Guest Editorial
Supply Chain Management as an Emerging Focus of Technology Management

I. Introduction

TECHNOLOGY management is a complex multidisciplinary field with different perspectives on diverse phenomena. Ostensibly, any place where technical personnel, knowledge, products, or processes intersect with management issues is fair game for the field. As evidence, we have seen the merging of engineering issues with managerial issues. Engineering schools have taken on a more managerial face, while business schools where management as a discipline has been studied over the years have shown a keen interest in the technical or engineering approaches. Indeed, the field of technology management has broadened considerably beyond management of engineers and technical personnel to management of technology, embracing both a managerial perspective of engineering as well as a technical perspective of management.

The technology management field has clearly matured over the years. Several researchers in this field have considered the evolution of technology as firms are born, grow, and die [1], [3], [25]. Others have investigated relationships across boundaries such as design and manufacturing [20], [34], [43] and some have studied the strategic planning process that leads to key technology decisions [31], [44], [48]. Some researchers have studied the relationship between buyers and suppliers [22], [23], [27], [51] and even the relationship between a supplier and another supplier [12]. Although the study by Choi and Hartley [9] spans several tiers of a supply chain, its technological consideration was limited to the context of supplier selection. In general, when we look at most of the published research in the field, it seldom goes beyond a single firm.

The field of supply chain management has also assumed different faces in different fields. In organizational theory, it falls under interorganizational relationships [16], [30], [40], [46], [52]. Purchasing management is the professional discipline of managing suppliers [15], whereas logistics management focuses on the flow of goods through the supply channels [5]. Transaction cost economics is the economics discipline that deals with make versus buy decisions [47], [49]. Corporate strategy also has focused a good deal on the strategic advantages of various types of strategic alliances [19], [37].

II. Underlying Orientation of the Special Issue

Recently, the field of supply chain management has appeared as a growth industry in consulting, technology services and academia. Many courses in engineering, operations, marketing, and information technology (IT) have incorporated various "supply chain" issues. The National Association of Purchasing Management has even renamed itself as Institute for Supply Management to move beyond purchasing and procurement to the broader field of supply management. Both Arizona State University and Michigan State University have supply chain in the name of a department.

There are many reasons for growing interest by academia, consultants, service providers, and industry in supply chain management. These reasons include the following.

- Supply chain management espouses the systems perspective, which is being widely adopted in academia and in industry; this perspective emphasizes looking beyond the parts to the linkages between the parts. Systems thinking also focuses on the environment as a context for strategic planning and organizational design [32], [38]. This naturally leads to considering linkages between firms and the supply chain as a key strategic context [16].
- There are many popular models in industry that lead to thinking across boundaries. Examples include quality management [11], [14] and the lean enterprise [50]. Concepts like "partnership" are reframing thinking in industry about the role of "vendors" in the extended enterprise [18].
- Advanced IT, particularly in the context of the Internet, enables much faster and real time information sharing which makes possible close collaboration across firm, geographical, and national boundaries. This has led in some cases to actual reconfiguration of firms into what some call "virtual organizations" [51]. It has also led to a rethinking of the basic concept of an organization from individuals who sit in the same building and share common reporting relationships to complex networks of firms that interact to serve a variety of stakeholders.
- The rate of change of technology has increased to the point that no one firm can know it all. While in the past a major factor was differentiation in the firm which created pockets of specialized knowledge, today it is more likely that the important differentiation is across firms with specialized expertise. The notion of a "core competence" of a firm recognizes that becoming expert at all facets of the business is not realistic for most firms [29], [37].
- Even aspects of supply chain management itself have become increasingly specialized. Transportation management is becoming a specialty distinct from overall logistics management [5], whereas purchasing is specializing in applied topics like sourcing strategies, supplier quality methods, value engineering, and so on [15].

