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Supply chain management information systems capabilities. An exploratory study of electronics manufacturers

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Abstract. Supply Chain Management Information Systems (SCM IS) play an increasingly critical role in the ability of firms to reduce costs and increase the responsiveness of their supply chain. This paper develops an empirically supported model of the organizational capabilities enabled by SCM IS. The model integrates and enriches theoretical and empirical studies of competitive strategy, supply chain management, and interorganizational information systems. Evidence from an exploratory case study of three large firms in the electronics manufacturing industry is examined to build a better-supported theory of SCM IS capabilities. The findings suggest the organizational capabilities enabled by SCM IS can be conceptualized as the level of support provided for: operational efficiency; operational flexibility; internal planning and analysis; and external planning and analysis. The theoretical model furthers an understanding of SCM IS capabilities and is sufficiently developed to permit operationalization for future studies evaluating the effectiveness of SCM IS.

Key words: IS capabilities, competitive strategy, supply chain management, multiple case study

1 Introduction

Supply Chain Management Information Systems (SCM IS) play an increasingly critical role in the ability of firms to reduce costs and increase the responsiveness of their supply chain (Chopra and Meindl 2001; Dagenais and Gautschi 2002; Lee 2000). SCM IS are information systems (IS) used to coordinate information between internal and external customers, suppliers, distributors, and other partners in a supply chain. Individual studies have explored the benefits and capabilities of different SCM IS such as Electronic Data Interchange (EDI) (Lee et al. 1999; Mukhopadhyay et al. 1995),

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Electronic Marketplace (Dagenais and Gautschi 2002; Kaplan and Sawhney 2000), or Enterprise Resource Planning (ERP) (Green 2001) systems. However, there are few empirically derived models suitable for analyzing the organizational capabilities supported by the range of SCM IS alternatives. As a result, firms face complex and risky decisions analyzing and selecting an appropriate SCM IS solution or ensuring that their implemented systems are aligned with their business strategies (Reddy and Reddy 2001).

An organizational capability is the ability of an organization to achieve its goals by leveraging its various resources (Ulrich and Lake 1990). IS capabilities are organizational capabilities which are enabled by IS. Similarly, SCM IS capabilities are organizational capabilities enabled by SCM IS. Over the years, research on the evaluation of IS has increased in abstraction from matching IS capabilities with functional requirements (Lucas 1981), to desired architecture (Allen and Boynton 1991), to competitive strategies (Henderson et al. 1996). Although strategic alignment has received considerable attention in recent studies of overall IS strategy (Kearns and Lederer 2001; Reich and Benbasat 2000; Sabherwal and Chan 2001), models have not yet been developed to a sufficiently detailed level to examine the organizational capabilities enabled by specific types of IS, such as SCM IS.

Determining how well SCM IS enable various organizational capabilities in a firm can reduce the complexity of evaluating different SCM IS. Previous studies have developed individual models of the organizational capabilities enabled by various types of IS (Bensaou 1997; Sabherwal and Chan 2001; Venkatraman and Ramanujam 1987; Zviran 1990). However, no single model exists that is suitable for examining and evaluating the capabilities enabled by SCM IS specifically. For example, this study found existing generic IS capabilities constructs such as "analysis" (Sabherwal and Chan 2001; Venkatraman 1989) did not sufficiently discriminate between *internal* and *external* analysis, which subsequent interviews showed to be an important distinction in SCM IS.

Furthermore, existing studies of IS capabilities have several shortcomings when used to model the capabilities enabled by SCM IS specifically. For example, ambiguities in the existing theories make it unclear whether or how a model of SCM IS capabilities should distinguish between complex concepts such as operational efficiency, operational flexibility, and internal or external business process coordination. Thus, the goal of this paper is to develop an integrated model of SCM IS capabilities that is supported by empirical evidence specific to SCM IS implementations.

The model developed integrates and enriches theories of competitive strategy, supply chain management, and interorganizational information systems. Findings from an exploratory case study of three firms in the electronics manufacturing industry are presented to further refine and explore the operationalization of the constructs.

