PROBLEMS AND PROSPECTS FOR INTERMODAL TRANSPORT: THEORETICAL TOOLS FOR PRACTICAL BREAKTHROUGHS?

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Abstract

Standardised cargo units, such as the container, have been a great technical invention for improving the efficiency and effectiveness of international transport chains. Maybe the biggest advantage of these units comes from their modularity. Modularisation can also be seen as a prerequisite for future transport systems while integrating the physcial cargo flows and related information more closely with each other. This paper describes the development and future prospects of three fundamental factors in intermodal transport: (1) modular service offerings, (2) transport chain coordination, and (3) enabling network technologies. The focus of service offerings is on the match between customer needs and different type of transportation services. Transport chain coordination concentrates on the service production perspective, and the coordination of activities in transportation chains. The enabling technologies focus on the developments regarding electronic information sharing and physical distribution.

1. Introduction

Since the introduction of containers in the 1950's, a significant growth of unitised cargo transport has taken place in international trade. The growth of unitised loads and intermodal transport can be attributed to transport deregulation and the need to standardise load units. At the same time, business globalisation and technological advancements have set new demands on transport performance. Tracking and tracing capabilities, global positioning systems and electronic data interchange are transforming the transport industry into a higher technology supported business with considerable investment requirements and specific skill demands for management and operational personnel.

There are several benefits to gain from using intermodal transportation. However, many problems have also been encountered in intermodal transport chains. These are often related with the organisational interfaces and technical incompatibilities between the various companies and systems involved in transport operations. Cargo handling technologies, communication links and various coordination measures are among the tools that can be employed for bridging the gaps in intermodal transport.

Research on intermodal transport has mostly focused on technical issues, such as cargo handling technologies, vehicles, information and communication technologies, and infrastructure networks. Some of the studies also look at the interfaces of different transport modes and organizational interfaces between the companies involved in intermodal transport operations. In a recent Finnish report, the main characteristics of intermodal transport were summarised as shown in Table 1.

Considering the growing importance of containerised intermodal transport, it is surprising that little research has been done linking the issues of intermodal transport with newer perspectives on supply chain management (SCM), business networks and logistics. However, to achieve the goal of seamless and efficient intermodal operations, the potential contributions of SCM and network analysis are clearly of vital importance. Issues such as service, coordination and technology are emerging as topics that offer new opportunities for cross-disciplinary analysis and development on conceptual as well as on operational and technical levels.

Table 1. Development trends of intermodal transport

Inermodal transport units	Transport, handling and terminal operations	Tracking & tracing, transport chain coordination
• No plans currently exist for a specifically intermodal transport unit. • The width of ocean line containers will remain unchanged, whereas the lengths will be varied. • Container use will increase. • The sizes of containers and pallets will be made commensurable. • The use of transport units outside the transport chain will increase. • Trailers will retain their position in regional transport. • Transport units will become intelligent (information on cargo, unit and transport methods). • New materials may replace old ones as prices are lowered. • In closed systems the need for special solutions will continue to exist.	• Evolution will lead to increasing concentration of operations (points where transport modes meet and value added services are performed). • Intermodal transport growth will lead to development needs in big but also smaller freight centers. • Container movement will take place on fast trunk lines, and handling will be concentrated to efficient terminals. • Terminals must be able to adapt their operations to changing transport requirements. • Growth of container use will allow increasing automation. • Large container vessels will dominate ocean transport and turnaround times in ports will be very short. • Cargo handling technology will be mounted on the vessel if required. • Simultaneous handling of containers will increase operational efficiency. • The need for semi-automated systems will be bigger than for complete automation. • The methods for container warehousing will be developed.	• Telematics will be a central factor for securing the competitiveness of intermodal transport. • Advanced planning & control systems will be needed for integrating the transport chain. • The users require advanced tracking and control systems. • Identification and positioning of transport units will be developed, as well as cargo detection, climatic control and information transfer capabilities. • The development of general solutions is hampered by the lack of global standardisation. • Telematics systems must be adapted to various demands, and interoperability will be a necessary prerequisite. • There are over 10 million containers owned and operated by a number of different actors in the world; this will require the systems to be operated simultaneously even when different standards are used.

Source: Ministry of Transport & Communications, Finland, report B2/1998

This study describes the problems and prospects of intermodal transport with a particular focus on intermodal service offerings, transport chain coordination and enabling technologies addressed from the perspective of different actors in the intermodal transport chain. The obstacles to smooth and efficient container transport will be examined, and areas for future development will be identified. The results will be evaluated in the light of contemporary views of logistics and supply chain management.

The study is mainly based on literature review and is largely descriptive in nature. However, interviews were also carried out among industry specialists, 27 interviews in 14 companies, to find out about the current state and future development opportunities in intermodal container transport (see Bask & Laine 2000). The study attempts to create an overall view of intermodal transport chains and their future prospects, mixing available literature and the interview material to achieve this purpose.

2. Conceptual Underpinnings

This chapter discusses some theoretical tools for analysing the logistics function of intermodal transportation. The chapter begins with the concept of supply chain management that is commonly used in logistics research and is often seen as an extended concept that goes beyond logistics. However, the conventional view of supply chains has also been challenged and concepts like value nets and supply chain communities have been offered as alternatives for describing the organisational constellations in the digital business era.

2.1. Supply Chain Management

Supply Chain Management (SCM) is a fairly new concept in business literature (e.g. Cooper et al. 1997; Kuglin 1998). Some researcher and practitioners see SCM as an extension of logistics whereby product and service flows are syncronized across a firm's internal functional areas as well as between suppliers and customers. Others have referred to the management of upstream and downstream relationships and to the integration of key business processes in the value chain (e.g. Lambert et al. 1998).

The fundamental assumptions behind SCM can be traced to the studies of inter-organizational operations and the distribuion channels research in the 1960's (e.g. Bucklin 1966, Cooper et al. 1997). Similarities can also be found with the studies on *strategic business networks* (Jarillo, 1988; Thorelli, 1986) and the *industrial network* approach developed by the IMP group (e.g. Håkansson & Snehota, 1989; Axelsson & Easton, 1992; Gemünden et al., 1997).

