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Information Flows Supporting Hinterland Transportation by Rail: Applications in Sweden

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Abstract This article analyses how information and communication technology (ICT) is used to support the hinterland transport of maritime containers. It focuses on the way information is conveyed between actors using an ICT facility structure, and how integrative information is used by different partners' information systems to make different transport operations more efficient and to offer improved service.

The analysis includes the identification of the actor network and the management components in line with supply chain management perspectives. To support this analysis, a conceptual model showing the relationship between integrative information and integrative technology was constructed and related to business processes and an ICT maturity model found in the literature.

Interviews were conducted with actors involved in Swedish hinterland rail transport. The information flows were mapped and the analysis shows that while the current level of integration and ICT maturity is fairly low, several actors are currently modernising their systems. Their main motivation is to reduce the administrative task load, and at the same time achieve better supply chain integration. The actors are focused on their own tasks and do not see the advantages of advanced integration of the information flows. The risk is identified that the IT level is increasing faster than business integration processes between the companies, which might lead to inefficiencies.

Keywords: *Hinterland transport, information and communication technology, intermodal freight transport, supply chain management.*

1 Introduction

Efficient and effective hinterland transport is of key importance for successful maritime transport, particularly for short sea shipping. Hinterland transport can be organised by various traffic modes and different actor categories, using different business models and network operation principles. The recent deregulation of the railway sector in Europe has seen several new actors employing new business models emerging for the operations and management of hinterland transport. The field of hinterland container transport and dryports has attracted substantial attention from researchers (for an overview see, e.g., Roso, 2009a), but most studies

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have focused on the design of the transport services, geographical aspects and environmental consequences.

The development of global supply chains has increased the pressure on maritime hauling, seaport operations and inland freight distribution (Notteboom and Rodrigue, 2005; Almotairi, 2010). The success of a company depends on its ability to integrate into a network of business relationships (Bowersox, 1997; Drucker, 1998; Christopher, 1998). Lambert and Cooper (2000) named this phenomenon of managing the business and its relationships across the supply chain "supply chain management" (SCM). It deals with managing the business and their relationships with other members by integrating activities, functions, and systems throughout the supply chain (Vickery *et al.*, 2003). The key to seamless supply chains is making available undistorted and up-dated information at every node within the supply chain (Towill, 1997). By taking the available data and sharing it with other parties within the supply chain, information can be used as a source of competitive advantage (Novack and Rinehart, 1995). The existence of integrative information technology facilitates the flows of relevant information throughout the supply chain and enables business process integration that goes beyond firms boundaries (Bowersox and Daugherty, 1995; Lewis and Talalayevsky, 1997).

Thus far, the administrative systems used for hinterland operations have not been heavily explored, especially when compared to the abundant literature on information systems (ISs) for container terminal operations (for an overview, see Henesey, 2006). Nevertheless, many researchers highlight problems in information and management systems (Bichou and Gray, 2004). Shortcomings in reliable data and information exchange are often mentioned as a reason for inefficiencies as well as lost business opportunities, which are mostly needed for collaboration or partnership arrangement with other logistics channel-members.

The aim of this article is to analyse how information and communication technology is used to support the hinterland rail transport of maritime containers. The focus is on what information the actors exchange and by which means they do it. In addition, an analysis has been made in order to identify which actors drive the development of more advanced information technology (IT) and for what reasons. The scope includes how ISs are used for making the operations more efficient and prospects for facilitating an extension of the service offer.

The methodological approach used for preparing this paper can be divided into three steps. First, the relevant literature on freight transport, logistics, SCM, information and communication technology (ICT), IT, and ISs is explored. Secondly, a conceptual model is developed from the literature to analyse the empirical findings and reinforce the applied terminology. Finally, an empirical study was conducted in which interviews were carried out with a number of actors involved in handling maritime containers in hinterland transport in Sweden. Their inter-organisational information flow is surveyed and categorised, as is their intra-organisational information processing. The paper begins with introducing the frame of reference within which relevant issues from the literature are discussed, and based on that, the conceptual model is described. The empirical outcome is then presented, followed by an analysis and description of the final findings.

2 Hinterland transport in a supply chain management perspective

Considerable attention has been given to SCM in the popular business press and some academic literature (Lambert and Cooper, 2000). According to Mentzer *et al.* (2008), SCM is a phenomenon that resembles different disciplines and consequently touches nearly all areas of business. SCM requires full systems visibility that manages the total flows of a distribution channel from early supplier to the end customer (Stevens, 1989; Houlihan, 1993). This is with the aim of achieving goals related to total system performance rather than optimisation of a single phase in a logistics chain. In this section, the SCM perspective is introduced along with IS and IT issues in a maritime and hinterland transport setting, in order to arrive at a conceptual model for further use in the analysis.

2.1 Coordination of transport network

While transport is one of the major activities within logistics where a creation of time and place utility is performed (Coyle *et al.*, 1996), transport network (links in supply chains) and transport infrastructure (nodes in the supply chains) are key elements in efficient logistics systems (Lumsden, 2006). It is now generally accepted that supply chains, and not individual firms or products, are the basis of most marketplace competition (Christopher, 1992). At the most fundamental level, a supply chain is considered to be a series of inter-firm relationships (Cooper *et al.*, 1997). In order to coordinate a transport network, SCM takes an integrative approach, which implies managing relational exchange with other supply chain entities. These relational exchanges can be expressed in the form of supply chain flows: both the information and the physical flows. The information flow relates to transfer of all relevant data and information related to the operational procedures involved in various logistics activities. The second flow, the physical flow, relates to the movement and handling of cargo through ports and/or terminals, including transportation activities (Paixão and Marlow, 2003). Organisational relationships tie firms to each other and may tie their success to the chain as a whole (Schary and Coakley, 1991). Thus, the main focus here is the integration of key business processes, which encompass a network of relationships that offers an opportunity to capture synergy of intra- and intercompany coordination and linkage optimisation (Lambert and Cooper, 2000).

