INFORMATION TECHNOLOGY INSTRUMENTATION IN SUPPLY CHAIN SECTOR

Dissertation submitted to Collage of Management & Economics Studies for the partial fulfillment of the degree of

MBA (LOGISTICS & SUPPLY CHAIN)

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CERTIFICATE

TO WHOMSOEVER IT MAY CONCERN

This is to certify that the dissertation report on "INFORMATION TECHNOLOGY INSTRUMENTATION IN SUPPLY CHAIN SECTOR" completed and submitted to University of Petroleum and Energy Studies, Dehradun by *SHIVOM VARADARAJAN* in partial fulfillment of the provisions and requirements for the award of degree of MASTER OF BUSINESS ADMINISTRATION (LOGISTICS AND SUPPLY CHAIN MANAGEMENT), 2013-2015 is a bonafide work carried by the scholar under my supervision and guidance.

To the best of my knowledge and belief the work has been based on investigation made, Case studies and analyzed by the scholar, and this work has not been submitted anywhere else for any other university or institution for the award of any degree/diploma.

Prof. Vibhav Mathur Dated……

(Professor – CMES)

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Information Technology & its use in organizations & across the supply chain has become a determinant of competitive advantage for many corporations. This research focuses on the usage of IT tools for Supply Chain Management. It also highlights the contribution of IT in helping to restructure the entire distribution set up to achieve higher service levels & lower inventory & lower supply chain costs. In this study, we also seek to better understand the value of information technology (IT) in supply chain contexts. Grounded in the resource-based theory in conjunction with transaction cost economics, we develop a conceptual model that links three IT-related resources (backend integration, managerial skills, and partner support) to firm performance improvement. The model differs from previous studies by proposing a moderating effect of competition on the resource-performance relationships. The technological resource alone, however, does not hold the answer to IT value creation. In fact, managerial skills, which enable adaptations on supply chain processes and corporate strategy to accommodate the use of IT, are shown to play the strongest role in IT value creation. Furthermore, backend integration and managerial skills are found to be more valuable in more competitive environments. While commodity-like resources have diminishing value under competition, integrational and managerial resources become even stronger. Overall, this paper sheds light on the key drivers of IT-enabled supply chains.

Reflection on the evolving & emerging IT trends like Software Agents, Web Services, Virtual Supply Chains, Electronic Commerce & Decision Support Systems further highlights the importance of IT in the context of increasingly global competition.

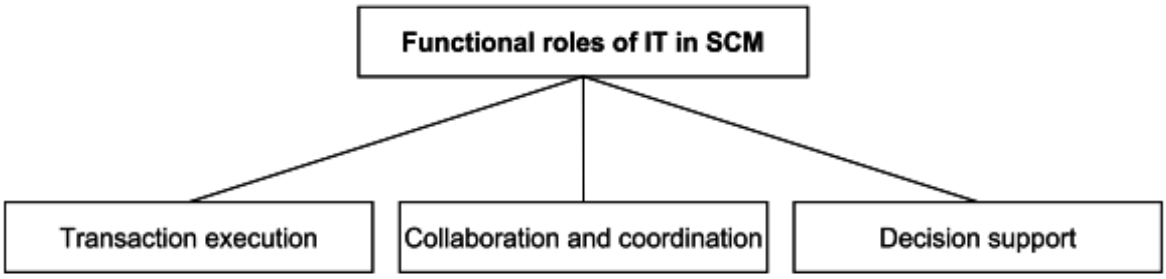
INTRODUCTION

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; but in this paper it is not limited to the 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 per cent of Cisco's sales are facilitated on-line (Copacino & Dik, 2001). Intel replaced hundreds of order clerks by an automated on-line ordering application (Chopra & Meindl, 2001). Celestica, one of the world's largest electronic manufacturing services company 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; and thus helping, for example, its customer Dell maintain its delivery promise to the end-customers. Although it is commonly acknowledged that information technology is an essential ingredient in managing logistics operations in networks, and will be an increasingly so over time, empirical evidence of the specific benefits of IT in supply chain management (SCM) are less clear. The issue of efficacy of new technologies in supply chains is of paramount interest to the companies operating in networks, as well as to governments investing funds in development and promotion of new technologies. Hence the reason why the National Technology Agency of Finland (Tekes) commissioned a 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 accrues 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.

According to Simchi-Levi et al., (2003, p. 267) objectives of IT in SCM are:

- Providing information availability and visibility
- Enabling single point of contact of data
- Allowing decisions based on total supply chain information
- Enabling collaboration with supply chain partners

Elaborating on the commonly viewed functional roles of IT in SCM, the following classification can be adopted-



The most typical role of IT in SCM is reducing the friction in transactions between supply chain partners through cost-effective information flow (for example, 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 et al., 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.

