Paper II

Benefits of IT in supply chain management – an explorative study of progressive companies

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Benefits of IT in supply chain management: an explorative study of progressive companies

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Abstract

Purpose – To provide empirical evidence of benefits from IT in supply chain management.

Design/methodology/approach – Data in this qualitative study were collected through multiple enquiries. SCM consultant interviews gave an understanding of the current state of practice. A survey of 48 progressive companies was conducted to identify what IT solutions they have implemented in SCM. This was followed by 18 in-depth case studies to identify the mechanisms for achieving benefits of IT in SCM.

Findings – Based on the empirical studies five propositions are presented on the use and benefits of IT. First, successful companies have developed focused e-business solutions for improving customer service elements that are most important in their business. Second, improved efficiency allows company personnel to focus more on critical business activities. Third, the use of e-business solutions improves information quality. Fourth, e-business solutions support planning collaboration and improved agility of the supply network. Finally, to gain strategic benefits, the use of IT has to be coupled with process redesign.

Research limitations/implications – The sample of companies used in the study was selected by expert assessment and is biased towards companies willing to discuss and share results openly. Additionally, the focus of the paper was on single companies and not on the entire supply network. However, the findings of this study present an opportunity to further develop understanding of the underlying mechanisms of how IT investments benefit supply chain management.

Originality/value – The paper fulfils an identified need for in-depth case studies that analyze the possible mechanisms behind the practical benefits of IT in supply chain management.

Keywords Information, Communication technologies, Supply chain management, Electronic commerce

Paper type Research paper

Introduction

Current key trends in logistics for application in the near future include e-business supported supply chain management (Skjoett-Larsen, 2000). The use of e-business in supply chains is allied to, but in this paper is not limited to, use of the internet. Prominent case examples demonstrate potential benefits. Cisco reported savings of $500 million by restructuring its internal operations and integrating processes with suppliers and customers with the help of web-based tools (Berger, 2000). Currently, 90 percent of Cisco's sales are facilitated online (Copacino and Dik, 2001). Intel replaced hundreds of order clerks by an automated online ordering application (Chopra and Meindl, 2001). Celestica, one of the world's largest electronic manufacturing services

companies, has applied a web solution to better coordinate its global supply base (Shore, 2001). Information technology (IT) has helped Celestica to improve its responsiveness to customers, thus helping, for example, its customer Dell to maintain its delivery promise to end-customers. Although it is commonly acknowledged that information technology is an essential ingredient in managing logistics operations in networks, and will increasingly be so over time, empirical evidence of the specific benefits of IT in supply chain management (SCM) is less clear.

The issue of the efficacy of new technologies in supply chains is of paramount interest to companies operating in networks, as well as to governments investing funds in the development and promotion of new technologies. Hence the reason why the National Technology Agency of Finland (Tekes) commissioned the study on which this paper is based.

This paper addresses these issues in the context of an empirical study conducted in Finland. The paper reviews, through a series of different research settings, the benefits IT specifically provides for managing supply chains in practice. Concurrently, how companies use different types of IT solutions in their networked logistics operations is examined. Finally, an answer is sought to the question of whether there is a trend in the use of IT for supply chain management. This paper is organized as follows: first, relevant literature on the themes of this study is reviewed. This is followed by a description of the research design. Second, key empirical findings paraded as propositions are presented. Finally, the results and conclusions of the study are discussed.

Literature review
Information technology and supply chain management
A review of the existing literature shows the abundance of papers dealing with IT in SCM. Gunasekaran and Ngai (2004) and Johnson and Whang (2002) provide two literature reviews on the subject, although neither is comprehensive. Common terms for business models using IT are "e-commerce" and "e-business" – the former relating typically to web-based sales, and the latter to a more holistic use of IT. In many instances, however, e-business refers to the use of the internet (Chopra and Meindl, 2001; Johnson and Whang, 2002; Lee and Whang, 2001; Cagliano *et al.*, 2003; Cross, 2000). In more recent literature, for example Simchi-Levi *et al.* (2003), Dawson (2002), Chopra and Meindl (2001) and Levary (2000), comprehensive discussion is given of the role of new information technology for SCM. According to Simchi-Levi *et al.* (2003, p. 267) the objectives of IT in SCM are:

- providing information availability and visibility;
- enabling a single point of contact for data;
- allowing decisions based on total supply chain information; and
- enabling collaboration with supply chain partners.

Elaborating on the commonly viewed functional roles of IT in SCM, the following classification can be adopted (Figure 1).

The most typical role of IT in SCM is reducing the friction in transactions between supply chain partners through cost-effective information flow (e.g. Cross, 2000). Conversely, IT is more importantly viewed to have a role in supporting the collaboration and coordination of supply chains through information sharing: for

example, Lee and Whang (1997) present IT as one of the key cures for bullwhip effect in supply chains. Third, IT can be used for decision support. In this instance the analytical power of computers is used to provide assistance to managerial decisions. For a detailed discussion of decision support systems for supply chain management, see Simchi-Levi *et al.* (2003, pp. 293-318) and Swaminathan and Tayur (2003) for a review of analytical models in the supply chain management literature.

