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A conceptual model for evaluating the financial impact of supply chain management technology investments

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Abstract

Purpose – The purpose of this paper is to review the literature concerning supply chain management technology (SCMT) and financial performance, and to present a model for evaluating the financial performance benefits of investments in supply chain management technologies. The literature review and the associated model also lead to a discussion of opportunities for future research in the area.

Design/methodology/approach – To develop the model, a comprehensive review of the literature investigating the financial performance benefits of SCMT and other closely-related information technologies, such as inter-organizational systems, was performed. Findings from the reviewed studies were assimilated and used as the basis for the proposed model and for recommended avenues of future research.

Findings – The literature reviewed suggested that financial performance improvements from SCMT investments are derived from improvements in knowledge-intensive capabilities, which lead to improvements in operational capabilities, leading, in turn, to first- and second-order benefits. The ability to realize benefits is also influenced by a firm's position within the supply chain and exogenous economic forces.

Originality/value – This paper contributes to the knowledge of how financial gains are realized as the result of investments in SCMT, and provides context within which future research efforts can be placed. Future research opportunities are also discussed.

Keywords Supply chain management, Operations management, Communications technology, Financial management

Paper type Literature review

Introduction

Evaluating the financial or operational benefits associated with information technology (IT) investments has proven to be an area of keen interest to scholars and researchers for several decades. Since the issue is important, and definitive results demonstrating clear, positive financial or operational benefits have been elusive, interest remains high and the literature has grown quite large[1]. A much smaller subset of what may be called the "IT Productivity" literature, and one of particular relevance to scholars in logistics, is the recent development of inquiry into the financial performance impact of investment in supply chain management technology (SCMT).

SCMT, broadly defined as any IT developed and implemented specifically for the purpose of managing some element or component of the supply chain, or an IT used to support supply chain management efforts (such as EDI or web-based applications) regardless of its original development intent, has become a critical element in firms'

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efforts to cut cost, reduce waste, and increase efficiency both internally and along their supply chains (Radjou, 2003; Wu *et al.*, 2006). It naturally follows that researchers would have an interest in evaluating the benefits attributable to this sort of investment. Not only is this an interesting question in its own right, but I believe there are three additional reasons why evaluating the benefits to SCMT investment is an important undertaking.

First, there is reason to infer that at least some firms have integrated supply chain management strategies into their overall corporate strategy. Or, put another way, supply chain management has become an important element of corporate strategy[2]. To the extent that supply chain management efforts depend upon the successful deployment of SCMT, then a transitive dependency exists between SCMT and the success of the firm's overall strategic initiatives. Second, SCMT often represents a material investment, both in dollars and employee time, and managers need to know what the return is on their investment in order to evaluate both the success of the current initiative and to improve future decision making.

Finally, the nature of the technologies employed in supply chain management suggests a more direct link to firm profitability than many other technologies. Barua and Mukhopadhyay (2000) suggest that in order to provide measurable business value, IT investments need to be well-targeted, well-timed, and well-managed. Of these qualities, Dehning *et al.* (2007) argue that the most important is that the investments are well targeted, in the sense that they are made to achieve specific business objectives. Dehning *et al.* (2007) go on to argue that, in a similar manner, the metrics used to measure the economic value of the investment should reflect the specific business objectives of that investment. The closer the ties are between the investment, the business objectives, and the metric measuring the economic value arising from accomplishing those objectives, the more likely it is that the metrics will indicate the resulting value of the investment. They further suggest that much of the IT productivity literature has been unable to measure the economic value of IT investments because the metrics employed to measure the economic value are at too high a level and not linked closely enough to the specific business objectives met by the IT investment. Overall, firm performance metrics, like income-based metrics (return on assets (ROA) or return on equity (ROE)), market capitalization, or changes in market price suffer from being too divorced from the business objectives being addressed by the IT investment, and, in addition, are influenced by too many other exogenous forces. As a result, researchers have a difficult time partitioning the influence of the IT investment on the high-level performance metric. The fact that SCMTs tend to be more closely linked to specific business objectives, which themselves can be measured by specific, observable metrics helps, at least to a degree, to mitigate the empirical difficulties researchers have had in measuring the financial and operational benefits of IT investments.

The rest of the paper is organized as follows. First, I present a conceptual model for evaluating the financial impact of SCMT investments that is both drawn, and assimilates different elements of the literature to date. Second, I review the relevant literature germane to SCMT investments and financial performance and place it within the context of the model. Since there are relatively few papers specifically studying the impact of SCMT on financial performance, the overall number of papers I review is small; however, I also discuss several papers that, while not examining SCMT specifically, study the impact of a complementary technology

(like EDI or other inter-organizational systems, for example) used in supply chain management and relate that technology to financial performance. Finally, I discuss opportunities for additional research suggested by the model and conclude.

The SCMT financial performance model

The model links SCMT to financial performance through several intermediate improvement stages resulting in some sort of financial impact. I show the model in Figure 1.

One of the key attributes of the model is its inter-relatedness. While it does have a chronological, or linear, aspect, it is not merely chronological. One entity tends to lead directly to another entity in the model, which leads to financial improvement over time, but it is also true that the same entity may influence another event or improvement concurrently and over time. In other words, the model represents linear relationships over time, but also represents recursive and transitive relationships among some of the components. Note first that an investment in SCMT influences, and is in turn influenced by, organizational alignment changes. The dashed arrows represent influence; the solid arrows represent causality or response. To explain the model, I describe the components and how they relate to one another, then discuss the various constructs supported in the literature classified under that component. For each item, I also provide a citation to the reference in the literature that supports that particular component construct in Table I.

In the organizational alignment component of the model, an investment in SCMT leads to important changes in the business. In order to ensure the success of the implementation, top management must support the project. As part of the organizational alignment, firms work to revamp their business processes, increase training, and make changes to their supply chain strategies (Byrd and Davidson, 2003; Gunasekaran and Ngai, 2004; Motwani *et al.*, 2000). The dashed lines in the model here suggest that as the firm begins changing its business processes and strategies (irrespective of the technology involved), it recognizes the importance of technological solutions to complement the change, and so may seek to augment existing implementations with further SCMT purchases (the firms may decide to purchase an additional module, for example). Thus, in the model, an investment in SCMT influences organizational alignment changes, which in turn may influence further investment in SCMT.

The model also recognizes that the investment in SCMT is influenced by the firm's position within the supply chain. Several studies have indicated that firms in different positions up- or down-stream in the supply chain are affected differentially – that is, the rewards from making the investment in SCMT are not necessarily allocated evenly, or even proportionately. As a result, managers are more (or less) likely to bear the investment costs based on their perceptions of the benefits accruing to the firm (Riggins and Mukhopadhyay, 1994; Kent and Mentzer, 2003; Subramani, 2004). In addition, the tendency of managers to optimize their individual objective functions at the expense of system-wide optimization may also lead to sub-optimal returns, and thus may also have some impact on the manager's level of investment in SCMT (Sahin and Robinson, 2002). Finally, a firm's position within the supply chain will influence both its ability to enjoy operational or functional improvements, and its ability to realize the first-order effects of implementation. For example, even with full supply

