INLAND TERMINALS WITHIN NORTH AMERICAN AND EUROPEAN SUPPLY CHAINS

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ABSTRACT

The growing focus on inland/dry ports is indicative of transport development strategies gradually shifting inland to address capacity and efficiency issues in light of global supply chains. The complexity of modern freight distribution, the increased focus on intermodal transport solutions and capacity issues appear to be the main drivers. Also the larger volumes of flows in networks, through a concentration of cargo on a limited set of ports of call and associated trunk lines to the hinterland, have created the right condition for nodes to appear along and at the end of these trunk lines. In the light of technological, market and supply chain changes this paper looks at how inland terminals play a role in the organization of regional freight distribution. The first part aims at discussing the number of functions played by inland terminals, from satellite to gateway terminals to inland load centers. The following sections look at inland terminals as elements of regional freight distribution systems, gateways and corridors. These sections also investigate the various means used by supply chain managers to use inland terminals in their freight distribution strategies.

Keywords: Inland port, terminal, Europe, North America, port, regionalization

I. A NEW ROLE FOR INLAND TERMINALS

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In many places around the world bimodal and trimodal inland terminals have become an intrinsic part of the transport system, particularly in regions having a high reliance on trade. Transport development is gradually shifting inland after a phase that focused on the development of port terminals and maritime shipping networks. There are many reasons behind this growing attention. The complexity of modern freight distribution, the increased focus on intermodal transport solutions and capacity issues appear to be the main drivers. While trucking tends to be sufficient in the initial phase of the development of inland freight distribution systems, at some level of activity, diminishing returns such as congestion, energy consumption and empty movements become strong incentives to consider the setting of inland terminals as the next step in regional freight planning. Also the massification (i.e. economies of scale through larger volumes) of flows in networks, through a concentration of cargo on a limited set of ports of call and associated trunk lines to the hinterland, have created the right condition for nodes to appear along and at the end of these trunk lines.

The evolution of inland freight distribution can be seen as a cycle in the ongoing developments of containerization and intermodal transportation. The geographical characteristics linked with modal availability and capacity of regional inland access have an important role to play in shaping this development. Thus, there is no single strategy in terms of modal preferences as the regional effect remains fundamental. Each inland port remains the outcome of the considerations of a transport geography pertaining to modal availability and efficiency, market function and intensity as well as the regulatory framework and governance.

The setting of global supply chains and the strategy of Pacific Asian countries around the export-oriented paradigm have been powerful forces shaping contemporary freight distribution. Indirectly, this has forced players in the freight transport industry (shipping companies, terminal operators, logistics providers) to examine supply chains as a whole and to identify legs where capacity and reliability were an issue. Once maritime shipping networks and port terminal activities have been better integrated, particularly through the symbiotic relationship between maritime shipping and port operations, inland transportation became the obvious focus and the inland terminal a fundamental component of this strategy. This initially took place in developed countries, namely North America and Europe, which tended to be at the receiving end of many containerized supply chains. The focus has also shifted to considering inland terminals for the early stages of global supply chains (outbound logistics), namely in countries having a marked export-oriented function.

In light of technological, market and supply chain changes this paper will look at how inland terminals play a role in the organization of regional freight distribution. The first part aims at discussing the number of functions played by inland terminals, from satellite to gateway terminals to inland load centers. The following sections look at inland terminals as elements of regional freight distribution systems, gateways and corridors. These sections also investigate the various means used by supply chain managers to use inland terminals in their freight distribution strategies. The last section looks at operational issues related to the setting-up and the exploitation of inland terminal facilities in Europe and North-America.

II. INLAND NODES: TOWARDS A TYPOLOGY

The nodes in the hinterland networks of ports have been referred to as dry ports, inland terminals, inland ports, inland hubs, inland logistics centres, inland freight villages, etc. When discussing the term inland terminal facility, Jaržemskis and Vasiliauskas (2007) and Roso (2005) make a distinction between inland clearance depot, inland container depot, intermodal freight center, inland freight terminal and inland port (Table 1). Also Cardebring and Warnecke (1995), Roso (2006), Roso et al (2009) and Wiegmans et al (1999) have proposed various definitions and classifications of inland nodes.

