Abstract
Supply chain management (SCM) has rapidly emerged as the central field of competition in many industries and has captivated the top executives of companies in the recent past. Electronic commerce (EC) technologies have the potential to revolutionize how firms coordinate and manage their supply chain activities. This paper focuses on the emerging paradigm of Internet-enabled supply chain management. It describes three forms of electronic supply chain management: Firm-centric SCM, industry-centric SCM, and cross-industry SCM. The paper examines the EC applications appropriate for each SCM model and the business and organizational implications.

Introduction
The introduction of Internet technology to business-to-business commerce has opened a plethora of opportunities for firms to make radical changes to their competitive profiles and to redefine their product or service offerings. An important component of business-to-business commerce is supply chain management. Supply chain management (SCM) is the integration of material, information and financial flows in a network of companies that source, manufacture and deliver products and services to end-consumers. The field of competition in many industries (e.g. electronics, retail) has shifted to the management of global supply chains. It is an area that is highly inherent information intensity and the dense inter-organizations like Dell, Wal-Mart, Cisco Systems, and GE have started deriving benefits like reduced cycle-time, faster time-to-market, and stronger customer retention from innovative Internet-based supply chain solutions (Bovet and Sheffi 1998; Kalakota and Robinson 1999; Roddy 1999). This paper proposes a framework to analyse the emerging paradigm of Internet-enabled SCM.

Electronic Commerce and Supply Chain Management
SCM has been defined as the delivery of enhanced customer and economic value through synchronized management of the flow of physical goods and associated information from sourcing to consumption. It envelops traditionally distinct functions such as forecasting and planning, purchasing, distribution and customer management (Bovet and Sheffi 1998). Integrated supply chains can deliver not only cost advantages, but also critical competitive advantages in the market place, as companies like Dell and Wal-Mart have amply demonstrated. There are three dimensions of integration for SCM: information, coordination, and organizational Linkage (see Table 1) (Lee 1998). Most firms practise SCM at the lowest level of integration, i.e. information integration, and the typical SCM model involves one dominant organization (usually the major manufacturer) driving the entire value chain activities. Current SCM models have several limitations including:

- the lack of coordination across the extended links of the supply chain (e.g. from the supplier’s supplier to the customer’s customer);
the lack of alignment of incentives of the multiple players in the supply chain; and

the lack of a uniform technology strategy across the supply chain that would support coordinated decision making by multiple firms/entities.

Important market forces including shifting channel power, faster cycle-time, and globalization of the enterprise are demanding a shift towards a more comprehensive management of supply chain activities. The newer forms of highly integrated and ‘egalitarian’ SCM would focus on all the different firms in the value chain who play varied roles in producing and delivering the product to the end-consumer, i.e. the focus will shift from one dominant firm to a network of firms. As firms graduate to higher levels of integration in the supply chain, two themes assume importance: a) stable and secure electronic linkages between firms; and b) an integrated, high-bandwidth environment to provide a host of SCM support services. EC technologies are aptly suited to cater to these demands and as such, they have an integral part to play in creating and facilitating new forms of SCM. We identify three emerging forms of SCM that would be enabled by Internet technologies: firm-centric SCM, industry-centric SCM, and cross-industry (or, inter-industry) SCM (see Table 2).

### EC APPLICATIONS FOR FIRM-CENTRIC SCM

In this model, supply chain activities are dominated by a single organization, i.e. the business model of the focal organization drives the entire supply chain. The other key characteristic of this model is the static nature of the supply chain – the participants of the supply chain and their linkages tend to be long term and fixed. The potential EC applications for such a model are varied. The primary objective of the dominant player in the supply chain is to create a closed loop by tying its enterprise solutions with those of its supply chain partners, thereby enhancing the overall integration. The EC applications do not change the fundamental nature of the supply chain activities, instead, they only enhance the efficiency.