Impact and benefits of IT in supply chain management
IT in general, and IT in SCM, is argued to enable great opportunities, ranging from direct operational benefits to the creation of strategic advantage. For example, McFarlan (1984), Benjamin *et al.* (1984) and Porter and Millar (1985) argued in the 1980s for the strategic possibilities of IT for business. Porter and Millar (1985), in particular, advocate that IT changes industry structures and rules of competition, creates competitive advantage, and creates new business opportunities. In the logistics/supply chain context, Bowersox and Daugherty (1995) outlined that IT is key in supporting companies creating strategic advantage by enabling centralized strategic planning with day-to-day centralized operations.

A common view is that IT has a profound impact on managing supply chains. Using case studies in six Finnish industrial supply chains as data, Kemppainen and Vepsäläinen (2003) argue that IT is, alongside specialization and outsourcing, a key precondition for networking of organizations. One group of scholars argues that because of information technologies, supply chains become less integrated and more market-oriented (Malone *et al.*, 1987; Golicic *et al.*, 2002; Williams *et al.*, 2002). For example, Williams *et al.* (2002) suggest that electronic SCM (in their discussion, "electronic" relates to the use of the internet) combines the structural benefits of SCM with the efficiency benefits of an arm's length approach, enabling, for example, lower cost through possibilities of selecting from a larger supplier base. The landmark work of Malone *et al.* (1987) proposes that the value offerings through IT are electronic communication (speed of communication), electronic brokerage (by IT providing a "lean", automated intermediary for resolving market transactions), and electronic integration (coupling of processes). IT seems to be particularly important in fast clock speed industries (Guimaraes *et al.*, 2002) or when flexibility and agility are needed (Sanders and Premus, 2002; Heinrich and Betts, 2003).

Many theoretical papers have addressed the value of IT in SCM (van Hoek, 2001; Lee and Whang, 2001; Levary, 2000; Cross, 2000; Bowersox and Daugherty, 1995). For example, Levary (2000) suggests that IT in SCM provides a reduction in cycle time, a reduction of inventories, a minimization of the bullwhip effect, and improvement in the effectiveness of distribution channels. There are also a number of articles presenting
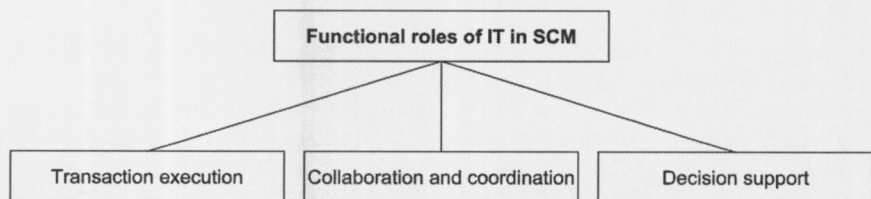
Figure 1.
Functional role of IT in SCM

empirical findings on the benefits of IT in SCM. The results of these articles are, unfortunately, diminished because of the typically narrow focus of discussion, for example estimating the dollar value of EDI in automotive manufacturer-component supplier-relationships (Mukhopadhyay *et al.*, 1995) or the impact of enterprise resource planning (ERP) on order completion performance under a period of one year after the implementation of the system (McAfee, 2002).

Reporting the benefits of IT in SCM on a general level, is fraught with problems, because, as noted insightfully by Walton and Gupta (1999) in their discussion of the benefits of EDI:

- some benefits are dyadic (or multilateral), depending on both (or a number of) supply chain parties, and some benefits are individualistic;
- the magnitude of change differs from slight to significant process change to the creation of competitive advantage; and
- benefits depend on where EDI is implemented.

Thus, the benefits of IT in SCM are manifold, and can vary according to the implementation method. Moreover, the use of IT is closely related to process changes. As such, SCM can be viewed as a process change that is helped or enabled by IT. This makes it difficult, or even in many cases a profane academic exercise, to separate the origin of the benefit, whether derived from IT, process change, or both.

Finally, with regard to the impact and benefits of IT, the controversial phenomenon of the productivity paradox of IT (e.g. Loveman, 1991) cannot be avoided. Macroeconomic studies in the US identified that despite growing IT investment, overall productivity statistics showed poor performance. However, several firm-level studies have argued for the non-existence of a productivity paradox. For example, in a longitudinal firm-level investigation, Brynjolfsson and Hitt (1996) showed that IT has a clear impact on firm output. More recently, Devaraj and Kohli (2003) argued that the conceptual problem relating to the productivity paradox of IT is that in many studies only IT investment, not actual usage, is considered. They showed how the observed use of IT was positively and statistically significantly related to revenue and quality improvements with a specified time lag, while investment in IT, as such, with the same data, was not. In addition, David (1990) draws a parallel between the IT productivity paradox and the introduction of a revolutionary electrical dynamo at the turn of the 20th century, and concludes that this innovation did not at first affect productivity, and argues that there are common problems with the introduction of new technology, which may realize productivity gains only after a considerable time lag.