Today, SCM poses new demands from the customer's side on efficiency and service requirements in terms of flexibility, speed and reliability. The key to meeting these demands is commonly attributed to supply chain integration. According to Christopher (1998), for instance, the competitive advantages of integrated supply chains include shorter delivery times, more reliable promises, less schedule disruptions, lower stock levels, faster implementation of design changes, fewer quality problems, stable and competitive prices, and higher priority given to orders.

There are also many questions related to the nature and intensity of supply chain integration. Typically, some of the supply chain processes are tightly synchronised, while others are loosely integrated and routinely managed. The nature of integration is also affected by the horisontal spesialisation of channels along specific tasks (e.g. ordering, payment, delivery), which creates multiple links between supply chain organisations. Therefore, the mechanisms of supply chain integration are becoming increasingly varied and multi-dimensional, with no uniform solution that brings the organisations into a sequential chain (Bask & Juga 2000).

According to Bovet & Martha (2000), the new business model should be conceptualised as a *value net* rather than a supply chain or pipeline. The value nets are customer-centric, collaborative, agile, scalable, and based on digital technology. Thanks to the diverse capabilities and service attributes of the organisations in the network, the value propositions to individual customers or customer segments can be designed and implemented flexibly and efficiently. Digital technology offers the connectivity and transaction automation capability as well as the information integration capacity required for collaborative decisions. Digital technology offers the connectivity and information integration capability required for collaborative decisions.

These approaches offer a multitude of concepts, propositions and ideas that could be developed and tested in the context of intermodal transport chain management. In this paper, however, focus is on three key elements of supply chains and networks that have been deemed as being especially pertinent to intermodal transport chains: modular service offerings, transport chain coordination and enabling network technologies (Figure 1).

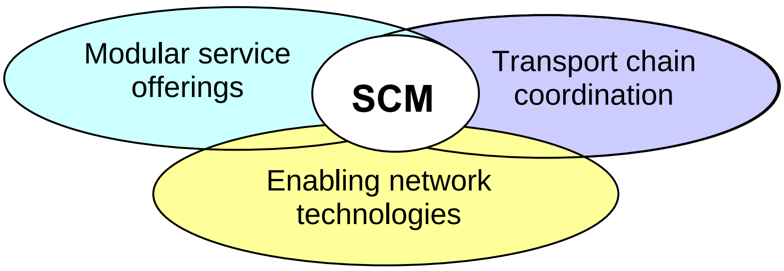

Figure 1 Elements of SCM affecting the development of intermodal transport

2.2. Elaboration of key concepts

Modular service offerings

Intermodal transport involves the movement of goods that use successively several modes of transport without handling of the goods themselves in changing modes (OECD Outlook 2000). The goods shall be transported in unbroken unit loads from sending point to receiving point; ISO-containers, swap bodies, semi-trailers and specially designed freight containers of corresponding size are regarded as load units; the unit loads must change between transport modes at least once between sending point and receiving point; and the shipper shall only need one contract between the consignor and the consignee. (Woxenius 1998)

From the customer's perspective, the demands on intermodal transport are no different from those on unimodal transport. The value of the service is evaluated in terms of the capability of the intermodal operator to satisfy the need of the customer (i.e. the shipper and/or the recipient), measured by service attributes such as delivery time, frequency, reliability, information exchange, flexibility, etc. In addition, the transport operator's service scope and geographic coverage (whether internally produced or networked-based) play an important role when assessing the value of the service. Moreover, the quality of the relationship between the service provider and the customer should be included in the overall service evaluation.

So, intermodal transport has to be market-oriented, based on users' requirements. Intermodal transport operators should produce a service of high quality integrating demand-sensitive aspects such as an integrated tariff based on transparent pricing and full liability. As stated by the European Commission's (1996) task force on transport intermodality, the demand side requires the following functional responses from new generation intermodal transport operators:

- the provision of value added logistics to meet sophisticated demands of customers;
- integration with the production and distribution cycles in comparison with what unimodal transport operators are offering (e.g. obtaining leaner stocks and reducing lead time);
- the optimisation of handling systems in view of limiting handling time and damage to the cargo (technological innovations should be faster integrated);
- the optimisation of transport equipment in view of using in the most efficient way the infrastructure capacity and in view of a better compliance with industrial needs.

In the service management literature, much emphasis is put on the ability to tailor services to the needs of individual customers or customer segments. However, customised services should not come at the cost of operational efficiency; rather it should be possible to combine coordination and responsiveness as is happening in the manufacturing industries where mass-customisation strategies are increasing popularity. In the service sector, there are features (intangibility, non-storability) that make it more difficult to implement mass-customisation strategies, but some opportunities do exist for utilising them in the transport industry, for instance.

By its very nature, the intermodal transport chain consists of modular elements that can be linked together. However, the generic transport service (moving goods from point A to B) hardly offers the potential for differentiation unless add-ins like logistics services, information management and other special services can be included in the service package. An increasing modularisation of services, combined with appropriate coordination mechanisms and enabling technologies, will improve the opportunities for intermodal transport operators to fulfil variable customer demands from basic transport operations to special deliveries and sophisticated logistics solutions.

Transport chain coordination

Coordination can be defined in many ways. Economists refer to coordination mechanisms or governance structures that range from market-based to hierarchical, intra-firm coordination. In between are various “hybrid” forms such as relational coordination, partnerships, joint ventures, etc. In logistics and SCM, coordination typically refers to planning and control activities or concerted efforts within and between organisations. According to Chopra & Meindl (2001), supply chain coordination involves actions in all stages of the chain that together increase total supply chain profits. Thus, supply chain coordination requires each stage of the chain to take into account the impact its actions have on other stages.