RESEARCH PROBLEMS FACED

- Earlier researches focus more on the technical aspect of the IT tools being used in Supply Chain & it is hard to find data regarding the exact impact made by up gradation of such tools.
- Connecting IT Instrumentation to Supply Chain from a financial point of view has not been researched much, so finding relevant data for the same is difficult.
- Previous researchers talk more on how IT can be implemented to improve the Supply Chain and do not focus on the after effects of such implementations.

RESEARCH OBJECTIVES

- To study the various IT tools being used in the Supply Chain Sector.
- To study the impact of these tools on the performance of the industry.
- To understand the basic working of such tools & learn about the significance of the same.

RESEARCH GAP

- Most previous researches only talks of the tools used & does not connect them with Supply Chain performance.
- Methods implemented in a particular sector only are usually discussed, no in depth analysis of any such implementations.
- Technical benefits of IT in Supply Chain are shown while it's financial as well as value based impact is usually ignored.

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*., (1985), and Porter and Millar (1985) argued previously in the 1980s for the strategic possibilities of IT for business. Porter and Millar (*ibid*), 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 held 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 argue 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*., (*ibid*) 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),

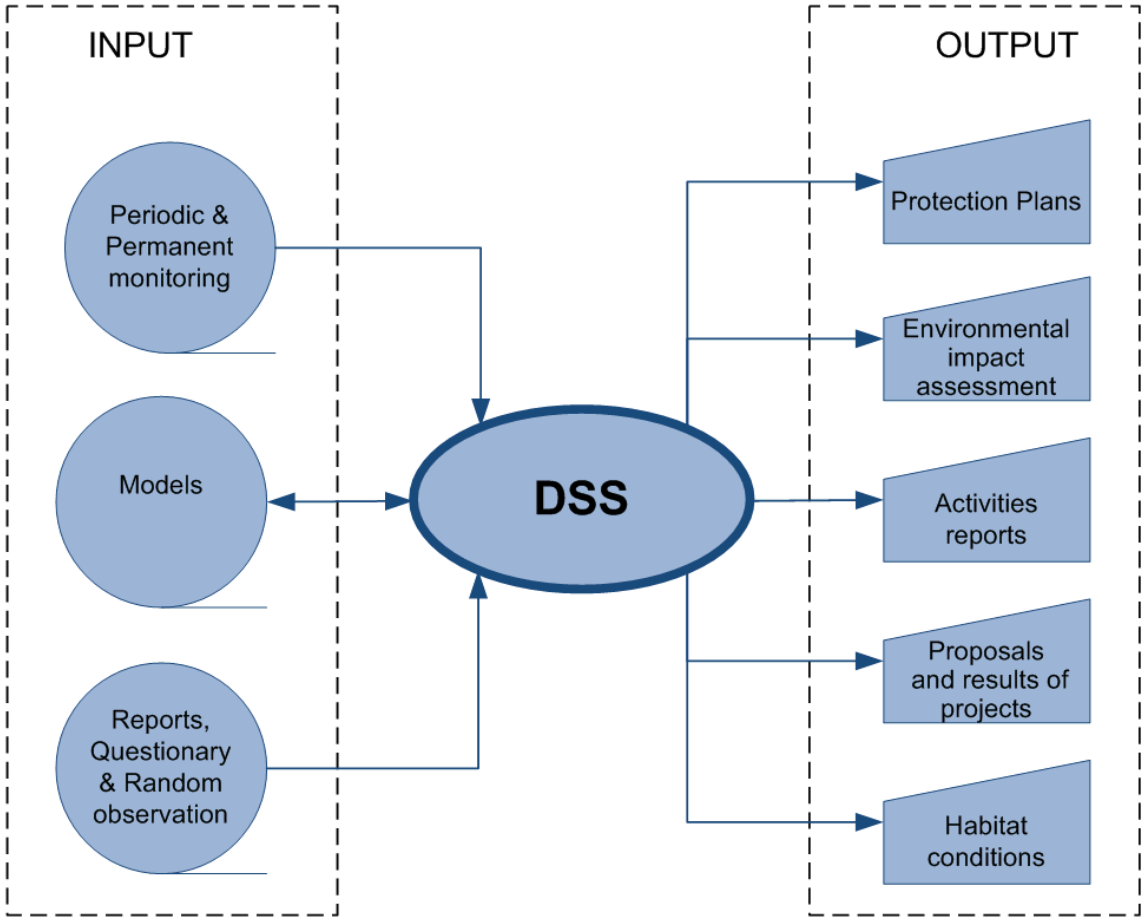
electronic brokerage (by IT providing a 'lean', automated intermediary for resolving market transactions), and electronic integration (coupling of processes). IT seems to be particularly important in *fast clock speed* industries (Guimaraes *et al*., 2002) or when flexibility and agility are needed (Sanders & Premus, 2002; Heinrich & Betts 2003). Many theoretical papers have addressed the value of IT in SCM (van Hoek, 2001; Lee & Whang, 2001; Levary' 2000; Cross' 2000; Bowersox & Daugherty, 1995). For example Levary (*ibid*) suggest that IT in SCM provides reduction of cycle time, reduction of inventories, minimization of bullwhip effect, and improvement of effectiveness of distribution channels. There are also a number of articles presenting 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 (Mukhopadhay *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 on a general level, the benefits of IT in SCM 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), dependent on both (or a number of) supply chain parties, and some individualistic
- The magnitude of change differs from slight to significant process change to the creation of competitive advantage
- Benefits depend on where (EDI) is implemented. Thus, the benefits of IT in SCM