For researchers, the model provides an interdisciplinary approach to understanding the range of SCM IS capabilities. With further study, the model and concepts could also be adapted for other strategic IS applications. Practitioners can gain a better understanding of the capabilities of their implemented SCM IS and the expected capabilities that future SCM IS may provide.

The next section describes the initial SCM IS capabilities model and its theoretical foundations. The third section describes the research methodology and the fourth presents the findings and the emergent SCM IS capabilities model. The final section discusses the implications of the findings for research and practice.

2 Initial research model and theoretical foundations

In organizational literature, the "resource-based view of the firm" makes an important distinction between resources and capabilities. *Resources* are the basic inputs to production, while *capabilities* are the ability to do something with the resources. Resources are the source of a firm's capabilities, while capabilities are the source of a firm's competitive advantage (Grant 1991). Similarly, this study makes the distinction between IS functional attributes and IS capabilities. The functional attributes of an IS identify what functions the IS is *intended* to provide. In contrast, measuring the organizational capabilities enabled by an implemented IS involves a more perceptual measure of *how well* the IS supports the firm's activities.

Several studies have noted that the benefits achievable from an IS often depend as much on how they are implemented and utilized than on what functions they are designed to provide (Lucas 1981; Markus 1983; Parr et al. 1999; Robey and Boudreau 1999). The effectiveness of an IS should therefore be measured by how well it meets a firm's goals rather than what functions it is designed to provide (DeLone and McLean 1992; Kaplan and Maxwell 1994). Thus, this study focuses on the organizational capabilities enabled by an implemented IS, rather than the functional attributes the IS is designed to provide. Furthermore, measuring the perceived capabilities of IS (such as the level of support for internal analysis) incorporates additional factors such as usability, reliability, and management support of the IS, which are often of equal or higher importance to the functions that the IS provide (Holland and Light 1999; Lucas 1981; Parr et al. 1999; Wixom and Watson 2001).

Researchers have studied various IS capabilities such as operational efficiency (Sabherwal and Chan 2001; Sethi and King 1994) or strategic planning (Venkatraman and Ramanujam 1987; Zviran 1990), but integrated models were not found which would be suitable for analyzing SCM IS specifically. SCM IS have varying capabilities for supporting the coordination of supply and demand information throughout a supply chain. Coordination of supply chain information reduces the "bullwhip effect", which is the increasing uncertainty in demand and lead times the further removed a supply chain partner is from the end-customer (Lee et al. 1997). SCM IS can enable more accurate and timely information coordination, which reduces inventory and administrative costs and increases responsiveness to market demands (Horvath 2001; Lee et al. 1997; van Hoek 2001). Effective use of SCM IS can reduce buffer inventory stocks, reduce lead times, increase sales, and improve customer service (Anderson and Lee 1999; Mentzer et al. 2000). The benefits achievable using SCM IS are influenced by a number of factors such as how well the systems support the efficiency and flexibility requirements of the supply chain (Reddy 2001) or the level of trust between the trading partners (Karahannas and Jones 1999). This study does not attempt to identify these success factors, but rather to develop a model

for measuring the capabilities that have been achieved with the implementation of SCM IS.

In a review of previous studies of SCM IS and other enterprise and interorganizational IS, the capabilities of SCM IS that appeared to be most relevant to supply chain coordination initiatives were identified. Several researchers have studied the various organizational capabilities which can be enabled by IS in general (Bakos and Treacy 1986; Sethi and King 1994). In general, firms with a more cost-focused strategy require greater IS support for operational efficiency, while those focused on differentiation strategies require more operational flexibility (Camillus and Lederer 1985; Porter 1985). Support for operational efficiency requires IS that enable product and transaction costs to be controlled (Simons 1987). This can be accomplished through IS that improve information coordination, reduce errors and administrative costs, and enable the standardization of business processes (Gattiker and Goodhue 2000).

Support for operational flexibility or agility requires IS that enable the rapid detection and response of competitive market opportunities (Sambamurthy et al. 2003). This can be supported by IS that enable the modularization and reconfiguration of business processes as well as ease of information sharing with customers, suppliers, and other business partners (Bogucki Duncan 1995; Sambamurthy et al. 2003).