In transport, it should be possible to coordinate customer service, cost structures, freights and fees charged and total delivery time through the whole chain in door-to-door deliveries. The target is to satisfy the customer needs and attract new business by offering services in the right place, at right price. The challenge is to respond to the long-term and short-term fluctuations and achieve high utilization of capacity by advanced allocation of technology investments. A central element is the development of information systems and market mechanisms for facilitating the distributed shipping services. Logistics management can be seen as a mean to get the demand and supply side of services to meet. (Laine 1998)

A division to low efficiency and high efficiency operations is presented in Figure 2 (Holmström 1995). The features of control and communication in transport chain presently define it to low efficiency operations. This may be related to the complexity of the operation environment for there is an enormous number of variables whose interactions are difficult to evaluate. In relation to this the changes may be so quick that the information is always incomplete, thus making efficient communication and control difficult. It is also typical that the ownership in the transport industry is fragmented and the opportunities for controlling bigger entities are reduced. Also the input to the transportation system – demand for services from the markets – may be beyond the control of transportation service suppliers (Laine 1998).

Ideally, it is through improved coordination that transport chains can be transformed from low to high efficiency operations. However, this should not be understood as a cry for formal coordination; rather, it means that appropriate coordination mechanisms should be employed to improve the balance between supply and demand and to reduce the impacts of uncertainty. In a changeable environment, this is achieved primiarily by increasing transparency and visibility. In other words, it could be said that the potential benefits from “positive integration” through harmonisation of processes and information in idiosyncratic pipelines are getting smaller, whereas the benefits of “negative integration” through standardisation and increased connectivity are gradually beginning to materialise with the digital technology applications.

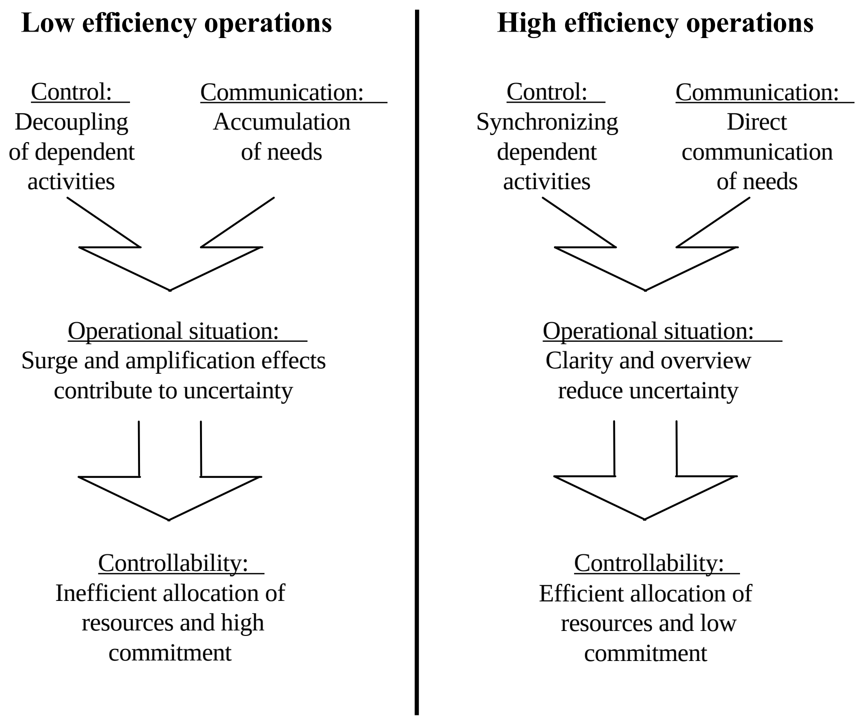

Figure 2. Interdependency of Communication, Uncertainty and Controllability (Source: Holmström 1995)

The main strength of containerised intermodal transport is the standardised cargo unit that can be handled efficiently anywhere in the world. However, as transport is becoming a high tech business with information and communication capabilities playing an even bigger role than the physical movement of goods, this strength has been weakened. In the future, efficient transport chains will be based on coordination mechanisms that enhance network connectivity, using enabling technologies as a supportive element.

Enabling network technologies

Intermodal technologies include physical movement and terminal handling technologies as well as the information and communication technologies required for coordination. As shown in Figure 3, the cargo handling revolution in the 1960s and 70s increased the amount of mechanised work in ports and terminals. Unitised (containerised) cargoes made it possible to increase efficiency through automation and mechanisation. The focus shifted from physical handling to information processing and communications in the 1980s, and information management tasks have increased in importance in terminal work ever since.

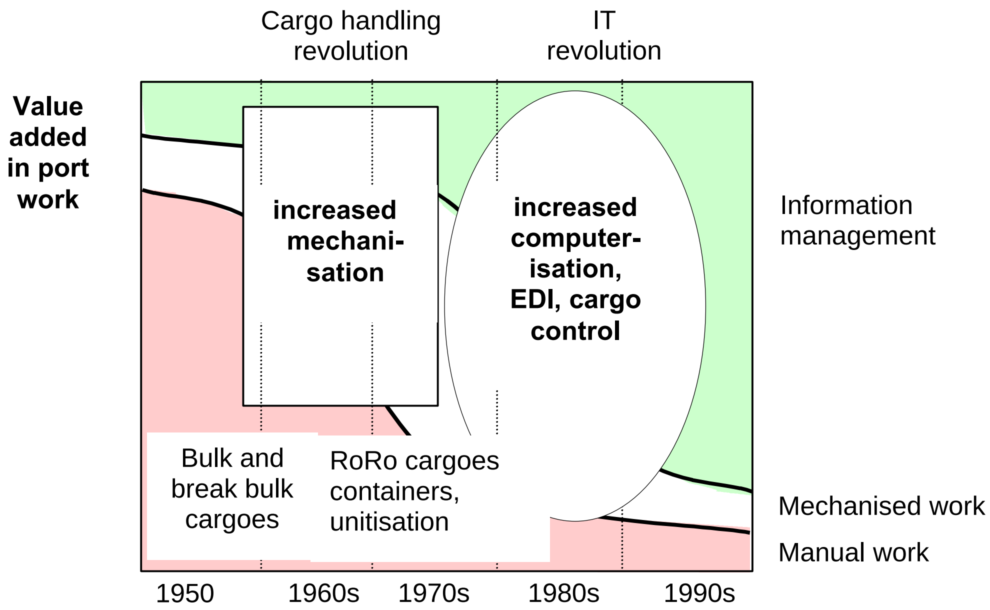

Figure 3. Change of port work since the 1950s (Source: Ojala, 1991)

It may be misleading to talk about an information revolution since there are several stages in an ongoing process that have affected the development in the transport sector. First, an important step was taken when computer-to-computer data interchange was introduced using standardised formats such as EDIFACT or Tradacoms. In the transport sector, where large amounts of transactional data are transferred over long distances, electronic data interchange (EDI) has produced significant improvements in administrative efficiency and data reliability.