In our view, supply chain management and technology management are inextricably connected. While this view has received attention recently, it is not a recent phenomenon. Our

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goal for the Special Issue was, as stated in the *Call for Papers*, to "bring together state of the art research on the role of technology in supply chain management." We wished to consider technology both as an enabler of effective supply chain management (e.g., Internets and Intranets) and as a product of supply chain management (e.g., various modes of interorganizational relationships for purposes of technological innovation). The topics we invited for this Special Issue included, but were not limited to the following.

1) *The role of technology as it shapes manufacturer–supplier relationships*. How do such technologies as Internet, ERP, EDI, product data exchange, and logistics management software impact manufacturer–supplier relationships?
2) *New logistics technologies for supply chain management*. What kinds of operations strategies lead to high-quality, low-cost, and short-lead time management of the supply chain? These include new operational strategies such as just-in-time (JIT) philosophies and methods.
3) *Implementation issues in supply-chain technologies*. What kinds of cultural and organizational changes are needed to implement new supply chain technologies? These include ERP, advanced planning systems, product data exchange, EDI, and simulation algorithms.
4) *New organizational forms for technology partnering across the supply chain*. These include joint ventures, technology licensing, partial ownership, and virtual organizations.

The peer review process does not allow us to hand pick authors or topics to cover the full range of supply chain issues. Rather, we cast a broad net to see what would come in and which papers would survive the review process. Nonetheless, presumably this journal reaches a broad enough pool of researchers that what we have assembled is representative of the better quality research being conducted by scholars who both know about this journal and are studying supply chain issues. Thus, we have an opportunity, admittedly with a very small sample size, to characterize the current state of research in the field. In this introduction, we will provide a simple model to frame the topics in supply chain management and place the accepted papers within this model. We will then provide an overview of the content of each of the articles. We also decided to go beyond content summaries and add a more personalized section where we describe why we like the papers, thereby taking liberty to give unabashed nonscientific personal opinions as editors of this publication.

III. Dimensions of Supply Chain and Technology

There are obviously many dimensions along which we could potentially classify the broad field of supply chain management. At the very least, to define the domain of supply chain management, we must consider connections across firm boundaries.

The minimum extent of supply chain involves two firms with one link connecting them. However, this is clearly a very short chain. Arguably, a true supply chain should be extended beyond the single link of a buyer–supplier dyad [8], [10]. Only when a chain with multiple links is involved can one begin to observe systems dynamics such as the "bull-whip" effect [6], [33]. To this end, we can distinguish the papers in this issue on the dimension of the extent of links across organizations—whether they focus on technology across a single organizational link or multiple links across several organizations.

A second dimension considers the technological issue being considered in the linkages across firms. Technology includes both social and technical aspects [7], [39]. Social aspects involve human interactions within and across the organizations as these effect technology development, implementation, and use and the technical aspects involve nonhuman elements such as tools, devices, and operational procedures [21], [26].

Social aspects of technology would include such issues as the knowledge creation by people and past knowledge built on by people, both tacit and explicit knowledge, such as the know-how of people embedded within and across organizations [2], [42], [45]. We also include the effect of different social and organizational relationships on technology issues across firms. Technical aspects would include hard technology such as computers and manufacturing equipment and softer process issues such as standard operating procedures and policies [39]. Much of IT that requires implementation of computers and automation would be subsumed under hard technology. In addition to the hardware and software that often is thought of as encompassing technology, our definition is broader and considers procedures and methods such as JIT processes using kanban that orchestrate the activities across different phases of materials movement across the supplying and buying organizations. We refer to these as operational processes.

Therefore, the focus of this Special Issue—supply chain management and technology—will be further differentiated into two dimensions. First, under supply chain management, we distinguish studies that consider single links versus multiple links. Second, we consider three dimensions of technological issues in the supply chain: social organization as it impacts technology, operational processes; and hard technology. The combination of supply chain and technology dimensions offers us a 2×3 matrix.

IV. Framing the Topography of the Papers

We have placed all papers in this Special Issue into this matrix, as shown in Fig. 1 and found a definite bias in the research. All but one of the papers in this Special Issue pertains to the technical aspect—operational processes and hard technology. Further, none of them look beyond the context of two organizations; they are all limited to a single, dyadic link connecting two organizations at most. More detailed discussion of how each of these articles has been categorized into one of the six boxes appears in the next section when we overview each paper.