Operational efficiency and flexibility are often seen as either incompatible or unrealistic goals (Reddy 2001). IS are sometimes viewed as inhibitors rather than enablers of flexibility (Allen and Boynton 1991). However, effective SCM IS can enhance operational flexibility by automating routine tasks and freeing up resources to concentrate on non-routine tasks (O'Leary 2000). Similarly, SCM IS can support flexibility by facilitating product and supplier searching (Bakos 1997; Kaplan and Sawhney 2000) and the management of multiple strategic sourcing and distribution relationships (Kalakota and Robinson 2001).

Traditionally, SCM IS that focus on efficiency have been relatively inflexible. EDI systems can reduce transaction-processing costs to near-negligible levels (Mukhopadhyay et al. 1995; O'Leary 2000). However, the systems and data integration efforts required to achieve this may result in a system that is less flexible in adapting to changing partners, processes, and data structures (Konsynski 1996). More flexible Internet technologies such as XML and web services promise to reduce the tradeoffs in achieving efficiency and flexibility, although the evidence is mostly anecdotal.

Planning and analysis capabilities are also widely cited in IS studies (Sabherwal and Chan 2001; Segev 1989; Venkatraman and Ramanujam 1987). However, the relative importance of each, and distinctions between different types of planning and analyses vary. SCM IS increasingly incorporate support for collaborative planning, forecasting, and replenishment (CPFR) capabilities to enable tighter supply chain coordination between partners (Peterson 1999). Through their support of joint planning initiatives such as CPFR, SCM IS can greatly reduce the bullwhip effect and yield more accurate demand forecasts (Barratt and Oliveira 2001).

Traditional conceptualizations of IS capabilities have focused on a firm's internal operations and processes. However, more thorough theoretical models should extend the conceptualization of capabilities beyond the

boundaries of a single firm and address the interorganizational coordination mechanisms (Bakos and Treacy 1986). Due to the unique requirements of interorganizational coordination (den Hengst and Sol 2001), it is often unclear whether the preceding conceptualizations apply to internal IS, interorganizational IS, or both.

SCM IS in particular must not only support internal coordination, but must also support interorganizational collaboration through the exchange and coordination of operational and tactical information such as electronic orders and supply and demand forecasts (Kumar 2001). The focus of this coordination can be internal, external, or both (Moncrieff and Stonich 2001; Poirier and Bauer 2001). SCM IS that provide a high level of support for external coordination have been successfully deployed at companies such as Dell Computers and Wal-Mart, although for other companies the focus is still on internal coordination (Dagenais and Gautschi 2002; Holland and Light 1999; Roloff et al. 2001). From these studies, it remains unclear whether a distinction between internal and external coordination is warranted, or whether the concepts are covered by conceptualizations of operational efficiency and flexibility.

In summary, a comprehensive model of IS capabilities directly applicable to SCM IS was not found in the literature. Although many of the preceding studies are expected to apply to SCM IS, there are sufficient ambiguities in the theories to warrant an exploratory field investigation of SCM IS capabilities. For example, at a high level, should long-term planning capabilities be distinguished from short-term? Similarly, is it useful to distinguish between internal and external process coordination capabilities or internal and external analysis capabilities?

To investigate these ambiguous constructs in a real world context, the various IS capabilities applicable to SCM IS discussed in the preceding are included in an initial research model. These candidate SCM IS capabilities include: operational efficiency and flexibility; planning and analysis; and internal and external business process coordination. The following sections describe how these conceptualizations were examined in light of exploratory case study evidence and used to build an empirically supported model of SCM IS capabilities.

3 Research methodology

The goal of this study is to develop a theoretical model of organizational capabilities that can be enabled by SCM IS. In order to ensure that the model developed is grounded in empirical evidence, the study iterated between data collection and analysis, theory-building, and validating the emerging capabilities model using informants from the supply chain field (Eisenhardt 1989; Strauss and Corbin 1998).