Another important step in the information management revolution involves the development of extended enterprise applications, virtual private networks (VPNs), value added networks (VANs) and other internet-based applications that are used to share business information and operations with suppliers, vendors, partners, customers and other businesses. Typical to these solutions is the development of standards and protocols for specific purposes and environments, often involving alliances between software developers and their customers to develop platforms for specific applications. In the auto industry, for instance, the online exchange Covisint offers a good example of these applications. The goal is the ensure interoperability of the systems and applications within the community or network in question.

The third stage of the information revolution is at its outset and involves an increasing openness and connectivity of the applications and technologies upon which the business processes are built. Some of the main innovations promoting this development include the introduction of the extensible markup language (XML) and the open source code applications based on Linux, for instance. It is these innovations that will allow the development of truly web-centric architectures and platform-independent information transfer. Moreover, it is expected that the convergence of technologies (internet, telephony, etc.) and the increasing digitalisation of business process will further improve the connectivity.

3. Intermodal transport evolution: problems and prospects

This chapter discusses the past, present and future development of services, coordination and technology of intermodal transport chains. Based on the discussion above, the key points related to the three areas of development are summarised in Figure 4. The problems and prospects in each of these areas will now be discussed in turn, mainly based on the interviews among the industry representatives. The results concerning the future development can be grouped into three areas that are (1) modular services, (2) transport coordination, (3) enabling technologies. Even though these elements are discussed separately, their interconnectedness should also be remembered.

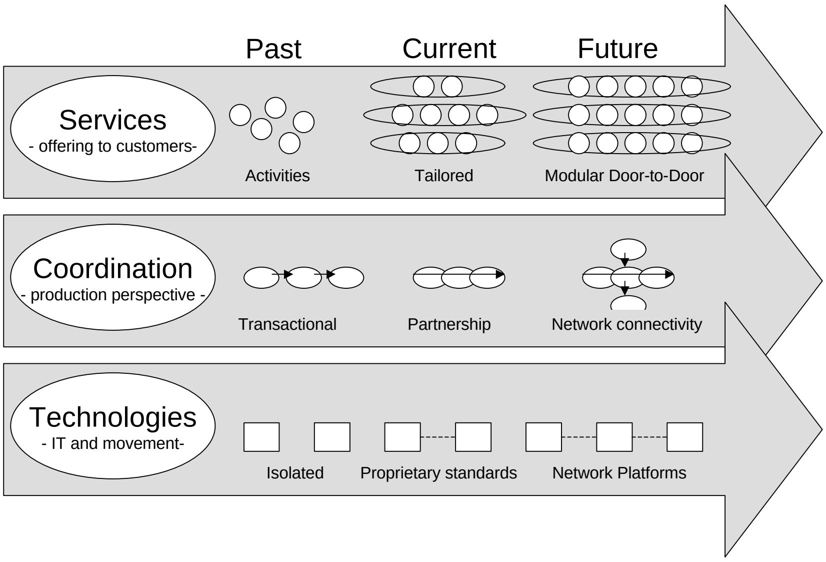

Figure 4. Evolution of Intermodal Transport: Services, Coordination, and Technology

3.1. Modular services in container transportation

In this section the focus is on matching the supply chain needs for transportation services and the intermodal transportation services offered. The discussion is based on a normative model of service strategies (Apte & Vepsäläinen 1993, Mäkelin & Vepsäläinen 1990), showing efficient combinations of service characteristics and service delivery channels. The chapter attempts to show how the model could be applied to the analysis of intermodal transport chains.

Past

Finnish industry started using sea freight containers during the period of growing export activity in the 1960's. The services can be described as basic container transport operations that were delivered in somewhat complex manner. Every transaction required considerable effort on either side, service provider's and service buyer's. A close interaction was needed, even though the services were mass-type services by their nature. Service buyers, the manufacturers, often had the responsibility for coordination the activities in the total transport chain. While the service offerings typically included the various activities of the total chain, a door-to-door service was a complex system to accomplish. The service providers offered the part of service that they owned themselves. The pricing of these services was quite rough.

Present

Today, the container transport services can be described as generic services, and it is hard to find real differences between service offerings in the market. However, the service providers are taking more coordination responsibility for the various activities in the transport chain. The customers are willing to give even greater responsibility to the service providers. In addition, the willingness to buy door-to-door services is growing. The service providers underline customer focus and offer customised services, combined with customer-specific pricing. Increasing customisation has led to high costs as the customer contact strategies have not been differentiated; instead, the varied service offerings are handled by service personnel in a relatively uniform manner.

Future

The interviews show that the service providers expect customers to be increasingly willing to buy container transport services on a door-to-door basis. It also seems that the co-operation is further extended between the service providers and the customers, i.e. offering services from production line to the customer (Bask & Laine 2000). This type of co-operation requires higher-level understanding of the customers' processes and an increase in information sharing, as well as advanced utilisation of automatic information systems. These expectations also follow the current trends in the procurement of logistics services generally. Regarding container transport the specialists argue that the customers are not interested in buying services that focus on the movement from one port terminal to another. In the future, the modularisation of transport services does not mean different stages of the chain between the manufacturer and the customer or offering of different activities to the customers, but involve different variations of door-to-door services of which some are routine types while others are more complex and tailored.