> are manifold; and can vary from 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, productivity paradox of IT (for example 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 the 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 the investment in IT, as such, with the same data, was not. In addition, David (1990) draws a parallel of IT productivity paradox with an example of the introduction of a revolutionary electrical dynamo during the turn of 1900, and concludes that this innovation did not 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.



A **Decision Support System** (**DSS**) is a computer-based information system that supports business or organizational decision-making activities. DSSs serve the management, operations, and planning levels of an organization (usually mid and higher management) and help to make decisions, which may be rapidly changing and not easily specified in advance (Unstructured and Semi-Structured decision problems). Decision support systems can be either fully computerized, human or a combination of both.

While academics have perceived DSS as a tool to support decision making process, DSS users see DSS as a tool to facilitate organizational processes. Some authors have extended the definition of DSS to include any system that might support decision making. Sprague (1980) defines DSS by its characteristics:

1. DSS tends to be aimed at the less well structured, underspecified problem that upper level managers typically face;
2. DSS attempts to combine the use of models or analytic techniques with traditional data access and retrieval functions;
3. DSS specifically focuses on features which make them easy to use by non-computer people in an interactive mode; and
4. DSS emphasizes flexibility and adaptability to accommodate changes in the environment and the decision making approach of the user.

DSSs include knowledge-based systems. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents, and personal knowledge, or business models to identify and solve problems and make decisions.

Typical information that a decision support application might gather and present includes:

- inventories of information assets (including legacy and relational data sources, cubes, data warehouses, and data marts),
- comparative sales figures between one period and the next,
- Projected revenue figures based on product sales assumptions.

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 the fast moving industries: particularly for managing contemporary supply networks. Moreover, the close relationship of these two concepts, SCM and IT, make it sometimes 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. Case method was selected as it permitted exploration to the question of what are the benefits of IT in SCM; even though many of the variables related to the phenomenon are still unknown (Meredith, 1998).

Data collection

Data were collected in September – December 2003 using multiple inquiries (Figure 2.):

1. *SCM consultant interviews (9 companies):* The goal was to understand about the current state of IT implementations in SCM
2. *Phone inquiry (48 companies):* The objective was to identify what IT solutions companies have implemented in SCM and what practical benefits they have recognized.
3. *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.

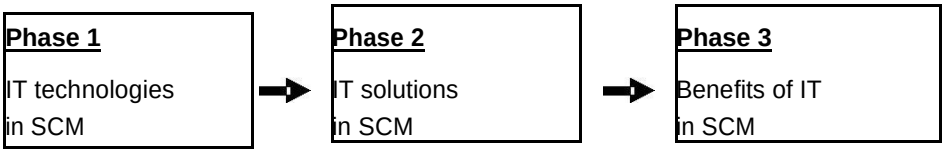


Figure 2 Data collection phases

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 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 9 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)
- third party transaction hubs that provide B2B integration services (service providers)

Phase 2: phone inquiry to 48 companies

A total of 48 interviews were conducted with manufacturing, trade and logistics services companies that were viewed as progressive in the use of IT in SCM. Expert opinions from industry representatives and academics were used when selecting the 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 use of IT in:

- Buy-side transactions
- Sell-side transactions
- Inbound and outbound material flows and inventory management
- 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 the phase 3. Cases that were still in the planning stage were excluded, since realised benefits were being sought.