2.2 Freight transport and the container shipping industry

Globalization and new distribution systems are imposing significant structural and functional changes in hinterland logistics (Robinson, 2002 and 2006). For instance, liner shipping has experienced an explosion in container ship size. The maritime element of the hinterland transport chains has employed ever-larger ships to cope with increasing transport demand and to facilitate lower unit costs as discussed by Cullinane and Khanna (2000). With the number of latest vessels on order reaching 14,000 TEU (World Cargo News, 2006) to fully utilise the economies of scale, progress in ports and hinterland operations must match (Parola and Sciomachen, 2005 and McCalla, 2007). Fleming and Baird (1999) noted that there have been many recent remarks and written comments to the effect that the real future competition will not be between seaports and individual transport carriers *per se*, but between a handful of "total logistics chains." Heaver *et al* (2000, p. 1), in their research into the European seaports and shipping sectors, noted that "the role of the port and the port authorities has to be redefined to guarantee that it remains a fully-fledged player in this fast evolving integrated market." By recognising that an enterprise can no longer effectively compete unilaterally or autonomously, SCM represents one of the most significant paradigm shifts in modern business management practice (Lambert and Cooper, 2000). It has been argued that partners' (supplier/customer) integration into the firms' value/supply chains is critical if the firm is to add value to its product and service offerings (Ragatz *et al.*, 2002, p. 28).

What is becoming increasingly important for seaports, as well as seaport users, is not merely the efficiency of the seaport *per se*, but the efficiency of the supply chain in which the seaport and its users are involved (Panayides and Song, 2008). Based on this understanding, the logistics or distribution chain, elements of which are the seaports/terminals, shipping lines and transport operators, needs to achieve a higher degree of integration in order to be successful (De Souza Junior *et al.*, 2003).

2.3 Information system support

As SCM became a prominent concept, IS, IT and ICT were identified as critical enablers of the integration of logistics processes (Auramo *et al.*, 2005; Mabert and Venkataramanan, 1998). The firm's goals for IT in a SCM context include ensuring information availability at a single point of data access, creating visibility to upstream and downstream changes in demand or supply, and enabling effective decision-making based on this broad base of information about the supply chain (Simchi-Levi and Simchi-Levi, 2008). The availability of real-time information puts more emphasis on flexible IT systems that deal with a large amount of data and are easy to interconnect (Helo and Szekely, 2005). Predominately, the ability of IT to make information available eases the implementation of integrated logistics processes (Gustin *et al.*, 1995).

Different types of ISs are available and used by industry today. These include proprietary in-house-developed legacy systems, off-the-shelf systems provided by major Enterprise Resource Planning (ERP) system suppliers, and single user simple office applications like Microsoft Excel (Stair *et al.*, 2008). Off-the shelf systems provide a certain degree of integration capability, not least if the applications are from the same supplier. Although middleware is needed, the implementations are likely to have experience with these systems, so it makes integration easier even if the applications come from different suppliers, as similar database approaches can be used in most instances (Narasimhan and Kim, 2001; Edwards *et al.*, 2001; Helo and Szekely, 2005). More tedious is the situation where legacy systems are used, as there is often poor system design documentation available and the capabilities for automatic data exchange can be somewhat limited. Simple office applications are even more difficult to integrate, as they do not work with database applications and flat files need to be sent back and forth between applications and organisations, often including manual processing that implies costs and increased risk of mistakes (Stefansson, 2002).

In addition to the variety of different systems that exists, communication systems are a vital enabler of organisations' integration efforts. Large organisations use Electronic Data Interchange (EDI) applications to automate their data exchange (Stair *et al.*, 2008) while others, often smaller organisations, use less cutting-edge methods, such as phone and fax. Technology is emerging that allows Internet based approaches to follow the eXtensible Markup Language (XML) data exchange methods. This method allows organisations of all sizes to participate in a relatively inexpensive data exchange setup where one or more actor in a supply chain establishes an Extranet web page for others to use without needing any backbone IS (Stair *et al.*, 2008). This is of possible interest for mobile applications where data exchange partners can be on the move, i.e. carrying out transportation assignments or assignments in distribution centres (Wang, 2009).

The maturity of business integration and its IT support in a supply chain can be divided into four levels (Heinrich and Simchi-Levi, 2005): 1) Disconnected, 2) Internal integration, 3) Intra-company integration and limited external integration and 4) Multi-enterprise integration. On the first level, the organisation has independent systems across the organisation and basic IT support based on spreadsheets and manual data manipulation. Redundant data is stored across the organisation. On the second level, the organisation has their internal operations integrated. The IS is integrated and the same processes and indicators are used throughout the organisation. IT-based planning tools are used. On the third level, the processes are integrated outside the organisation, towards key partners. The internal integration and data visibility is complete and some data is also visible to key partners. Important processes are shared with the partners. On the fourth level, the integration is complete towards the supply chain. Collaboration exists throughout the supply chain and the partners share a common goal. The IT systems are completely integrated and the data visibility is total. The IT maturity and maturity of business processes do not always have to be on the same level. However, the IT maturity should not be more advanced than the business integration, as this causes inefficiencies. It is better to use a simpler IT system than to try to combine high level IT with low level business integration (Heinrich and Simchi-Levi, 2005).

2.4 The conceptual model

The conceptual model used in this study is inspired by the SCM framework proposed by Lambert and Cooper (2000). It involves closely interrelated SCM components that are assumed to be essential to designing and successfully managing supply chains:

- *The network structure*: includes the actors in the supply chain and their links. These actors can include shipping lines, terminal operators, transport operators, forwarders, shippers, etc.
- *The key business processes*: include the activities that produce value to the customer; typically this include transportation, terminal operation such as lifting on and off units, short time storage, consolidation of units, etc.
- *The management components*: includes the managerial variables by which the business processes are integrated and managed across the supply chain. The components used in this study includes a variety of technical subcomponents, including IS and IT.