Summary of literature review
The literature review identifies that IT is expected to have a pivotal role in managing supply chains, now and in the future. In fact it seems that the use of IT is crucial, especially in fast-moving industries, and particularly for managing contemporary supply networks. Moreover, the close relationship of the two concepts of SCM and IT sometimes makes it hard to assess which one contributes what benefits. For example, implementing a VMI model with EDI information transmission can lead to substantial reduction of inventories, and at the same time increase material availability. But could the benefits have been achieved without EDI by, for example, exchanging information via fax? Or, on the other hand, could the information exchange even have been possible

in any other way? Finally, consideration is made of the lack of in-depth case studies describing optimum situations and recording the impacts and benefits of IT. Extensive, focused, quantitative surveys are also needed, but a phenomenon as non-trivial as IT in SCM also needs a thorough examination from a more qualitative perspective, thus enabling a broader scope of discussion.

Research design

As the research was exploratory in nature, qualitative methods were deemed more appropriate. The case study method was selected as it permitted exploration of the question of what the benefits of IT in SCM are, even though many of the variables related to the phenomenon are still unknown (Meredith, 1998).

Data collection

Data were collected in between September and December 2003 using multiple inquiries (Figure 2):

- *SCM consultant interviews* (nine companies) – the goal was to understand the current state of IT implementations in SCM;
- *telephone inquiry* (48 companies) – the objective was to identify what IT solutions companies have implemented in SCM and what practical benefits they have recognized; and
- *in-depth interviews* (18 companies) – the goal was to expand our understanding of the practical benefits of IT in SCM through more detailed case analysis.

Phase 1: SCM consultant interviews. First, it was relevant to develop an understanding of the current state of IT implementations in SCM. In the following discussion the work of Patterson *et al.* (2003) is drawn upon, and IT in SCM is used as a synonym for all those technologies that can be used for managing and controlling supply chain related data, activities and information exchange between organizations, except that we rule decision support systems to be beyond the scope of this study. This is because decision support systems represent a somewhat separate area, with different challenges and benefits. The consultant interviews with nine different consulting companies operating in the SCM field gave us an understanding of what type of IT technologies leading-edge companies have been implementing in recent years. The research was limited to the following IT technologies:

- ERP;
- EDI, XML (system to system integration);
- internet, extranet, electronic B2B marketplaces (web portals); and
- third-party transaction hubs that provide B2B integration services (service providers).
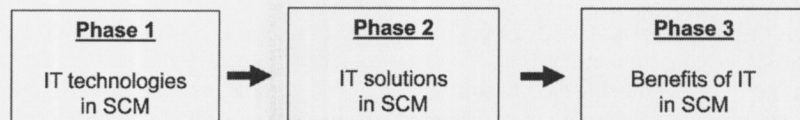
Figure 2.
Data collection phases

Phase 1		Phase 2		Phase 3
IT technologies in SCM	➡	IT solutions in SCM	➡	Benefits of IT in SCM

Phase 2: telephone inquiry to 48 companies. A total of 48 interviews were conducted with manufacturing, trade and logistics services companies that were viewed as progressive in their use of IT in SCM. Expert opinions from industry representatives and academics were used when selecting companies for this stage. The objective was to identify what IT solutions companies have implemented in SCM and what practical benefits they have recognized. The questions were sent to the informants beforehand, and the interviews were conducted over the telephone. In larger organisations informants were logistics or SCM managers, development managers or IT managers, and in smaller organisations questions were addressed to managing directors. The SCOR process model (Supply Chain Council, 2002) was used as a basis for the questionnaire to cover all relevant SCM issues. The questionnaire contained questions regarding the use of IT in:

- buy-side transactions;
- sell-side transactions;
- inbound and outbound material flows and inventory management; and
- planning collaboration.

A total of 18 cases were identified during telephone interviews to have clear benefits from IT implementations in SCM. These cases were selected for phase 3. Cases that were still in the planning stage were excluded, since realized benefits were being sought.

Phase 3: 18 in-depth case interviews. This phase was a more in-depth analysis of practical e-business solutions in various SCM areas. Semi-structured interviews were conducted with teams of two investigators. Questionnaires were sent to the informants beforehand to enable them to acquire necessary knowledge about the topics to be covered. Topics included case-specific elements related to the selected IT implementation in addition to questions regarding benefits and challenges during and after the implementation process.

Data analysis
The data in phase 3 was analysed at two levels: within-case analysis and across-case analysis, followed by an expert analysis where the results were presented to the research project steering group consisting of industry experts and research advisors.