Phase3: 18 in-depth case interviews

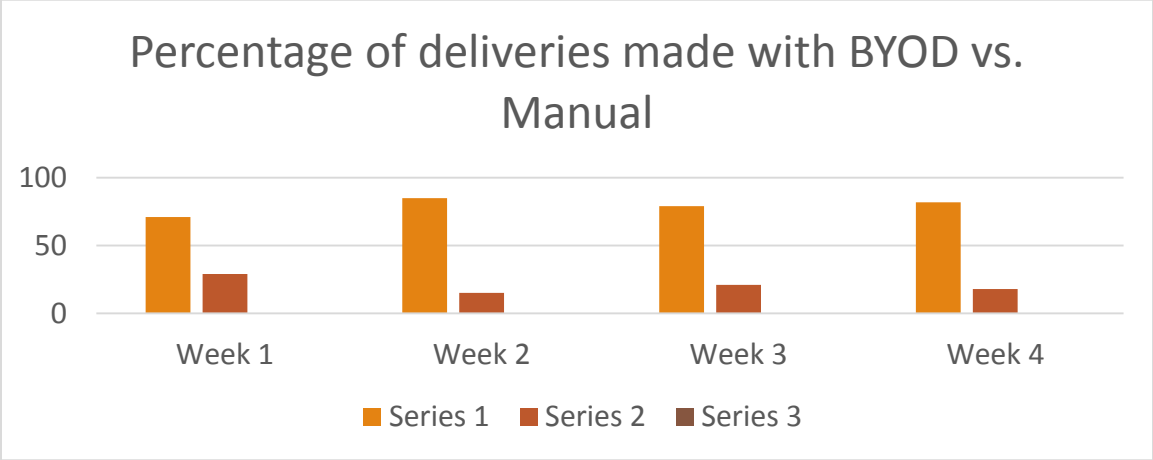
This phase was a more in-depth analysis of practical e-business solutions in various SCM areas. Semi-structured interviews were conducted with teams of two investigators. Questionnaires were sent to the informants beforehand to enable them to acquire necessary knowledge about the topics to be covered. Topics included case specific elements related to the selected IT implementation in addition to questions of the 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 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 in section four. All of the 18 e-business solutions were then reviewed and grouped according to which propositions they related to.



A note on validity and reliability

Concerns regarding validity and reliability are particularly important for case-based research (Yin, 1989; Ellram, 1996; Meredith, 1998; Voss, 2002). External validity reflects how accurately the results represent the phenomenon studied, establishing 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 beenenhanced by including multiple in-depth cases in the study that represented different industries and diverse areas of SCM.

The second issue in research design quality – 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.

S. No.	TIME PERIOD	AVG. SHIPMENT COUNT	AVG. REVERSE PICKUPS
1	WEEK 1, February 2015	1605	133
2	WEEK 2, February 2015	1895	151
3	WEEK 3, February 2015	2066	145
4	WEEK 4, February 2015	1788	167

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:

Proposition 1: A key operational impact of IT in SCM is the enhancement of service level.

Proposition 2: IT in SCM improves operational efficiency.

Proposition 3: IT in SCM improves information quality.

Proposition 4: IT in SCM enables agile supply chain operating models.

Proposition 5: Use of IT has to be coupled with process re-design 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 distinctive increase in the last five years of companies using IT in transaction execution. Table II summarizes the answers of 48 industrial and logistics services provider companies and the number using the most common e-business technologies and the time of use.

As expected, EDI/EDIFACT has in general been used over 5 years with, however, some companies being recent with the solution. According to this data EDI is “alive and well”. Novel solutions include the 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 50per cent of the 21 companies using an extranet for receiving customer orders have

implemented the solution less than five years ago. Interestingly, electronic B2B marketplaces (Grieger, 2004; Skjott-Larsen *et al*., 2002) were non-existent in the sample. In conclusion, companies have progressed in the use of e-business technologies in transaction execution, but comprehensive electronic models are still yet to emerge. The key enabling factors for increased use of IT have been the proliferation of the Internet and emergence of third-party service providers in information transmission.

Table II The time in use of the most common IT solutions in purchase and sales transactions based on answers of 48 companies (pct of companies using the technology)

	< 3 years	*3 - 5 years*	*> 5 years*	*Total*	*n *)*
Purchase orders:					
EDI/EDIFACT	13 %	13 %	73 %	100 %	15
Extranet	44 %	33 %	22 %	100 %	9
3rd party transaction hubs **)	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 ***)	17 %	25 %	58 %	100 %	12

Proposition 1: Successful companies have developed focused e-business solutions for Improving customer service elements that are most important in their business