Table 1. Terms used in relation to inland nodes

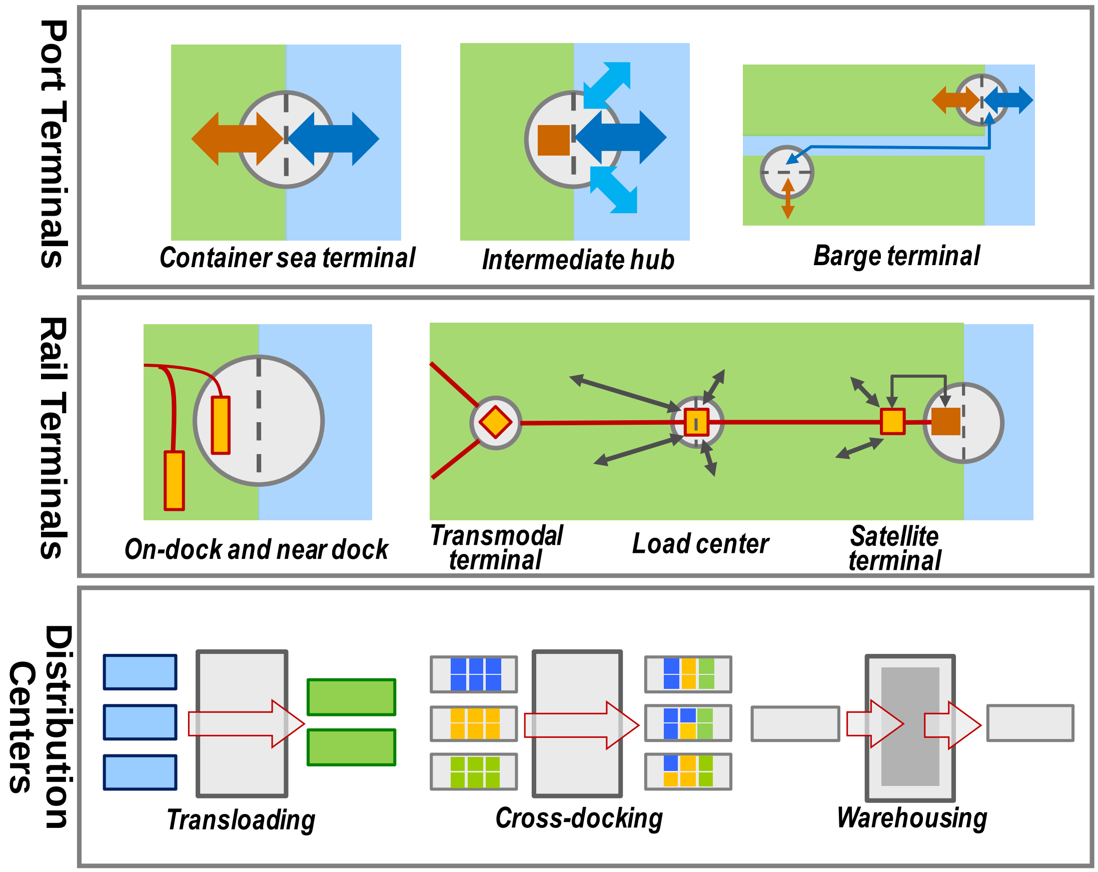
Source	Term	Definition
Economic Commission for Europe (1998), see also Roso (2005), Jaržemskis and Vasiliauskas (2007), Roso et al (2009)	Inland clearance depot	A common-user inland facility, with public authority status, equipped with fixed installation, and offering services for handling and temporary storage of any kind of goods (including container) carried under customs transit by any applicable mode of inlandsurface transport, placed under customs control to clear goods for home use, warehousing, temporary admission, re-export, temporary storage for onward transit, and outright export.
Roso (2005), Jaržemskis and Vasiliauskas (2007), Roso et al (2009)	Inland container depot	A common user facility with public authority status, equipped with fixed installations and offering services for handling and temporary storage of import/export stuffed and empty containers.
Cardebring and Warnecke (1995), Roso et al (2009)	Intermodal freight centre	A concentration of economic independent companies working in freight transport and supplementing services on a designated area where a change of transport units between traffic modes can take place.
Economic Commission for Europe (1998), see also Jaržemskis & Vasiliauskas (2007), Roso et al (2009)	Inland freight terminal	Any facility, other than a seaport or an airport, operated on a common-user basis, at which cargo in international trade is received or dispatched.

Economic Commission for Europe (2001), see also Jaržemskis and Vasiliauskas (2007), Roso et al (2009)	Inland port	An inland port is located inland, generally far from seaport terminals. It supplies regions with an intermodal terminal or a merging point for traffic modes – rail, air, and truck routes – involved in distributing merchandise that comes from seaports. An inland port usually provides international logistics and distribution services, including freight forwarding, customs brokerages, integrated logistics, and information systems.
Leveque and Roso (2002), Roso (2005), Roso et al (2009)	Dry port	A dry port is an inland intermodal terminal directly connected to seaport(s) with high capacity transport mean(s), where customers can leave/pick up their standardised units as if directly to a seaport.
Ng and Gujar (2009)	Dry port	Dry port can be understood as an inland setting with cargo-handling facilities to allow several functions to be carried out, for example, consolidation and distribution, temporary storage, custom clearance, connection between transport modes, allowing agglomeration of institutions (both private and public) which facilitates the interactions between different stakeholders along the supply chain.
Wiegmans et al (1999)	Transfer terminal	This type of terminal is almost exclusively aimed at transhipping continental freight. There is almost no collection and distribution in the region where the terminal is located. The freight arrives at and departs from the terminal in huge flows. The terminal is characterised by large areas that enable direct transhipment between trains and/or barges. The corresponding bundling model is the hub-and-spoke network.
Wiegmans et al (1999)	Distribution terminal	At this terminal value added is created in the form of an extra service provided by the terminal operator. From location A, B, and C continental freight arrives at the terminal and is consolidated into shipments for customers X, Y, and Z. One or more terminal services is added bythe terminal operator to the shipments at the terminal. The corresponding bundling model is line network.
Wiegmans et al (1999)	Hinterland Terminal	Small continental cargo shipments are brought to the hinterland terminal and consolidated into bigger freight flows. These bigger freight flows are further transported by larger transport means such as trains or barges. The corresponding bundling model is the trunk line with a collection and distribution network.

Source: Edited by the authors

Thus, there seems no consensus on the terminology to be used. The reason for this lies in the multiple shapes, functions and network positions these nodes can have. We argue that there are three major types of intermodal terminals each having their own locational and equipment requirements: sea port terminals, rail terminals and distribution centres (Figure 1).

