# The use of information technology in supply chains: transactions and information sharing perspective

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### Abstract

Whilst mid in an era of rapid development in information technology (IT), companies face increasing need to coordinate their logistics activities with their up- and downstream counterparts, that is, in their supply chains. New technological solutions have provided companies with completely new ways for information sharing in support of coordination and on the other hand, for handling of transactions with less friction. However, with existing literature we are left with less clear view how companies actually use IT in these two areas and also, are these areas linked in some ways. This study examines these issues through a small-scale survey and a set of focused interviews with selected progressive companies from Finland.

Based on the study we find that the use of IT has become commonplace in industrial companies under the last five years, but relates currently in many instances to the handling of ordinary supply chain transactions. Progressive companies are willing to share logistics execution related data with their selected 1<sup>st</sup> tier partners, but on average, use less IT for this purpose. Advanced supply chain management practices are limited to selected base of supply chain parties, and flexible supply networks including a number of participants and the diverse use of modern IT solutions, especially in information sharing are rare. A set of hypotheses on the possible reasons for this are presented.

**Keywords**: Coordination, information sharing, information technology, logistics, supply chain management, transactions

#### **Introduction**

Supply chain management (SCM) has been receiving growing interest from both academics and practitioners especially under the last 10 years, although the idea itself, holistic view of demand fulfillment processes of a company and between companies, is of older origin (see for example the value chain concept of Porter 1985). The current view of supply chains is shifting from linear chains of supplier's supplier to customer's customer more into complex networks of companies. For example, Kemppainen and Vepsäläinen (2003) discuss this change and suggest encapsulated networks entailing groups of companies with varying degrees of integration as a modern view of supply networks. Moreover, Kemppainen and Vepsäläinen propose that improved information technology (IT), specialization, and outsourcing are key preconditions for networking. Indeed, new IT solutions, reducing the friction in transactions should open up new avenues for networking (cf. transaction cost analysis of Williamson 1981). In addition, many authors hold that information sharing is the basis for supply chain management. For example, Lee (2000) states that information sharing is the foundation for supply chain integration, the term in many cases used as a synonym for SCM. However, commonly these authors present their postulates by not evaluating actual empirical data, and not discussing the relation of transactions and information sharing. This raises an important question: how companies actually use IT in supply chains, taking into account both the transaction execution and information sharing perspective?

In our study the research question is: how companies are using new IT in their supply chain transactions and information sharing? In addition, we aim explain why IT is used the way it is. As for IT, we limit ourselves in the discussion to some typical web and EDI solutions. This paper is structured as follows. First, a brief literature review is presented. Second, research setting and data are explained. Third, main empirical findings are viewed. Fourth, possible reasons for the way IT is currently used in SCM are discussed in the form of hypotheses. Finally, the results are discussed.

#### Literature review

It is well acknowledged that the use of IT is an integral part of modern SCM. For example, Simchi-Levi et al. (2003, p. 267) list the objectives of IT in SCM:

- 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

Examining extant literature, we can grossly classify the functional roles of IT in SCM in three categories (Figure 1). Firstly, IT supports frictionless transaction execution. Secondly, IT is a means for enhancing collaboration and coordination in supply chains. Thirdly, IT based decision support systems (such as APS – advanced planning and scheduling and SCEM – supply chain event management) can be used to aid better decisions. In our discussion we will limit ourselves to the first two functional roles, as the decision support role is somewhat separate area entailing less interaction with different supply chain parties.