The conceptual model was formulated using a two-dimensional conceptualisation of an integrated supply chain strategy. The first dimension, *integrative information* (communication and information flow structure), captures desired/valuable information that enables supply chain integration. The second dimension, *integrative technology* (IT's facility structure), captures the flexible/inter-connected ISs that are able to span the supply chain boundaries. The conceptual model shown in Figure 1 illustrates these dimensions and their links to each other. It shows the network actors as well as the key business processes in a simplified supply chain setup, where the first-tier member firms are represented by shipping lines (identified as the first actor in a hinterland transport study), followed by the seaport terminal operator, which works as a central hub and pivot, systematically joining different modes of transport. Transport operators feed the inland terminals, which are connected to consignees that have the role of end customers.

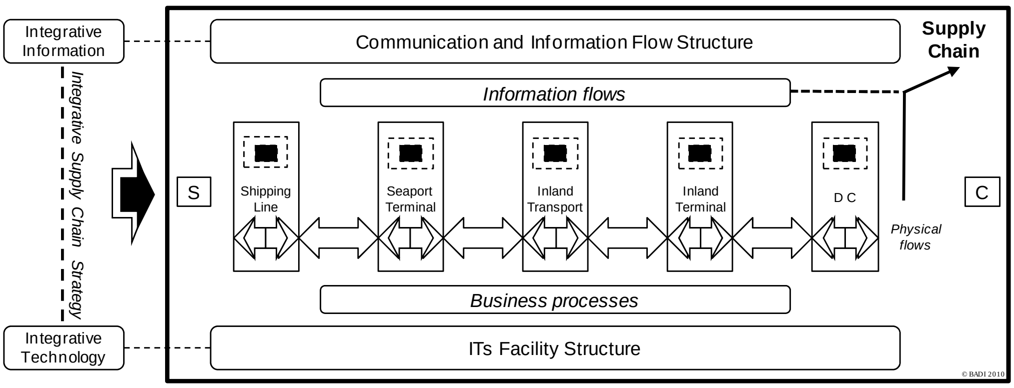

Figure 1: A conceptual model for managing the information flow supporting hinterland transport.

3 Information Support to Swedish Hinterland Container Transport

The rail shuttle system connecting the Port of Gothenburg (PoG) with its hinterland is described fairly extensively in the scientific literature (see, e.g., Bergqvist, 2007, Bergqvist, 2008, Bergqvist and Woxenius, 2009, Bergqvist *et al.*, 2010, Roso, 2009b, Roso and Lumsden, 2010, Woxenius *et al.*, 2003 and Woxenius and Bergqvist, 2009). These scientific studies have addressed the transport system in terms of terminal and rail service development and quality, competition with road transport, and environmental performance. The administrative system, however, is not extensively explored, although Lamberg and Frostberg (2007) have addressed information handling. European policy makers have held the shuttle system up as a model of rail liberalisation, and it is often used as a showcase for the potential of rail to capture, or re-capture, market shares from road.

Rail shuttles to other Swedish seaports are an emerging business and Swedish hinterland transport is arguably suitable for illustrating and analysing how information flows that support hinterland transport of containers by rail are managed. Sweden has consequently been chosen as the empirical setting of this section. Eight interviews have been conducted to collect data on hinterland information flows. Four terminals, three intermodal operators, two ports, one shipper with significant experience in intermodal transport, and one software supplier have been interviewed. Some of them have multiple roles and were asked about all their roles (see Table 1). The interviews thus address 12 network actors' roles. The interviewees were selected to represent both small and large actors of different types. The interviews were done by telephone, except for the interview with an official at the PoG, which was done at the port. The interviews were held with the person in charge of hinterland intermodal operations and at the various organisations and lasted between 30 minutes and 2 hours. No respondent refused to be interviewed.

Table 1: Interviewed companies and their roles.

Actor / Role	Size of intermodal flow	Location	Terminal	Intermodal operator	Port	Shipper	Software supplier
Gävle Containerterminal	medium	Gävle	X		X		
Hallsbergsterminalen	small	Hallsberg	X				
IKEA	large	Älmhult				X	
Intercontainer	large	Nine destinations in Sweden		X			
PGF Tåg	small	Vaggeryd	X	X			
Port of Gothenburg	very large	Gothenburg	X		X		
Vänerexpressen	small	Karlstad, Västerås, Insjön	X (Karlstad, Insjön)	X			
Hogia	-	-					X

The SCM components proposed by Lambert and Cooper (2000) are used to structure this section, but are slightly adapted to distinguish between the *transport network* structure and the *actor network structure*.

3.1 The hinterland rail transport network

The Swedish intermodal transport network structure was simplified during the 1990s and the network was actually almost fully dismantled by the early 2000s, resulting in a number of full trains directly servicing two terminals overnight. The hinterland rail transport to and from PoG was accordingly very focused on direct connections. Although both corridor and hub-and-spoke network principles (Woxenius, 2007) have reappeared in the national system, the PoG shuttle system is still marketed as a number of independent shuttles, along with Oslo, as a hub for Norway. In 2010, the system included 26 dedicated services to 23 terminals (Port of Gothenburg, 2011a), or “railports” in the PoG’s terminology, as seen in Figure 2. The system moved 365 000 TEU in 2009 (Port of Gothenburg, 2011b).