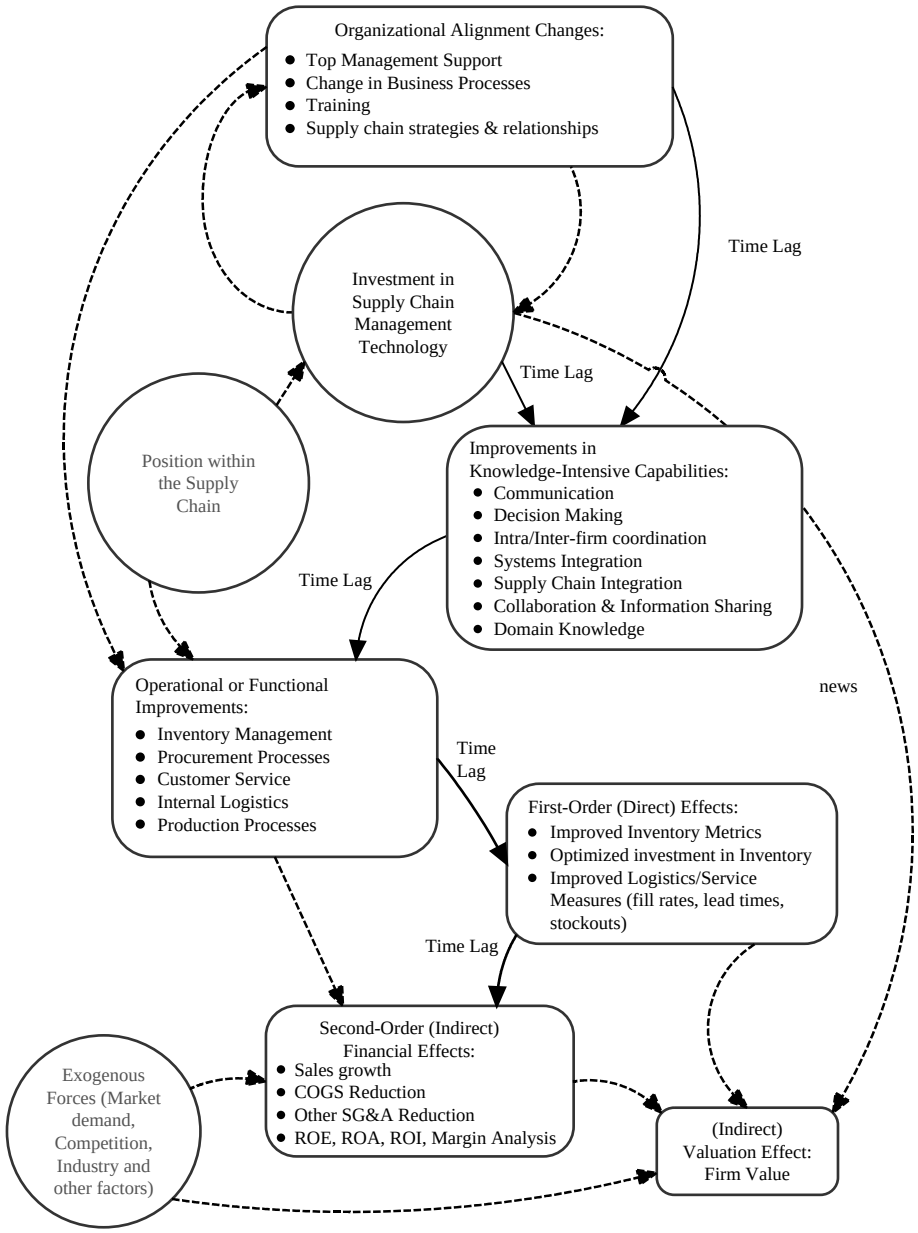

Figure 1.
Model of SCMT and the link to financial performance

chain participation in the investment, an upstream firm may not have the same ability to manage inventory as a member farther downstream, and so may be prevented from realizing improved inventory measures – or improvements comparable with the downstream firm – based on its relative position within the supply chain.

Table I. Components of the SCMT model with the associated constructs and supporting literature

Model component	Component construct	Supporting literature
Investment in SCMT	Scope/configuration of investment	Cassivi *et al.* (2004), Kent and Mentzer (2003) and Blankley *et al.* (2008)
Position within the supply chain	Differential benefits accruing upstream/downstream	Riggins and Mukhopadhyay (1994), Cassivi *et al.* (2004) and Subramani (2004)
	Firm/system optimization issues	Sahin and Robinson (2002)
Organizational alignment changes	Top management support	Byrd and Davidson (2003)
	Change in business processes	Gunasekaran and Ngai (2004) and Motwani *et al.* (2000)
	Training	Gunasekaran and Ngai (2004)
	Supply chain strategies and relationships	Kent and Mentzer (2003), Wisner (2003) and Subramani (2004)
Improvements in knowledge-Intensive Capabilities	Communication	Warkentin *et al.* (2001)
	Information sharing and collaboration	Lee *et al.* (1997a, b) and Chen *et al.* (2000)
	Decision making	Bharadwaj (2000), Simchi-Levi *et al.* (2000) and Warkentin *et al.* (2001)
	Systems integration	Simchi-Levi *et al.* (2000) and Vickery *et al.* (2003)
	Supply chain integration	Vickery *et al.* (2003), Gunasekaran and Ngai (2004) and Wu *et al.* (2006)
	Intra/inter-firm coordination	Mitya and Chaya (1996), Tallon *et al.* (1997) and Wu *et al.* (2006)
	Domain knowledge	Bharadwaj (2000) and Subramani (2004)
Operational or functional improvements	Inventory management	Dehning *et al.* (2007) and Blankley *et al.* (2008)
	Procurement processes	Dehning *et al.* (2007)
	Customer service	Vickery *et al.* (2003) and Wisner (2003)
	Internal logistics	Dehning *et al.* (2007)
	Production processes	Cassivi *et al.* (2004)
First-order (direct) effects	Inventory metric improvement	Mukhopadhyay *et al.* (1995), Dehning *et al.* (2007) and Blankley *et al.* (2008)
	Fill rates, lead times, stock outs, on-time deliveries, product quality	Cassivi *et al.* (2004)
Second-order (indirect) financial effects	ROA, ROE and other income-based profitability metrics	Dröge and Germain (2000), Byrd and Davidson (2003) and Dehning *et al.* (2007)
	SG&A reduction	Dehning *et al.* (2007)
	COGS reduction	Poston and Grabski (2001) and Dehning *et al.* (2007)
Valuation effect	Abnormal returns	Dehning *et al.* (2003), Hendricks and Singhal (2003) and Hendricks *et al.* (2007)

After the firm begins utilizing its investment in SCMT and exploiting its organizational alignment changes, it begins to realize improvements in higher-order, knowledge-intensive capabilities. This is the aspect of the model that indicates the value of the information provided by the SCMT. The literature indicates that SCMT investments may lead to improvements in communication, decision making, and coordination between supply chain member firms, as well as segments or divisions within the firm. In addition, investments in SCMT have been found to lead to greater systems integration, tighter supply chain integration, better information sharing capabilities, and increased domain knowledge[3]. These constructs are frequently identified in the literature as the theoretical link between the technology and the measured results of its implementation. For example, several authors have suggested that one of the primary benefits of IT implementation is that IT reduces the cost of coordinating the firm's activities (Gurbaxani and Whang, 1991; Mitya and Chaya, 1996; Shin, 1999). In these papers, improvements in inter-firm and/or intra-firm coordination is the hypothetical construct linking IT implementations to cost reductions. Each of these items represents an improvement in knowledge-intensive tasks, and are the result not only of the quality of the information flow along the supply chain, but also to the speed of the information delivery through the technology.

Improvement in these critical knowledge-intensive capabilities eventually leads directly to operational or functional improvements over inventory management, procurement, customer service, internal logistics, and production processes (Vickery *et al.*, 2003; Cassivi *et al.*, 2004; Dehning *et al.*, 2007; Blankley *et al.*, 2008). As a direct consequence of the earlier improvements in communication, coordination, integration and the other knowledge-intensive capabilities mentioned above, firms are able to improve the quality of these particular operational functions. These operational improvements are also influenced by the organizational alignment changes discussed above. At this stage, the model indicates that SCMT is a transitive determinant of these operational or functional improvements; that is, SCMT fosters improvements in critical operational areas through improvement in firm knowledge-intensive capabilities.