Within-case analysis of each case involved detailed case study write-ups of each case. These write-ups were descriptions that were structured according to the constructs used in the data collection. They were central in the generation of insight into each case, because they helped to manage the analysis process of the large volume of data (Eisenhardt, 1989). This process allowed the unique patterns of each case to emerge. Each case analysis contained a detailed description of the particular IT application in SCM, including the process description and the technology used. The reported benefits were identified using qualitative and quantitative data where available.

Cross-case analysis was conducted in two dimensions: using the recorded benefits of IT in SCM and whether the implementation of IT was related to single processes within a company, co-operation between two SCM partners or if there was a clear network impact. Benefits were further developed into propositions that are presented

below. All of the 18 e-business solutions were then reviewed and grouped according to which propositions they related to. The results are shown in Table I.

A note on validity and reliability
Concerns regarding validity and reliability are particularly important for case-based research (Ellram, 1996; Meredith, 1998; Voss, 2002). External validity reflects how accurately the results represent the phenomenon studied, establishing the generalisability of results (Yin, 1981). The problem of external validity has been a major barrier in carrying out case studies, according to critics of a case-based approach. In case research, generalisation is from each case to a broader theory, not from samples to population. In this study, generalisability, as recommended by Yin (1994), has been enhanced by including multiple in-depth cases in the study that represent different industries and diverse areas of SCM.

The second issue in research design quality – i.e. reliability – addresses the repeatability of the experiment, and whether replication is possible and will achieve the same results. Pilot interviews were used to refine the research content and procedure before each data collection phase. Additionally, the informants in telephone interviews, as well as in the 18 in-depth case interviews, were sent a copy of the interview guide beforehand, so they knew the types of questions and the type of documentation that may be requested. To further corroborate the reliability, a case study database was established, which included a copy of the complete interview guide for each case and detailed summary write-ups of each case.

The term "construct validity" addresses establishment of the appropriate operational measures for the concepts studied. One way to deal with construct validity, according to Yin (1994), is to return the case study reports to the informants for verification. Respective company personnel reviewed all 18 case descriptions before the across-case analysis stage. Multiple sources of evidence were used during the study that also enhanced construct validity.

Results
Based on the study, five propositions are developed on the use and benefits of e-business technologies in supply chain management. The content of the propositions can be summarized as follows:

P1. A key operational impact of IT in SCM is the enhancement of service level.

P2. IT in SCM improves operational efficiency.

P3. IT in SCM improves information quality.

P4. IT in SCM enables agile supply chain operating models.

P5. Use of IT has to be coupled with process redesign to receive strategic benefits.

A detailed discussion on the propositions follows. First, a brief discussion is offered on several empirical observations of the use of e-business technologies in the sample companies. Data collected in the phone inquiry showed a distinct increase in the last five years in companies using IT in transaction execution. Table II summarizes the answers of 48 industrial and logistics services provider companies and the number

Case and company	Industry	Technology solution	Propositions[a]	Scope of solution[b]
Datex Ohmeda, supplier web	Medical instruments	Third-party transaction hub	P1, P2, P3	Process
Elcoteq, demand forecasts to suppliers	Electronics	EDI, RosettaNet XML	P1, P2, P3, P4, P5	Network
Finnish Post, web service for centralised purchases	Logistics services	Extranet, EDI, XML	P1, P2	Process
GNT-Finland, sell-side web	IT wholesale	Extranet, systems integration over web	P1, P2, P4	Process/dyadic
Innogas, VMI	Logistics services	EDI	P1, P2, P4	Dyadic
Kiitolinja, sell-side web	Logistics services	Extranet	P1, P2, P3	Process
Kone, supplier web and collaboration with LSP	Machinery manufacturing	Extranet, EDI	P1, P2, P3, P4, P5	Network
Kväerner Power, RFID tracking	Machinery manufacturing	RFID, XML	P1, P2, P3	Process
Nokia, dynamic VMI	Telecommunication	EDI, RosettaNet XML	P1, P2, P3, P4, P5	Network
Optiroc, integration with logistics service provider	Construction supplies	System integration, mobile data terminals in vehicles	P1, P2, P3, P4	Dyadic
Orion Pharma, integration with package manufacturer	Pharmaceuticals	EDI	P1, P2, P3	Dyadic
Rocla, supplier web	Machinery manufacturing	Extranet	P1, P2, P3	Process/dyadic
SE Mäkinen, logistics control system	Logistics services	Extranet, EDI, system integration, mobile data terminals in vehicles	P1, P2, P3, P4, P5	Dyadic
Tellabs, direct delivery model	Telecommunication	EDI	P1, P2, P3	Dyadic
Tellabs, integration with logistics service provider	Telecommunication	EDI	P1, P2	Dyadic
UPM Kymmene self-billing	Forest products	—	P1, P2	Process
Vaisala, back office integration, supplier web	Electronics	Third-party transaction hub, system integration	P1, P2, P3, P4, P5	Network
Wärtsilä, sell-side web	Machinery manufacturing	Intranet, extranet	P1, P2, P3, P4	Dyadic