The first set of EC applications emphasizes integration at the information level and tries to integrate existing legacy, custom and packaged enterprise solutions with those of the other supply chain partners via the Internet. A whole generation of tools, termed enterprise application integration (EAI), have emerged which use the Internet medium to integrate diverse enterprise solutions. For example, the Alliance application suite from Extactivity Software enables organizations to tie their enterprise resource planning (ERP) systems with those of their supply chain partners over the Internet. Similarly, B2B Integration Server from webMethods provides an Extensible Markup Language (XML) based solution that automates the exchange of data between applications, websites, and legacy data sources by enfolding business services in an XML wrapper (Adhikari 1998).

The second set of EC applications that have emerged enable supply chain partners to achieve the second level of integration, coordination. Rather than merely enabling the sharing of information between two enterprise systems, these EC applications facilitate coordination and optimization of supply chain activities between two firms. Such collaborative supply chain operations systems (for demand estimation, stock replenishment, etc.) use the Internet as the basic platform, with several supply chain decision support tools running on top of that. For example, solutions from Numetrix Inc. and i2 Technologies provide a collaborative demand management environment that can be deployed across the Internet and which enable constraint-based demand forecasting, optimization, dynamic demand alerts, etc. Similarly, Paragon Management System provides Web-based agents that use Internet linkages with suppliers to intelligently synchronize purchasing, inventory management, and order fulfillment across the extended supply chain.

Given the limited scope and the minimal business redesign requirements, the development and implementation of EC applications at this
level can be rapid and the benefits can be realized relatively quickly. However, the key weakness of these EC applications tends to be their limited flexibility due to the incorporation of business rules peculiar to the focal organization during implementation. Further, most such systems focus on optimization or coordination across only two links in the supply chain.

EC APPLICATIONS FOR INDUSTRY-CENTRIC SCM

In this SCM model, supply chain partners are ‘selected’ and their linkages ‘defined’ from a set of firms (suppliers, manufacturers, logistics service providers, etc.) dynamically based on market conditions. Supply chain activities are more decentralized and the ‘centre of gravity’ of the supply chain tends to be evenly distributed rather than being concentrated on a single organization. The dynamic nature of the supply chain indicates a higher level of uncertainty, and hence, a higher level of coordination (i.e. across more than two links) to ensure that planning and servicing of supply chain requests are synchronized in the extended value chain. Such supply chain arrangements result in lower inventory levels throughout the chain, enhanced flexibility to react to market dynamics, multiple product design/delivery options for customers, and profit sharing among supply chain partners based on value addition. The model resembles a web or network form rather than a chain and has been referred to as the ‘value collaboration community’ (Ng 1999).

EC applications at this level should provide a high level of flexibility to ‘connect and coordinate’ a dynamic set of supply chain partners. Thus, the three important functions of EC applications are: a) to provide a safe and secure electronic environment that incorporates the industry’s peculiar needs; b) to present highly standardized interfaces for firms to plug their supply chain applications into; and c) to support sophisticated coordination arrangements.

Given the dynamic nature of the supply chain, firms need to conduct and coordinate supply chain tasks based on a set of industry-standard practices rather than on highly customized and firm-specific business logic. Several initiatives are underway to define such supply chain standards for various industries and to incorporate them in EC solutions. For example, Japan’s Ministry of International Trade and Industry (MITI) is promoting a supply chain project in the retail industry (involving firms like Mitsui, MYCAL, and Paltak) aimed at increasing efficiency and cooperation among its members through standardization. Similarly, in the US consu-
mer goods industry, the Collaborative Planning, Forecasting, and Replenishment (CPFR) Committee, which includes firms like Nabisco, P&G, and Wal-Mart has devised industry-wide standards for key supply chain tasks like demand and order forecasting, exception management, etc. (CPFR 2000). These standards are already being incorporated into EC-based supply chain solutions by firms like Manugistics (e.g. NetWORKS) and Syncra (e.g. QuickWin).

The second EC application area is the development of secure integrated electronic environments, which provide extremely flexible and rich media for supply chain operations. Such environments would need to provide a variety of SCM support services including directory and relationship management services for enlisting new partners, scrutinizing their credentials, and managing task assignments. Further, given the diversity of the IT infrastructure of the partners, translation services (e.g. from EDI to Web and vice versa) would also need to be provided. A typical example is the Automotive Network Exchange (ANX), which enables all supply chain activities among Detroit’s Big 3, overseas automakers, and their thousands of suppliers and distributors. Recently, Ford and GM decided to combine their B2B exchanges (Autoxchange run by Ford and TradeXchange run by GM) to create a single global portal for the auto industry. Similarly, there are procurement-focused EC environments that unite suppliers and buyers in a specific industry under a single umbrella. Such industry-specific electronic trading hubs (e.g. PaperExchange for the paper industry, MetalSite for the metal industry) handle all aspects of EC from processing an order to delivery and payment (Kaplan and Sawhney, 1999).