While aiming to increased efficiency transportation companies may distinguish different types of transport services based on various modules. Container transport services are seen rather standardized services or even routine ones due to first of all the use of standard unit (container). In *basic container transport service* use is made of standard containers and the services/chains do not include special arrangements or planning during the transportation process. In *special transport service* a need exists for special arrangements during the door-to-door transport and these arrangements can be related to one or several stages of the chain (reefer - electricity, open-top, open-side - special place, IMCO - storage, documentation, terminal - special packaging of the product/products, etc.).

Efficient container transport services in the future include mass-customized door-to-door services that are diverging from each other, based on the combinations of service characteristics and channels as shown in Figure 5. However, to increase efficiency of these services they need some more standardization both in terms of service offerings and channels used. From figure we find that channel used for special service need to transform toward service personnel channel, and for standard container transport service toward self-service. Movement toward more effective service offerings allows also modularity in terms of e.g. persuasion, ordering and payment operations. We see that efficient container transport services in the future include mass-customized door-to-door services that are diverging from each others based on the type of the service. Furthermore, prerequisites for mass customization are increase in standardization level of services and transformation of service production toward mass-production form. Also standardization is needed for pricing as well as transparency of pricing. Concluded, container transport modularity starts from divergence of service offerings, and modularity comes from different type of modules (or processes) in terms of persuasion, ordering, and payments that are included in a specific type of service.

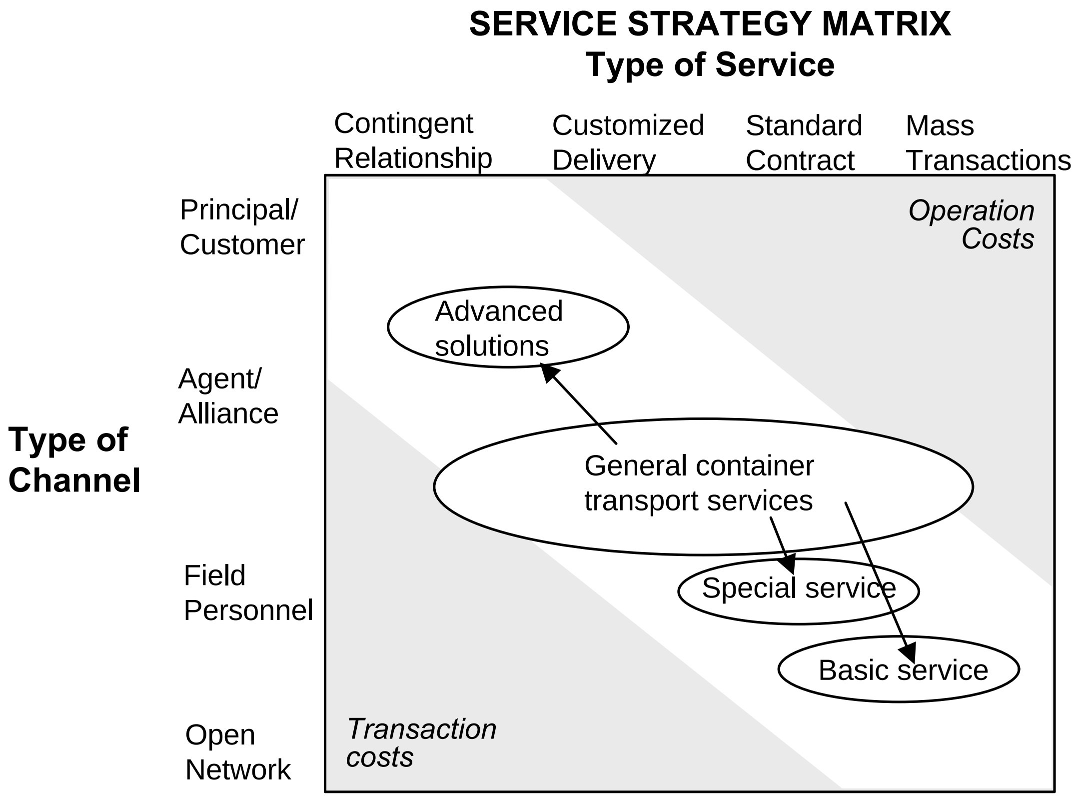

Figure 5. Container transportation services transform to more efficient form (Source: adapted from Bask & Laine 2000)

The interviewees brought up the need for an overall efficiency improvement in intermodal transport chains. More precisely, the objective should be to achieve a constant flow of containers, shorten the ships' port times, achieve more effective use of port cranes, increase the speed and frequency of rail transport, offer faster terminal operations, and decrease the number of ports. Regarding reliability there is a need to increase reliability in for example domestic transport and port operations. From a capacity utilization perspective, there is a need to improve the availability of special containers and land transport. There is also a need to increase overall flexibility, and adjust the pricing according to the various modules of the service package (see appendix 1).

3.2. Transport chain coordination

The basis of intermodal transportation resides in the development of systems that integrate or combine the various elements of the five modes of transportation i.e. motor, railroad, water, pipeline and air transport (Ross 1998). However, the various modes are not the only parts of the intermodal transportation chain but also several different activities/tasks during the transportation process. This section focuses on production side of the intermodal transport process.

Past

Earlier it was common that at least part of the transportation services required by the shippers was produced in-house. Therefore it was natural that they also had own shipping departments and responsibility for coordination of different activities of the transportation.

On the other hand forwarding companies have always offered their services especially when question transportation to geographically more distant locations. The scope included office works e.g. billing and tasks related to documentation handling in addition to coordination of transportation. The coordination role of forwarding companies has been to combine individual alternative activities (produced by several companies) case by case to form an entity or part of it to fulfill the transportation needs.

Present

As the container transport chain consists of several operations and often also several parties, the main problem areas are still today found in company interfaces. The operators in transport chains have been quite willing to co-operate with only few partners due to high investment needs while streamlining the processes between companies. The solutions have been customised, not aimed for general use in the whole container transport industry. This type of focused collaboration has led to pipeline specific systems and high coordination costs that often come as a result.