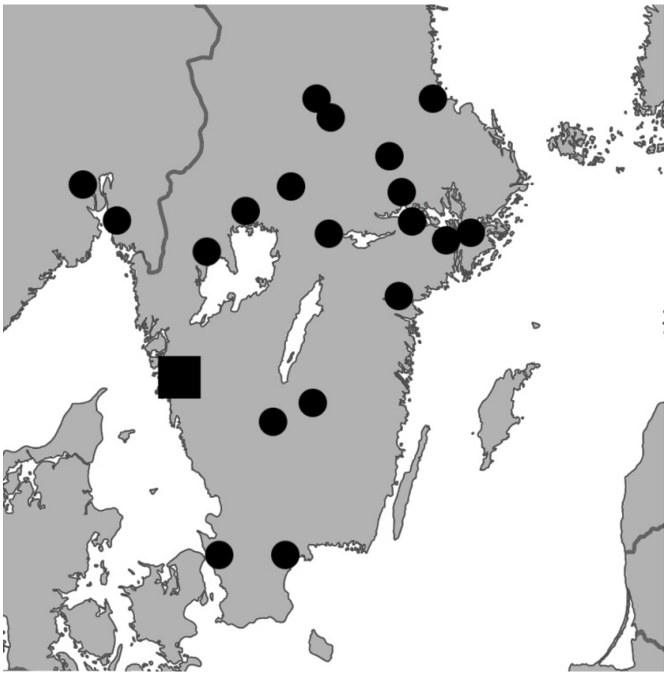

Figure 2: The PoG rail shuttle system as of February 2011. Source: Adapted from Port of Gothenburg, 2011b.

While the shuttles servicing the PoG are by far the most described and discussed, other seaports have also developed rail shuttles. Many of them, e.g., Åhus, Gävle, Karlstad, Norrköping and Södertälje, are mostly used for connecting to PoG or larger European hub seaports as an alternative to container feeder shipping. The seaports then assume a dryport or conventional intermodal terminal role transhipping containers between trains and trucks.

A revival of the network idea is clearly observable, and the largest port shuttle operator, Intercontainer Scandinavia AB (ICS), uses a hub in Västerås for connecting not only the PoG but also the Port of Helsingborg (PoH) to several terminals in central Sweden, as shown in Figure 3. In contrast to most other port shuttles, ICS mixes maritime containers with semi-trailers in its trains, and has an increasing share of semi-trailers (Gustavsson, 2010).

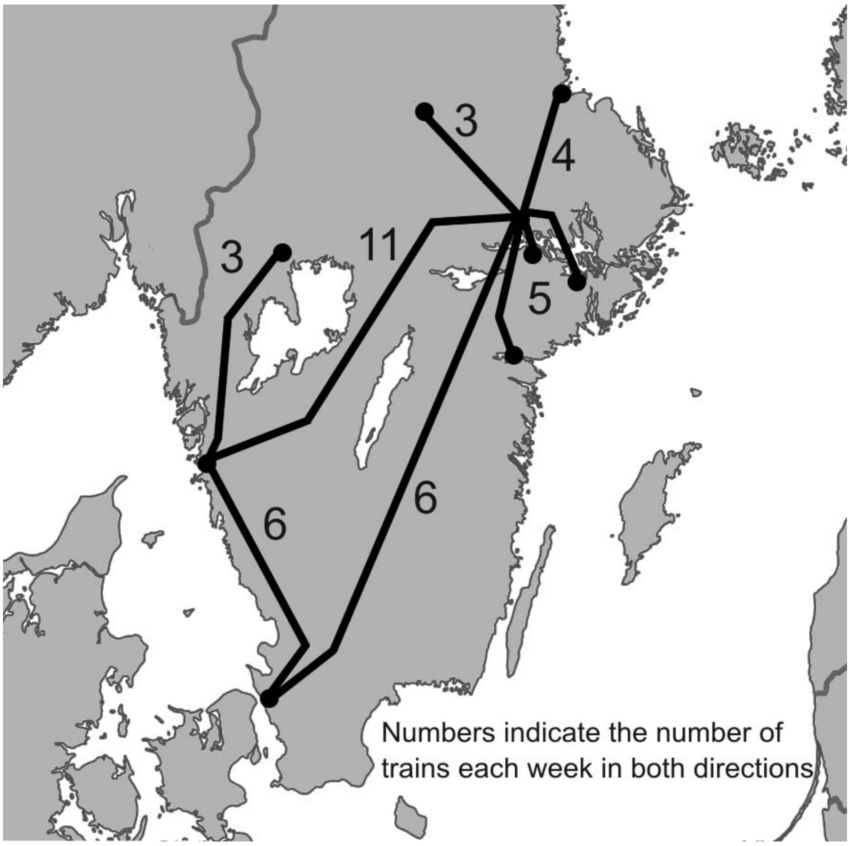

Figure 3: Intercontainer Scandinavia's rail shuttles from January 2011. Source: Adapted from TrainDrivers, 2010.

According to Gärdin (2010), intermodal operators have suggested PoG to become a hub, connecting shuttles without requiring that the containers pass the quay in Gothenburg. Using the PoG as a hub would allow the intermodal operators to interchange containers between different train services (*ibid.*) and thus increase the utilisation rate, but perhaps more importantly, enter the domestic transport market. The PoG, however, does not embrace this idea, assumedly since it would limit the competitive advantage it has built up with the shuttle system. One example is that the Port of Helsingborg could access all PoG rail services through an extra transhipment in the PoG; a more realistic challenge, however, is that the PoG domestic shuttles are connected to direct trains to the continental hub ports, undermining the volumes that the shipping lines need in order to maintain direct calls. Capacity constraints in the port rail network could also be an issue.

The dominant Scandinavian operator of continental (road-rail-road) intermodal transport, CargoNet, fully owned by the Norwegian state, operates a network connecting several seaport cities but often at terminals outside the seaports, with the RoRo/ferry port Trelleborg as an exception. The trains connecting Trelleborg with its hinterland aim for semi-trailers and fall outside the scope of this article, since they address quite a different transport market (Woxenius and Bergqvist, 2011).