Eventually, operational improvements bring about improvements in intermediate process measures like inventory turnover, inventory investment, fill rates, lead times, stockouts, and other internal logistics or customer service metrics (Mukhopadhyay *et al.*, 1995; Cassivi *et al.*, 2004; Dehning *et al.*, 2007; Blankley *et al.*, 2008). I call the direct effects arising from these operational improvements "First-order" effects, because these occur as a proximal result of the operational improvements. Some of these first-order effects are directly observable from the company's financial statements (inventory metrics, for instance), while others affect financial results indirectly. For example, inventory reductions attributable to SCMT may appear directly on the balance sheet and income statement, so inventory metrics calculated from them could indicate improvement. On the other hand, the financial statement impact of customer service improvements is likely to be more diffuse (may be realized in several different accounts as both eventual revenue increases or cost reductions) and take significantly longer to realize due to the length of time it takes customers to become aware of the improvements and adjust demand in response.

The "second-order" effects – those referred to as indirect financial effects – are those that arise as a direct result of first-order improvements. As, say, procurement costs decline over time, *ceteris paribus*, SG&A will also decline. As production costs

decline, overhead allocations to products will also fall and as a result, cost of goods sold and ending inventory would decline. However, these declines could take some time to be realized as improvements in the operations would likely span multiple accounting periods and some of the product cost reduction would be capitalized in inventory and not realized until sold. Dehning *et al.* (2007) found some support for the notion that SCMT adoptions had some impact on SG&A, and in another setting, Poston and Grabski (2001) indicated that enterprise resource planning technology implementation reduced the ratio of cost of goods sold to revenue, but the reduction was not observable until the third year following implementation.

It is important to point out that many of these second-order effects may not be empirically observable due to the dilutive effect of environmental conditions. It is difficult to definitively attribute some financial statement impact to SCMT investment because of the time lag between implementation and improvement, and because of the offsetting nature of other, exogenous forces affecting the financial statements (like economy-wide downturns or supply shocks). Note that the model considers this aspect by indicating the influence of market forces, competition, industry and other economic factors on the financial results (Barua *et al.*, 1995). So, even though a firm may enjoy cost reduction in production costs from SCMT investment relative to what costs might have been without the investment, total production costs might increase as a result of economic forces unrelated to the efficiency of the firms' (or the supply chain's) operations. In this case, any financial statement impact could only be uncovered by comparing actual revenue and cost to some benchmark of what the revenue and cost might have been had the firm not made the investment. While not impossible, developing such a benchmark while maintaining construct validity is difficult and presents the researcher with several empirical challenges. Note, too, that the operational improvements discussed above are considered to have an influence on the second-order financial effects (Dröge and Germain, 2000). The model includes this link to indicate some residual benefit from these improvements will result in revenue growth or cost reduction over and above the direct effects.

Finally, the model indicates that financial performance has an impact on firm valuation[4]. Despite evidence that the extent of the usefulness of earnings to investors is limited in predicting stock returns (Lev, 1989), there is more recent evidence that with modifications to the typical earnings-return model, the earnings contribution to valuation is substantially greater (Strong and Walker, 1993). In addition, Lev and Zarowin (1999) link the declining usefulness of financial information to change; that is, the current reporting model under Generally Accepted Accounting Principles does not adequately account for the impact of change on firms' operations, yet capital markets attempt to value this impact. SCMT investments represent a major change, not only in the technology deployed by the firm, but also (potentially) to the firm's processes and methods of doing business, as well as its relationships with upstream and downstream trading partners. Since there is some evidence that earnings influence firm valuation, and because SCMT investments would be a strong signal of change to the market, the SCMT model includes indirect influence links from the investment itself to valuation, as well as the first-order and second-order effects to valuation (Dehning *et al.*, 2003; Hendricks and Singhal, 2003; Hendricks *et al.*, 2007). These links allow the model to recognize the valuation impact that may occur as the result of firm profitability, news announcements concerning SCMT initiatives, process improvements, successful

roll-outs of SCMT, or other news concerning SCMT investment as it becomes available to the market. The model also recognizes the role exogenous economic forces have in shaping firm value as well.

Previous work supporting the model

Organizational alignment and linkages

Several papers underscore this aspect of the model and its linkages. Mentzer (1993) notes that for twenty-first century firms, decision-making will center around maximizing performance through efficiency and effectiveness improvements engendered through supply chain management efforts. Kent and Mentzer (2003) then note that IT investments play an important role in facilitating these efforts. In their study of the effects of investments in inter-organizational IT (IOIT) on long-term, retail supply chain relationships, Kent and Mentzer (2003) test a supply chain relationship model having four behavioral and four operational variables. Two of the operational variables related to investment in IOIT: the retailer's investment, and the retailer's perception of the supplier's investment. They found that the retailer's investment in IOIT was positively, but not significantly, related to relationship commitment. On the other hand, they found that the retailer's perceptions of the supplier's investment in IOIT was significantly, and positively, related to the relationship commitment. The relationship commitment, in turn, was significantly, and positively, related to logistics efficiency, which was significantly, and positively, related to relationship dependence and ultimately a long-term relationship orientation. Kent and Mentzer's empirical finding suggests that that when the retailer perceives that its suppliers are investing in IOIT, its commitment to the supply chain relationship increases, which has direct bearing on logistics efficiency. In this respect, the investment (or, more precisely, the perceived investment) in SCMT was influential in strengthening the supply chain relationship between supplier and retailer. Although their paper did not consider the financial impact of the investment in IOIT, it is relevant here because it demonstrates the links between investment in SCMT and the resultant or concurrent organizational alignment changes identified in the proposed SCMT model. For convenience, Table II lists the linkages in the model and identifies the paper(s) supporting the link or suggesting the necessity of the link.

Subramani (2004) also considered the impact of SCMT on supply chain relationships, but unlike Kent and Mentzer (2003), considered it from the supplier's perspective. Benefits from investments in inter-organizational systems tend to be unevenly distributed in favor of the network leaders (initiators), rather than accruing evenly to suppliers (followers) (Riggins and Mukhopadhyay, 1994). Subramani (2004) hypothesized that suppliers benefit from SCMT by appropriating its use for both exploitation and exploration. Exploitation implies using the technology to foster certain goals, including improving, applying, and refining firm capabilities; exploration implies using the technology to create new capabilities or new solutions to problems. To examine the issue, Subramani developed an inter-related theoretical model. The model posits that SCMT use for both exploration and exploitation lead to two relationship-specific intangibles, business-process specificity and domain-knowledge specificity. Business-process specificity focuses on relationship-specific activities leading to efficient task execution; domain-knowledge specificity focuses on the development of a deeper understanding of causal

Model linkages	Supporting literature
Influence links	
Investment in SCMT to organizational alignment	Kent and Mentzer (2003) and Wu *et al.* (2006)
Investment in SCMT to firm value	Lev and Zarowin (1999), Dehning *et al.* (2003), Hendricks and Singhal (2003) and Hendricks *et al.* (2007)
Organizational alignment to investment in SCMT	Kent and Mentzer (2003)
Organizational alignment to operational improvements	Kent and Mentzer (2003), Wisner (2003) and Subramani (2004)
Operational improvements to second-order financial effects	Dröge and Germain (2000)
Position within supply chain to investment in SCMT	Riggins and Mukhopadhyay (1994) and Cassivi *et al.* (2004)
Position within supply chain to operational improvements	Sahin and Robinson (2002) and Subramani (2004)
Exogenous forces to second-order (financial) effects and firm value	Barua *et al.* (1995) and Quan *et al.* (2003)
Causal links	
Investment in SCMT to knowledge-intensive capability	Mukhopadhyay *et al.* (1995), Vickery *et al.* (2003), Subramani (2004) and Wu *et al.* (2006)
Organizational alignment to knowledge-intensive capability	Bharadwaj (2000), Subramani (2004) and Wu *et al.* (2006)
Knowledge-Intensive Capability to Operational Improvement	Mukhopadhyay *et al.* (1995), Vickery *et al.* (2003) and Subramani (2004)
Operational improvement to first-order effects	Barua *et al.* (1995), Wisner (2003), Dehning *et al.* (2007) and Blankley *et al.* (2008)
First-order-effects to second-order (financial) effects	Barua *et al.* (1995), Dröge and Germain (2000) and Dehning *et al.* (2007)