Figure 1. Types of intermodal terminals



Source: Rodrigue and Hatch (2009)

First of all, *sea port terminals* are the most substantial intermodal terminals in terms of traffic, space consumption and capital requirements. A container sea terminal provides an interface between the maritime and inland systems of circulation. The containerization of inland river systems has led to the development of an array of barge terminals linked with major deep sea terminals through scheduled barge services. At the maritime container terminal, barges can either use regular docking areas or have their own terminal facilities if congestion is an issue.

Although barge to barge terminal container services are technically possible, they are not very common.

Secondly, at the start and end of the inland intermodal chain *rail terminals* are linked with port terminals. The fundamental difference between an on-dock and a near-dock rail facility is not necessary the distance, but terminal clearance. While for an on-dock rail terminal containers can be moved directly from the dock (or the storage areas) to a railcar using the terminal's own equipment, accessing a near-dock facility requires clearing the terminal's gate (delays), using the local road system (congestion) and clearing the gate of the near-dock rail terminal (delays). Near-dock facilities tend to have more space available however and can thus play a significant role in the maritime/rail interface, particularly if they are combined with transloading activities. The satellite terminal, the load center and the transmodal terminal (interchanges within the same mode) all qualify as a form of inland port. For the satellite terminal, it is mainly a facility located at a peripheral and less congested site that often performs activities that have become too expensive or space consuming for the maritime terminal. Rail satellite terminals can be linked to maritime terminals through rail shuttle or truck drayage (more common) services. A load center is a standard intermodal rail terminal servicing a regional market area. If combined with a variety of logistical activities, namely freight distribution centers, it can take the form of a freight distribution cluster (or freight village). The surge of inland long distance containerized rail traffic may also require transmodal (rail to rail) operations as freight is moved from one rail network to the other. This can be done by switch carriers or trucking containers from one terminal to the other. Eventually, dedicated rail-to-rail terminals are likely to emerge.

Finally, *distribution centres* represent a distinct category of intermodal terminals performing an array of value added functions to the freight, with transmodal operations dominantly supported by trucking. Distribution centers can perform three major types of function. A transloading facility mainly transfers the contents of maritime containers into domestic containers or truckloads (or vice-versa). It is common in North America to have the contents of three 40 foot maritime containers to be transferred into two 53 foot domestic containers[1]. Sometimes, shipments are palletized as part of the transloading process since many containers are floor loaded. Cross-docking is another significant function that commonly takes place in the last segment of the retail supply chain. With very limited storage, the contents of inbound loads are sorted and transloaded to their final destinations. Warehousing is a standard function still performed by a majority of distribution centers that act as buffers and points of consolidation or deconsolidation within supply chains.

Table 2. Examples of typical inland nodes based on different dimensions

	Cross-dock facility (trucks)	Rail hub	Barge terminal as local 'extended gate' for seaport terminal	Fully-fledged inland port and logistics zone
Examples	UPS Willow Springs Distribution Center (Chicago)	Dry Port Muizen operated by IFB – Belgium Norfolk Southern Rickenbacker Intermodal Terminal (Columbus, Ohio)	TCT Belgium operated by ECT – Belgium Barge terminal Oss – the Netherlands	Inland ports of Duisburg (Germany), Paris (France), Strasbourg (France), Liège (Belgium)
Transport modes	Unimodal (truck)	Bimodal (rail/truck)	Bimodal (barge/truck)	Trimodal (rail/truck/barge)
Primary function	Transport and cargo handling	Transport and cargo handling	Transport and cargo handling Customs formalities	Transport and cargo handling Customs formalities Warehousing VALS (value-added

[1] Two 53 feet domestic containers account for a volume of about 8,180 cubic feet while three high-cube 40 feet maritime containers account for a volume of about 8,100 cubic feet.

			Container repair	logistics)
Size	Vary according to the level of cross-docking	Several rail bundles and a temporary stacking area	Typically 5,000 – 50,000 TEU (Europe) Stacking area for full and empty containers.	Large, consisting of multimodal terminal facilities and logistics zones
Geography	Between distribution centre and final destinations	Intermediacy function in rail-based hub-and-spoke network	End terminal with a local service area of e.g. 25 km radius	Combination of end terminal (local service area) and cargo transit point (intermediacy)
Cargo type	Conventional	Containers	Containers	Containers and conventional
Openness of the node	Single-user	Single-user	Common-user	Common-user
Operational - technology	Forklifts, conveyors belts (parcels), small handling equipment for pallets	Rail-mounted gantry cranes (RMG) and reach stackers	Gantry crane for handling of barges/trucks and managing stacking area	Gantry crane for barge operations, RMG for rail, reach stackers, truck gates, warehouses
Operational – transhipment	Indirect transhipment, but very short storage time	Direct (between wagons) and indirect (via stack) transhipment	Indirect transhipment	Indirect transhipment with modal separation in time and space

Source: edited by the authors

Several dimensions contribute to the above typology. Höltgen (1995) suggested that intermodal terminals can be classified according to a set of functional criteria including traffic modes, transhipment techniques, network position or geographical location. Also Konings et al (1995) proposed a typology of hinterland nodes. We propose seven dimensions characterizing inland nodes as depicted in Table 2.