Notes: [a]Numbers refer to propositions presented in the paper and indicate the relation to the case; [b]indicates whether the case is related to a single SC process, is a dyadic partnership, or has a true network dimension

Table I.
Specific information of cases used in the study

	<3 years	3-5 years	>5 years	Total	n [a]
Purchase orders					
EDI/EDIFACT	13	13	73	100	15
Extranet	44	33	22	100	9
Third-party transaction hubs[b]	25	75	0	100	4
Purchase invoices					
EDI/EDIFACT	31	19	50	100	16
System to system with other means	80	0	20	100	5
Sales orders					
EDI/EDIFACT	24	33	43	100	21
Extranet	47	33	20	100	15
Sales invoices					
EDI/EDIFACT	22	22	57	100	23
EDI/EDIFACT with EPL[c]	17	25	58	100	12

Table II.
Time in use of the most common IT solutions in purchase and sales transactions based on answers of 48 companies (percentage of companies using the technology)

Notes: [a]Indicates the total number of companies using the solution; [b]third-party transaction hub refers to B2B integration service offered by a third party: service provider is a node to which the interacting companies attach to without having to be concerned about integration issues; [c]sending invoices as EDI messages to a third-party service provider who, either via mail or electronically, transmits the invoices to the receiver

using the most common e-business technologies, along with the length of time they have been using them.

As expected, EDI/EDIFACT has in general been used for over five years, but with some companies having adopted the solution only recently. According to this data, EDI is "alive and well". Novel solutions include use of an extranet for orders and the use of third-party transaction hubs of inter-company exchange of transaction data. Some companies have recently created proprietary system-to-system links with suppliers to receive purchase orders. Some 50 percent of the 21 companies using an extranet for receiving customer orders implemented the solution less than five years ago. Interestingly, electronic B2B marketplaces (Grieger, 2004; Skjoett-Larsen et al., 2002) were non-existent in the sample. In conclusion, companies have progressed in the use of e-business technologies in the execution of transactions, but comprehensive electronic models are still yet to emerge. The key enabling factors for the increased use of IT have been the proliferation of the internet and the emergence of third-party service providers in information transmission.

P1. Successful companies have developed focused e-business solutions for improving customer service elements that are most important in their business
The relationship between SCM information and communication systems and customer service has been identified in previous research. Earlier studies have mostly focused on specific ICT solutions, such as EDI or integrated information systems. Lim and Palvia (2001) found that EDI contributes positively (statistically significantly) to order cycle time, product availability, distribution flexibility, distribution information, and distribution malfunctions. They studied 114 US companies, of which 61 were from the automotive industry and 53 from the pharmaceutical industry. Ahmad and Schroeder

(2001) reached similar results in their study, which was based on data from the World Class Manufacturing project, involving 85 manufacturers from the US, Japan, and Europe. Vickery *et al.* (2003) observed the statistical causality of integrated information systems, supply chain integration, customer service and financial performance. Their study involved 57 first-tier automotive industry suppliers. However, their results can be criticized because the correlation coefficients identified were relatively low.

Customer service is commonly an essential part of any company's strategy, but views of its contents vary. In logistics it means making the products available for the customer. However, this involves much more than just delivering the products when ordered. Christopher (1998) discusses logistical customer service using the classifications "pre-transaction", "transaction" and "post-transaction" elements. Good pre-transaction customer service means that customers understand what the company is able to supply, the company is easy to contact, and the company can adapt delivery systems to particular customer needs. The transaction elements of customer service are between order and delivery, for example order cycle time, delivery preciseness and order status information. The post-transaction elements refer to issues after the customer has received the original product, for example the availability of spares and correct billing.

Our research revealed that a wide variety of e-business solutions exist that aim at improving customer service. The solutions are commonly tailor-made for the company's situation, and they focus on improving the customer service elements that are most important in that specific business. This way, e-business solutions have reached a perceived acceptable return on investment and extensive leverage to the company's competitiveness.

An example of improving both pre-transaction and transaction elements of customer service is Kone Elevators' e-procurement system for modernization projects. When the customer places an order for Kone, it is also immediately visible to suppliers. Major suppliers receive an EDI message directly via their ERP system; for smaller suppliers, Kone has an extranet solution. A few suppliers still receive the information by fax. With this operation model Kone is able to check its suppliers' capabilities and confirm customer orders within three days. Using also a collaboration model with a logistics service provider, their delivery time has shortened from eight weeks to four weeks, and delivery accuracy has improved. Customers also have real-time access to information related to their order. In another case, Optiroc, a supplier of construction materials, is able, in close collaboration with a logistics service provider, to send accurate pre-warnings to customers about forthcoming shipments. SE Mäkinen, a provider of vehicle (primarily new cars) transporting services, uses its real-time information system to deliver at the right time to the right place, keeping its promises to customers while maintaining operational efficiency.