Figure 1: Functional roles of IT in SCM

There is an abundance of studies from recent past examining how companies have adopted technologies in transaction execution in supply chains. Lancioni et al. (2003) compare the use of IT in 1999 and 2001 among CLM companies. Their study shows a clear increase in the use of web-technologies especially in purchasing and transportation. Same kinds of results are reported by Rahman (2003) having the 1000 largest Indian companies as the study population. On the other hand, another recent study by Supply Chain Council (2002) on the use IT in supply chain management in large US companies, mainly manufacturers, revealed that although the use of IT has progressed, companies have still much to go. For example, 60-70 % of transactions were still done by manual methods (phone, fax, and mail). This might demonstrate how companies having to interact with multiple partners cannot use IT with all. As for the information sharing in supply chains, besides well known success stories such as Cisco and Dell, there are less clear empirical evidence how companies actually use IT in their supply chains for coordination. The main view seems to be that the use of IT in this sense is limited. For example, van Hoek (2001) holds that "e-supply chains" coupling integrated supply chain scope and strategic approach for the use of IT are very rare cases. Skjoett-Larsen and Bagchi (2002) observe in their recent case study among 14 European companies in 5 networks that in many cases supply chain integration is based on more traditional methods. Also evidence suggest that the scope of collaboration is limited: based in their extensive research with over 50 in-depth interviews and a survey with nearly 600 responses within APICS, NAPM and CLM members, Fawcett and Magnan (2002) report that true collaboration beyond first-tier is rare.

In summary, companies have adopted new technologies especially for conducting transactions. However, there is less discussion on how companies actually use new IT in managing their supply chains and on the links of using IT in transactions and information sharing.

#### Research setting and data

Case research provides an excellent means of studying emergent practices in logistics and SCM (Ellram 1996 and Meredith 1998). The use of new IT in transactions and information sharing is in our view an emergent practice with limited discussion on the subject in literature. For this reason we followed in our research the case-study approach as described for example in Ellram (ibid.). The study, executed in the end of 2003 consisted of four phases:

- 1. Selection of companies: 36 Finnish companies from manufacturing and trade viewed by experts as progressive were selected. The company sizes ranged from small local to large global companies (company turnovers ranging from under 7 million euros to nearly 10 billion euros with 50 % of companies having turnover over 500 million euros).
- 2. Phone inquiry: An inquiry over phone on the use of IT using a questionnaire was conducted with the selected companies.
- 3. In-depth interviews: 15 companies were selected to in-depth interviews based on their answers in the phone inquiry
- 4. Analysis: The results were analyzed in several expert workshops.

In all phases we aimed for traceability of our conclusions. Therefore study data were documented into case-study database and this documentation was checked for their correctness. For example, case-descriptions prepared based on in-dept interviews were sent to interviewees for validation.

In our study we limited ourselves to several common IT solutions, several ordinary transactions, and several common types of shared information. In this paper by IT we mean the following technologies: Internet and Extranet-pages (restricted access Internet-pages), EDIFACT-standard EDI, and other system to system methods: XML, 3rd party transaction hubs (information integration services, such as a portal, offered by a third party), system to system messaging with other means, and the use of a shared database. Note that e-mail is excluded as an IT-solution in our discussion, unless otherwise specifically stated. We included as transactions purchase and sales ordering and invoicing. By information sharing we mean the sharing of either one of the following information between supply chain parties: demand information and forecasts, inventory levels, and production capacity and plans.

### <u>Results</u>

The results are reported in three categories. First, we present observations on the use of IT in transactions and in information sharing. Second, we examine the links of IT usage in transactions and in information sharing. Third, seven company cases are examined in more detail.

### IT in transactions

In Table 1 we present the use of IT in our data set in ordinary supply chain transactions. The table presents the percentage of companies using some IT solution in at least some supply chain relationships.