The first dimension relates to the *transport modes* served ranging from unimodal to trimodal. *Unimodal inland nodes* can be found in the road haulage industry. Good examples are the French 'road stations' developed in the 1970s. Unimodal inland nodes also appear in distribution networks in the form of cross-dock facilities, i.e. places where cargo is consolidated in a covered storage area for a short time and moved from one truck to another. Rail networks can also contain some unimodal transport nodes, namely in the case of horizontal and vertical handling of containers in the central node of a hub-and-spoke network (see later). *Bimodal facilities* are equipped to accommodate two transport modes, typically rail and truck, or barge and truck. *Trimodal inland nodes* are designed to handle cargo between three modes: rail, barge and trucks. Important to underline is that trimodal terminal configurations do not necessarily shift cargo between all transport mode pairs. In Europe, for example, trimodal terminals handle a lot of cargo between barge-truck and rail-truck combinations, but far less cargo is being shifted from barge to rail or vice versa.

The second dimension encompasses the *primary functions* of the inland node. The raison d'être of inland nodes is linked to transport and cargo handling functions. However, inland nodes can develop a range of other functions and services including customs clearance, warehousing, container repair and value-added logistics services (VALS). It is thus common to see a diversification of the primary function with the clustering of logistical activities near the inland node. In North America, inland ports are solely the outcome of an interface between intermodal rail terminals and service areas.

The third dimension of an inland node relates to *size*. This dimension can be measured in the cargo volume passing through the node or also the scale of the land area occupied by the node. There is a relationship between size and function, but for many intermodal rail terminals size is scalable on site or to a new location in the vicinity.

The *geography* of the node constitutes the fourth dimension. This includes the size of its service area, the geographical orientation of the node vis-à-vis its service area and the position of the node in the transport system and modal networks. An inland node can function as end terminal in a network, with the specific role to distribute goods to local destinations in its service area or to consolidate goods from origins in its hinterland. Inland nodes typically act as cargo consolidation and deconsolidation centres with a local service area; load centers. The size of the service area generally depends on the terminal size, the distance to the gateway ports and the proximity to big shippers. Other inland nodes have a strong intermediacy function handling transit cargo moving through from one region to another region.

The fifth dimension relates to the dominant *cargo type*. The transport and cargo handling function of an inland node can relate to a wide range of commodities and cargo flows. While this paper mainly focuses on inland nodes designed to handle containerized cargo, inland nodes can be specifically constructed to deal with other unit loads such as trailers.

The *openness of the node* is another dimension that deserves attention. Quite a lot of inland nodes comprise common-user terminals. The neutral management of these terminals allows for accommodating a broad range of customers without discriminating between them. Single-user nodes are however common as well, particularly in cases where the terminal has an operational purpose within a network, e.g. a rail hub used by one rail operator in the framework of the operations within its hub-and-spoke shuttle network. Thus, the nature of ownership changes the competitive setting of the inland node.

Another dimension relates to the *operational characteristics linked to the cargo handling function* of the node. Terminal operations at an inland node can be based on conventional technology (e.g. manned gantry cranes and reach stackers) or follow a (semi-)automated design (e.g. automated guided vehicles – AGV or automated stacking cranes – ASC). Automated terminal designs are becoming more common in the world of deep sea container terminals as illustrated by the port of Rotterdam (combined AGV and ASC system), Hamburg (idem), Melbourne (automated straddle carriers), and Hampton Roads (semi automated terminal and gate access), see also Stahlbock and Voss (2008) for a more detailed discussions on relevant literature on terminal operations. However, the design of inland terminals remains quite conventional, notwithstanding plenty of ideas for further automation also in this area. We refer in this respect for example to the analysis of Kreutzberger (1997) on automated rail cargo handling facilities in Europe, Rodrigue (2008) on a handling concept for large North-American rail hubs, and Ballis and Stathopoulos (2002) on automated terminals in the European barging industry. The design and layout of an inland terminal will typically depend on factors such as the expected cargo volumes, and the interactions of the terminal with local or regional trucking (this to anticipate operational peak hours at the terminal). Inland terminal operators often opt for a modular design that allows for a gradual and phased enlargement of terminal capacity in line with demand.

A last operational factor relates to the handling of the transport means. *Simultaneous batch exchange* involves a system where several trains or barges are present at the terminal at the same time and load units are directly exchanged among them without the interference of a storage area (i.e. *direct transhipment*). Direct transhipment is associated with very short dwell times (the average time the cargo remains stacked on the terminal and during which it waits for some activity to occur), requiring only a small temporary storage area on the terminal. Alternatively, the term *sequential exchange* refers to a system whereby the transport modes pass a terminal sequentially. Load units can only be transshipped to a later train, barge or truck. A temporary storage area is needed (i.e. *indirect transhipment*). Scale increases in the unit capacities of trains and barges combined with fast handling equipment have led to larger cargo volumes per terminal call and shorter handling times per volume of freight. Both factors have made direct transhipment less feasible in modern inland terminals. The result has been a modal separation, particularly at trimodal inland terminals, and the setting of a significant buffer in the form of large storage areas. Each transport mode receives a specific area on the terminal, so that operations on barges, trucks and trains cannot obstruct one another. This modal separation in space is a requirement for setting up a system of indirect transhipment whereby each transport mode follows its own time schedule and operational throughput, implying a modal separation in time. For rail terminals, indirect transshipment takes the form of containers on chassis parked at an angle enabling for easy drop and pick up by truck. Under the indirect transshipment system, the terminal stacking area functions as a buffer and temporary storage area between the different modal operations.

III. FROM INTERMODALISM TO CLUSTER FORMATION: THE RISE OF LOGISTICS ZONES AND FREIGHT VILLAGES

Inland terminals have evolved from simple intermodal locations to their incorporation within co-located freight distribution activities, commonly labeled as logistical parks. Inland terminals (particularly rail) have always been present since they are locations from which specific market coverage is achieved. Containerization has impacted this coverage through the selection of terminals that were servicing a wider market area. This spatial change also came with a functional change as intermodal terminals began to experience a specialization of roles based on their geographical location but also their ‘location’ within supply chains.