Another set of EC applications relates to the optimization and coordination in the extended value chain – as compared to optimizing the operations of two partners in the supply chain. The collaboration facilitated by such solutions needs to be much more than a series of triggered responses along a pre-set path. For example, they should provide event and information visibility across the value chain, automated supply chain planning keeping in view resource and capacity constraints at various nodes of the chain, and Web-based agents capable of interpreting and acting upon messages related to unexpected variations in supply chain processes. Contrary to vendor’s claims, current solutions provide limited support for extended collaboration in the value chain (Adhikari 1998; O’Donnel 1998). To a great extent, this is due to the lack of standardized supply chain practices in the industry. It also reflects the lack of readiness of firms to open up their internal databases to their supplier’s supplier or their customer’s customer in the value chain (Bovet and Sheffi 1998; Doyle 1998).

EC APPLICATIONS FOR CROSS-INDUSTRY SCM

An increasing number of firms are outsourcing their supply chain activities ranging from purchasing and inventory management to logistics, sales and promotions. The new set of firms who provide such supply chain services enhance their profits by exploiting the potential synergy among the supply chain operations of multiple industries and deriving economies of scale and scope advantages (Jones 1998). Cross-industry SCM refers to an open environment where supply chain services can be traded among participating members belonging to multiple industries with little loss of efficiency. Inter-industry supply chains enable specialist firms with core competencies in generic supply chain operations (e.g. logistics, purchasing, bid management, promotion management) to sell their services to manufacturers of diverse products and services. An inter-industry SCM requires a high-bandwidth EC infrastructure with the following three layers: a) a top layer that guides cross-industry supply chain activities and provides open connectivity to diverse enterprise solutions; b) a middle layer that offers SCM support services like bidding, directory, payment, and insurance; and c) a bottom layer that offers technical support services like messaging and standards conversion. While such cross-industry SCM environments may not exist in complete form today, several elements of such systems are already in operation or under development.

A key task of the EC applications is to define and implement practical working models of cross-industry SCM. For example, EC solutions that are designed based on standardized supply chain processes in various areas like procurement, inventory management, and product promotion would guide supply chain service requesters and service providers in formulating contracts and conducting transactions. The Supply Chain Council is developing such a generic, cross-industry supply chain process model called Supply-Chain Operations Reference (SCOR) (SCC 2000). The model would enable firms to identify opportunities for improving and simplifying supply chain tasks through collaboration and consolidation. Already software firms like Manugistics and Oracle are developing products based on SCOR guidelines.

Similarly, the National Initiative for Supply chain Integration (NISCI), a private, not-for-profit trade association, comprising a diverse set of members like Chrysler, Procter & Gamble, and IBM guides the integration of multi-industry supply chains in the US (NISCI 2000). It focuses on developing solutions that optimize the performance of inter-industry supply chains comprising three links or more, and enable firms to redefine supply chains at the third level of integration, organizational linkages. Supply chain integration at the first two levels (information, coordination) enables primarily short-term decision making. EC solutions that focus on the third level of integration support medium-term supply chain decision making (e.g. promotion plans) that considers the potential impact on various nodes of the chain (in terms of manufacturing requirements and lead
times required by suppliers) and also guides redefining the supply chain, if necessary, to optimize the resources.

The concept of MetaHubs reflects the push towards integrated inter-industry supply chains. MetaHubs, a hub of hubs, ‘offers a hosted shared infrastructure platform for businesses and hooks to a diverse set of individual vertical and horizontal B2B hub’ (Sawhney 2000: 6). Such an infrastructure would enable firms across industries to find synergy in their supply chains. The potential areas for such synergy include both inbound business processes (e.g. procurement) and outbound business processes (e.g. customer relationship management, logistics/shipping). Whether such initiatives are driven by intermediaries (e.g. a MetaHub like Biztro.com) or through partnerships among firms themselves, the potential benefits are likely to be significant.