Unless the issues of organizational relationships across multiple links do not matter or have no implications for technology (which we do not believe) and unless one can learn all that one needs to know about supply chains from dyadic links (which we certainly do not believe), there appears to be a big gap in the research in this area. With the emergence of contract manufacturers such as Flextronics, large system suppliers such as Delphi and Visteon, and other companies that supply to them, we might say that the tiering of the supply base or the "supply chainization" of the supply base has become a common sight in the landscape of the supply chains. Therefore, if we are going to study supply chains or develop theories of supply chain management, we must go beyond a simple dyadic context and reach

	Social Organization	Operational Processes	Hard Technology
Single Link	• Supplier development (Reed and Walsh)	• JITP (Kaynak) • Methods to reduce safety stock (Yan et al.) • Managerial techniques, methods and knowledge (Vachon and Klassen)	• Electronic commerce (Lin et al.) • IT applications (Ellram and Zsidisin) • IOIS (Shah et al.) • IT (Carr and Smeltzer)
Multiple Links	None	None	None

Fig. 1. Categorization of articles into supply chain and technology dimensions.

out to the dynamics that may unfold in the world of multiple links.

Furthermore, the absence of papers on the social side of supply chain as it effects technology management is conspicuous. Certainly, there have been papers written on buyer–supplier relations with technological implications [17], [24], [36], [41] such as how buyer–supplier relationships effect new product development [13], [28], [35]. Nonetheless, we feel that there can be more studies that investigate the social fabric of firms linked by their supply chain and how compatible or incompatible the cultures; if incompatible, studies can investigate what firms do to overcome it and how the social relationships can in fact be viewed as unimitable and rare resources [4]. All of these social issues have serious implications for joint technology development, technology sharing, use of collaborative information technologies, technology strategy, new product introductions, and design-manufacturing integration.

V. Overview of the Papers

Here is what you can expect in this Special Issue. We have summarized the context and methods used for the papers in Table I. We further provide a summary of each paper.

A. Social Organization

Reed and Walsh explore the impact of supplier development programs on the technological capability of small suppliers. In case studies from the U.K. aerospace industry, supplier development programs were found to have a positive effect on supplier technological capability, but this was not due to a strong emphasis on technological elements within the schemes. Rather, the supplier development programs strengthened relationships between the customer and supplier firms and also involved customer engineers and technologists in the process. This enabled the communication of strategic technological information, which is likely to benefit the innovation processes of the supplier and, ultimately, should enhance their technological capability. The authors suggest that an opportunity remains for supplier development programs to engage more directly with technological capability concerns, by promoting technology management practices in supplier firms.

B. Operational Processes

Kaynak examines the beneficial effects of just-in-time production (JITP) techniques on firms' performance. Drawing on organizational change and operations management literature, the author views JITP as a process technology and identifies internal (top management commitment, training, and employee relations) and external (supplier value-added, transportation, and quantities delivered) techniques of JITP. The findings, obtained from structural equation modeling, show that the implementation of JITP techniques results in increased financial, market, and operating performance. The results also highlight the fact that implementing internal JITP techniques is crucial to the effective implementation of external techniques. Since JITP is an important component of supply chain management, this study sheds a new light on how JITP techniques should be implemented to benefit firms' performance.

Vachon and Klassen develop a conceptual model to characterize supply chain complexity, which includes technological factors. They also explore the relationship between complexity and delivery performance. This paper synthesizes the notion of object- versus human-related complexity in technological systems and static versus dynamic complexity in manufacturing and information systems. Results show strong support for the linkages between delivery performance and both complexity of the product/process and uncertainty of the management systems. However, little evidence was found that greater product variety and more complicated supply networks adversely affected performance. Thus, management initiatives to improve delivery performance are best focused on improving informational flows within the supply chain and leveraging new process technologies that offer flexibility to respond to uncertainty.