A functional and added value hierarchy has emerged for inland terminals as depicted in Figure 2. In many instances, freight transport terminals fit within a hierarchy with a functionally integrated inland transport system of gateways and their corridors:

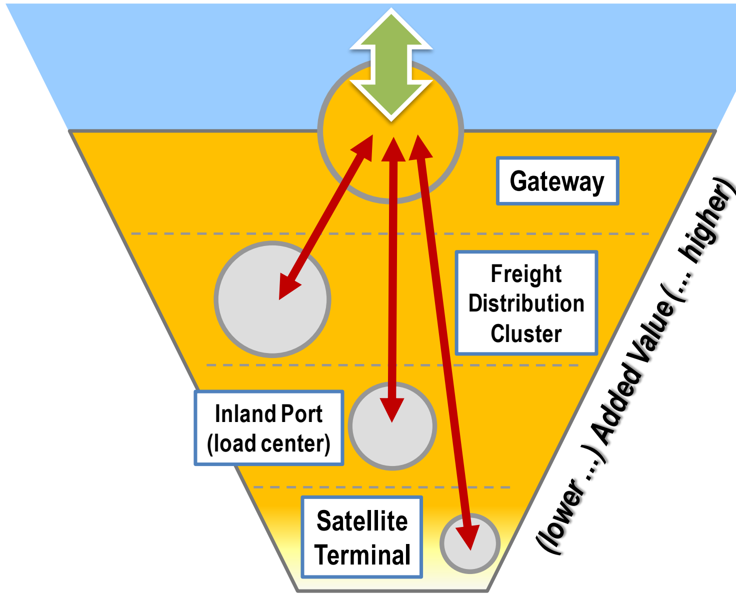
- Gateway (Level 1): A world class gateway should contain the whole range of value added activities related to transportation, from financing to modal and intermodal infrastructures. Still, basic gateways can also exist, mainly focusing on transhipment between maritime and inland transport systems.

- Freight distribution cluster (Level 2): Characterizes a complex of large inland terminals and freight distribution centers that command the distribution of a vast market area. Some like Duisburg, Chicago or Kansas City can have as much added value activities as a gateway.

- Inland port (Level 3): Often a single intermodal terminal coupled with an array of distribution activities. Commonly acts as a load center for commodity chains.

- Satellite terminal (Level 4): Perform a very specific function such as transloading, often in the vicinity of a gateway. Some satellite terminals, such as in Los Angeles, are very significant at providing specialized freight distribution activities.

Figure 2. Freight Terminal Hierarchy and Added Value



Source: Rodrigue (2009)

It can thus be seen that the functional specialization on inland terminals has been linked with cluster formation of logistical activities. Inland terminals in many cases have witnessed a clustering of logistics sites in the vicinity, leading to a process of logistics polarization and the creation of logistic zones. They have become excellent locations for consolidating a range of ancillary activities and logistics companies. In the last fifteen years, the dynamics in logistics networks have created conditions favorable for a large-scale development of logistics zones, particularly in Europe. Particularly, the range of functions of inland logistics zones is wide ranging from simple cargo consolidation to advanced logistics services. Many inland locations not only have assumed a significant number of traditional cargo handling functions and services, but also have attracted many related services including distribution centres, shipping agents, trucking companies, forwarders, container repair facilities and packing firms. The concept of logistics zones in the hinterland is now well-advanced in Europe. The first such zones were created in France, notably Sogaris and Garonor near Paris. In the late 1960s and 1970s, logistics zones appeared in Italy and Germany, by following the concept of extended inland intermodal terminals. In the 1980s and 1990s, the number of such zones multiplied in France, Germany, Italy, the Netherlands, Belgium and the United Kingdom. Logistics zones are usually created within the framework of regional development policies as joint initiatives by firms, intermodal operators, regional and local authorities, the central government and or the Chambers of Commerce and Industry.

Logistics zones comprising intermodal terminals and logistics sites are often referred to as freight villages. Europlatforms, the European Association of freight villages (in Italy, France, Spain, Denmark, Portugal, Luxembourg, Greece, Hungary, Ukraine), provides a comprehensive definition for freight villages: ‘A freight village is a defined area within which all activities relating to transport, logistics and the distribution of goods, both for national and international transit, are carried out by various operators. These operators can either be owners or tenants of buildings and facilities (warehouses, break-bulk centres, storage areas, offices, car parks, etc) which have been built there. Also, in order to comply with free competition rules, a freight village must allow access to all companies involved in the activities set out above. A freight village must also be equipped with all the public facilities to carry out the above mentioned operations. If possible, it should also include public services for the staff and equipment of the users. In order to encourage intermodal transport for the handling of goods, a freight village must preferably be served by a multiplicity of transport modes (road, rail, deep sea, inland waterway, air). Finally, it is imperative that a freight village be run by a single body, either public or private (see www.freight-village.com).