Finally, Wärtsilä Service, a supplier of ship machinery and power plants, recognised that the post-transaction elements of customer service are critical in their business. Three years ago they implemented a Spares Online extranet system for shortening order confirmation time and helping their customers to order the correct spare part. The system also requires the customer to key in all the necessary information that Wärtsilä needs to process the order. In 1996 the average time from order to order confirmation was 5.3 days, while today it takes an average of only 1.8 days, and in the

best cases only a few hours. Approximately 80 percent of all spare part orders come through Spares Online.

P2. Efficiency has improved, which allows company personnel to focus more on business-critical activities
The adoption of IT has enhanced the efficiency of SCM, as reported in various studies (Power and Sohal, 2002; Supply Chain Council, 2002; Min and Galle, 2001; McAfee, 2002). Also, the findings of this study supports the notion that by improving the efficiency in information transfer, IT has made it possible to streamline logistics flows, reduce inventory and improve customer service. In the current study, supplier web solutions are explored along with how they have allowed procurement staff to spend more time focusing on building strategic supplier relationships. The purchasing function has traditionally been a very labour-intensive activity, where a large proportion of procurement staff's time is spent on non-value adding activities such as data entry, correction of errors in paperwork and delivery expedition.

Included in this study was Rocla, a manufacturer of electronic warehouse trucks and automated guided vehicles, which implemented its supplier web solution in 2002. All of the direct procurement to a specific customer order is conducted through this extranet. This accounts for 30 percent of total purchases. Suppliers have real-time visibility to Rocla's demand (item, quantity, price, and requested delivery date) and they are requested to view Rocla's supplier web daily. Rocla has estimated its savings in ordering and checking invoices after implementing the supplier web to be 2.5 man-years. The second case, Datex-Ohmeda, has since 2001 moved all communication (demand forecasts, purchase orders and order confirmations) with its suppliers to an electronic form. It uses a third-party transaction hub that is linked to Datex-Ohmeda's ERP system. Some 15 percent of suppliers have integrated their ERP systems with the service provider. Some use EDI, and the majority of the suppliers use the Supplier Web solution. Currently, 95 percent of Datex-Ohmeda's purchases with 120 suppliers are processed electronically. The company reports that the 20 staff that were previously involved with routine paper work can now concentrate on more productive jobs.

A similar phenomenon was reported from sell-side IT implementations, where customer service personnel can focus on more value-adding tasks. Wärtsilä Service has been able to keep the number of customer service personnel the same as previously, while improving the response time to customer orders. SE Mäkinen has been systematically developing its IT system since 1995, and today approximately 75-80 percent of all incoming orders come in electronic form into a central database. Personnel who were previously engaged in front-line customer operations can now allocate more time to ensure optimisation and so increase operative effectiveness and company competitiveness.

P3. The use of e-business solutions improves information quality
The informational benefits of IT are generally broken into information access, information flexibility, and information quality (Mirani and Lederer, 1998). Information access benefits provide supply chain decision makers with faster and/or easier access to internal and external information. Information flexibility benefits allow decision makers to easily manipulate the content and format of retrieved information. Information quality benefits make the available information more useful, accurate, and

reliable. It improves the usefulness of information for strategic planning and operational control (Mirani and Lederer, 1998).

Information quality has been studied extensively by researchers interested in computing, management information systems, databases and their management, data security and data warehouses, to mention just a few (Melkas, 2004). Conventionally, information quality has been described as how accurate information is. English (1999) represents information by a formula where all three components – data, definition, and presentation – must have integrity to provide information quality. In a supply chain context there are business processes that produce information (planning, designing, selling, distributing, etc.), other processes that transcribe from one form to another, and processes that can be considered as users of information. When planning e-business solutions and the underlying processes, attention should be paid to information quality management (English, 2001).

In this study we identified three different mechanisms of how the use of e-business solutions can improve information quality. The first mechanism identified is related to the actual design of the e-business solutions. An effective design is based on a clear understanding of the underlying process and the relevant information flows. Those cases where enough time and effort was invested in analysing what data is needed, in what context, to what purposes it is used in various parts of the process and the right accuracy and objectivity level, reported that the overall quality level of information had improved. The sell-side web-portals of Wärtsilä Service and GNT Finland (an IT wholesaler) force the customer to specify all the necessary information to the web site before the order is processed. These companies reported that they had been able to rely on the quality of the information in decision-making. Kiitolinja, a logistics service provider, receives complete customer orders through its web portal. This helps in executing deliveries and pick-ups without any additional verification.