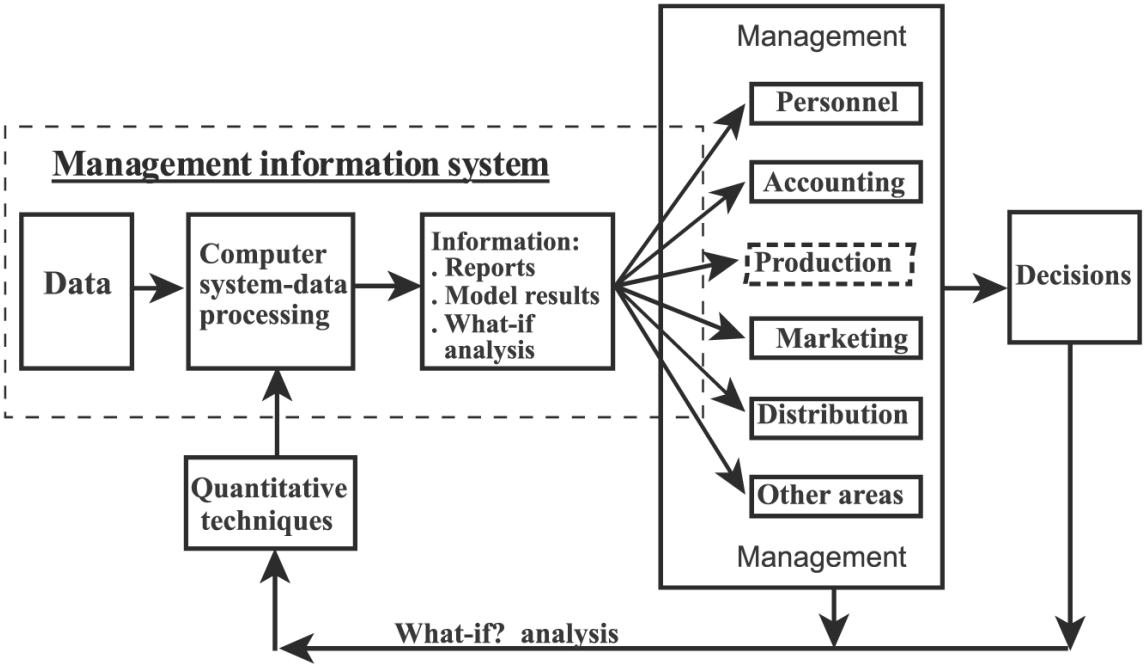
The relationship between SCM information and communication systems and customer service has been identified in several previous researches. Earlier studies have mostly focused on specific ICT solutions, such as EDI or integrated information systems. Lim and Palvia (2001) found that EDI contributes positively (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 that was based on data from the World Class Manufacturing project involving 85 manufacturers from US, Japan, and Europe. Vickery *et al*., (2003) observed statistical causality of integrated information systems, supply chain integration, customer service and financial performance. Their study involved 57 first-tier automotive industry suppliers. Their results can, however, be criticized because the identified correlation coefficients 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. This involves, however, much more than just delivering the products when ordered. Christoper (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 availability of spares and correct billing.

Our research revealed that there exist a wide variety of e-business solutions that aim at improving customer service. The solutions are commonly tailor-made for the company's situation and they focus on improving customer service elements that are most important in that specific business. This way the e-business solutions have reached a perceived acceptable return to investment and extensive leverage to the company's competitiveness. An example of improving both pre-transaction and transaction elements of customer service is Kone Elevator's e-procurement system for modernization projects. When the customer places an order for Kone, it is also immediately visible for suppliers. Major suppliers receive an EDI-message directly by 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' capability and confirm customer orders within three days. Using also a collaboration model with a logistics service provider, their delivery time has shortened from 8 weeks to 4 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 tight collaboration with a logistics service provider, to send accurate pre-warnings to customers about forthcoming shipments. SE Mäkinen, a provider of vehicles (primarily new cars) transporting services, uses its real time information system to deliver at- right-time-to-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 customer to order the correct spare part. The system also requires the customer to key in all the necessary information that Wärtsilä needs for processing the order. In 1996 the average time from order-to-order confirmation was 5,3 days, yet today it takes an average of only 1,8 days; and in best cases only a few hours. Approximately 80per cent of all spare part orders come through Spares Online.



Proposition 2: 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 & 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 and 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 paper work and delivery expedition.

Included in this study was Rocla, a manufacturer of electronic warehouses trucks and automated guided vehicles that 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 30per cent 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 electronic form. It uses a third party transaction hub that is linked to Datex-Ohmeda's ERP system. Some 15per cent 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, 95per cent of Datex-Ohmeda's purchases with 120 suppliers is processed electronically. The company reported that those twenty staff that were previously involved with routine paper work could now concentrate on more productive jobs.