Depending on the European country considered, freight villages are known under different names: ‘platformes logistiques’ in France, the Güterverkehrszentren (GVZ) in Germany, Interporti in Italy, Freight Villages in the UK, Transport Centres in Denmark, and the Zonas de Actividades Logisticas (ZAL) in Spain. The ‘interporti’ in Italy are a variation on the freight village theme (Iannone et al, 2007). The first interport was set up in 1966 in Rivalta Scrivia (Northern-Western Italy) with the aim to accommodate the traffic of the port of Genoa. Other interporti followed in the 1970s (Bologna, Verona and Padua). The real success came when the Italian parliament voted Law No. 240 of 1990, which made it possible to financially support the development of interporti. Article 1 of the Law gives a clear definition of the term interport: 'an organic complex of integrated facilities and services providing for the exchange of goods between the various transport modes, including a railway yard capable of composing and accommodating complete trains and linked to seaports, airports, and highways. The main services of an interport consist of transport and sorting of load units, storage of goods and further services such as customs, maintenance of vehicles and containers, service areas, etc.'. An interport in Italy typically encompasses a land area of 40 to 150 ha, in some cases even reaching up to 500 ha and has direct rail access.

In North America, the emergence of planned logistics zones came later as governments rarely placed much attention on these activities, outside zoning regulations at the municipal level. The general availability of land and the private nature of rail operations involved a freight distribution industry that was self-regulated in its locational choices. Cluster formation was mainly a 'natural' process strongly conditioned by national and regional market accessibility. A variety of private real estate promoters, often in partnership with local or state governments, built logistics or industrial parks on an ad hoc basis where land was available, inexpensive and in proximity to a major highway. This led to three major forms of North American logistics cluster dynamics:

- Near gateways where logistics clusters are strongly conditioned by warehousing parks in the vicinity of container port terminals as well as in suburban settings nearby ring roads. This is prone to the usage of satellite terminals.

- Around the inland rail terminals, which took place at the same time that new facilities were being designed in a suburban setting, away from the more traditional locations nearby central business districts. This reinforce the emergence of load centers.
- Along major highway corridors that can service a large metropolitan area or a group of metropolitan areas. For instance in the United States, many distribution clusters in the central part of Pennsylvania state were establish because of the convenient access to large cities along the Boston – Washington corridor, with most of the cities accessible within 3 to 6 hours.

Kansas City can be considered the most advanced inland port initiative in North America as it combines intermodal rail facilities from four different rail operators, free trade zones and logistics parks at various locations through the metropolitan area. There is even the world's largest underground warehousing facility, Subtropolis, where temperature stable space can be leased. Like Chicago, the city can essentially be perceived as a terminal (Hesse, 2008).

IV. COMPETITION BETWEEN SEAPORTS AND INLAND LOGISTICS ZONES

Quite a few logistics zones are competing with seaports for the location of distribution facilities and value-added logistics. There is a tendency in the container sector to move away from the deepsea terminal. Shortage of industrial premises, high land prices, congestion problems, the inland location of the European markets and severe environmental restrictions are some of the well-known arguments for companies not to locate in a seaport. In North America, inland ports mostly compete with gateways in terms of costs and a better level of service to large inland markets. The further integration of intermodal transport and supply chain management will undoubtedly lead to new value-added services in inland locations. This will enhance the provision of logistics services at key transfer points and the organization of distribution patterns around such nodes. The availability of fast, efficient and reliable intermodal connections is one of the most important prerequisites for the further logistical development of inland terminals.

As the hinterland becomes a competitive location, the question remains as to which logistics activities are truly port-related. In Europe, the chances for European Distribution Centres (EDCs) in the traditional processing industries for a location in seaports may be good, because of the existence of large industrial clusters in seaports. Next, seaports may be attractive alternative locations for the relocation of EDCs – especially EDCs focussing on sea-sea operations. In the new logistic market environment, the following logistics activities typically find a good habitat in ports:

- Logistics activities resulting in a considerable reduction in the transported volume;
- Logistics activities involving big volumes of bulk cargoes, suitable for inland navigation and rail;
- Logistics activities directly related to companies which have a site in the port area;
- Logistics activities related to cargo that needs flexible storage to create a buffer (products subject to season dependent fluctuations or irregular supply);
- Logistics activities with a high dependency on short-sea shipping.

Moreover, port areas typically possess a strong competitiveness for distribution centres in a multiple import structure and as a consolidation center for export cargo. Many seaports have responded by creating logistics parks inside the port area or in the immediate vicinity of the port. The concentration of logistics companies in dedicated logistics parks offers more advantages than providing small and separated complexes. Five basic types of port-based logistics parks can be distinguished (Buck Consultants International, 1996; Kuipers, 1999):

- *Traditional seaport-based logistics park*. This type of logistic park is associated with the pre-container area in seaports.
- *Container oriented logistics parks*. This is the dominant type with a number of large warehouses close to the container terminal locations and intermodal terminal facilities. It also includes transloading and empty container depots.
- *Specialized seaport-based logistics parks*. This type of park specializes on different functions, often closely related to the characteristics of the seaport. The park may focus on the storage of liquid bulk (chemicals), on trade in which a combination of warehousing and office space is offered to a number of import-export companies from developing countries or on high-value office related employment in which Fourth Party Logistics Service Providers, logistics software firms, financial service providers to the maritime industry and consultants are located in the park.
- *Peripheral seaport-based logistics parks*. These parks are located just outside the port area which typically offers advantages with respect to congestion, costs of land and labour. These peripheral parks are part of the greater seaport region and may benefit from suppliers and other specialized inputs associated with the seaports.
- *Virtual port-based logistics parks*. These parks are located outside the greater seaport area, sometimes at a distance of more than hundred kilometers from the seaport itself, but have a clear orientation to one or more seaports with respect to the origins of the (containerized cargo).