Table II.
Linkages in the SCMT model and supporting literature

relationships and using that understanding to resolve ambiguities within the business. Each of these "specificities" leads to potential first-order benefits, which could be operational improvements or strategic improvements. Either of these improvements could then potentially yield second-order performance benefits. To test the theoretical model, Subramani surveyed 640 suppliers to one large Canadian retailer, and supplemented the survey data with in-depth field interviews and information from the retailer's supplier databases. His results indicated that that both exploitation and exploration mediated domain-knowledge specificity, which in turn led to operational and strategic benefits. Only exploitation, however, mediated business-process specificity, which in turn led to strategic benefits, but not operational benefits. Subramani did not find support for the notion that operational benefits led to competitive performance, but did find support for the notion that strategic benefits did lead to competitive performance improvements. In short, Subramani found that suppliers could use SCMT to their advantage by leveraging exploitation and exploration uses of the technology in the context of their relationships with the large retailer. By creating greater domain-knowledge and business-process specificities, suppliers could strategically position themselves to capture a greater portion of the financial benefits to the supply chain as a whole and thus enjoy increased performance as a result. Subramani (2004 p. 65) writes:

> When suppliers combine SCM[T] use with investments in relationship-specific intangible assets [. . .] the causal ambiguity of the combination raises barriers to imitation and enables system use to become a lever for differentiation [. . .] This causal ambiguity enables suppliers to offset the asymmetry in bargaining power in the exchange, which in turn allows them to retain some of the benefits created by SCM[T] use.

Subramani (2004) is important paper in the area because it suggests the theoretical underpinnings of several aspects to the overall model. First, it suggests that SCMT investments are accompanied by organizational changes aligning the firm with strategic objectives of the investment. Second, it theorizes both operational and endogenous benefits arising from SCMT investment that lead to second order performance results. Third, both Subramani and Riggins and Mukhopadhyay (1994) point out that a firm's position within the supply chain affects the operational and strategic benefits derived from the investment in SCMT, as well as the derivative financial value to the firm.

Byrd and Davidson (2003) also examined the impact of IT on the supply chain and firm performance. They identified three factors – IT department technical quality, IT plan utilization, and top management support of IT – which they argue are antecedents to any expected supply chain impact. The authors developed a set of measures for each of these three antecedents as well as firm performance. They then surveyed top-level IT executives in 225 firms concerning the measures relating to these four areas. Some of the measures relating to IT's impact on the supply chain dealt with activities related to purchasing, receiving, production, marketing, coordinating and interacting with suppliers and customers. A structural equation analysis of the data indicated that all three factors were significantly and positively associated with an IT impact on the supply chain, which in turn was significantly, and positively associated with improved financial performance at the firm level. Byrd and Davidson's (2003) paper recognizes the need for organizational alignment to occur as a necessary precondition to the successful deployment of IT leading to improved firm performance. They also suggest that the process of generating financial value runs from IT through intermediate-level (supply chain) variables to financial performance.

Bharadwaj (2000), while not writing specifically about supply chain systems, also lends some support to the notion that technology investments lead to changes in organizational processes, which, in line with a resource-based view of organizational strategy (Barney, 1991), may lead to inimitable and valuable use of the technologies, which in turn lead to firm performance improvements. Using a matched-pair experimental design, Baharadwaj found that profitability performance metrics were higher for "IT leader" firms than for the matched firms, and attributes this greater profitability to leveraging IT to generate unique and valuable intangible resources, such as superior organizational knowledge and synergy. Bharadwaj's paper supports the notion that investments in IT lead to valuable endogenous improvements in critical knowledge resources like decision making, coordination of units, and knowledge. He also indicates that IT investments support organizational alignment.

Position within the supply chain

As mentioned above, Kent and Mentzer (2003) and Subramani (2004) both consider the firm's position within the supply chain and its ability to realize financial performance improvements given its position. Sahin and Robinson (2002) touch on the issue

from a broader perspective. Using the advances in IT capabilities to enhance inter-organizational cooperation as motivation, Sahin and Robinson (2002) review the literature associated with physical flow coordination and information-sharing within a supply chain. Their paper does not consider financial performance and its relation to technology investments directly, but their review does implicitly suggest that any SCMT financial performance model should include consideration of the firm's position within the supply chain. They note that one of the problems in coordinating a supply chain for system-wide efficiency is that different channel members may behave in a way that optimizes their own interests and not that of the chain. The result is sub-optimal performance, which may include irregularities like the bullwhip effect or pricing externalities like double marginalization within the supply chain. Sahin and Robinson (2002) note that many authors have considered information sharing to be the solution (Lee *et al.*, 1997a, b; Simchi-Levi *et al.*, 2000; Chen *et al.*, 2000), and then point out that information sharing does not completely solve the problem when channel members are evaluated on their individual performances. One conclusion they draw after reviewing the literature seems particularly relevant to this paper: that system improvements impact each channel member differently, and that it is important to consider the nature of information-sharing at both the system level and the individual firm level. They further note that in order to encourage optimal system-wide behavior from individual firms, some mechanism for allocating system benefits equitably among channel members must be employed. Their conclusions support the contention that a firm's position in the supply chain will be relevant to the operational and financial benefits it enjoys as a result of its participation.

Cassivi *et al.* (2004), also consider the issue of a firm's position in the supply chain as a control variable, but they did not find that the position within the chain influenced the relationship between efficiency of supply chain collaboration tools and firm performance. What appeared significantly more influential was the configuration of the tools within the firms. Their paper focuses on the differential impact e-collaboration tools have on performance of firms upstream (supplier perspective) and downstream (customer perspective) along the supply chain. Cassivi *et al.* (2004) define performance more broadly than simply financial performance, and ultimately adopt Beamon's (1999) key measures of performance across three categories: resources, output, and flexibility[5]. The performance measures used in their study included measures of operational or functional improvement in internal logistics, like inventory levels, lead times, fill rates, and on-time deliveries, as well as various cost measures and product quality measures. With respect to the SCMT model presented in this paper, Cassivi *et al.*'s measures of performance spanned both categories of benefits entitled "Operational or Functional Improvements" and "First-Order (Direct) Effects."

The authors performed a detailed case study of a large OEM in the telecommunications industry, and then augmented the study with an electronic survey of 53 supplier firms that used e-collaboration tools. Based on the case study, Cassivi *et al.* conclude that the collaboration technologies increased visibility along the supply chain leading to higher component turnover and lower component inventory levels. The technology also was credited with reducing human intervention in procurement and improving data integrity. Their survey results suggested that the efficiency of e-collaboration tools was, in general, greater for the upstream perspective than it was for the downstream perspective. They attribute the difference, in part,

to having to comply with customer data formats on the downstream side, and noted that the difference was particularly acute for procurement. Overall, the authors find that e-collaboration technology contributes more to key dimensions of performance when firms use them with suppliers than when using them with customers. They conclude that e-collaboration tools are positively related to the three performance dimensions, but that the relationships are stronger on the upstream side. Interestingly, the authors note that the relationship between efficiency of the e-collaboration tools and performance was not influenced by the position of the firm within the supply chain or the size of the firm. Rather, they find that the e-collaboration configurations of the firms allowed them to differentiate among the firms. Firms having more complex configurations (Leaders) including both supply chain execution tools (procurement, replenishment, etc) and supply chain planning tools (forecasting, planning, and business strategy) had much higher performance scores than firms focusing mainly on execution tools (Traditionalists) and those not finding either group of tools efficient (Laggers). This result suggests that the nature of the investment, or perhaps, how the investment is deployed within the firm, has direct bearing on the firm's performance.