Similar phenomenon was reported from the sell-side IT implementations, where the 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 before, whilst improving the response time to customer orders. SE Mäkinen has been systematically developing its IT system since 1995, and today approximately 75-80per cent of all incoming orders come in electronic form into a central database. Personnel that were earlier engaged in front-line customer operations can now allocate more time to ensure optimisation and so increase operative effectiveness and company competitiveness.

Proposition 3: The use of e-business solutions improves information quality

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 (*ibid*).

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 a few (Melkas, 2004). Conventionally, information quality has been described as how accurate information is. English (1999) represents information by 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 if 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 on 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 what is the right accuracy and objectivity level, reported that the overall quality level of information had improved. Wärtsilä Service's and GNT Finland's, an IT wholesaler, sell-side web-portals force the customer to specify all the necessary information to the web site before the order was 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 have 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 bill of materials (BOMs) to ensure that the information transferred from the web related 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; and which has had a positive impact on accuracy of suppliers' delivery.

The first two mechanisms are associated with careful planning of the e-business solutions and its impact on 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 either as 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 the 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

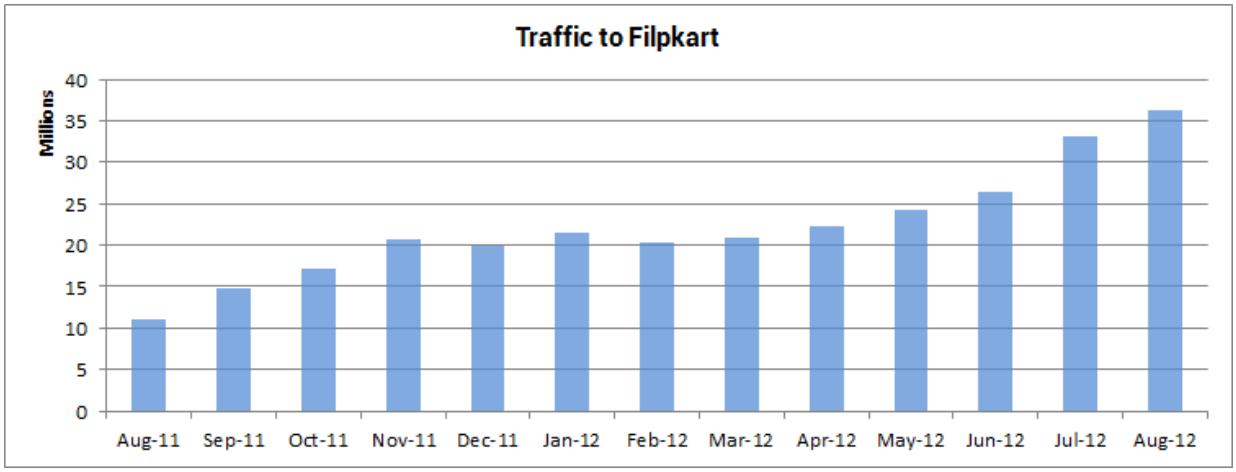
information regarding packages changes constantly. Previously, when photocopy of a changed package was sent through the mail, it took three days for the packaging company to process it. In addition, for the long lead-time there was frequently confusion about the latest version of a package. Now when Orion Pharma sends packaging information electronically (both EDI and Internet are used) this problem has disappeared.

Rank 2014	Rank 2013	Company	R&D Spending 2014 US$ Billions	R&D Spending Change from 2013	R&D Spending As a % of Sales	Headquarters Location	Industry
1	1	Volkswagen	$13.5	18.9%	5.2%	Europe	Auto
2	2	Samsung	$13.4	28.0%	6.4%	South Korea	Computing and Electronics
3	4	Intel	$10.6	4.6%	20.1%	North America	Computing and Electronics
4	5	Microsoft	$10.4	6.1%	13.4%	North America	Software and Internet
5	3	Roche	$10.0	-1.8%	19.8%	Europe	Healthcare
6	7	Novartis	$9.9	5.6%	17.0%	Europe	Healthcare
7	6	Toyota	$9.1	-7.0%	3.5%	Japan	Auto
8	10	Johnson & Johnson	$8.2	6.8%	11.5%	North America	Healthcare
9	12	Google	$8.0	17.1%	13.3%	North America	Software and Internet
10	8	Merck & Co.	$7.5	-8.1%	17.0%	North America	Healthcare
11	11	General Motors	$7.2	-2.3%	4.6%	North America	Auto
12	14	Daimler	$7.0	4.8%	4.4%	Europe	Auto
13	9	Pfizer	$6.7	-15.1%	12.9%	North America	Healthcare
14	30	Amazon	$6.6	43.8%	8.8%	North America	Software and Internet
15	23	Ford	$6.4	16.4%	4.4%	North America	Auto
16	15	Sanofi	$6.3	0.1%	14.5%	Europe	Healthcare
17	13	Honda	$6.3	-6.6%	5.4%	Japan	Auto
18	16	IBM	$6.2	-1.2%	6.2%	North America	Computing and Electronics
19	17	GlaxoSmithKline	$6.1	-2.4%	14.8%	Europe	Healthcare
20	24	Cisco Systems	$5.9	8.3%	12.2%	North America	Computing and Electronics
		TOP 20 TOTAL	$165.3	5.4%	8.0%		