The term ‘virtual’ is associated with a process called ‘virtual subharborisation’, the rise of port-based activities in the hinterland of the ports together with a stagnation of these activities in the ports itself. Distribution centres are the main example of this activity (Buck Consultants International, 1996). The process of virtual subharborisation is closely linked to the creation of large logistics poles (see next section).

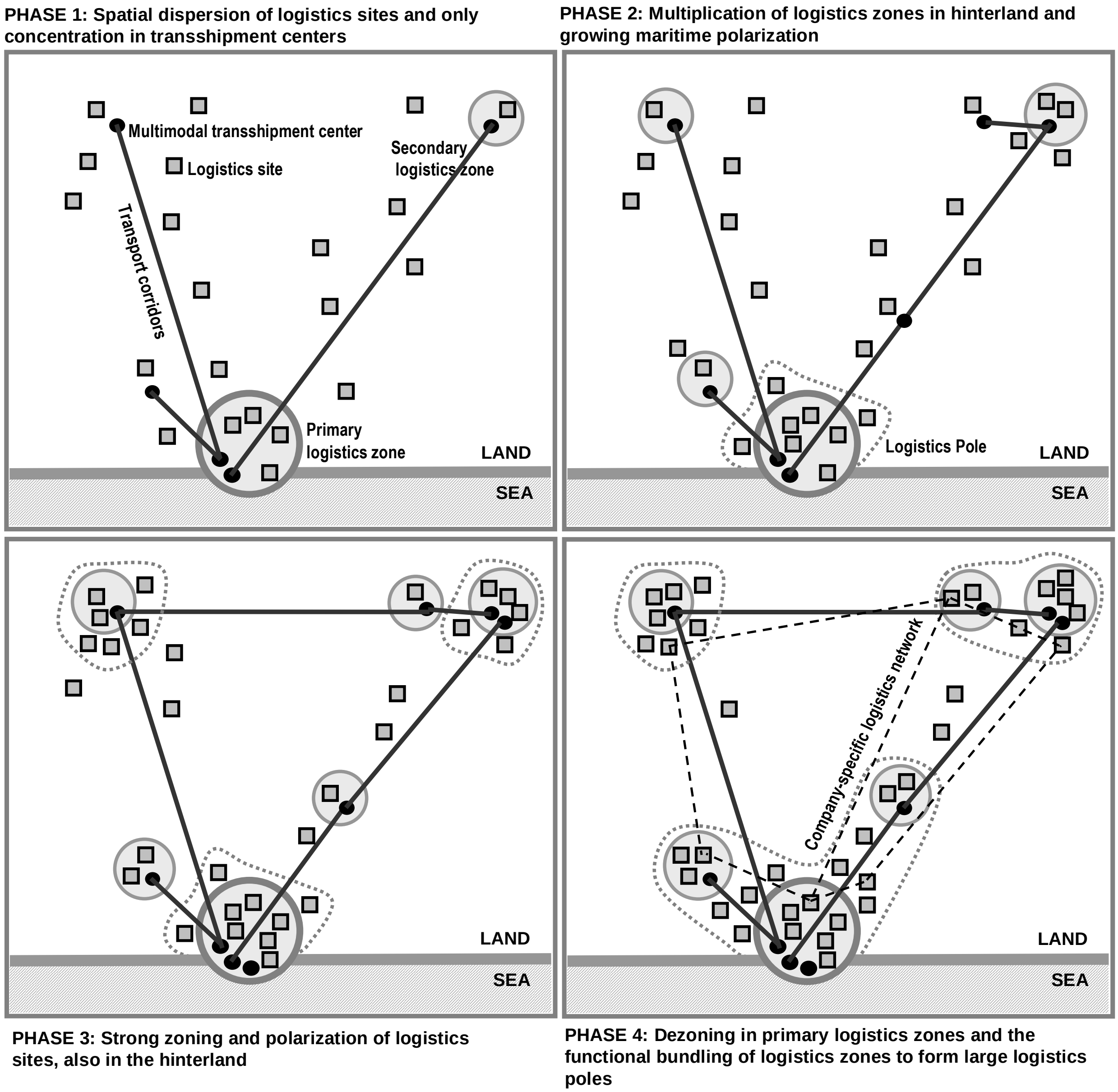
V. PORTS AND INLAND NODES AS TURNTABLES IN LARGE LOGISTICS POLES

Logistics companies frequently set up close to one another, since they are attracted by the same location factors such as the proximity of markets and the availability of intermodal transport and support facilities. The geographical concentration of logistics companies in turn creates synergies and economies of scale, which make the chosen location even more attractive and encourage concentration of distribution companies in a particular area. Corridor development enhances the location of logistics sites in seaports and inland ports and along the axes between seaports and inland ports. The interaction between seaports and inland locations leads to the development of a large logistics pool consisting of several logistics zones (Figure 3). This trend towards geographical concentration of distribution platforms in many cases occurs spontaneously as the result of a slow, market-driven process. But also national, regional and/or local authorities try to direct this process by means of offering financial, regulatory and real estate incentives. Thus, the relation between ports and inland locations is not only of a competitive nature but also of a complementary nature.

Logistics poles exert a locational pull on logistics sites by combining a strong intermodal orientation with cluster advantages. Geographical differences in labour costs, land costs, availability of land, level of congestion, the location vis-à-vis the service markets, labour mentality and productivity and government policy are among the many factors determining observed (de)polarization of logistics sites. A virtuous cycle is created, producing scale effects, which ensures high productivity from intermodal synchronization and the compatibility of goods flows with the logistics of shippers.