The motivation for the study by Yan *et al.* comes from a real-life supply chain management problem encountered by security device and equipment manufacturers. A pipeline hedging method is used to derive a model for estimating the safety stock cost in a supply chain. The procedures the authors develop for process re-engineering are merging and sequencing. Merging delays the point of differentiation by combining product independent operations, whereas sequencing balances the required safety stock by revising the order of product dependent operations. In a study of one- and two-product families, the authors develop conditions and insights for better supply chain management. These findings help in deciding when the process re-en-

TABLE I
OVERVIEW OF ARTICLES

Authors	Technology Context	SCM Context	Types of Research	Data Source
Kaynak	Just-in-time purchasing	Buyer-supplier dyad	Empirical	Survey research
Lin, Huang, and Lin	Electronic commerce	Multi-agents	Simulation using SWARM	Five sets of experiments
Ellram and Zsidisin	Information technology applications	Buyer-supplier dyad	Empirical	Survey research
Shah, Goldstein, and Ward	Inter-organizational information systems	Buyer-supplier dyad	Empirical	Secondary data
Carr and Smeltzer	Information technology	Buyer-supplier dyad	Empirical	Interviews and surveys
Vachon and Klassen	Managerial techniques, methods, and knowledge	Buyer-supplier dyad	Empirical	Secondary data
Yan, Sriskandarajah, Sethi, and Yue	Methods to reduce safety stocks	Manufacturing and distribution process	Mathematical modeling	An actual case as an illustrative example
Reed and Walsh	Supplier development	Buyer-supplier dyad	Empirical	Multiple case studies

gineering is appropriate and suggest the scale and form of the process re-engineering operations. In addition, the study shows how the merging and sequencing procedures can be applied hierarchically to a general product family consisting of multiple products.

C. Hard Technology

Lin *et al.* investigate the effects of information sharing on supply chain performance in electronic commerce. Modeling of the order fulfillment process follows the logic of minimizing the transaction costs involved in the decisions made by each agent operating under varying levels of information sharing in different demand patterns. This study identifies the effects of information sharing on supply chain performance. Firms that share information with trading partners tend to transact with smaller numbers of suppliers. The level of detail of the information shared is correlated with lower total cost, higher order fulfillment rates, and shorter order cycle times. The conclusions regarding the relations between information sharing strategies and order fulfillment process performance can guide the deployment of information systems between supply chain partners, especially in electronic commerce.

Ellram and Zsidisin study the relationship between certain types of purchasing and supply management (PSM) activity and the use of IT. The nature of buyer–supplier relationships, such as using supplier alliances, has a strong positive influence on PSM's use of IT. In addition, the study supports that IT is used for data gathering in terms of monitoring and sharing cost data with specific suppliers on an ongoing basis. This finding suggests that supplier opportunism is minimized when the buyer retains market knowledge. Surprisingly, no significant relationship was found between PSM's involvement in the use of IT and general market monitoring. It appears that PSM is still relying on the plethora of industry-specific printed data and subscriptions to gather market information, although the authors anticipate that many of these will migrate to online-only applications on secure websites.

Shah *et al.* first propose an integrative framework, an SCM-IOIS Matrix, to develop conceptually the alignment of Interorganizational Information Systems (IOIS) capabilities with the needs of supply chain members. Testing of the matrix yielded two significant findings. First, performance improves when either coordination or integration is increased. Specifically, performance improves when there is more coordination with the customer or the supplier at any given level of IOIS integration. Similarly, higher performance is linked with increased IOIS integration at any level of supply chain coordination. Second, the average gain in performance is significantly greater for firms that maintain an approximate balance between development of IOIS and supply chain coordination, as indicated by the SCM-IOIS Matrix.