		% of companies (n=36)	1
		Using IT	Implemented IT under
	Using IT	and e-mail	the last 5 years
Purchase orders	64 %	92 %	36 %
Purchase invoices	47 %	50 %	28 %
Sales orders	67 %	89 %	39 %
Sales invoices	64 %	64 %	28 %
In purchase or sales transactions	89 %	100 %	72 %

The use of IT is commonplace within our progressive companies. Two thirds of the companies use some IT in purchase ordering or sales order intake. Typical solutions used are traditional EDIFACT and

extranet-portals. If we count e-mail with, all the companies used electronic solutions either in purchase or sales transactions. On the other hand, there is still a wide use of manual methods (phone, fax, and email). In fact, only in a few special instances the transactions were conducted completely with IT. In these cases the amount of supply chain parties was limited or the focal company had power over the other parties to implement a solution it has desired to use. In total, the majority (72 %) of companies have implemented some IT in purchase or sales transaction in recent years. It seems that the main technologies allowing the increase of IT use have been the extranet and 3rd party provided services, since these technologies have highest rates of new implementations under last five years.

## IT in information sharing

Table 2 summarizes information sharing extent in our data set. The table shows the percentage of companies giving and receiving information with and without IT towards and from 1<sup>st</sup> and 2<sup>nd</sup> tier supply chain parties.

	% of firms giving info (n=36)			% of firms receiving info (n=36)			
Towards/from	In total	/w IT	/wo IT	In total	/w IT	/wo IT	
1st tier customers	75 % =	44 % +	31 %	86 % =	31 % +	56 %	
1st tier suppliers	92 % =	44 % +	47 %	83 % =	14 % +	69 %	
2nd tier customers	8 % =	3% +	6 %	11 % =	0%+	11 %	
2nd tier suppliers	8 % =	0%+	8 %	3 % =	0%+	3 %	

Table 2: Information sharing and the use of IT

A total of three quarters of companies give at least some information to their first tier customers. However of these only little over half (or 44 % or all companies) uses IT for information sharing. Similar kinds of information sharing practices are observed when giving information to 1<sup>st</sup> tier suppliers and when receiving information from 1<sup>st</sup> tier customers and suppliers. On the other hand, and as expected, information sharing with 2<sup>nd</sup> tier parties is more of an exception, and, moreover, only in one instance IT is used. Our findings point out to that information sharing with selected first tier customers and suppliers is common but IT is used less for this purpose.

### The relationship between IT in transactions and in information sharing

The relationship between IT usage in transactions and information sharing is examined in Table 3. The table shows which information sharing method, if any, the companies use, given the method they use in transaction execution. Note that in Table 3 information sharing refers to both receiving and giving information and takes into account all tiers. This is why the numbers are a little bit different than in Table 2 above.

Pan	el A: Buy side						
		Info	ormation sh	aring meth	od <sup>1)</sup> : perce	entage of	
			companies	for each tra	Extranet	etnod	T
		N/A	Manual	Extranet	& EDI	EDI	n
poų.	Manual	0 %	100 %	0 %	0 %	0 %	10
n met	Extranet <sup>2)</sup>	0 %	25 %	75 %	0 %	0 %	4
ctior	Extranet & EDI <sup>2)</sup>	0 %	25 %	0 %	25 %	50 %	4
ansa	EDI <sup>2) 3)</sup>	0 %	44 %	11 %	6 %	39 %	18
7	Total	0 %	56 %	14 %	6 %	25 %	36
Pan	el B: Sell side	1			- 71		
		Info	ormation sh	aring meth	od ′′: perce	entage of	
		(	companies	for each tra	insaction m	ethod	π
		N/A	Manual	Extranet	Extranet & EDI	EDI	n
poq	Manual	25 %	50 %	0 %	13 %	13 %	8
n met	Extranet <sup>2)</sup>	0 %	100 %	0 %	0 %	0 %	1
ction	Extranet & EDI <sup>2)</sup>	0 %	20 %	10 %	50 %	20 %	10
ansa	EDI <sup>2) 3)</sup>	12 %	47 %	6 %	18 %	18 %	17
Ť	Total	11 %	42 %	6%	25 %	17 %	36

	Table 3: Relationshi	b between	information	sharing and	l transaction	execution metho	bd
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Note 1: Information sharing entails both giving and receiving information

Note 2: Manual methods used also besides IT-solutions

Note 3: EDI refers to EDIFACT, XML, 3<sup>rd</sup> party transactions hubs, system to system messaging with other means, and shared database