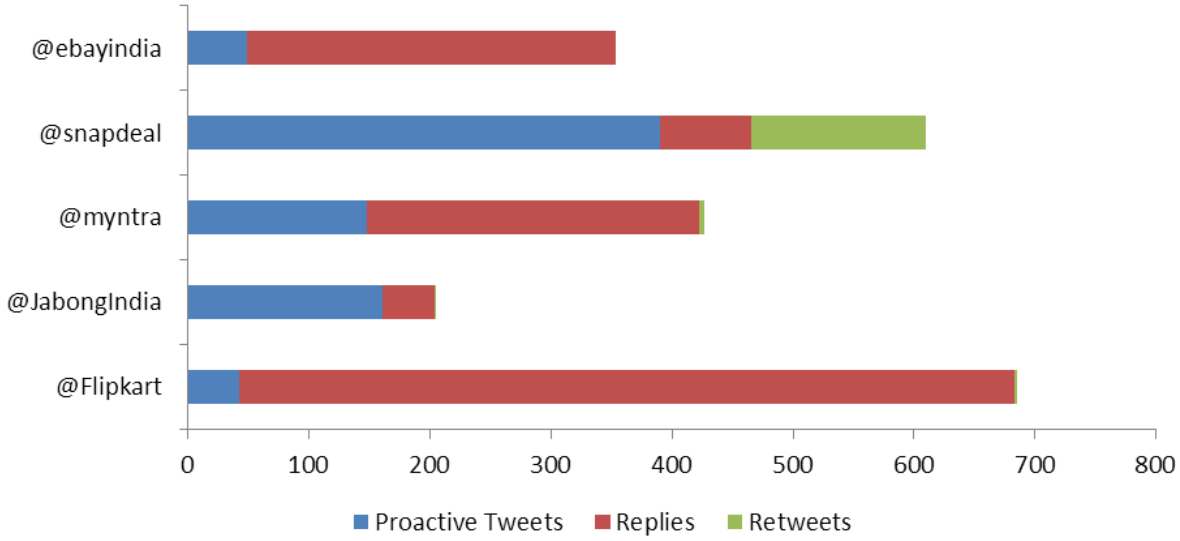
Proposition 4: e-Business solutions that are based on planning collaboration Improve agility of the supply network

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 agile supply chain is market sensitive, which means capability to respond to real demand in volatile markets. Bruce and Daly (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 92per cent of the studied companies shared demand information, 47per cent order status information and 42per cent inventory level information with their suppliers. Most companies shared some material flow related information in addition to orders also 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 proposition 1. In these cases the agility of a part of the supply network has improved.