In summary, several articles indicate that a firm's position within the supply chain is a factor in the firm's ability to realize performance benefits from SCMT. The available evidence is mixed, however. While Riggins and Mukhopadhyay (1994), Subramani (2004), Kent and Mentzer (2003) and Sahin and Robinson (2002) all indicate the likelihood of differential performance gains based on position, Cassivi *et al.* (2004) did not find it influential. Their results are based on self-reported measures of process improvements and cost reductions, and it may be that firms enjoy these improvements as the result of improved collaboration irrespective of their position within the supply chain. However, they also report that tangible resource measures (like cost reduction and inventory levels) received lower performance scores than intangible measures like product quality and customer satisfaction, and it may be that the magnitude of the performance gains varies by position within the supply chain, or that empirically observable financial performance would more likely vary by position within the supply chain than self-reported scores representing an internal view. Nevertheless, Cassivi *et al.*'s (2004) results are intriguing and suggest the need for additional research in this area.

Endogenous knowledge-intensive task improvement leading to operational improvement

Tallon *et al.* (1997) assessed the value of IT from a multi-dimensional perspective, and concluded that the value of IT investment stems from its ability to coordinate value-added activities. This notion is consistent with Mitya and Chaya (1996), who suggest that the primary benefit of IT investment is that it reduces the costs of coordinating both vertical (inter-firm) and horizontal (intra-firm) economic activities. Gunasekaran and Ngai (2004) claim that it is impossible to achieve a successful supply chain without IT to integrate the chain. Vickery *et al.* (2003) propose a firm performance model based on integrative IT yielding greater supply chain integration, which in turn improves customer service. Improved customer service, in turn, leads to financial performance benefits. They hypothesize that integrated IT improves the integration between supply chain member firms because it reduces coordination costs and transaction risk, and improves the volume and speed of information flows (Holland *et al.*, 1992). They then suggest that greater supply chain integration could lead directly

or indirectly to financial performance benefits. The indirect link runs through customer service. They argue that companies with greater supply chain integration will provide better customer service, and cite several papers providing empirical justification (Stank *et al.*, 1999; Stanley and Wisner, 2001; Frohlich and Westbrook, 2001). They then hypothesize that customer service leads directly to financial performance and also a direct link between supply chain integration and financial performance. Using structural equation modeling on data provided by a survey of 57 automotive industry suppliers to the Big 3 auto manufacturers, they found the path from integrative IT to supply chain integration statistically significant, as well as the paths from supply chain integration to customer service and customer service to financial performance. They found no support for supply chain integration leading to improved financial performance directly. Thus, Vickery *et al.* (2003) is an important paper because it establishes a link between SCMT investment (in their case, integrative IT) which leads to improvements in some knowledge-intensive capability (integration), and then provides empirical evidence that these improvements lead to intermediate operational or functional improvements (customer service), which ultimately lead to second-order financial benefits[6].

Wu *et al.* (2006) build on the concept of integration by suggesting that IT used in supply chain management can improve firm performance through supply chain "capabilities," which they define as improved information exchange, inter-firm coordination, integration of activities, and supply chain responsiveness. The authors hypothesize that firms investing in the most sophisticated information technologies (which the authors referred to as IT Advancement) could improve their technological compatibility with trading partners (IT Alignment), which in turn, could improve supply chain capabilities. IT advancement could also directly improve supply chain capabilities as well. Results of a survey of supply chain managers, logistics managers, and/or purchasing managers suggested that, consistent with their hypotheses, IT alignment strongly influences supply chain capability. Supply chain capabilities are also influenced by IT advancement. A higher level of supply chain capabilities provides the firm with an information advantage relative to competitors, which leads to improved financial performance. Again, in Wu *et al.*'s (2006) model, the authors suggest that investment in SCMT provide improvements in knowledge-intensive capabilities such as inter-firm coordination and integration, which ultimately lead to financial performance results.

While not specifically related to SCMT, Barua *et al.* (1995) is worth discussing here in the context of the SCMT financial performance model. The authors attempt to assess the economic value of IT on strategic business units. They argue that difficulties in attributing performance to IT investment is largely a measurement issue, and then propose a process-oriented methodology for *ex post* measurement of performance. Specifically, Barua *et al.* speculate that IT will have first-order effects on operational variables, like inventory turnover and capacity utilization. These first-order variables then affect higher-order variables, like profitability or market share. As part of their model, they also include economy-wide exogenous variables acting upon the performance variables. To test the model empirically, the authors regress IT spending measures against the intermediate-level operational variables and then the intermediate-level variables against higher-order performance metrics. Their results generally supported their contention that the IT impact would be observed in

operational measures, and strongly supported the contention that the operational variables in turn affected performance metrics. In substance, then, Barua *et al.*'s (1995) results suggest that any model relating SCMT adoptions to financial performance should show the performance as a derivative function of operational improvements.

First-order effects

In a detailed case study of EDI use at Chrysler, Mukhopadhyay *et al.* (1995) linked improvements in inventory carrying costs and inventory obsolescence to implementation of EDI technologies. They suggested that Chrysler achieved these inventory improvements because the system enabled higher-quality information to flow as well as greater coordination of activities between Chrysler and its suppliers. Blankley *et al.* (2008) examine the effect of SCMT adoptions on inventory metrics as well. In line with Barua *et al.*'s (1995) empirical findings, Blankley *et al.* (2008) examine the impact of full-scale SCMT implementations relative to partial implementations on firms' inventory levels and turnover. They argue, like Barua *et al.* (1995), that prior empirical studies had difficulty observing a link between SCMT adoptions and financial performance because the financial performance metrics (usually ROA, return on sales (ROS), or some other income-based metric) were second-order results. While the first-order impact of SCMT adoptions on inventory could certainly influence income-based metrics through cost reductions, there are too many other influences on net income in particular (White *et al.*, 1997), to draw a direct link between the two. Using a multi-method approach, Blankley *et al.* (2008) first develop an analytical model of inventory optimization, then analyze it using a numerical experiment, and finally test the model empirically using a sample of firms that implemented SCMT in 1999 and compare results against a control group of non-implementing firms. Their results suggested that inventory optimization could be achieved by a system-wide perspective. That is, the analytical model and numerical experiment showed that if each participant in a three-stage inventory model optimized inventory according to its own demand, then reductions in inventory holdings and costs are not as large as they would have been had each firm optimized system-wide inventory. They theorize that firms adopting SCMT across the entire firm have greater visibility through improved information and coordination of activities, and will be more likely to optimize inventory holdings system-wide than for each particular unit. Firms without SCMT, or firms implementing SCMT across only a portion of the firm, will be less likely to optimize inventory system-wide.

To test their model, they analyzed inventory data for three years following SCMT adoptions. The two inventory metrics of interest were, first, the differences in pre- and post-adoption inventory amounts scaled by revenue and, second, the differences in pre- and post-adoption inventory turnover. These variables were then regressed against indicator variables for implementation and the scale of the implementation as well as control variables for firm size, SCMT vendor, and whether the firm purchased the full suite of SCMT applications. Their empirical results indicated that implementation alone did not lead to improved inventory metrics. Rather, only firms that implemented the SCMT across the entire firm enjoyed improved inventory metrics following implementation. Inventor-to-sales levels relative to pre-implementation levels improved by year two following implementation for full-scale implementers, and that improvement was sustained through year three following implementation.

Inventory turns increased for full-scale implementers in years one and two post-implementation relative to pre-implementation turns. Partially implementing firms and non-implementing firms did not show improvement. Thus, Blankley *et al.* (2008) supports several aspects of the SCMT financial performance model. First, their study suggests, like Barua *et al.* (1995), that SCMT stimulates operational or functional improvements, which, in the case of inventory, yield measurable first-order results. These results may be traceable to income-based firm performance metrics, but there will be considerably more noise in the relationship. Second, and perhaps more importantly, their results suggest that the nature of the investment in SCMT needs to be considered. Since implementation alone did not yield significant improvements in inventory, then it is important to consider the magnitude or the scope of the investment when theory suggests that performance improvements occur as a result of coordination or integration of information and activities.