The literature review revealed various IS capabilities that may be relevant in evaluating SCM IS. However, since many of the supporting studies were either not done specifically for SCM IS, or were only for specific types of SCM IS such as EDI systems, an exploratory field study was conducted to investigate and improve the relevancy of the constructs and enable future operationalizations.

The lack of an existing theoretical model of SCM IS capabilities prohibited the pre-specification of propositions and causal relationships, so an exploratory rather than confirmatory research approach was chosen (Eisenhardt 1989; Lee 1991). As firms were expected to differ in the relative importance they assign to each SCM IS capability, a multiple case study design was chosen for building theory from case study research (Eisenhardt 1989; Yin 1994). As the exploratory case studies involved researcher interpretation, care was taken to discuss potential alternative interpretations as well as the limitations of the theories and instruments used (Klein and Myers 1999; Stake 1995).

The study was limited to a single industry to facilitate comparison and theoretical replication amongst the cases while reducing extraneous phenomena and cross-industry differences (Weill and Olson 1989; Yin 1994). The electronics manufacturing industry was selected, since the maturity of SCM practices and IS used is relatively high compared to other industries (Roloff et al. 2001). The primary researcher also had previous experience working in and researching this industry, which gives the researcher a measure of *theoretical sensitivity* in interpreting the cases and understanding the issues that arise from the evidence (Strauss and Corbin 1998).

Three business units (Cases A, B, and C) in three large firms in the electronics manufacturing industry in Canada were investigated. Each of the three firms studied had corporate revenues for fiscal year 2002 in excess of US$10 billion. Although historically each firm had enjoyed gross profit margins of over 10%, only one of the firms had achieved that in fiscal year 2002.

Following Reich and Benbasat (2000), the number of cases (three) was chosen to maximize coverage of the research variables, while maintaining a manageable and economical investigation. The cases were selected for several reasons. First, the three firms involved were widely known to be early adopters of SCM IS and were thus expected to have well-developed experiential knowledge of SCM IS capabilities. Secondly, two of the firms were direct competitors, while the third firm was a contract manufacturer and supplier to the other two. This interrelationship enabled comparisons of the constructs and findings to be made between the competitors and between supplier and customer. This ''theoretical sampling'' strategy helps ensure all aspects of the proposed theory are included in the evidence gathered from the informants (Eisenhardt 1989).

Several sources of evidence were examined to determine the SCM IS capabilities that were relevant to the cases studied. These included: interviews and questionnaires with senior managers and consultants who have worked within the case; public documentation including documents from Internet-enabled SCM IS websites; and previous case reports, interviews, newspaper and magazine articles (see Appendix A). In analyzing these sources of data, the researchers looked for corroboration of results and probed contradictions with follow up interviews conducted by email or in person (Eisenhardt 1989; Yin 1994). The semi-structured interviews probed each firm's strategies, current and planned SCM IS initiatives, the rationale for their SCM IS choices, and the costs and benefits they are experiencing and expect to encounter. Multiple business units (BUs) within the firms were examined and multiple informants were used to ensure the

data covered a range of experiences with different SCM IS used under different circumstances (see Table 1).

As the aim of this study is to build theory from case studies, the focus is on generalizing the findings to a theoretical model of SCM IS capabilities, rather than generalizing the findings to other situations (Eisenhardt 1989). As with any case study, the findings are not statistically generalizable, and readers must decide whether the findings are applicable to other cases (Stake 1995). The external validity of the findings and resultant theories are only applicable to firms with similar characteristics. Although further investigation is warranted, the findings have been reviewed with SCM experts from several other industries. Based on the feedback from this review, the researchers expect the generic SCM IS capabilities model proposed also applies to other industries.

The objectivity of a study refers to the chance that findings are based solely on the researcher's perceptions and biases. Objectivity was increased through "member checking" — having the informants review the draft case reports and highlight any inaccuracies in the findings (Yin 1994). Each researcher and informant reviewed the interview transcripts, case reports, and findings to ensure that the findings followed from the evidence. Objectivity was also ensured through triangulation of multiple data sources, constant comparisons and pattern matching between the theories and data, and searching for rival explanations (Strauss and Corbin 1998; Yin 1994).