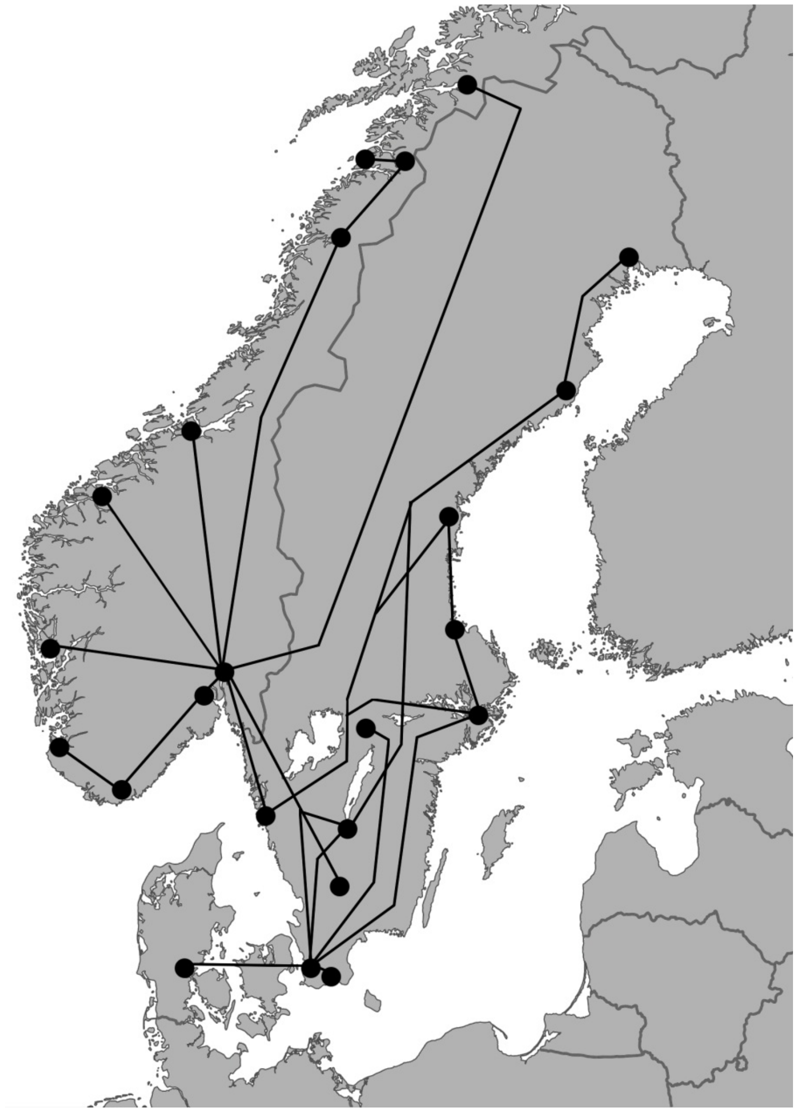

Figure 4: CargoNet’s rail shuttles as of September 2010. Source: Adapted from CargoNet, 2010.

In addition, some international services combine continental and maritime flows through the main hub ports in Western Europe.

3.2 The intermodal terminal structure

The Swedish intermodal terminal structure was formed in the 1970’s when some 40 road-rail transhipment terminals were built. Many of the original terminals are now closed, but Jernhusen, the real estate arm stemming from the division of Swedish State Railways, includes six large terminals in its terminal concept and owns six more terminals (Jernhusen, 2011) for which it assumes a landlord or principal role. The terminals have, in theory, always been open to all intermodal operators, but as CargoNet and its predecessors operated all the terminals, the new entrants often felt discriminated against. Accordingly, Jernhusen runs a scheme for developing the terminal areas and has invited firms to submit tenders for operating the terminals. The large terminal in Malmö is not yet included in the concept and CargoNet still operates it. Nevertheless, the intermodal terminals in Stockholm and Jönköping are on contract by Danish ISS TraffiCare AB, Gothenburg by Norwegian Baneservice, Gävle by Green Cargo and Sundsvall by Norwegian Logent. The new terminal in Västerås is co-owned with the port Mälarhamnar, which operates the terminal (Jernhusen, 2011). Except for Green Cargo, the new operators do not offer rail transport services. Jernhusen has advanced its position by stipulating service standards for tenders.

Beside the fear of discrimination in the CargoNet terminals, the new intermodal operators servicing PoG generally aim at markets outside the larger cities, and thus often turn to seaports or new smaller terminals. The smaller terminals are often started by municipalities as principals, with small entrepreneurs operating the terminals, as found by Bergqvist *et al.* (2010).

A variety of dryport definitions are used in the scientific literature, but in this article the more generic term ‘inland terminal’ is used for all terminals. Some Swedish inland terminals denote themselves as dryports; others can be characterised as such by the offer of an extensive range of services, while others are simple transhipment places for containers. It is its role connecting the seaport to the hinterland that is of interest, and hence seaports transhipping to road-rail are included in the rendering.

The PoG has created a grading system for inland terminals in its Railport concept for use in the marketing of the PoG and the connected terminals. The PoG includes the parameters of a) preconditions and geographical location, b) service offerings, c) security and d) physical design (Port of Gothenburg, 2011a). Points critical to a high score are ICT support and a bonded warehouse service for temporary storage, without having to pay duties and other taxes. The grading system is an incentive for improving services and, according to Thorén (2010), the long term aim is for inland terminals to offer the same services as PoG itself.

3.3 The actor network structure and the key business processes

The empirical findings reveal a complex network structure of many actor categories. The actor categories involved in container transport within the context and scope of this article is described in Table 2. In addition, the key business processes that produce value for the customers are shown, as well as the typical customers and suppliers, and examples of organisations. Note that the actor roles, as defined here, can be divided between organisations, such as a landlord port and a container terminal operator; an organisation can assume several roles, like a shipping line that also assumes a forwarder role. There are several examples of ownership links between actor categories, like intermodal operators, rail hauliers and inland terminal operators.

Table 2: The actor network structure and key business processes of the Swedish hinterland transport system.