Second-order effects

Dröge and Germain (2000) study the effect that EDI technology has on two areas of performance: inventory holdings and financial performance measured as ROS and return on investment. Studying a sample of 200 US manufacturing firms, they develop a structural equation model examining EDI and inventory holdings, financial performance, and contextual factors thought to mitigate the relationship. Dröge and Germain report that, in general, the greater the EDI investment, the greater the inventory holdings are and the better the financial performance is. They also find that JIT bears an inverse relationship to inventory and has a positive relationship to financial performance. The somewhat counterintuitive result that EDI increases inventory was examined in a series of subgroup analyses where Dröge and Germaine analyze binary groups for each factor. They broke the sample into two groups for each contextual variable and then regressed each group's contextual variables separately against inventory and financial performance measures. For example, the variables of interest and contextual variables were broken into binary categories: small and large firms, volatile and non-volatile demand, routine and non-routine production, high/low JIT, and high/low EDI. Each of these variables was treated as an independent variable in regression models having inventory and performance as dependent variables, and each subgroup was regressed separately. Their subgroup analysis revealed that EDI was associated with increased inventory in small firms, but not associated with it in large firms. They interpret this as an indication that small firms increase inventory as EDI increases because "near instant access to inventory information requires near instant access to inventory," and speculate that small firms lack the ability to offset pressure to increase inventory levels placed on them by their larger trading partners. So, in order to prevent stockout losses, small firms are willing to hold more inventory as the EDI relationship increases.

EDI is also positively associated with inventory when the production technology is routine and when JIT is high. Interestingly, they found that EDI was positively related to financial performance metrics, but that the association was not transitive through inventory. In fact, they write:

> Managers should thus understand that EDI associates with financial performance [and that] relationship is not attributable to changes in inventory (for example, reduced inventory costs), but rather to direct and other efficiency gains (p. 227).

Dröge and Germain (2000) indicate that EDI provides for efficiency gains that translate into financial performance improvements, but fail to relate this to inventory improvements. Their results are interesting in that they are able to uncover a performance advantage to the technology, but they do not indicate how, or through what mechanism, the efficiency advantage they suggest is achieved, except to note that it is not through inventory reductions. Also, although there may be much in common with EDI, or EDI may represent a part of SCMT broadly considered, SCMT would likely be more tailored to inventory optimization than EDI would. In other words, a general information exchange technology like EDI would be less likely to result in reduced inventory holdings than SCMT applications written specifically to manage inventory. Finally, Blankley *et al.*'s (2008) results suggest that the nature of the implementation (whether it was full-scale or not) may help explain Dröge and Germain's findings.

In a study specifically examining SCMT, Dehning *et al.* (2007) analyzed the financial performance of SCMT adoptions on a sample of 123 manufacturing firms from 1994 to 2000. Using a slight modification to Porter's (1985) value chain as their theoretical construct, Dehning *et al.*, associated different performance metrics with inbound processes, operations processes, and outbound processes as well as support activities. The inbound, operations and outbound processes were linked, respectively, to raw materials, work-in-process, and finished goods inventory levels, and they further linked gross margin to inbound, and market share to outbound, processes, respectively. As in Dehning and Richardson (2002), they claimed that IT-based SCM systems led directly to improvements in intermediate process measures (those metrics they identified with inbound, operations, and outbound processes) and also indirectly influenced overall firm profitability (total inventory turnover, ROA, and ROS) through lower costs of coordination, better decision making, and, presumably, other knowledge-specific task improvements. To analyze the performance effect of SCMT adoptions, the authors took the change in each performance metric from one year prior to the implementation to both one and two years following implementation, adjusted each variable to eliminate the change in industry median, and then used these differences as the dependent variables in individual general linear models. After controlling for size and year of implementation, they found that raw materials, finished goods, and total inventory turns were significantly improved from pre- to post-adoption for both years, but that WIP inventory turns were not improved in either post-adoption year. In addition, they found that ROS improved in both years following adoption, but that ROA did not. Finally, they observed some reduction in SG&A in the second year following adoption, but not in the first year.

In order to study the linkage between these intermediate process improvements and performance metrics further, Dehning *et al.* tested several regression models. Using firm performance metrics (ROA and ROS) as dependent variables, and inventory turnover, SG&A, and high-tech variables as independent variables, Dehning *et al.* also included control variables for the scope of the implementation (a dummy variable indicating firm-wide implementation or not), size, and the year of implementation. Their results indicate that inventory turnover improvements following SCMT implementation are significantly associated with the changes in ROA and ROS following implementation; SG&A changes, which they linked conceptually to support process improvement, prove significant for ROA but not ROS, and asset turnover also

proved significant for ROA but not ROS. These results stand in contrast to Dröge and Germain (2000), who were unable to link inventory improvements to firm profitability.

Interestingly, Dehning *et al.* also find that the scope of the implementation was significantly, but negatively, related to both performance metrics. In other words, firms that implemented SCMT firm-wide were less profitable following implementation than firms that did not implement firm-wide. They attribute this counter-intuitive result to the complexity of the firm-wide implementations, relative to limited roll-outs, that result in short run reductions of profitability. It may also be attributable to glitches in the system that need to be worked out (Hendricks and Singhal, 2003) before expected profitability can be realized. Their primary finding of SCMT adoptions leading to in-bound and out-bound process improvements that result in inventory turnover improvements is consistent with Blankley *et al.*'s (2008) findings, and extends those findings to include a link to profitability metrics derived from these first-order improvements. Dehning *et al.* also note that their inability to find work-in-process inventory turnover improvements, which they conceptually related to operations processes, may indicate that inbound and outbound processes inventory turns improve by a greater (and statistically significant) amount due to the greater benefits of information flow between these functions and upstream and downstream partners, which the SCMT facilitates.

Dehning *et al.* (2007) is an important paper in the area first because it demonstrates a link between SCMT investment and intermediate process improvements, and then demonstrates that these improvements are influential to firm profitability. The paper also develops and supports Barua and Mukhopadhyay's (2000) notion that technology investments need to be well targeted, well timed, well-managed and accompanied by complementary initiatives in order to be successful in fostering firm performance. Both, their results and the fundamental theory, they develop in their paper are consistent with the model developed in this paper.

Valuation impact

There have been relatively few papers examining the valuation impact of SCMT investments. Dehning *et al.* (2003) and Dehning *et al.* (2004) looked at the value-relevance of IT announcements, but neither paper was specifically related to announcements of SCMT investments. However, it is fair to argue that Dehning *et al.* (2003), was at least tangentially related to SCMT. In that paper, the authors studied the IT investment announcements categorized according to four strategic roles, which the authors credited to Schein (1992) and Zuboff (1988); automate, informate-up, informate-down, and transform. The definition of transform is to fundamentally redefine business and industry processes and relationships. Briefly, the authors found that IT investment announcements were value-relevant when the announcements reflected transformative technology investments. In other words, the authors were able to observe abnormal returns to companies announcing transformative IT investments. While not related to SCMT directly, it seems reasonable to suppose that SCMT investments represent a form of a transformative investment, and thus may lead to a valuation impact.

In a more directly related study of supply chain management, Hendricks and Singhal (2003) examined the valuation impact, not of SCMT investments, but of "glitches" within the supply chain resulting in production or shipment delays.

Using a sample of 519 glitch announcements from 1989 to 2000, Hendricks and Singhal (2003) found that supply chain glitch announcements were associated with negative abnormal returns of 10.3 per cent. Their work indicates that the market reacts to news concerning supply chain management problems, and so lays the groundwork for their follow-up work on the market impact of SCMT implementations.

In 2007, Hendricks *et al.* published the only paper to date examining the long-term market reaction to SCMT investments. Specifically, they examined the market reaction to a sample of announcements concerning ERP, SCMT, and CRM implementations. They also examined two profitability metrics of adopting firms following the adoptions. For the SCM implementation portion of their study, Hendricks *et al.* (2007) find long-run abnormal price returns for each SCMT implementation announcement firm relative to a matched control group[7] of firms for the implementation year and for three years following implementation. Their results indicate that there was no difference in returns for the implementation year; over the full, four-year window, the mean abnormal return of SCMT announcing firms was 18.75 percent, which was significantly positive at p-values of 0.07, but the median return was -9.24 percent. They also report that only one-half of the announcing firms do better than the median return of their matched control portfolio. Overall, they conclude that there is some evidence of abnormal, long-run market returns accruing to SCMT investing firms. Their results for financial performance metrics (ROA and ROS) are stronger. More than 60 percent of the firms had performance metrics better than their assigned portfolio median metric, and the results indicate the change in the metrics were both significant at p-values < 0.01. Overall, Hendricks *et al.* (2007) finds further support for the notion that investment in SCMT leads to financial performance improvements based on accounting metrics, and also finds some (weak) support for a long-term valuation impact from SCMT investment. Interestingly, investment in SCMT was the only technology they examined that demonstrated any long-run valuation impact; ERP and CRM implementations were not associated with stock price improvements.