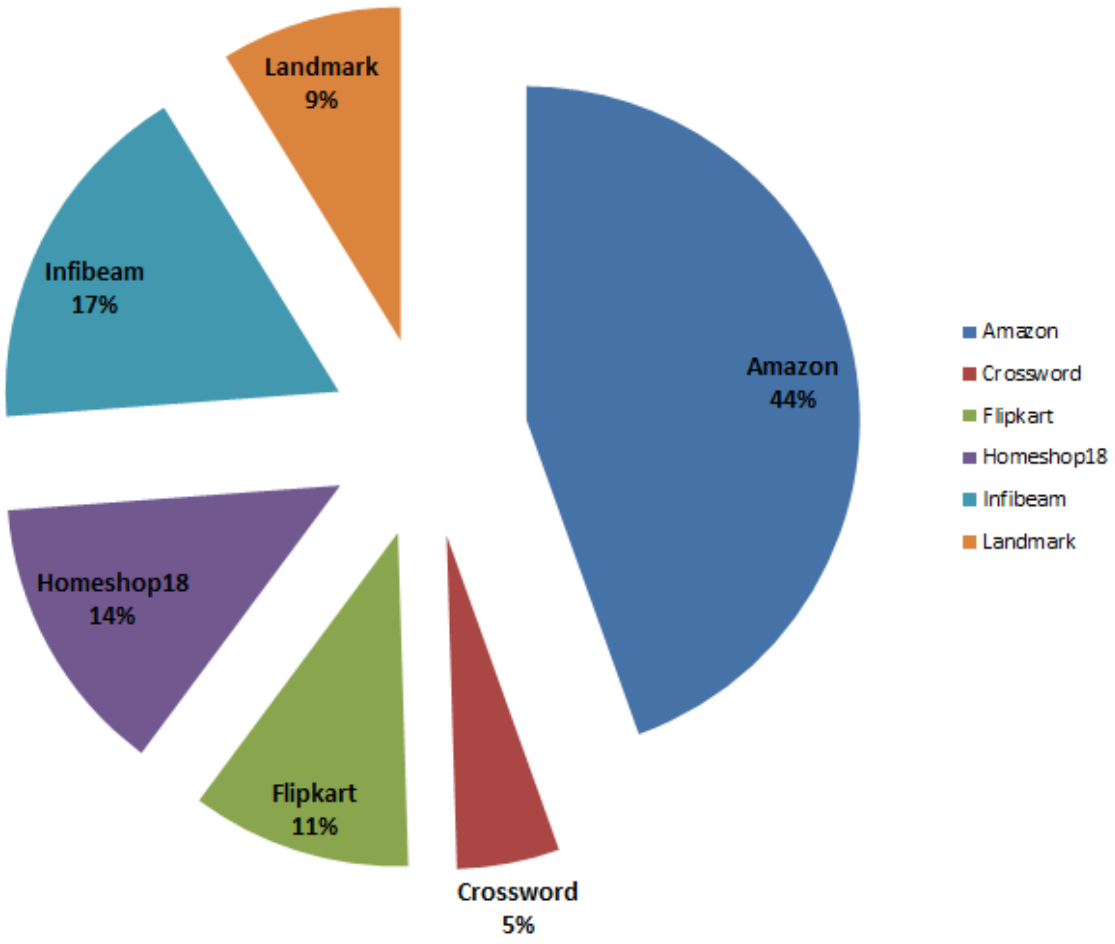
An example of improved agility is the previously described Optiroc-case. The company implemented an e-business solution together with their logistics service provider that is based on real time information transfer between the two partners. When the customer order is keyed into Optiroc's ERP system, it is instantaneously visible at 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 also status information is updated instantaneously. The use of mobile terminals enables optimisation of deliveries and pick-ups up to the last minute and this has as well improved Optiroc's competitiveness at 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 about the 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 updates continuously 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 have also visibility to 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 suppliers improved planning systems have had a positive impact on agility of the supply network.

A third case example is 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 customer, they are immediately passed on to the supplier base. Subsequent to the suppliers' confirmation of their ability to fulfil the requested demand, Elcoteq confirms its ability to the customer. Fulfilment is based on the 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 that 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 at the market.



Proposition 5: For receiving strategic benefits, the use of IT has to be coupled with Process re-design

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 receive strategic benefits with IT, supply chain processes have to be changed; and undoubtedly that some companies have been able to do this. In extant literature, authors in business process re-engineering (BPR) hold that the link of IT use and simultaneous design of business processes is a vital ingredient to bring benefit from development efforts (for example Venkatraman, 1994; Hammer, 1990; Davenport & 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 interviewed supply chain managers 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 jointly deploying 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 change 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 less vulnerable to risks, as regional

inventories of finished goods have been removed. In addition, previously, regional sales forces were tied with 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 the sales planning: this includes incorporating the expected sales in key countries with highest sales with sales force opinion and based on this, planning of both own and supplier production capacity. After the capacity is set, the sales force receives sales quota that is the level of sales that can be fulfilled with promised lead-time of five days world-wide. The 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:

- 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
- System integration with 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 the 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 effectiveness of the e-business application. 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 operational perspective. A reason for this may be the relative novelty of IT, meaning that larger scale and strategic solutions are still yet to come, and after companies have installed a basic IT infrastructure.

When observing those e-business solutions that genuinely are dyadic it can be noticed 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 where 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 level and effectiveness simultaneously.

Benefits of IT in SCM are multitude 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. Then, 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 re-design. The ideas of BPR are then closely related to current study. Our study corroborates that business process re-engineering skills are vital to benefiting from IT strategically in SCM. The change in processes needs not 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 viewpoint of this paper was on single companies rather than on the 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 investments benefits supply chain management. To further knowledge development is to study entire supply networks and analyse the situation from various points of view. Sufficient emphasis should be paid

to various organisational issues. Additionally, propositions presented in this paper should be tested with larger data set to gain further understanding of various contingencies (type of network, business environment, used technology etc.) that have an impact how the benefits are composed.

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