Future

In the future, the focus in coordination of the container transport chains will be increasingly on how well and efficient way different interfaces and processes in the chain are organized. Different interfaces are found not only between companies but also between different tasks/activities in the chain. Companies will focus more on specialized competencies. Some companies focus on owning of one of few tasks of the chain and some of several tasks. Effectiveness and efficiency calls for modularisation of the activities in the chain in terms of easy access and connectivity of the tasks to each other's to create reliable, flexible and fast container transport chains. In Figure 6, the efficient positioning of tasks in the container transport chain is shown. The dimensions used are service type and technology solution. As the container unit is standardised for different tasks, the coordination in the chain can be organized at least semi-automatic way. Concluded, modularization in container transport services production is modularization of different activities in the transport chain that have easy accessibility and connectivity to each others. This is a prerequisite for offering of effective and efficient types of diverged transport services. Moreover, basic or special services are offered by combining of different modules/activities with each other.

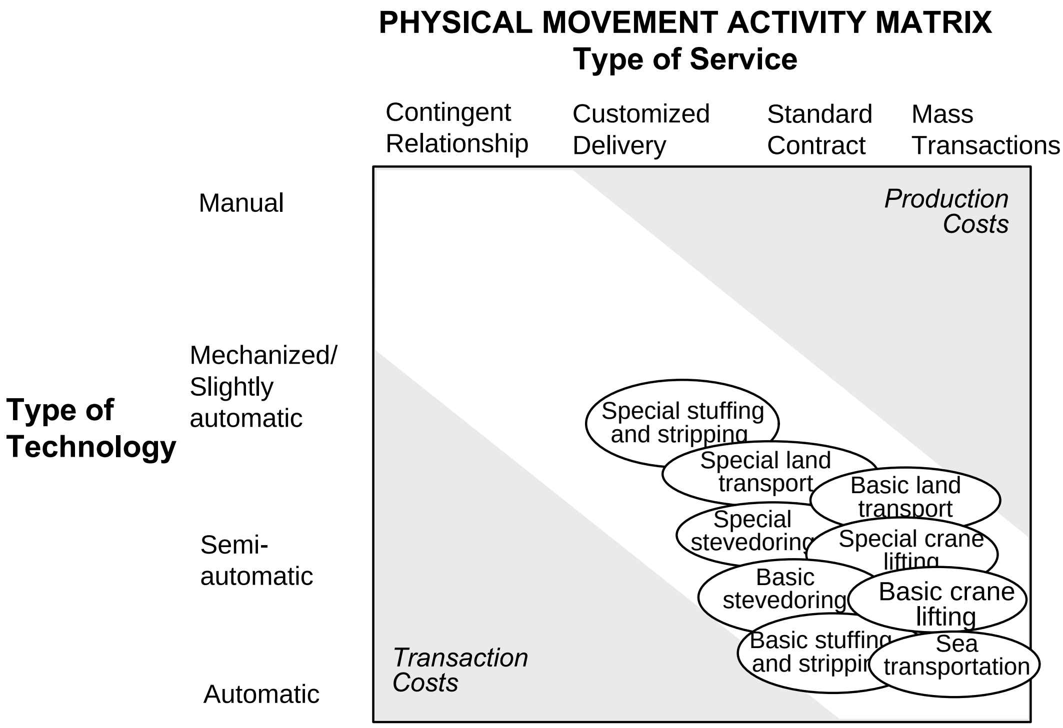

Figure 6. Efficient relocation of activities/tasks in container transportation chains (Source: Bask & Laine 2000)

Container transport specialists find several areas for improving coordination in the transport chains. With regard to standardisation, this means simplifying of routines in different interfaces of the chain, using packages that are optimal to container sizes, and creating clear EU standards. Also general standards to data and information transmission are needed. With regard to cooperation, there is a need for improved collaboration at company boundaries or interfaces, matching better opening hours in the chain, total optimization of routes, and more efficient combining of return loads. From information management perspective, coordination includes an increase in information sharing, availability of advance information, faster feedback from shipping companies to transport inquiries, finding adequate equipment to land transport, and an increase in information management between the port operator and other organisations.

3.3. Network technologies

Intermodal transport involves technologies for physical movement and terminal handling technologies as well as the information and communication technologies required for coordination. In this section the technologies for handling of physical and information related transactions are discussed.

Past

When the standardised container units were established the prerequisites for developing mechanised transportation and handling equipment were also created. In an early stage no computerized information systems were available, but such systems began to expand around the same time when the unitised cargo transportation (e.g. containerised cargoes) achieved popularity in the transportation industry. This allowed industrialization of transportation and led to significant increase in the productivity. In general however the information systems were developed to support individual functions of the company. Typically the data transfer between the functions was not possible. Later the emphasis in developing Enterprise Resource Planning (ERP) systems (where same information is available for all functions within the company) improved integration within the company.

Present

Present equipment and systems for physical movements are standardised, widely used and thus allow relatively flexible allocation of capacity - containers can be moved flexibly between transport pipelines. However in certain connection points (especially in the truck loading and customer terminals) further development of physical transfer of containers is still required. Containers are able to carry different kind of cargoes combined in one unit, although the package sizes could be improved to better fit into the container. Unfortunately in many cases the information systems cannot adapt to the varying information related to the different cargoes without special arrangements or previously agreed procedures. The information systems are integrated within organisations, but the challenge still remains to achieve linkages outside the company's boundaries. Another problem area is that the information flows are "pipeline-specific", i.e. information sharing is difficult due to different routines (work practices, manuals etc), communication standards (coding) and information systems. The objective should be to create general standards for data and information transmissions. Neuman and Samuels (1996) notes that supply chain partners lack trust and conviction in implementing activities like joint forecasting, information sharing and performance measurement. Regarding the standardization the main objective should be to create general standards for data and information transmissions and develop more clear EU standards.