Hendricks *et al.* (2007) supports the SCMT model in several ways. First, they find that firm performance is related to SCMT investment, and so support the results of several other studies discussed above. Importantly, they support the SCMT investment/performance link using a different methodology that introduces stronger controls to their study than several previous studies, which suggests that the link in not an artifact of some missing, correlated variables. Second, they also test for a long-run valuation impact, which should accrue to the firm if the SCMT investment does, in fact, lead to sustainable financial performance improvements. Presumably, the financial improvement leads to increased positive future cash flows (i.e. all performance gains are not attributable to non-cash accruals), which should result in firm valuation increases. Hendricks *et al.* (2007) is the first paper to address the issue and provide some evidence in this respect.

Opportunities for future research

Within the relatively narrow scope of research evaluating the financial performance benefits to investments in SCMT, there are still unanswered questions which provide opportunities for future research efforts. To date, the research methods employed have been varied, but have been primarily survey-based (Dröge and Germain, 2000; Kent and Mentzer, 2003; Vickery *et al.*, 2003), and to a lesser extent, archival

(Barua *et al.*, 1995; Dehning *et al.*, 2007), or a combination of methods (Cassivi *et al.*, 2004 – survey and case study; Blankley *et al.*, 2008 – analytic and archival). Field studies have also provided data (Subramani, 2004). The fact that several different approaches have been used suggests that there are multiple approaches to addressing the research questions, but publicly available data pertaining specifically to SCMT investments is scanty and tends not to be particularly detailed. For example, Blankley *et al.* uses news wire announcements to find the sample of SCMT-implementing firms and find that press releases are frequently not detailed enough to provide useable observations. Despite this caveat, there are still remaining questions to be answered and improvements to existing research that could be made. I discuss these opportunities below and classify them according to three approaches to the existing literature: inconclusive issues, measurement issues, and extensions.

Inconclusive issues

Given the research to date, several of the findings appear inconclusive. For example, Subramani's (2004) paper examines the supplier – customer relationship for a large Canadian retailer and finds that SCMT can help offset the difference in bargaining power between the supplier and the retailer. Subramani finds that the value in the investment is realized differently for both parties, and that the supplier is at a distinct disadvantage in the relationship. Indeed, without strategic use of the SCMT, the supplier runs the risk of foregoing valuable benefits from the use of the technology. On the other hand, in a study of supply chain e-collaboration tools, Cassivi *et al.* (2004) do not find evidence to support that view. Cassivi *et al.* study the supply chain for a telecommunications equipment OEM through a detailed case study and an electronic survey. They find that the relative efficiency of the technology was related to the performance dimensions, but that this relationship was not influenced by the firm's position in the supply chain. A research opportunity exists to examine the issue of whether or not, and to what extent, a firm's position within the supply chain impacts its ability to realize performance benefits from an investment in SCMT. This is not a trivial question. If upstream firms are less able to realize performance gains, they become relatively less willing to make the necessary investment, and system-wide costs increase. This suggests the need for benefit sharing, or efficient contracting (Cachon, 2003), to offset the positional disadvantage. Of course, Subramani's paper (in this context) was the only paper that examined the issue of relative power, so perhaps the real issue is, as Riggins and Mukhopadhyay (1994) suggest, not so much an issue of location within the supply chain as it is of relative power within the supply chain. With the exception of Subramani (2004), this question, as it pertains to financial performance of SCMT investments, has received relatively little attention.

A second inconclusive issue deals with the impact of SCMT on inventory holdings and the potential performance benefits from optimizing inventory holdings. Dehning *et al.* (2007) and Blankley *et al.* (2008) both find that SCMT leads to improved inventory turns, although Dehning *et al.* did not find that true for work-in-process inventories. Dröge and Germain (2000), however, found that EDI use was positively related to inventory holdings for small firms, and suggests that the firm's size (measured by number of employees or total assets) may be a surrogate for its relative bargaining power, which may explain why small firms using EDI hold more inventory than large firms. More to the point, Dröge and Germain's results indicate that the financial

performance benefits observed were not related to inventory reductions while, after controlling for firm size, Dehning *et al.*'s results strongly indicated that the inventory improvements were significantly related both to ROS and ROA. Both authors used a sample of manufacturing firms. Thus, the evidence seems inconclusive concerning the effect of SCMT investment on inventory holdings and any resultant financial performance. One of the issues that still needs to be addressed is how the imperative to optimize inventory factors in with evidence that firms implementing SCMT both reduce inventory (Dehning *et al.*, 2007; Blankley *et al.*, 2008) and increase inventory (Dröge and Germain, 2000). Inventory optimization for one firm, or one product line, may mean increasing inventory levels, but may mean the opposite to another firm. Future research could address this issue by considering ways to measure inventory optimization based on firm-specific or demand-specific characteristics, and then use these measures in tests of SCMT performance.

Finally, the two most recent studies, Dehning *et al.* (2007) and Blankley *et al.* (2008), report conflicting results with respect to the scope of the implementation and the impact of SCMT on performance. Blankley *et al.* found that only firms implementing SCMT on a firm-wide basis (full scope firms) enjoyed inventory reductions and increases in inventory turns. Dehning *et al.* on the other hand, found that full-scope implementation actually reduced profitability. This issue is an important one for managers considering implementing SCMT. It may be that the pay-back in terms of financial profitability to full scale implementation takes much longer to achieve than inventory improvements, but that inventory improvements require much greater investment in SCMT to realize. If so, then this represents a trade-off of interest to SCMT customers and vendors. The issue is not clear. Further research into this question is necessary help resolve this particular issue.

Measurement issues

In general, a significant number of the papers examining financial performance benefits to SCMT or derivative technologies construct profitability measures based on popular accounting performance ratios like ROA, ROS, and ROE. While useful, these metrics are somewhat limited in evaluating a firm's overall performance because of the measurement issues associated with net income. Net income frequently includes transitory or random components, which are not related to the firm's core operations (White *et al.*, 1997, p. 45). As a result, these components of income are not sustainable or persistent, and therefore of less analytical value than other income components in determining the operating impact of SCMT investments. Future research efforts could therefore focus on determining the performance impact of SCMT investments using alternative metrics, particularly operating income metrics, or metrics removing the effect of accruals from net income (Sloan, 1996), which may better represent core performance. Relating SCMT investment to superior measures of core performance will likely yield less biased, more reliable results.

In addition, if SCMT investment improves the fundamental value of the firm as Hendricks *et al.* (2007) suggest, then it is reasonable to assume that there should be an observable, positive cash flow impact of the SCMT investment, which, in turn, in an efficient and unbiased market, would be reflected in long-run price changes. No study to date has evaluated the impact of SCMT investment on long-run operating cash flows and the relation to price changes.

Extensions

There are several opportunities available to extend this nascent literature or to move it in new directions. I discuss the opportunities in increasing order of the ambition of the research effort. First, a number of the studies discussed above link SCMT investment with operational improvements leading to first-order financial effects. The first-order impact most often hypothesized and linked back to SCMT was inventory metric improvement. However, there are several other likely first-order performance improvements not included in the model because I could not find them supported in the literature. It is likely that SCMT investment would lead to improvements in transportation costs, reduced warranty costs, higher product quality, or reduced down time as the technology improves communication, integration, and decision making, which leads to operational improvements in production, customer service, or internal logistics. Future research documenting these links would result in useful extensions of the current studies in the area.