Because of the size of our data set statistical testing of interrelationships between IT usage in information sharing and in transactions was not possible. However, even taking the limitations into account we can make two observations. First, our data demonstrate a simple relationship that is intuitively clear: information sharing method is typically either the same as in transactions or less integrated. Consider Table 3, Panel A. All the companies not using IT in buy-side transactions share information, but do so manually. On the other hand, of those four companies using only extranet solutions in buy side transactions, three uses extranet also in information sharing, while the last one shares information manually. Moreover, EDI information sharing seems to be used only when such methods are used in transaction execution. There is a slight exception to this in the data: two companies use EDI and/or extranet in sell side information sharing although they conduct transactions manually (Table 3, Panel B). The explanations for this can be found by examining these two cases more thoroughly, which we will not go into because of the space limitation of our discussion. We only note that although the observed relationship seems clear, it does not hold for all of the data. Second, the data also imply that companies using EDI but no extranet in transactions share information proportionally more manually than companies using also extranet in transactions. This might suggest that it is easier to share information with less integrated means, such as extranet pages, and thus using formal system to system messaging might be demanding. We will return to this issue in the discussion part. Before that we examine selected cases in transaction execution and information sharing.

#### Cases in the use of IT in supply chains

Table 4 presents seven selected cases from our data. The cases represent the best-in-class approaches to using IT in supply chains in our data set.

Case	IT solution	Direction	Volume	Orders with IT	Invoices with IT	Information shared with IT
GNT Finland; IT wholesale	Web-portal (extranet) and system to system integration (web- based)	Sell	Over 70 % of sales	Yes	Planned	Inventory levels from/to customers
Wärtsilä service unit:; spareparts for machinery	Web-portal (extranet)	Sell	Several key customers	Yes	No	Inventory levels to customers
Kone SBÜ; machinery manufacturing	Web-portal (extranet) and system to system integration (EDIFACT)	Buy	All key suppliers	Yes	Yes	Inventory levels from/to suppliers
Rocla; machinery manufacturing	Web-portal (extranet)	Buy	30 % of purchases	Yes	Yes	Inventory levels and demand information to suppliers
Datex-Ohmeda Helsinki BU; medical instrument manufacturing	3 <sup>rd</sup> party transaction hub	Buy	95 % of purchases	Yes	No	Demand forecasts to suppliers
Vaisala Instruments; high end electronic measuring device manufacturing	3 <sup>rd</sup> party transaction hub	Buy	80-90 % of purchases	Yes	Planned	Inventory levels, demand information, and demand forecasts to suppliers
Elcoteq; electronics manufacturing services	Web-portal (extranet) and system to system integration (EDIFACT) <sup>1)</sup>	Buy and sell	Several key customers and suppliers	Yes	Yes	Inventory levels to suppliers and from/customers, demand forecasts from customers and to suppliers

Table 4: Seven selected case	s in the use o	of IT in	supply ch	nains
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Note 1: Planned system to system with RosettaNet XML and the use of APS-tool

In our selected seven cases inventory level is the typical shared information. This is natural since inventory levels are basic product availability related information in the supply chains. Some companies have had a need to coordinate more. A means for this in these case companies has been sharing demand and especially demand forecast data. The companies, Datex-Ohmeda Helsinki business unit, Vaisala Instruments, and Elcoteq, all operate in electronics and mainly on a make-to-order basis. Datex-Ohmeda sends demand forecasts to its suppliers weekly, and thanks to IT can easily update the forecasts also within a week. Vaisala Instruments communicates demand forecast information with its suppliers daily with IT. On top of this, suppliers a required once a month to confirm their delivery capabilities against forecasted demand. Elcoteg receives demand forecasts daily from its customers and delivers it to its suppliers after braking down the bill-of-materials (BOM). The suppliers return with availability confirmation which is passed on to the customers. In this way the whole network prepares itself based on demand forecast. The confirmation runs through the chain within days. The objective is, however, to run the confirmations through the chain within hours. This kind of rapid demand forecast sharing and availability confirmation could not be possible without the planned more-flexible-than-EDIFACT system-to-system information sharing with RosettaNet XML and the advanced planning tool converting the BOM-data from customers into form that can be delivered to suppliers. The need for such rapid information exchange originates from turbulent environment: demand for goods delivered by this network fluctuates significantly. Moreover, product life-cycles are short and product introductions frequent.