Second, we note that successful implementation of e-business solutions has forced companies to systematize data structures. Rocla's representatives commented that when implementing the supplier web it was necessary to systematically check all the product structures and related bills of materials (BOMs) to ensure that information transfer from the web relating to the components to be sourced was a flawless process. The company has benefited from this "by-product" as it is now possible to rely on documented product structures, which was not necessarily always the case before. Additionally, Rocla's suppliers have a real-time view to their order backlog, which has had a positive impact on the accuracy of suppliers' delivery.

The first two mechanisms are associated with careful planning of e-business solutions and its impact on the accuracy and reliability of information. The third method is how information quality is improved and how all the network parties base their operative decisions on same data. Nokia's demand information management can be used as an example to illustrate this mechanism. Nokia's demand information is broken down to component needs and distributed to various suppliers as either an EDI or XML message or through the supplier web extranet. New technology solutions enable almost real-time demand information distribution to component suppliers. As a result, all supply chain partners use same information when making demand fulfilment decisions. According to Lee and Whang (2001), this should counter the problem of demand information distortion – the bullwhip effect – in a supply chain, which is an important element of information quality.

Well-planned e-business solutions also guarantee that all the parties use same version of changed information. Orion Pharma's co-operation with a packaging company is a good example. It is a medical company that has 20,000 different packaging items. The information regarding packaging changes constantly. Previously, when a photocopy of a changed package was sent through the mail, it took three days for the packaging company to process it. In addition to the long lead-time there was frequently confusion about the latest version of a package. Now that Orion Pharma sends packaging information electronically (both EDI and the internet are used) this problem has disappeared.

P4. E-business solutions that are based on planning collaboration improve the agility of the supply network
Agility is a key capability for companies in an environment of rapid and unpredictable change. Christopher and Towill (2000, p. 206) define agility as "a business-wide capability that embraces organizational structures, information systems, logistics processes and, in particular, mindsets". They state that an agile supply chain is market-sensitive, which means it has the capability to respond to real demand in volatile markets. Bruce *et al.* (2004) state that information sharing between supply network partners is essential for reaching operational agility.

Our research revealed that information sharing is already common practice. For example, 92 percent of the companies studied shared demand information, 47 percent shared order status information, and 42 percent shared inventory-level information with their suppliers. Most companies also shared some material-flow related information in addition to orders with logistics service providers and customers. In many instances the information sharing was manual: telephone, face-to-face conversations, telefax or e-mail. Some companies, however, had developed e-business solutions in collaboration with their supply network partners. These solutions were more than just information sharing – they involved simultaneous process and technology development of several supply chain partners. The benefits of these kinds of e-business solutions were not just amendments of single customer service elements, as in examples of *P1*. In these cases the agility of a part of the supply network has improved.

An example of improved agility is the previously described Optiroc case. The company implemented an e-business solution together with their logistics service provider that is based on real-time information transfer between the two partners. When the customer order is keyed into Optiroc's ERP system, it is instantaneously visible in the logistics service provider's planning system. As the logistics service provider completes the order the updated information is also observable from Optiroc's ERP system. Most of the vehicles are equipped with mobile terminals and status information is also updated instantaneously. The use of mobile terminals enables the optimisation of deliveries and pick-ups up to the last minute, and this has also improved Optiroc's competitiveness in the market. However, Optiroc has not limited the collaboration to the transfer of operational information. They have agreed on a process to meet regularly, four times a year, with the logistics service provider to discuss development plans and future business scenarios.

Another example is a dynamic vendor-managed inventory (VMI) system that Nokia Networks has developed with its suppliers. Nokia continuously updates the upper and

lower inventory limits of its VMI system and provides this information to its suppliers either by their supplier web-portal or by EDI or RosettaNet XML messages. The suppliers also have sight of Nokia's sales forecast and inventory accounts of their own products. The suppliers have developed their own planning processes to utilize this information. The VMI system, together with dynamic control parameter updating, enhanced visibility and improved supplier planning systems, has had a positive impact on the agility of the supply network.

A third example comes from the same industry as Nokia. Elcoteq, a contract manufacturer of electronics components, operates with a pull strategy to manage its production. When Elcoteq receives demand forecasts from its customers, they are immediately passed on to the supplier base. Subsequent to suppliers' confirmation of their ability to fulfil the requested demand, Elcoteq confirms its ability to the customer. Fulfilment is based on forecasts and no actual orders are passed between the supply chain partners. At the moment all the data is transferred as EDI messages, but the company is piloting RosettaNet XML, which would enable more dynamic exchange of information in the supply chain. As a result, Elcoteq has been able to build a supply chain that can quickly react to demand changes in the market.