Actor category	Key business processes	Typical customers (C) and suppliers (S)	Examples of organisations	Appr No. of actors in Sweden
Shipper:	Order and pay for the transport service.	S: forwarder, shipping line, intermodal operator, road haulier	Manufacturers (Volvo, SKF, StoraEnso...), retailers (IKEA, H&M...)	>1000
Forwarder:	Design, market and coordinate the door-to-door transport chain.	C: shipper; S: shipping line, seaport	Kuehne+Nagel, DHL, DB Schenker…	>100
Shipping line:	Move containers between ports.	C: shipper, forwarder; S: seaport, intermodal operator, road haulier	ACL, CMA CGM, Eimskip, Maersk, MSC, K Line, Team Lines, Unifeeder... + Ro-Ro/RoPax shipping lines	>25
Seaport:	Tranship between ship and rail.	C: shipping line, forwarder, intermodal operator	With rail shuttles: ports of Gothenburg, Gävle, Helsingborg, Mälarhamnar, Norrköping, Södertälje, Trelleborg	20 handling containers (LoLo and RoRo)
Intermodal operator:	Design, market and coordinate the rail transport service including terminal handling.	C: shipper, forwarder; S: rail haulier, inland terminal operator	CargoNet, ERS Railways, Green Cargo, Intercontainer (Scandinavia), MidCargo, SCT Transport, VanDieren, Vänerexpressen	10
Rail haulier:	Move trains between terminals.	C: intermodal operator	Hector Rail, MidCargo, RushRail, TGOJ Trafik...	5
Inland terminal operator:	Tranship between rail and road.	C: intermodal operator	CargoNet, Gävle Containerterminal, ISS Trafficare, Logent, Vänerexpressen, large manufacturers and retailers...	>25
Inland terminal principal:	Own terminals. Manage the tendering process.	C: inland terminal operator (on tender)	Jernhusen (Swedish state), Municipalities, Vänerhamn...	>25
Road haulier:	Move containers between the inland terminal and the consignor/consignee.	C: shipper, forwarder		>500

3.4 The management components

Both the ISs and IT used in Swedish hinterland intermodal transport are currently undergoing modernisation. Compared to the shipping industry and its well-developed ISs, the hinterland transport system is lagging far behind. For instance, the current information flows for a port shuttle are heavily based on sending Excel spreadsheets by e-mail and fax. A typical information flow is shown in Table 3, where a consignee expects a container to arrive by ship, which will then be sent to the consignee's location inland.

Table 3: Typical information flow guiding the flow of a container load imported to Sweden.

Physical location of container	Transmission trigger	Activity	Key data content	Transmission media	Actors involved
			Container arriving by ship		
1. Ship	Estimated arrival time at port known	Consignee informed of arrival time at port	Estimated arrival time, container number and type etc.	EDI	Shipping line to consignee
2. Ship	Consignee informed about arrival time at port	Consignee contacts forwarder and orders an intermodal hinterland transport	Destination, container number, type and weight, arrival time in port etc.	Phone, fax, e-mail	Transport customer to forwarder
3. Ship/ Port	Forwarder receives booking	Forwarder contacts intermodal operator and makes a booking on the train	Destination terminal, train departure, container number, type and weight etc.	Excel-sheet by mail, fax	Forwarder to intermodal operator
			Container unloaded from ship in port (sometimes before 3)		
4a. Port	A few hours before train departure (according to agreement with the port)	Intermodal operator sends a loading list for the train to the port	Destination terminal, train departure, container number, type and weight, sometimes which wagon or group of wagons to load each container on	Excel-sheet by mail, fax, webpage forms	Intermodal operator to port
4b. Port	Same as 4a	Intermodal operator sends a loading list for the train to the rail haulier for calculating train weight etc.	Same list as 4a	Excel-sheet by mail, fax	Intermodal operator to rail haulier
			Container loaded on train in port and train departs		
5. On train	Loading completed	Port sends confirmation of loading to intermodal operator, listing any discrepancies from the loading list	Same list as 4a, with any discrepancies added.	Excel-sheet by mail, fax	Port to intermodal operator
6a. On train	Intermodal operator receives confirmed loading list	Intermodal operator sends the confirmed loading list to the inland terminal operator to use as unloading list	Same list as 4a, with any discrepancies added.	Excel-sheet by mail, fax	Intermodal operator to inland terminal operator
6b. On train	Same as 6a	If discrepancies, Intermodal operator informs forwarder that container is delayed etc.	Delay information	Phone, mail	Intermodal operator to forwarder
			Train arrives inland terminal and container unloaded		

7. At inland terminal	Unloading completed	Inland terminal sends confirmation to intermodal operator, listing any discrepancies from the unloading list	Same list as 4a, with any discrepancies added.	Excel-sheet by mail, fax	Inland terminal to intermodal operator
8. Port	Intermodal operator receives unloading list	If discrepancies, Intermodal operator informs consignee that container is delayed etc.	Delay information	Phone, mail	Intermodal operator to consignee
9. At inland terminal	Road haulier arrives to pick up container after scheduled release time	Inland terminal sends confirmation to intermodal operator that container has been picked up	Container number, time etc.	e-mail	Inland terminal to intermodal operator
Container is picked up at inland terminal and delivered by truck to consignee					

The information flow could look different if no forwarder is used, but the core procedure is the same. Similarly, the information flow for an export container is reversed. The shipper/forwarder then books a hinterland transport that should be in the seaport in time for a given ship. More complex flows could also be in place if some parts of the operations are outsourced.

The current information flow is not very complex. A booking procedure is first performed, similar to the booking procedure in any type of transport. The rest of the information flow is centred around the loading list, which is the list of containers to be loaded on a train. The intermodal operator is responsible for creating this list and thereby performing the load planning, which includes determining which containers should be sent by which train and ensuring that the maximum weight of the train/wagons is not exceeded. The forwarder normally does not book a position on a specific train, but only books the latest delivery time. The loading list is used by the seaport to unload containers, by the rail haulier to move the train and by the inland terminal to unload the train. The rail haulier needs the data to calculate the weight of the train in order to set the train brakes correctly. The actual flow of the loading list information might be different in some situations. The inland terminal might use the preliminary loading list (4a) as an unloading list or receive the list directly from the port (5), e.g. when loading takes place during the night and the intermodal operator is closed and cannot forward the list.

The actual information that is communicated between actors is highly streamlined. The interviewees collect and transmit very little information that they themselves do not use. This indicates a well-structured information flow, but also that the processes are not very complicated. For example, the amount of information communicated is small and rarely more than a sheet of paper per train.