As standards for electronic information has been established it is possible to exchange business information from previously incompatible computer systems. One of the earlier modes of electronic information exchange is electronic data interchange (EDI), or "electronic inter-company transfer of business documents in a standard format" (Gattorna & Walters 1996). EDI is commonly used among large companies for exchanging orders and invoices, and the scope of applications is increasing (Pawar & Driva 2000). However, the main focus today is on the Internet, intranet and extranet technologies (see Figure 7). The path of evolution is toward technologies that enable sharing of information in supply chain. On the other hand internet-based systems alone do not solve the problem as long as they are only front-end applications without connectivity to operational or back office systems. Normally this requires standard interfaces, previously integrated software packages or time-consuming integration work.

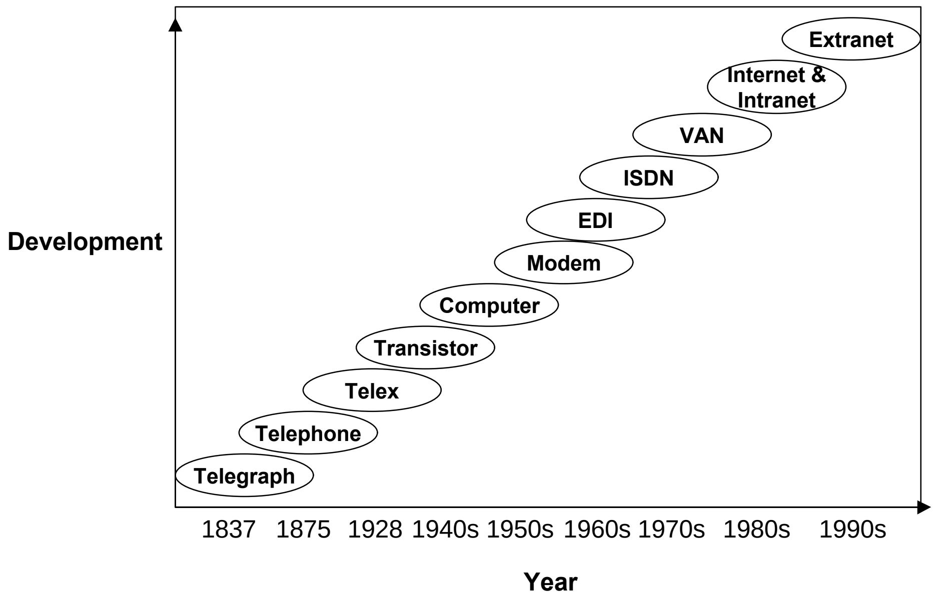

Figure 7. Development of Communication Technology (Source: Pawar & Driva 2000)

Future

The supply chain approach is materialising through advances in information technology that make electronic information sharing substantially easier and correspondingly cheaper (Pawar and Driva 2000). However, there are still several improvements needed. The main improvement areas in the future for total supply chain integration include network technology platforms, standards and protocols, and cost-efficient connectivity. Technology platforms should be developed towards generally accepted and useful generic technologies for information sharing in networks. While EDI has offered an efficient means for exchanging point-to-point information, the Internet technologies and new standards (e.g. XML) are expanding and creating improved connectivity between multiple organisations in the supply chain communities.

The visibility through the entire supply chain (availability of e.g. real-time transaction data) is required for matching demand and supply - "… the need for networkwide visibility increases because you can't manage what you can't see" (Klappich 2001). The more real time information is required, the more mobile devices and technology has to be used for data transfer and support of information systems functionalities (e.g. tracking and tracing). The visibility together with collaboration between companies offers opportunities to establish collaborative societies and may end up to so called virtual supply chain (no boundaries in the supply chain, no rigid structures). In order to further increase the efficiency, other development areas are related to automation of information transmission e.g. significant reduction of need for telephone communication and algorithms for total optimization of transportation routes.

In the development of general cargo handling performance two periods of major change can be distinguished (Figure 8). The first period is related to the development of modern general cargo ship. Despite modern cranes on shore and on board, as well as wide hatches, rectangular holds etc., the handling performance has leveled off. The second period of change started with the introduction of the container; and the resulting improvements in ship design, gantry cranes on board and on shore, efficient terminals etc., led to a phenomenal increase in productivity. However 30 years after this worldwide breakthrough, the productivity in the ship-to-terminal interface has levelled off again. In order to make short-sea shipping of unit-loads competitive, a third wave of change is required, based on very fast self-loading and unloading unit-load ship-terminal systems (Wijnolst et al. 1994).

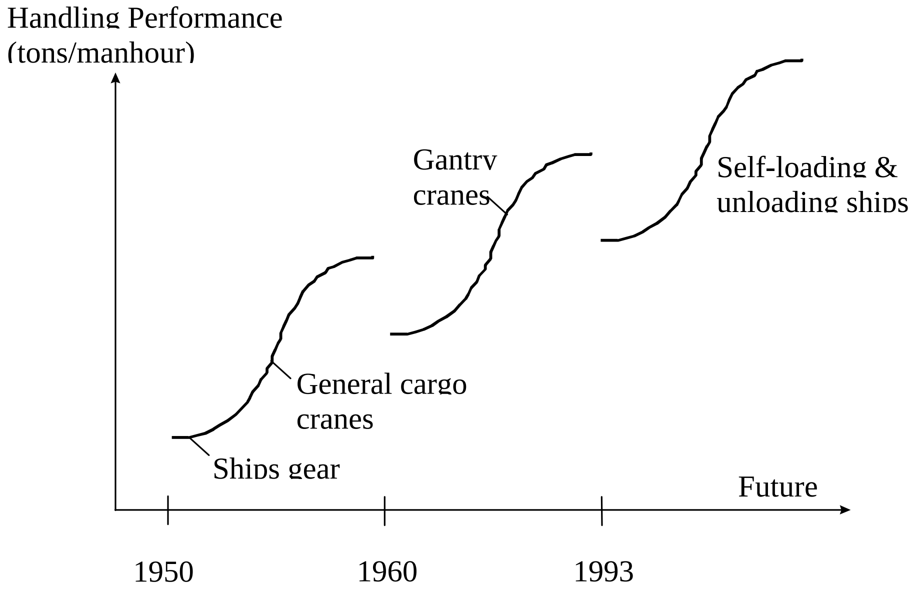

Figure 8 **Development of General Cargo Handling Performance**
(Source: Wijnolst et al. 1994)

In the future, further improvements in productivity will be achieved by combining cargo handling systems with new information and communication systems. Synchronising information and material flows offer a big potential for operational savings, but it is also a prerequisite for creating interlinked transport chains using containerisation. However, it seems that the main barrier to full supply chain integration in terms are not technologies themselves, but inertia to change. Although there are several documented successes, many firms, especially from traditional sectors, are reluctant to change over their logistics activities into a primaty electronic format (Pawar and Driva 2000).