P5. To achieve strategic benefits, the use of IT has to be coupled with process redesign
As identified in the literature review, IT is suggested to have a strategic impact on companies and supply chain management. Consequently, it is proposed that to achieve strategic benefits with IT, supply chain processes have to be changed, and undoubtedly some companies have been able to do this. In the existing literature, authors in business process re-engineering (BPR) hold that the link between IT use and simultaneous design of business processes is a vital ingredient to bring benefit from development efforts (e.g. Venkatraman, 1994; Hammer, 1990; Davenport and Short, 1990). Several other studies in a supply chain context have identified the same finding. The study conducted by the Supply Chain Council (2002) reported managers' views that technology is only a facilitator, not an end target itself. According to the supply chain managers interviewed the biggest challenge was "changing the process". Jayaram *et al.* (2000) show statistically that supply chain time-based performance drivers are an information-intensive IT structure, the utilization of process improvement practices, and joint deployment of these two factors.

A suitable case in our data to support this notion is Vaisala Instruments, the manufacturer of high-tech measuring devices. Vaisala Instruments transformed its global operations with three main market areas (Asia, US, and Europe) into a true make-to-order mode, coupling process changes in sales and capacity planning with the implementation of several IT solutions. As a result, the new supply chain coordinated by Vaisala Instruments is operating based on projected demand, transmits information without delays, is responsive to changes in demand, and is less vulnerable to risks, as regional inventories of finished goods have been removed. In addition, regional sales forces were previously tied to the supply of regional inventories. With a truly global make-to-order mode and centralized manufacturing operations in Finland, the regional sales forces can sell the full product offering of Vaisala Instruments. The key process change was sales planning: this includes incorporating the expected sales in key countries with the highest sales with sales force opinion, and based on this, planning of both their own and supplier production capacity. After the capacity is set, the sales

force receives a sales quota that is the level of sales that can be fulfilled worldwide with a promised lead-time of five days. Realized demand is monitored continuously, and changes to projected demand are communicated electronically on a day-to-day basis with key suppliers. The IT solutions used in Vaisala Instrument's operating model are:

- a third-party transaction hub with suppliers enabling capacity collaboration on a day-to-day basis with key suppliers and exchange of transaction data with practically all suppliers;
- ERP system integration with subsidiaries, enabling real-time visibility to end customer demand in manufacturing operations; and
- system integration with a global courier company, enabling efficient handling of transaction data.

The findings also show that only relatively few companies have been able to implement larger e-business solutions and use IT strategically, and most companies still view IT primarily as a means for operational efficiency rather than a tool for strategic advantage.

Discussion and conclusions
The results of this study indicate that operational use of IT has developed in the last five years. In particular, internet technology and third-party transaction integration services have provided companies with increased possibilities to network with supply chain partners. However, in most cases the solutions used are quite individualistic, as they are developed from a single company's point of view. Of course user aspects (customer and supplier) have been taken into consideration when planning, for example, buy-side and sell-side portals, but the driving force has been to increase the effectiveness of e-business applications. These applications are relatively general with clear specifications, and the solutions do not technically differ significantly from each other. Furthermore, only implementing IT, as such, for example in invoicing automation, is not likely to lead to higher-level business impacts. Stating this, it is interesting to observe that in the SCM context the main body of companies view IT primarily from an operational perspective. One reason for this may be the relative novelty of IT, meaning that larger scale and strategic solutions are still yet to come, after companies have installed a basic IT infrastructure.

When observing those e-business solutions that are genuinely dyadic, it can be seen that it is important to allocate sufficient resources to planning the processes and selecting the technologies, in conjunction with the network partners. These e-business solutions are more specific to the particular application, and there is more variety within implemented solutions. The case examples in this study demonstrate the multiple ways that IT can be deployed. There is no single way of using IT and, moreover, the broader the business area that IT impacts, the more solutions have to be customized. As applications are more tailor-made, it is also more difficult to copy a solution from one company to another. It was further observed that to achieve real competitive advantage it is important to focus on improving those processes that are most critical for customer service. Successful companies have been able to improve service levels and effectiveness simultaneously.

The benefits of IT in SCM are manifold, and vary in the context of their implementation. Moreover, as the use of IT is closely related to process changes, most

of the benefits are overlapping and interlinked. Thus, it is hard to specify the origin of benefit very explicitly. Notably, strategic benefits are only achievable when the introduction of IT is coupled with process redesign. The ideas of BPR are then closely related to the current study. Our study corroborates that business process re-engineering skills are vital to benefiting from IT strategically in SCM. The change in processes does not have to be total, but without any process changes, IT becomes merely an automating force, providing efficiency benefits in a limited scope.

The study presented in this paper has limitations. First, the sample of companies included in the study was selected by expert assessment and is biased towards companies willing to discuss and share results openly. Second, the focus of this paper was on single companies rather than on entire supply networks. Additionally, since each company was interviewed only once, some important insights might not have been captured during the process.

However, the findings of this study present an opportunity to further develop understanding of the underlying mechanisms of how IT investment benefits supply chain management. It would be beneficial to study entire supply networks and analyse the situation from various points of view. Sufficient emphasis should be paid to various organisational issues. Additionally, the propositions presented in this paper should be tested with a larger data set to gain further understanding of the various contingencies (type of network, business environment, technology used, etc.) that have an impact how benefits are composed.

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