Reliability in case studies is related to how easy it would be for another researcher to replicate the study and arrive at similar findings. Reliability was enhanced by using a formal case study protocol and maintaining a database of the evidence and findings (Yin 1994). The use of QSR Nvivo software facilitated the organization, coding, comparison, and analysis of electronic documents. Hard copy documents and tape-recorded transcripts were also archived to maintain a "chain of evidence" leading from the evidence to the theoretical assertions (Miles and Huberman 1994).

The qualitative data analysis used pattern matching (Yin 1994) and coding of constructs (Eisenhardt 1989) to parse the interview and archival data for

Table 1. Case studies and information

Case	Business description	Typical profit margins	Number of interviews with[a]:		
			Senior manager	Senior consultant	Other expert
A	Sales, service, and manufacturing of "long haul" telecom. Devices	High	1	1	2
B	Sales, service, and manufacturing of "long haul" telecom. Devices	High	2	1	1
C	Contract manufacturing of telecommunication devices	Low	2	1	2

[a] Managers were responsible for SCM IS or at the most senior level available; Consultants had previous SCM IS experience at the company; Other experts did not have work experience with the company, but had knowledge of the company through public documents. A total of 5 managers, 2 consultants, and 3 other experts were interviewed as some had knowledge of multiple cases. Quotes used in this paper are from interviews with the senior managers only; the other sources were used for triangulation.

consistent patterns that were used to develop and revise the model of SCM IS capabilities. As demonstrated in Sarker and Lee (2002), pattern matching can be applied to case study analysis using the positivist approach of specifying initial propositions and looking for evidence that supports or disconfirms the propositions. While pattern matching was used to examine the initial constructs, we did not pre-specify formal hypotheses. This was to retain theoretical flexibility and to better ensure the emergent theory is based on the empirical evidence rather than solely on the researchers' preconceptions (Eisenhardt 1989).

Following techniques from Strauss and Corbin's (1998) grounded theory method, the transcripts and archival document data were analyzed for recurring themes and patterns and coded into categories. As new evidence was analyzed, constant comparison with the emerging categories was used to iteratively reorganize, expand, and collapse the categories until the model was sufficiently developed. The data gathering, analysis, and model building was repeated until "theoretical saturation" was achieved — in other words, until the probability of new insight being obtained from further data collection and analysis significantly diminished (1998).

In coding our data, we used both manifest and latent content analyses. Manifest content is "the surface structure present in the message", while latent content is the underlying "deep structural meaning conveyed by the message" (Berg 1998, pg. 226). Since people use different words to convey the same meaning (and may even use sarcasm), we must therefore interpret some of the latent meaning of the words. However, to reduce interpretive bias and increase the reliability of findings, other reviewers repeat the coding and interpretation process to check that they arrive at the same findings (Berg 1998). We also have the informants review the case reports to determine if the interpretations and findings are accurate and to demonstrate their validity (Yin 1994).

As described in the following section, the case study evidence was examined to determine the constructs or categories that are particularly relevant to a model of SCM IS capabilities.

4 Findings

Using an iterative process of data gathering and analysis (Eisenhardt 1989), the researchers evaluated the case study evidence to assess the relevance of each of the candidate IS capabilities constructs found in the literature review. The relevance of each of the candidate IS capabilities constructs to an initial model of SCM IS capabilities is discussed below and summarized in Table 2. A high, medium, or low level of relevance was assigned to each construct based on the researchers subjective evaluation of the case study evidence. For example, if a capability was mentioned several times in the interviews and archival documents, it was judged to have high relevance, whereas if it was not mentioned or the participants indicated that it did not contribute significantly to the overall organizational capabilities of the firm, then it was given a rating of low.