A few years ago, very few of the inland terminals had any IT support other than Microsoft Excel. In recent years, the terminals and intermodal operators have started to invest in modern ISs. Today, a majority of the terminals have invested in new systems, or are considering investing in them. For example, in 2009, Jernhusen purchased the Hogia Terminal System (Jernhusen, 2009). The system went into operation in early 2010 on the three largest terminals, and is currently about to be implemented in more of the 12 terminals for which Jernhusen is principal. The intermodal operator Intercontainer Scandinavia, responsible for eight of the port shuttles, purchased the InPort RailIT system in March 2010 (InPort, 2010a). The actors have the intention of utilising these new systems to offer an EDI connection for booking and reports. However, many of their partners still lack the ability to send EDI messages, so fax and e-mail messages are not likely to disappear anytime soon.

Hogia's and InPort's systems are the two main systems on the Swedish market. Hogia is a family-owned firm with a large market share on the Swedish market for administrative business systems, particularly small business accounting ISs, and transportation ISs, such as TMS, WMS and booking systems for ferry lines. Its terminal system departs from terminal operations, while the InPort system comes from the port management side. InPort is currently used by some 20 ports, and the Port of Helsingborg has bought a majority share in the InPort firm (InPort, 2010b). Apart from the home-made IT systems in some terminals, Hogia and InPort practically form an oligopoly on the Swedish market for small and medium size intermodal terminals, offering similar basic functionality. The systems keep track of all containers at the terminal, and manage and optimise the terminal tasks, including train and ship loading and unloading. The system has an open interface, can be integrated towards any other system and actor, and can be configured to automatically send messages, e.g. when a container arrives or departs. Both systems can be adapted to any communications standard and file format and can, from a technical point of view, integrate with all actors in the industry. InPort also has a module for rail operations.

The four levels of maturity of business integration and their IT support, as presented by Heinrich and Simchi-Levi (2005) and discussed above, are used for analysing the information support for the Swedish hinterland transport of containers, as presented in the table below.

Table 4: The Swedish hinterland IS, classified according to the four types of business integration defined by Heinrich and Simchi-Levi, 2005.

IT and integration level	Intermodal system characteristics	IT support	Data transmission media	No. of Swedish terminals at this level
1. Disconnected	Low cooperation, single terminal actors, single route, small volumes (<100 TEUs/day)	Excel, home-made systems, paper	Phone, Fax, E-mail	Many
2. Internal integration	Larger actors or multi-terminal actors, several routes, larger volumes (100-400 TEUs/day)	Excel, Hogia, InPort etc.	Phone, Fax, E-mail, webpage forms	Medium
3. Intra-company integration and limited external integration	Larger actors or multi-terminal actors, many routes, very large volumes (>400 TEUs/day)	Hogia, InPort, Modality, CA-TOS etc.	EDI, webpage forms	Few
4. Multi-enterprise integration	Integrated supply chain, very large volumes (>400 TEUs/day)	Hogia, InPort, Modality, CA-TOS etc.	EDI	None

The Swedish system is about to leave step 1 and move into step 2. It is likely to witness a transition into step 3 in the near future, as all interviewees have expressed an interest in doing so. To then move into step 4 is more of a management issue than an IS or ICT issue. The system in step 3 will also support operations under step 4, but the actors must first agree to operate as one integrated supply or transport chain.

4 Drivers and effects of the information system modernisation

There are several drivers behind this modernisation. Increasing volumes are forcing the terminals to invest in more advanced IT systems. As one respondent said, “You cannot run a terminal with 200 containers per day without an IT system.” The number of IT systems offered on the market is also increasing and the relatively low cost of a terminal system (a few ten thousand Euros for a standard system) makes it affordable.

The general trend in the transport industry towards using more IT systems is also influencing port shuttles. The port shuttles, in particular, are under pressure due to their connection to the shipping industry, which has a more advanced and more highly functioning IT infrastructure. Accordingly, the shippers expect the same level of IT support from the intermodal and terminal operators. A large Swedish retailer explained during the interview that they wanted firm control of their import container movements in order to prioritise movements according to urgency at their warehouses, but also to facilitate shipping individual containers directly to their stores. The seaport also pressures the shuttles to modernise their systems.

There is also an interest among firms to qualify for the PoG's Railport concept, where the seaport ranks the shuttles according to the range of services they offer. Having advanced IT services is a key factor in the ranking. A special issue is to offer traceability of all load units to be allowed to offer bonded storage, which is of high importance for most interviewees.

The deregulation of the Swedish rail market has seen several new actors in the hinterland transport market. This has opened up a new market for IT systems. Before the deregulation, the terminals used a local system for terminal operations and the national rail haulier's IT system for the train operations. Today, the terminals are actively seeking to integrate the systems. One particular characteristic in the market is the decision of the largest terminal principal, the state-owned Jernhusen, to put the operations on all terminals out on tender according to a pre-defined "terminal concept" which includes the stipulation that the operator must use the Hogia system.

It is likely that intermodal operators with level 2 or 3 IT systems would also like to cooperate with terminals at the same level. Thus, the modernisation of the IT system among the intermodal operators will also force the terminals to also modernise their system. The intermodal operator has power within the hinterland transport chain and might switch to a nearby terminal if it offers a more appropriate IS and more advanced ICT. In turn, the decision by Jernhusen to introduce a modern IT system will also influence the intermodal operators to use a modern IT system. Normally, the terminals would not have any power to influence the intermodal operators, but Jernhusen has a unique position due to their dominant size.

4.1 The effect of new IT systems

There are two main advantages of the new IT systems currently being introduced. The first is the simplification of the practical operations at the terminal, e.g. keeping track of where the containers are and optimising the use of the storage area, etc. The second main advantage is in the network's communication capabilities; the new systems support EDI connections where the different actors' ISs are directly connected. As is widely known, EDI increases transfer speed, reduces transmission and typing errors and reduces the need for manual work, and thus is an integrative technology.