Second, several studies link SCMT investment and financial performance through knowledge-intensive capabilities, but few, if any, have linked SCMT investment both to knowledge-intensive capability improvements and financial performance through operational or functional improvements. For example, an important extension would be to show that SCMT investment leads to improved collaboration, which in turn leads to improved procurement processes, and ultimately reduced SG&A. Another example may be to explore the question of how communication improvements resulting from investment in SCMT affect customer service efforts, and what first-order effects derive from that improvement.

Third, one area that has received little attention is the impact of SCMT on pricing and the extent to which it helps mitigate the double marginalization problem. Double marginalization refers to sellers within a supply chain selling at prices above their marginal costs with the resulting series of markups reflecting higher retail prices for end consumers but lower combined profits for the supply chain. Research into the extent to which SCMT ultimately affects pricing decisions and the resulting impact on profitability would represent an important extension for the research stream. This problem could potentially be mitigated to some extent by technology that provides visibility into suppliers' pricing and product quality and reduces the search costs of finding and approving alternative suppliers. At the same time, supply chain management has begun to be studied within a complex adaptive systems framework (Choi *et al.*, 2001). A complex adaptive system is a system that emerges over time without any centralized control directing it. Choi *et al.* argue that the current literature emphasizes a deliberate or deterministic approach to managing supplier networks through inter-organizational metrics facilitated through IT, and suggests that this may ultimately prove ineffective because the networks are subject to change (new suppliers, products, processes, prices, etc.) that disrupt the system's ability to respond to changes. To what extent, then, is SCMT responding to an adaptive model, rather than a deliberate control model, and what are the potential operational improvements derived from such a system? Would an adaptive model eliminate pricing anomalies like double marginalization or reduce procurement costs? What are the potential financial benefits of adaptive SCMT relative to existing SCMTs?

Finally, no study that I am aware of has tried to model the financial performance benefits of SCMT to the entire supply chain. Each of the studies examined above focus

on the performance of the individual firms. Lambert and Pohlen (2001) argue that current metrics used to evaluate supply chains are actually more reflective of internal logistics performance, and that to be effective, performance metrics need to reflect the overall performance of the supply chain. A valuable contribution to the literature would be to study the financial performance of the supply chain following investment of its members in SCMT. Because of the limitations of publicly available data, this project would most likely need to take the form of an in-depth field study, where performance metrics for the chain were developed along the lines of those suggested by Lambert and Pohlen (2001) with the aid of the participating firms and compared to pre-adoption metrics.

While there are clear empirical difficulties in attempting to develop this project using archival sources, it may be possible to create small, two- or three-member supply chain observations where all firms have adopted the technology by examining news wires for press releases, surveying target firms, or developing contacts at professional meetings. If the obstacles involved in developing a (necessarily small) sample of public firms comprising a supply chain could be overcome, then aggregate performance measures could be developed using both accounting information and shareholder value measures and compared to the same aggregate measures for non-implementing chains or sample-matched, randomly developed chains (as in Hendricks *et al.*, 2007).

Conclusion

This paper reviews the literature relevant to the financial performance of SCMT investments and presents a model for examining the financial performance impact of such investments. To date, there have been relatively few studies that looked specifically at this issue. Over the last few years, however, the topic has attracted increasing attention, as the majority of papers examining the topic have appeared since the year 2003. This may be partly explained by the fact that SCMT is a relatively recent technology, or set of technologies, itself, and partly as a result of researchers' attempts to link targeted technologies to specific business outcomes and then link those outcomes to profitability. SCMT represents a more clearly targeted a technology than, say, ERP systems.

The model presented in this paper considers investments in SCMT and the position of the investing firm within the supply chain. In order to prepare to optimize the value of the investment, or perhaps as a result of the investment, investing firms will undergo some sort of organizational alignment in which the firm makes critical process changes, revisions to supply chain strategies, and training. The model then suggests that, after a time period, investment in SCMT leads to improvement in knowledge-intensive capabilities, which in turn lead to tangible operational or functional improvements. These operational or functional improvements provide first-order benefits to the firm, which may result in financial benefits ultimately discernible in the firm's financial statements, depending on the particular measure. These operational improvements take time to develop due to the learning effects, so there is likely to be some time lag between the improvements in knowledge gained by SCMT and the practical outcome. There is also likely to be a time lag between the operational improvements and the first-order effects as firms sell through inventory, increase quality and renegotiate contracts with suppliers. Finally, as the first-order effects take hold, the firm will start realizing financial benefits, first internally, and then

eventually appearing in the financial statements. These benefits or financial improvements will not appear all in one period, but, due to the nature of accrual accounting, be recognized over several periods, and so, again, there will be a time lag. The model also indicates that financial performance results will also be affected by industry trends, competition, and other market forces, further diluting the observable impact of the investment. Finally, as information concerning the SCMT investment becomes publicly available through news announcements or through other means, and as the firm begins reporting improved profitability and balance sheet metrics, the model indicates a valuation impact.

Notes

1. Discussing the IT investment productivity literature is beyond the scope of this paper, and its size precludes a comprehensive reference list here, but for a useful introduction to the nature of the work across time, see Bender, 1986; Banker *et al.*, 1990; Feeny and Ives, 1990; Brynjolfsson, 1993; Barua *et al.*, 1995; Kettinger *et al.*, 1995; Mata *et al.*, 1995; Brynjolfsson and Hitt, 1996, 1998, 2003; Benaroch and Kauffman, 1999, 2000; Bharadwaj, 2000; Sircar *et al.*, 2000; Dehning and Richardson, 2002; Dedrick *et al.*, 2003; Dehning *et al.*, 2003; Kohli and Devaraj, 2003; Melville and Kramer, 2004.
2. Elmuti (2002), for instance, cites a Deloitte and Touche consulting survey indicating that 91 percent of North American manufacturers rank supply chain management as very important or critical to their companies' success. It seems reasonable to infer that a critical component of corporate success (in this case, supply chain management) would play some role in the firm's strategy. Indicating the growing importance of the supply chain, Horvath (2001) argues that competition in the future will no longer take place between individual businesses, but among entire value chains. If such a claim is true and predictable, then it follows that such competition would require firms to align their individual business strategies with the strategic objectives of the supply chain. As a final example, Brewer and Speh (2000) argue that for firms to achieve competitive advantage, it is important to align supply chain management practices with strategic performance measurement.
3. The citations supporting this point would be rather extensive, so in the interest of readability, rather than list them all here I refer the reader to the appropriate section of Table I.
4. This contention is supported by a great deal of the financial accounting, finance, and financial economics literatures. It is beyond the scope of this paper to list these here.
5. There is a fairly substantial body of work addressing performance measurement systems, metrics, and measures used in evaluating internal logistics and supply chain performance. Beamon's (1999) paper provides a comprehensive look at performance measures in the literature to that date. More recent efforts in the area include Lambert and Pohlen (2001), Gunasekaran *et al.* (2004), Bremser and Chung (2005), Chenhall and Langfield-Smith (2007) and Griffis *et al.* (2007).
6. Like the IT productivity and performance measurement literatures, there is a relatively large body of work studying the impact of integration as it involves logistics, supply chain management, and firm performance. Vickery *et al.* (2003) is important because it introduces SCMT and links it through integration and customer service to performance. For additional reading on integration and performance, see Stank *et al.* (1999); Ellinger *et al.* (2000); Mollenkopf *et al.* (2000); O'Leary-Kelly and Flores (2002); Gimenez and Ventura (2005); and Chen *et al.* (2007).
7. The control groups were based on methodology suggested by Barber and Lyon (1997) and Lyon *et al.* (1999). In this case, Hendricks *et al.* (2007) developed a portfolio of control firms

for each test subject firm based on industry, size, and prior performance metrics. No control for prior implementation of SCMT within the matching firm portfolios was included, but they argue that the methodology used in examining the firm against its control portfolio tends to mitigate that potential impact.

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