The relevance of the operational efficiency capability construct for modeling SCM IS capabilities was found to be high for each case overall. However, the evidence highlighted the fact that not all firms require the same

Table 2. Relevance of candidate IS capabilities to initial model of SCM IS capabilities

Case	Operational efficiency	Operational flexibility	Planning	Analysis	Process coordination
A	High[a]	High	Short-term: Low Long-term: Low	Internal: Low External: High	Internal: High External: High
B	High	High	Short-term: High Long-term: Low	Internal: High External: High	Internal: Medium External: Medium
C	High	Medium	Short-term: High Long-term: Medium	Internal: High External: Medium	Internal: High External: High

[a] Respondents for Cases A and B suggested the relevance was Medium for the specific business unit studied in the case, but High for the company overall.

level of support for operational efficiency. A respondent for Case C noted, *''We focus more on cost control compared to our competitors.''* Similarly, within a firm, different business units often require different levels of support for operational efficiency. For example, a Case A respondent noted, *''For the company it's very important because we sell a lot of units*…[But in my BU,] it's an expensive product… the logistics systems don't need to be as good''. The respondent appears to support Fisher's (1997) proposition that operational efficiency is more important for products with high transaction volumes and low profit margins (Fisher 1997). Case B had similar responses, with one respondent noting the need for operational efficiency changes over time: *''When the market becomes saturated* …margins decrease and saving money internally is more of a focus''.

Operational flexibility was judged to be of high relevance for Cases A and B. Case A noted *''Flexibility is way more important [than automation], we have to be able to make quick changes and override things just based on a meeting.''* It was of medium relevance to their contract manufacturer. Case C stated it is *''less of a focus than [for] our competitors''*, but *''at the last minute [the customer] changes the way a component works, we have to be flexible enough to change the design and retool.''* Case B remarked, ''*We could be dissatisfied with our supplier and change suppliers overnight*… so there is not very much business-to-business systems set up''. This suggests the need for operational flexibility may be an inhibitor to the adoption of SCM IS.

Evaluating the relevance of the planning and analysis capabilities was more complicated. The initial ''analysis'' construct (Sabherwal and Chan 2001; Venkatraman 1989) was split into external (market scanning) and internal (company performance) analysis, after the interviews showed differing levels of relevance between the two. For example, for internal analysis, Case A stated, ''*For things like planning and analysis, our IS are not a competitive strength''*. However, for external analysis, they noted, *''In knowing what the customers need I would say [we're] probably best [in the industry]* …we have better systems [than our competitors] for information on competitive products.''

Similarly, the planning construct was initially split into ''long-term'' and ''short-term'' planning to distinguish findings on strategic planning from shorter-term operational and tactical planning. Supporting long-term planning did not appear to an important consideration for the SCM IS. For example, Case B noted, ''*These systems are great at* gathering *the information, but unfortunately, there is very little intelligent use of the*

information gathered''. In a related study, the researchers also interviewed a firm in the petroleum industry where long-term planning is more relevant, and found similar evidence that the SCM IS were not perceived to contribute significantly to long-term planning (McLaren 2002).

However, the usefulness of separate planning and analysis constructs was unclear. For short-term planning, the responses were difficult to distinguish from the responses for internal analysis. In each of the cases, the perceived relevance of short-term planning was similar to that of internal analysis. For Case B, both were high, as they noted, "*With a company of this size, a reliable order processing and production planning system is imperative''* and *''Collating the data for analysis requires an exceptional expenditure of time and effort''*. For Case A, both were rated low, as they noted, *''I don't think [short-term planning] systems would make as much of an impact as making very sound business decisions''* and *''For things like planning and analysis, our IS are not a competitive strength''*. Thus, this study could not distinguish between short-term planning and internal analysis, although both were judged to be of high relevance to two of the three cases.

After analysis of the interviews, the business process coordination construct was initially split into internal and external process coordination as the responses noted significant differences between these two dimensions. For Cases A and C, their high level of usage of integrated ERP, EDI, and web-based portal SCM IS indicated both internal and external process coordination was of high relevance. However, Case B appeared to place only moderate importance on internal coordination. They noted, "*There is some aggregation that the purchasers do, but I'm not certain that it crosses business units''*. They also noted that *''various ERP systems are used in different BUs''*, indicating that while internal coordination was important enough to warrant using an ERP, it was not relevant enough to justify a single corporate-wide ERP. Similarly, for Case B, external process coordination capabilities were apparently important only for supporting collaborative design processes rather than other planning or replenishment activities. Thus, it was judged to be of only medium relevance to Case B overall.