Carr and Smeltzer recognize that ERP, computer, and EDI systems that link buyers and suppliers are receiving increased attention due to Web-based XML systems. These systems can be strategically important in making the supply management function more efficient. The authors address the relationship between the use of IT and frequency of information shared be-

tween buyers and suppliers, the relationship between the use of IT and the richness of information shared between buyers and suppliers, and the relationship between the use of IT and buyer-supplier trust.

VI. What We Liked About Each Paper

A. Social Organization

Supplier development is a broad concept and can include developing supplier's performance from the buyer's point of view (e.g., cost, quality, and delivery). In our experience, supplier development initiatives are aimed at concrete outcomes most often in terms of supplier performance or in some cases in increased technological capability. Reed and Walsh's study has an interesting twist in finding that the formal process of supplier development minimally affects the supplier's technological capability but does strengthen relevant communication channels. It would be interesting to know whether strengthened communication channels have any long-term benefit in manufacturing performance or technological development.

B. Operational Processes

Kaynak's study points out a significant relationship between the level of JITP implementation and the buying company's performance. This finding by itself is not surprising. However, from a structural perspective, parts of JITP practices that involve suppliers (e.g., supplier value added, quantities purchased) work as key links between the internal practices (e.g., top management commitment) and the buying firm's overall performance.

A commonly held belief regarding supply chain complexity is that it would lead to negative consequences for the buying firm. Vachon and Klassen suggest a more careful evaluation of this belief. They provide empirical evidence that at least in the area of delivery, supply chain complexity does not automatically lead to an adverse impact. Rather, the impact on delivery performance varies depending on the type of technology and information processing required.

Yan and colleagues develop resequencing and merging procedures. They begin their study with an interesting supposition regarding the impact of postponing product differentiation on safety stock as in postponement reduces uncertainty and the reduction of uncertainty should reduce the safety stock.

C. Hard Technology

Lin and colleagues begin with a very interesting observation—IT has decreased the search cost for new suppliers, yet, at the same time, IT has also caused an increase in the switching cost with existing suppliers. They subsequently point out that sharing demand information across the supply chain can lead to inventory cost savings and on-time order fulfillment. In this environment, buyers share inventory information with a smaller number of suppliers, but they switch suppliers more frequently.

Ellram and Zsidisin offer a list of key proactive purchasing activities—supplier alliances, market monitoring, cost analysis, total cost of ownership, and target costing. They also capture key areas of purchasing that could benefit from IT and explain each of these. They make a case that the use of IT is dependent on the closeness of buyer-supplier relationships through successful supplier alliances and the role IT plays becomes more significant when inclusive of more data intensive purchasing activities such as cost analysis.

Shah and colleagues propose the SCM-IOIS Matrix and offer preliminary empirical evidence supporting it. The results offer tentative support for the alignment of different stages of supply chain coordination with the corresponding levels of IOIS integration. In other words, supply chain strategies should be formulated in conjunction with the appropriate information system capabilities.

Carr and Smeltzer offer us one of the rare studies that combine qualitative and quantitative data. The qualitative data come from field interviews, whereas the quantitative data come from survey research. An interesting conclusion of this study is that the use of IT is more closely associated with the frequency of information shared than with the level of trust in the buyer-supplier relationship.

VII. Where Do We Go From Here?

Our matrix offers an obvious conclusion. It is certainly easier to get data on dyadic relationships, but the more challenging and perhaps more interesting questions involve longer supply chains. This is where key systems dynamics will be revealed.

We also favor more sociotechnical studies in the supply chain arena. In the field of technology management, a study purely of interorganizational relationships without a technological dimension would not be appropriate. On the other hand, there seems to be a bias in the literature from the papers accepted and the broader set we reviewed toward focusing on IT as the pivotal aspect of supply chain management. There is more to technology than IT and there is much more to supply chain management than technology. Studies that look at the interaction between technology and interorganizational relationships would be particularly rich.

Having said this, we commend the papers we received that broaden the study of technology management and supply chain management. We hope this Special Issue helps facilitate future knowledge development. We certainly anticipate this field of study growing even more in the future as organizational partnering becomes more common and, no doubt, increasingly complex.

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