. An IOS usage approach does assist in addressing the impact of IT systems and the extent to which they are utilized. However, our study context required that we delineate the IT system from its supporting processes. Thus, the IOS characteristics approach we used was deemed to be more appropriate for our study.

Overall, we believe that our endeavor is in line with the calls in IS research to examine the underlying facets of the IT system. Untangling IOS into its subdimensions provides a much broader conceptualization. Technology aspecific conceptualization ensures that it can be used effectively by researchers, even as newer technologies are developed and implemented. Such an approach creates new avenues in extending prior theoretical understanding of the IOS phenomenon. Expounding on the underlying dimensions offers a better measurement approach, and enhances the ability to specify better research models.

Effective deployment of IT systems enables organizations to transform their processes and build capabilities. The results of the study support this line of reasoning, albeit in an interorganizational context providing several implications for theoretical development. Subramani (2004) proposes that IT systems create multiple affordances, which are different ways in which firms can leverage IT systems. Affordances capture the cost and benefits of different possibilities that IT systems may offer to the organizations. Sambamurthy, Bharadwaj, and Grover (2003) propose the concept of digital options, which are IT enabled capabilities in the form of digitized processes and routines that can enable organizations to exploit emergent opportunities. Our study examines the underlying IT structures that create these digital options and shows how IT structures are leveraged to support the integration of diverse processes between firms. Further, our results bring forward the notion that firms focus on certain IOS characteristics at different stages of SCI, which in turn creates opportunities for adding new IT features to support advanced process integration capabilities.

Our study raises many specific issues that deserve further attention. First, environmental factors, such as rate of change in products and markets and different order fulfillment approach of the manufacturing firms can provide further insights. Eisenhardt and Martin (2000) emphasize that turbulence in an organization's operational environment can alter the nature of relationship among constructs. A similar concept proposed by Fine (1998) is that of clock speed, which captures the rate of change in products, markets, and environment. An extension of this study could be to examine how the configuration of IOS characteristics in firms is impacted by the firms' clock speed. Second, the preliminary evidence presented in this study assists in understanding the IOS configuration choices made by firms in the context of SCI. Recently, firms have started to pursue new initiatives such as supply chain flexibility and supply chain agility. Future studies can explore the IOS characteristics that organizations deploy to support these new initiatives and programs.

For managers, we provide guidance on the structural configuration of IOS that supports integrated supply chains. Our inductive assessment reveals the selection and configuration of IOS characteristics at different stages of SCI. These results help managers better comprehend the IOS phenomenon and gain insights into the sequence in which IOS characteristics are deployed to support higher levels of SCI. Further, deployment of IOS is an endeavor that requires time and resources. For example, investing in developing an integrated IOS requires ongoing effort, the results of which are only visible across firms that are at the extreme end of the SCI spectrum. Cumulatively, this study provides a preliminary diagnostic tool for identifying opportunities to develop and deploy IOS features in a supply chain context.

In an environment where interorganizational relationships and the IT artifact are becoming increasingly prominent, we believe that this work offers a conceptual foundation for further work. Future research in this area can utilize and further refine the IOS conceptualization proposed in this study, and examine more elaborate models that incorporate IOS, supply chain capabilities, and supply chain performance across both manufacturing and distribution settings. [Received: December 2009. Accepted: October 2010.]

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APPENDIX A: REVIEW OF SUPPLY CHAIN SOFTWARE PRODUCTS OF DIFFERENT COMMERCIAL VENDORS

Variables/Products	Application Integration	Data Compatibility	Analytic Ability	Evaluation Ability	Alertness
Tibco Inc.	X				
Manugistics (Acquired by JDA Software Group)	X	X	X	X	X
Celarix (Acquired by GXS)	X	X	X	X	X
SAP	X		X	X	X
Savi	X	X	X	X	X
J.D Edwards	X	X	X	X	X
Baan (Acquired by SSA Global)	X		X	X	X
People Soft (Acquired by Oracle)	X		X	X	X
Ariba	X		X	X	
I2	X		X	X	X
Oracle	X		X	X	

Continued

APPENDIX A: Continued

Variables/Products	Application Integration	Data Compatibility	Analytic Ability	Evaluation Ability	Alertness
Commerce One (Acquired by Perfect Commerce)	X		X	X	
Siebel Systems (Acquired by Oracle)	X		X	X	
BEA Systems	X	X			