The cases also show that IT is used prominently with only a selection a supply chain parties. Only key suppliers or customers are included within a system. This indicates that companies evaluate the benefits and costs of IT and as a result implement suitable solution where they really are necessary. An exception to this can be noted in cases where 3<sup>rd</sup> party transaction hubs are used: in these cases, with the aid of 3<sup>rd</sup> party in charge of the actual information integration, the electronic operating models are more easily scaled up to a wide base of supply chain parties.

### Discussion: The use of IT in information sharing

An important question arising from our data is that why IT is not used more in information sharing. We propose following four hypotheses as possible answers for this question.

# Hypothesis 1: Benefits of IT in transaction execution are easier to quantify and thus it is easier to justify investments.

Simple transaction processes such as order intake can be easily measured, and thus the benefits of automating them with IT can be quantified. In competition for a company's scarce resources, IT investments with clear return on investments are easier to justify than those with less certain gains. Information sharing is a good example of less certain profits: how will the benefits of sharing, for example, demand forecast information turn into real positive cash flow might be hard to demonstrate.

# Hypothesis 2a: Drivers and prerequisites of using IT in transaction execution and in information sharing differ.

Drivers for using IT in transactions are different from those of in information sharing. Whereas key drivers in implementing IT systems transactions, especially EDI, are transaction volume and stability of relationship, in information sharing other aspects have to be considered as well. While messaging volume might be an important factor as well, the cases in this study show how especially demand uncertainty and frequent product introductions have driven certain companies for using system to system integrated IT also in information sharing.

Also the prerequisites in using IT in transactions and information sharing differ. Effective information sharing with IT, especially if system to system, requires more efforts than automating transactions. Before systems can be used there has to be mutual understanding on the use of shared information. Using IT in information sharing requires thus process re-design that is less straightforward than just automating ordinary transactions. Because of this fewer companies engage in information sharing with IT. Moreover, in regard to system to system information sharing, an important part of realizing benefits of information sharing is the use of advanced planning system, as the Elcoteq case demonstrates. Without the capability to use and analyze the information intelligently, there is less use of the shared information with systems. Before such systems for analysis are in place it is sufficient to receive supply chain visibility information in more manual ways (for example through web-portals).

#### Hypothesis 2b: The need to share information with IT is highly contextual related.

An extension to hypothesis 2a is that sharing information with IT is highly contextual related. The selected cases in this study show that the need for sharing information, especially demand related, grows with the used manufacturing mode (make-to-order compared to make-to-stock) and business volatility. These two are closely interrelated: the more demand varies the more it is useful, whenever possible, to produce only on actual orders. In this way supply chain risks, for example obsolete inventory, are diminished. However, manufacturing based on actual orders demands flexibility that can be built by, among other things, sharing reliable demand information. Moreover, the turbulent the environment and thus the faster the needed response times, information sharing has to be to at least some extent executed between information systems to minimize information delays and errors. Thus in less volatile environments using IT for information sharing is not that vital.

# Hypothesis 3: Use of IT in transactions and in information sharing is linked. Inflexible technology selected for transaction execution might hinder the use IT in information sharing.

The selected cases demonstrate that transaction integration might be the first step to other kind of use of IT. All of the cases show the use of selected IT solution in order handling and also sharing of some information. In addition in most of the cases invoices are or planned to be exchanged with IT. We then hypothesize that using IT in transactions is a vital backbone for other uses of IT. Then, as we seem to be in a transition phase where companies implement more and more IT for transaction execution, a viable future scenario is that we will see more integrated supply chains also in regard to information sharing in the near future.