Since both internal and external coordination were judged to be of equal relevance within each case, the constructs were then collapsed back into a single business process coordination construct. However, evidence on the distinction between operational efficiency and business process coordination was also ambiguous. Within Cases A and C, operational efficiency and internal and external process coordination were all judged to be of equally high or medium relevance depending on whether the respondent was judging the specific business unit or the company overall. Thus, this study found that at a high level, there was little difference in the relevance of the SCM IS capabilities of internal and external process coordination and operational efficiency. However, a more detailed study is suggested to resolve the conceptual ambiguities uncovered.

An examination of the summary results in Table 2 suggests that several of the initial candidate SCM IS capabilities identified in the review of IS literature should be either collapsed together or split into different dimensions. The operational efficiency and operational flexibility constructs appeared to be highly relevant to the cases and thus should be included in the revised model of SCM IS capabilities. There did not appear to be

Table 3. Relevance of IS capabilities to revised model of SCM IS capabilities

Case	Operational efficiency	Operational flexibility	Internal planning and analysis	External planning and analysis
A	High	High	Low	High
B	High	High	High	High
C	High	Medium	High	High

empirical support for distinguishing between short-term and long term planning and analysis. However, the evidence did suggest that internal planning and analysis should be distinguished between external planning and analysis. Finally, there did not appear to be significant differentiators between the operational efficiency construct and the internal or external process coordination constructs — at least at the relatively high level of abstraction of the model.

Thus, the empirical evidence from the case studies suggest that the resultant revised model of organizational capabilities enabled by SCM IS should include: operational efficiency, operational flexibility, internal planning and analysis, and external planning and analysis. Table 3 presents the summarized results using the revised SCM IS capabilities constructs.

5 Conclusions and discussion

Through analysis of exploratory case study evidence, a model of SCM IS capabilities has emerged that will enable better understanding of SCM IS for researchers and practitioners. The findings suggest that the organizational capabilities of SCM IS can be evaluated in terms of the level of support provided for: operational efficiency; operational flexibility; internal analysis; and external analysis. The perceived relevance of each of these capabilities was collectively high in the cases studied. While different firms and business units within firms may view the relative importance of each of these capabilities differently, each capability is important to the understanding and evaluation of SCM IS.

The emergent model presents a promising conceptualization of SCM IS capabilities. However, there are significant interrelationships between each of the capabilities. Operational efficiency and operational flexibility are sometimes seen as contradictory goals (Camillus and Lederer 1985), yet this study supports the notion that "efficient flexibility" (Allen and Boynton 1991) is an important capability of SCM IS. The findings support the suggestion that firms distinguish between their processes that require support for efficiency (such as order processing) with those that require support for flexibility (such as sourcing) (Reddy 2001).

Evidence on planning and analysis capabilities showed that some conceptualizations were problematic when applied to SCM IS. Internal analysis should be distinguished from external analysis, as there were differences in their relative importance in the firms studied. Thus, models that distinguish between internal and external analysis such as Segev (1989) are recommended. Similarly, long-term planning should be distinguished from short-term planning. Long-term planning did not appear to be an important capability

of SCM IS. However, this finding may be due to perceived shortcomings in existing SCM IS or an anomaly of the firms or industry studied. Furthermore, this study found insufficient discrimination between short-term planning and other types of internal analysis, which suggests that the planning construct does not need to be differentiated from the other types of analysis in the SCM IS capabilities model.

Finally, the interviews suggested that at a high level, a conceptual model of SCM IS capabilities may not need to distinguish between internal and external process coordination capabilities and operational efficiency. However, at a more detailed level, SCM IS are expected to exhibit different levels of support for internal and external process coordination (Roloff et al. 2001), both of which could be conceptualized as contributing to overall operational efficiency (Bakos and Treacy 1986).