APPENDIX B: COMPANY EXAMPLES

- In Dana Corporation, several different procurement applications were being used to coordinate with the suppliers. This required 9 months to gather necessary information to renegotiate contracts with their suppliers. Through a strategic sourcing solution (from i2 Technology Inc. later acquired by JDA software group), Dana was able to integrate these applications (application integration). This required standardization of procurement processes. In addition, consolidation of part number information was also undertaken for managing data compatibility issues (data compatibility).
- At BMW, mySAP automotive extracts custom configured manufacturing orders from the BMW planning system (application integration). The orders include all parts required to build each car. mySAP automotive generates delivery schedules for each part to match BMW's assembly-line planning and sequencing directives. This information (release schedules, purchasing documents, invoices and engineering documents) is sent to suppliers or can be accessed by them through mySAP automotive supplier portal. mySAP automotive monitors the production status in real time and parts consumed are removed from the inventory count every 3 minutes (application integration and data compatibility). In addition, the system also provides various analytical tools to support decision making and creates reports to assess supplier performance (analytic and evaluation ability).
- For logistics management, BMW uses the logistics optimization application provided by Manugistics. This application, along with interfacing with other supply chain applications, allows the firm to conduct what-if analyses and also assesses the performance of the carriers on various dimensions (analytic and evaluation ability).

APPENDIX C: MANUGISTICS[1] SUPPLY CHAIN SUITE

Manugistics Inc. was selected to illustrate the practical application of various IOS characteristics for two specific reasons. First, the company offers one of the most comprehensive sets of products to support supply chain management. Second, the company is considered an industry leader in offering systems for collaborative

[1] Manugistics was acquired by JDA Software Group.

commerce. Manugistics offers many software applications that are targeted at various processes that an organization uses in managing its supply chain. Network Collaborate© is a comprehensive Internet-based solution that can be used by firms to jointly create and maintain business plans, monitor execution of those plans, and measure their success. In addition, some other solutions that can be used in conjunction with Network Collaborate© are:

- Network market managers can be used to manage promotions and pricing decisions (analytic ability).
- Network fulfillment that allows optimization of inventory and replenishment (analytic ability).
- Network master planning, sequencing, and supply supports constrained based planning for resources and materials (analytic ability).
- Network Monitor enables exception handling through email-based alerts (alertness).
- Network ONEview contains prebuilt data marts to support analysis and reporting (evaluation and analytic ability).
- Pricing and Revenue Optimization combines demand management with supply constraints for optimizing pricing and demand forecasts (analytic ability).
- Supplier relationship management system that focuses on supplier management and includes submodules such as collaborative design, spend analysis and optimization, strategic outsourcing and contract management, collaborative planning, and procurement execution (application integration).
- By implementing the modules as an integrated system that also interfaces with the company's ERP systems, Manugistics enables firms to effectively manage extended business processes. In an integrated system, one business process such as ordering may automatically update the inventory (inventory management system) and accounts payable (general ledger). Thus, a common user interface can provide access to any application within the integrated system. In addition, integrated systems also enable the firms to access and aggregate data that may be residing in different databases associated with specific applications (application integration).
- The Network Collaborate© allows firms to follow standard data formats, conventions, and metrics. The system also offers cross-referencing between data elements if the two firms are using different data conventions and metrics (data compatibility).
- Network Collaborate© interfaces with Microsoft Excel© for supporting analytical activities (analytic ability). The company also offers applications that support decision-making. ONEview supports analysis and performance reporting on collaborative processes. ONEview contains a prebuilt data mart, metrics, and reports that pull data from other applications. It also provides various tools that decision makers can use to undertake customized reporting (evaluation ability) and analysis (analytic ability). Networks Monitor provides email based alert and thus supports exception handling (alertness).

APPENDIX D: CHANGES TO THE QUESTIONNAIRE BASED ON CASE INTERVIEWS

Items	Firm A	Firm B	Firm C	Firm D
Products	Automobile Cooling Systems	Automobile Audio Systems	Automotive Assembler	Prop Shafts and CV Axles
Type of IS in Use	MRP (QAD), Supplier Database, and EDI System	MRP (Man-Man), Supplier Database, I2 (APS), and EDI System	Multiplant SAP System, Supplier Performance System, and EDU System	MRP (Man-Man), Supplier Web, and EDI System
Person Interviewed	Senior Buyer and IT Manager	Materials Manager and IT Manager	Manager Supply Chain Group	Master Scheduler
Major Changes	• The wording for IOS characteristics was changed to IT based supply chain applications and/or IT systems/IT applications. This was done to clarify the ambiguity raised by the respondent regards IOS systems.	• Examples of type of decision tools (optimization, scenario analysis etc.) were added.	• The items related to evaluation ability of the IT systems were reworded to emphasis their role in measuring key performance indicators.	
	• Two items for application integration measuring integration between IOS systems and internal systems of the firm and the supplier were merged into a single item.	• The words “data mining tools “in the item for analytic ability were reworded to “trend analysis tools.”	• The item capturing the use of IT systems to measure the performance on the basis of contractual agreements was dropped.	
	• Based on the respondent’s suggestion, AIAG was added as an example of a common industry standard for the item measuring data compatibility.			

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