The interviewees do not see any immediate need for information other than that which they currently receive. In general, they are happy with the information flow and do not lack any information. The actual transfer speed and number of errors is not currently considered a problem. They perceive the main advantage as reducing the administrative work caused by typing in faxes and handling Excel files. The prospect of a better work environment for employees was mentioned as one benefit (Gärdin, 2010). There are no services or business models that the interviewees want to use that are not feasible with the current IS. It is apparent that the interviewees are much more focused on "hands-on" operations and business processes than on optimising computer systems.

The interviewees are interested in getting bookings earlier to facilitate their planning. This is not related to EDI or the transfer speed, but rather to the planning process with their customer. Road hauliers and forwarders tend to book very late, normally the same day, which makes planning for intermodal service difficult. The interviewees who have direct contact with the end customer obtain a more stable flow and earlier bookings than those who only wholesale their services to forwarders and shipping lines in their forwarder role (Gärdin, 2010; Guthed, 2010). Similarly, the port will not always know if a container is to be sent by rail when it is unloaded from the ship, which might lead to inefficient handling at the port. However, this issue is mainly related to when the ship arrives and the booking deadline, and not how the way in which the booking is transmitted.

The PoG expressed concern that information might be delayed during non-office hours, as the information is sent manually. A level 3 integration with automatic EDI links could speed up this process, although it would be limited to pure forwarding of information, e.g. arrival times and discrepancies, since most decisions still are made manually and require staff presence. The smaller actors with limited opening hours did not perceive this as a problem. For the planned information flows, this issue is handled by having the sending partner send a copy of the e-mail/fax to the relevant actors.

No respondent believed that achieving a fully integrated level 4 supply chain was possible, as they believe actors are unwilling to share information. Interestingly, most interviewees themselves say they are willing to share information, under the conditions that their customers approve it and that they get information in return.

However, if a more integrated IS became a reality, it would theoretically be possible to improve operations in a number of ways. A horizontal integration (port to inland customer) could improve capacity planning. Services could also be improved, with better information going to the customers and more targeted marketing. System integration (where all port shuttles cooperate) would facilitate horizontal integration, where the geographically close terminals cooperate with each other and utilise the trains as a common capacity by slot sharing. It would also allow them to utilise a common pool of rail wagons.

To reach a level 4 horizontal integration would require a completely different view of the actors' core business. The actors do not see their role as being part of a supply chain, but rather as actors with a limited purpose, e.g., terminal handling. They even deliberately avoid integration towards actors further up or down than the next link in the chain to avoid upsetting their closest partner. It is feared that an attempt to circumvent their closest partners and contact their customers would be perceived as an attempt to "steal" the customer. One respondent said that their customers completely refused to even tell them which customers they had. A large gap lies between keeping the customers' identity secret and openly integrating the information flow. However, the most important obstacle today is that the interviewees do not perceive the benefits that would come with a complete level 4 integration. They are not lacking any information, and a level 3 integration would accomplish their goal of avoiding manual administrative labour.

A level 4 system integration, where all port shuttles work together as one, is even less likely to be adopted. Today, most of the intermodal operators and terminals view each other as competitors, increasingly so, when terminal patterns grow denser. The overlap of terminal catchment areas also implies that overly intimate cooperation between terminals might violate competition laws. Also, the total number of actors involved in the total system is very large (roughly 20-30 companies), which makes cooperation difficult.

From an ICT-perspective, it is important that the systems follow an open standard and "talk" to each other. Although the time and work it takes to integrate two systems should not be underestimated, there appear to be no technical obstacles to integration between the leading systems.

5 Discussion and conclusions

The starting point of this article was the analysis of how information and communication technology is used to support the hinterland rail transport of maritime containers. The focus was on what information the actors exchange and by which media they do it. To do so, an SCM approach has been taken to develop the conceptual model used in this study. The conceptual model, formulated from an imperative two-dimensional conceptualisation of an integrated supply chain strategy, consists of:

1. Integrative information (communication and information flow structure) and;

2. Integrative technology (IT facility structure)

To tie these dimensions together, a framework of maturity of business integration and their IT support in a supply chain has been used which includes four maturity levels: 1) Disconnected, 2) Internal integration, 3) Intra-company integration and limited external integration and 4) Multi-enterprise integration.

The results show that the IT and IS maturity level is fairly low in the hinterland information flow, but that it is rapidly improving as many actors currently invest in new ISs. This is caused by pressure from customers and a desire to reduce administrative tasks. The information flows are relatively simple, and the actors are happy with the information they receive today, but would like to avoid the manual tasks of typing in lists, etc.

It is apparent that the information and communication flow structure in the Swedish hinterland rail transport system are about to undergo drastic changes, as many actors invest in the new ISs. Today, the IT maturity is low (level 1 or 2), but is likely to increase to level 3 with the introduction of EDI connections in the coming year. However, the actors expressed no real interest in a level 4 IT integration, as they can reach their goals at a lower integration level. Other actors in the network perceive this situation as troublesome, as data sharing becomes difficult. It is not possible for an entire supply chain to reach level 4 if not all supply chain members are committed. This might prevent a level 4 supply chain from using intermodal transport, and thus reduce the competitiveness of hinterland rail transport.

The integrative information structure works well in the current system and is not perceived by the actors to require any immediate changes. The integrative technology can, however, be significantly improved to facilitate the information flow, with a focus on automating data exchange. The development of a higher level business integration is related to the development of more advanced ICT solutions. As shown by Heinrich and Simchi-Levi (2005), it is important that business integration is aligned with, or at a level higher than, the IT maturity in order to avoid inefficiencies. The IT maturity is entering level 3, while the business integration is still on level 2, as can be seen from the disconnected processes and problems experienced with late bookings, lack of shared forecasts, secretiveness about customer identity, etc. It is therefore important that the actors also develop their business integration processes and not only invest in IT. The overriding conclusion is that the two influential dimensions must work in tandem for best effect.

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