On the other hand, certain technologies selected for transaction handling might actually hinder the use of IT in sharing information. In this study we observed that companies using EDI but not extranet in transactions were more prone to share information manually (see Table 3 above). This leads us to the assumption that information sharing might require flexibility that all EDI-technologies cannot deliver. Thus a selection of certain IT-solution for transaction execution, such as point-to-point EDIFACT might actually be an impediment for further use of IT in information sharing.

# **Conclusions**

With our study we have shed with a selected data set some more light to the actual use of IT in SCM, but also, raised some new questions. Our results from this study show that the development of e-business models in supply chains is clearly well underway. Companies have implemented new IT solutions especially under the last five years. On the other hand, currently IT is used in supply chains mainly in transaction execution and relatively less in information sharing. Thus, real time supply chains exchanging all the necessary information with modern communication technologies are more of a vision. As an explanation for the limited use of IT we prepared four hypotheses. Testing these is a good way forward in research. Of particular interest is the relationship between transaction and information sharing methods. This could be examined, for example, through longitudinal case studies and observing the implementation sequence of IT systems in supply chain interaction. Another interesting topic is the difference between formal and information sharing. In efficient supply chains, what information should be shared formally with systems and for what kind of information a more informal information exchange would suffice? We also contribute to practitioners by noting that using IT in and selecting IT for transaction execution and information sharing might be closely linked.

We acknowledge the limitations of our study. The main weak point of ours is the small data set that does not allow testing it with statistical methods. Moreover, in order to present the data in meaningful ways we have aggregated it. This may have resulted in loss of details that actually are important. For example, sharing of different kinds of information with IT might differ significantly. Inventory levels should be fairly straightforward to share. On the other hand, demand forecasts are less so, entailing uncertainties and questions on format (for example, what is the proper aggregation level of shared forecast). Still, we find that the results of the study are valid in the discussion level we have chosen.

### **References**

- Ellram (1996) "The use of the case study method in logistics research", *Journal of Business Logistics*, Vol. 17, No. 2, pp 93-138
- Fawcett, S.E. & Magnan, G.M. (2002) "The rhetoric and reality of supply chain integration", International Journal of Distribution & Logistics Management, Vol. 32, No. 5, pp. 339-361
- van Hoek, R. (2001) "E-supply chains virtually non-existing", *Supply Chain Management: An International Journal*, Vol. 6, No. 1, pp. 21-28
- Kemppainen & Vepsäläinen (2003) "Trends in industrial supply chains and networks", International Journal of Physical Distribution & Logistics Management, Vol. 33, No. 8, pp. 701-719
- Lancioni, R.A., Smith, M.F. & Schau, H.J. (2003) "Strategic Internet application trends in supply chain management", *Industrial Marketing Management*, Vol. 32, No. 3, pp. 211-217
- Lee, H.L. (2000) "Creating Value Through Supply Chain Integration", Supply Chain Management Review, September/October, pp. 30-36
- Meredith J. (1998) "Building operations management theory through case and field research", *Journal of Operations Management*, Vol. 16, No. 4, pp. 441-454.
- Porter, M. E. (1985) *Competitive advantage: creating and sustaining superior performance*, Free Press, New York, 557 p.
- Rahman, Z. (2003) "Internet-based supply chain management: using the Internet to revolutionize your business", *International Journal of Information Management*, Vol. 23, No. 6, pp. 493-505
- Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E. (2003) *Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies,* McGraw-Hill, New York, 354 p
- Supply Chain Council (2002) *eBusiness and Supply Chain Processes,* USA, 218 p.
- Williamson, O.E. (1981) "The Economics of Organization: The Transaction Cost Approach", The American Journal of Sociology, Vol. 87, No. 3, pp. 548-577