4. Discussion and Conclusions

In this paper three key issues related to the development of intermodal transport have been examined, and an attempt has been made to link these with newer trends in logistics and supply chain management. In the past, the biggest increases in productivity were achieved when new technological innovations were combined with the physical cargo handling e.g. the standardised container unit itself, storage automation etc. As stated above, the emphasis in supply chain management is now shifting from linear, integrated pipelines to open networks characterised by increasing transparency and service modularity (see Table 2). Interoperable information systems have been mentioned as the most important prerequisite for the future growth of intermodal transport.

Table 2. Features of intermodal transportation in different times

	Past	**Present**	**Future**
Services • **offering to customers**	Separate services Basic services Rough estimate pricing	Generic services Customized services Customer-specific pricing	Mass-customized door-to-door services Service divergence Transparent pricing
Coordination • **service production perspective**	Own operations focus Ownership focused Internal services	Pipeline specific transport chains Focused collaboration Outsourcing	Specialized competencies Modularization of operations Networked sourcing
Technologies • **IT and Movement**	Internal IS Internal standards Paper focused SC interfaces	Actor specific IS Dyadic (customized) IS Costly SC interfaces	Technology platforms Standards and Protocols (EDI, XML) Easy cost-efficient SC connectivity

One development area of special importance is combining the physical flows and information flows in the system level. According to Pawar and Driva (2000), ‘consideration should be given to how material flow can keep pace with the movement toward ”commerce at light speed” information flow.

This is a challenge for transport and distribution managers that affect the strategy of the whole company.’ Striving for increased connectivity between physical and information frows requires improved coordination and collaboration in order to synchronize these flows through the organizational interfaces. The future is for divergent, mass-customized door-to-door transport services based on modularity of individual services. Container transport service production is coordinated through networks in true collaboration between companies based on information transparency throughout the network. This is achieved by increasing standardisation of interfaces and protocols allowing synchronisation in integrated information systems, and on the other hand at least semi-automated cargo handling systems and intelligent container units.

In intermodal transport, the progress towards interoperable information systems has been rather slow. Unlike global information systems like the airline-operated Amadeus, where the bookings involve relatively simple reservations of seats for people who find their way autonomously at the junctions, an intermodal transport information system must handle a variety of transport chain operations, cargo types, sizes and units, together with a multitude of origins and destinations practically anywhere in the world. On the other hand, there have also been improvements in cargo transport information management with systems like Bolero (Bill of Lading Electronic Registry Organization). In addition, advances have been made in the development of “intelligent” transport units (radio frequency identification, for instance), and the prospects for integrating cargo flows with information flows have thereby been greatly upgraded.

This paper has brought up some key issues that have shaped and will further shape the development of intermodal transport in the future. On the technical side, there are still unsolved problems regarding incompatibilities in the business requirements, the kind of information shared as well as the kind of information systems used. In more general terms, the entity of services offered for customers, the coordination strategies of services and the enabling technology solutions will play an important role in fulfilling the true potential of intermodal transport. However, also other aspects of supply chains and networks, including the various actors, activities and resources, still need to be studied to promote the development of competitive services in intermodal transport.

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Appendix 1. Main Future Development Needs in Container Transport Chains

Services	No	Example
Efficiency (8)	1 1 1 1 1 1 1	• Increase in efficiency in general • Shortening of total transport chain cycle times in general • Constant flow of containers • Shortening of ships port times • Faster crane lifting operations • Development of rail transport speed, frequency reliability and service concepts • Decrease in number of ports in general, fewer liner shipping ports • Faster terminal operations
Reliability (2)	1 1	• Development of reliability in domestic transports • Decrease of failures in port operators activities
Capacity (2)	1 1	• Better availability of special containers • Better availability of land transportation
Flexibility (2)	1 1	• Increase of flexibility in general • Development in customs operations
Pricing	1	• Right pricing in land transportation operations
Coordination		
Information management (10)	4 1 1 1 1 1 1	• Development of information sharing and utilization among chain members • Availability of pre-information • Development of information management in general • Faster feedback of capacity requests from shipping companies • Easier finding of adequate equipment for land transport • Better time matching between transport vehicles and containers • Development of information sharing between port operators and others
Cooperation (7)	2 2 1 1 1	• Development in cooperation among chain members • More efficient combining of return loads • Easier finding of different service operators in the container transport market • Development in matching of opening hours in the chain (8 h vs. 24 h) • Better total optimization of routes
Standardization (6)	1 1 1 1 1 1	• Development of generic standard for information sharing • Development of currently unclear EU standards • Standardization of information that is shared among chain members • Development in container standards, decrease in number of types of containers • Development of packages to be more optimal to container sizes • Simplification of routines in the chain
Technologies		
Information systems (4)	1 1 1 1	• Development in communication systems, decrease in use of telephone • Automatization of information sharing in the chain • Development of IS systems for total route optimization of the chain • Development of electronic information exchange among chain members
Track and trace (4)	2 1 1	• Better availability of real time information among members in the chain • Enabling of tracking and tracing from computers • Better utilization of tracking and tracing in the chain
Transport technology (3)	1 1 1	• Development of stuffing and stripping capabilities • Development of lifting capabilities of containers to road vehicles • Development of port operations