The goal of the study was to *explore* SCM IS capabilities rather than confirm any presumed relationships. However, several interesting relationships between the constructs were observed, which require further study to determine if they are generalizable phenomena or anomalies of the specific cases. For example, a respondent from Case A appeared to suggest operational efficiency was of lower importance to their BU because of the high product margins and low transaction volumes, while other business units within the same firm place higher importance on support for operational efficiency. If confirmed, this relationship would support Fisher's (1997) efficiency-innovativeness theory, but would suggest that implementing a single supply chain management information system that fits the requirements of the entire firm would be infeasible. Such complexities require further study, as there are significant implications to the selection and implementation of enterprise-wide SCM IS. Similarly, future studies should look at the relationships between the SCM IS capabilities highlighted in the model with measures of organizational performance. While the relative importance of each IS capability is expected to vary according to a firm's strategies (Henderson et al. 1996), these relationships and contingencies require further study.

Although the model of SCM IS capabilities presented is supported by evidence from three specific firms in the electronics manufacturing industry, the capabilities described are at a sufficiently high level that they are expected to apply to many other situations. The model is sufficiently developed to permit operationalization for further exploratory and confirmatory studies within the electronics manufacturing and other industries.

Future research should also measure a firm's SCM IS capabilities and their association with supply chain performance. Quantitative measures of supply chain performance should focus not only on costs or prices, but also on supply chain wide metrics such as total supply chain costs, assets performance, responsiveness, flexibility, and reliability measures (Supply Chain Council Inc. 2002). However, none of the three firms in this study were willing to provide such metrics as they were either too sensitive or they were unable to produce such measures from their current systems. It may be more feasible to gather intermediate measures such as satisfaction with the SCM IS.

In summary, this study found existing conceptualizations of IS capabilities to have shortcomings when applied to SCM IS. Through integrating existing

theories with findings from three case studies in the electronics manufacturing industry, this study presents an emergent theoretical model of the organizational capabilities of SCM IS. For practitioners, the model is expected to be useful in the selection and evaluation of SCM IS. For researchers, the study contributes an empirically supported theory of SCM IS capabilities to the body of knowledge. While the findings cannot be generalized beyond the specific cases, the model is sufficiently developed to permit future operationalization and study in other situations.

Appendix A – Excerpt from interview protocol

The information gathered includes the interviewee's perceptions of:

A. How a business positions itself to compete in its industry;
B. How closely integrated the business is with other members of its supply chain;
C. The organizational capabilities of the business' current and desired SCM ISs;
D. The overall level of satisfaction management has with their current SCM ISs; and
E. How well do the current SCCSs fit the firms' needs?

Sources of Data:

- Website documentation (e.g. supplier/customer portals, electronic markets, EDI)
- Previous case reports, interviews, newspaper and magazine articles.
- Public documentation (e.g. annual reports, press releases)
- Senior Managers in the company
- Consultants who have worked for company

Sample Questions:

C1) What types of SCM ISs are used and/or anticipated to be used in the business unit?
PROBES:
- What is their purpose? What processes do they support?
- What is the information sharing mechanism? Messages? Portals? Jointly shared systems?
- What technologies are used? EDI? Email? XML? ERP? eMarketplaces?
- How quickly are the SCM ISs evolving new functionality?

C2) What has motivated the use of the current and/or anticipated SCM ISs?
PROBES:
- How was the system proposed/championed? Internal or partner?
- Is the system a response to what competitor's are doing?

C3) What are the capabilities of the current and anticipated SCM ISs?
PROBES:
- How do the SCM ISs support the firm's objectives?
- Which SCM ISs provide which capabilities? How integrated are they?
- Do the capabilities address short-term or long-term time periods?
- Are the capabilities focused on internal or external processes?

C4) How do these capabilities compare with those provided by competitor's SCM ISs?

PROBES:

- How much do you know about your competitor's systems?
- To what degree do you expect to maintain or gain a competitive advantage with your current or planned SCM ISs?

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