Efforts at building cross-industry electronic supply chains are also being facilitated by the development and deployment of standard electronic business interfaces like RosettaNet. RosettaNet provides a common e-Business language aligning processes between supply chain partners across industries (RosettaNet 2000). As an increasing number of supply chain solution providers (e.g. 12 technologies, PeopleSoft, Manugistics) adopt such standards, firms in different industries will find it easy and cost-effective to dynamically integrate their supply chains and derive significant strategic and economic benefits. The promise of such initiatives combined with the fact that much of the enabling technologies are already existing indicate that it is a matter of time before comprehensive EC environments are established to support cross-industry SCM (see Table 3 on Singapore’s initiatives).

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<th>Table 3. Singapore – building the EC infrastructure for a regional SCM hub</th>
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<td>Singapore aims to become the supply chain management hub for the Asia Pacific region and has started building an EC environment appropriate for that role. Its key strength is its excellent IT infrastructure – a broadband electronic network with business support services (e.g. online banking) is already in existence. Further, it has considerable expertise in supply chain operations given that:</td>
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<td>a) it has one of the world’s busiest ports with advanced logistics management systems; and</td>
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<td>b) most MNCs run their regional supply chain operations from Singapore.</td>
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<td>Singapore’s EC initiatives in the SCM domain, primarily led by its National Computer Board (NCB), include:</td>
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<td>a) Establishment of a secure, high-bandwidth EC environment that will enable suppliers, manufacturers, and logistics service providers to communicate and collaborate. Singapore-ONE, the broadband public network, will provide the basic infrastructure for business-to-business commerce. The Integrated EDI Program (IEP) provides a platform for the deployment of common EDI standards (EDIMAN, EDICHEM, EDITRANS) for the manufacturing and logistics industries. CommerceExchange will provide secure electronic payment and other business support services for supply chain partners.</td>
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<td>b) Establishment of SCM Special Interest Group (SIG) Committee to guide the adoption of inter-industry supply chain process standards and the implementation of EC infrastructure and applications for SCM.</td>
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<td>c) Enterprise solutions offered as a bureau service enable small and medium sized firms to attain sufficient internal automation, to be able to coordinate supply chain tasks with larger organizations, without incurring high initial cost and with minimal IT resources. For example, the MRP On-Line project, with subscription and transaction-based costing, allows firms to time-share the resource planning system.</td>
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<td>d) Implementation of comprehensive product and partner information services network that provides access to information needed for SCM processes (e.g. SingaporeConnect which provides supply chain partner information, Product Data Exchange Service (PDEX) project, Standard Parts Database Server project).</td>
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A recent NCB survey (National Computer Board 1998) indicated that the key barriers to the adoption of EC applications in SCM are lack of training and education, lack of significant investments in decision support tools in the SCM area (the primary focus of most firms still being transaction systems), and the security issues related to the use of Internet for SCM activities.

ORGANIZATIONAL AND BUSINESS IMPLICATIONS

While EC technologies are crucial for all three models of SCM, several organizational and managerial issues assume importance for their implementation. The first issue relates to the development of trust among supply chain partners as the shared EC applications get more and more integrated with the internal business processes of individual firms and the span of collaboration in the supply chain increases. NISCI and other agencies are leading broad investigations into the mechanisms that can enhance trust in EC settings in SCM (Doyle 1998; NISCI 2000). The second issue relates to the ownership and management of the EC infrastructure for SCM. Such infrastructure may be offered as a service by a private provider (e.g. GE TradeWeb is owned by GE Information Services) or owned jointly by several firms within an industry (e.g. AXN in the US automobile industry). This has implications on the selection of technology standards, technology adoption strategy, sharing of costs and benefits, etc. The third issue relates to the radical changes that are being brought about by EC-based supply chain solutions in
the firm-level and industry-level business models. Adoption of technological solutions without making the required changes in the internal business processes or the way a firm relates to its supply chain partners, is bound to fail.

References