Seaports are the central nodes driving the dynamics in such a large logistics pool. But at the same time seaports rely heavily on inland ports to preserve their attractiveness. For example, the logistics zones in the Netherlands are mainly located in ports or around new or existing barge or rail terminals in the hinterland. Dordrecht and Moerdijk are important overflow locations for the port of Rotterdam. There are now large concentrations of logistics sites in and around the port of Liège, along the Geel-Hasselt-Genk axis and the Antwerp-Brussels axis, and in the Kortrijk/Lille border region. The existing geographical concentration of logistics sites has stimulated the development of inland terminals in these areas.

Figure 3. Logistics polarization and the creation of logistics poles

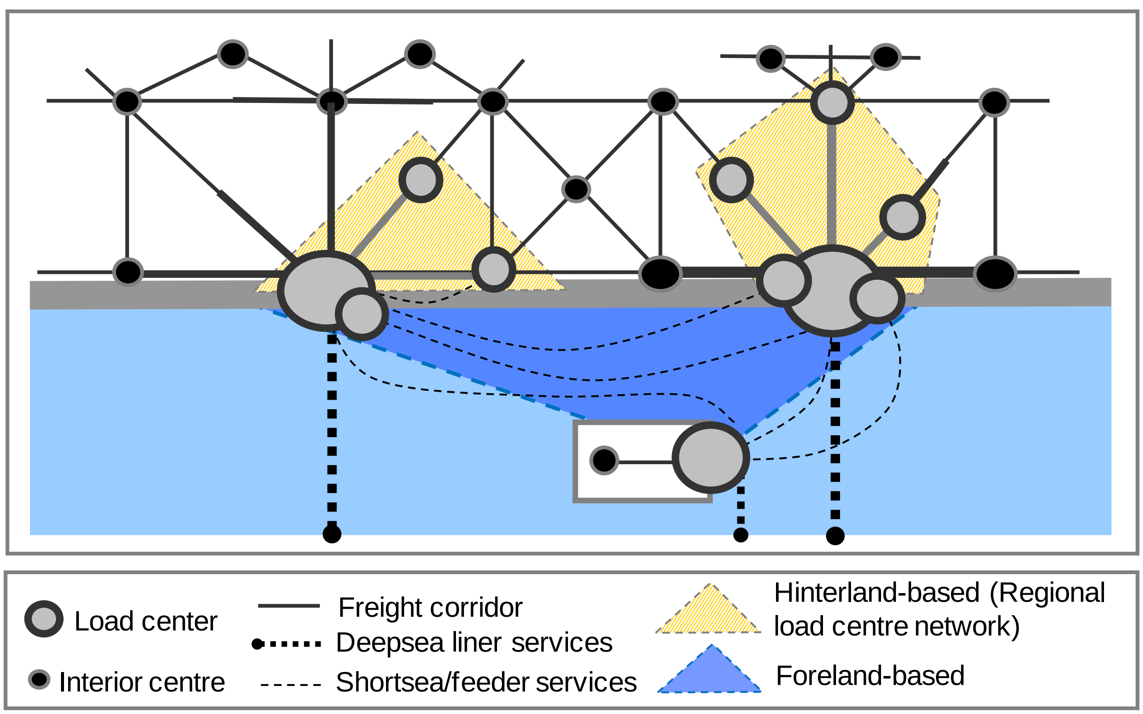


Source: Notteboom (2000) and Notteboom and Rodrigue (2005)

VI. PORT REGIONALIZATION: AN INTEGRATED DEVELOPMENT OF INLAND TERMINALS, GATEWAYS AND CORRIDORS

The creation of large logistics poles poses new challenges in the relations between seaports and inland ports. The performance of seaports is strongly entwined with the development and performance of associated inland networks that give access to cargo bases in the hinterland. To reflect changes in port-hinterland dynamics, Notteboom and Rodrigue (2005) introduced a regionalization phase in port and port system development by extending existing spatial models (as shown in Figure 4). Regionalization expands the hinterland reach of the port through a number of strategies linking it more closely to inland freight distribution centres. The phase of regionalization brings the perspective of port development to a higher geographical scale, i.e. beyond the port perimeter. The port regionalization phase is characterized by a strong functional interdependency and even joint development of a specific load centre and (selected) multimodal logistics platforms in its hinterland, ultimately leading to the formation of a regional load centre network. The port system consequently adapts to the imperatives of distribution systems.

Figure 4. The regionalization phase in the spatial development of a port system



Source: based on Notteboom & Rodrigue (2005)

An important driver for the creation of regional load centre networks relates to the requirements imposed by global production and consumption networks. No single locality can service efficiently the distribution requirements of a complex web of activities. Port regionalization permits the development of a distribution network that corresponds more closely to fragmented production and consumption systems. The transition towards the port regionalization phase is a gradual and market-driven process that mirrors the increased focus of market players on logistics integration. In the regionalization phase it is increasingly being acknowledged that land transport forms an important target for reducing logistics costs. The responses to these challenges go beyond the traditional perspectives centered on the port itself. Regionalization as such provides a strategic answer to the imperatives of the inland distribution segment of the supply chain in terms of improving its efficiency, enhancing logistics integration and reducing distribution costs.

Another factor having a major impact on port development dynamics are local constraints. Ports, especially large gateways, are facing a wide array of local constraints that impair their growth and efficiency. The lack of available land for expansion is among one of the most acute problem, an issue exacerbated by the deepwater requirements for handling larger ships. Increased port traffic may also lead to diseconomies as local road and rail systems are heavily burdened. Environmental constraints and local opposition to port development are also of significance. Port regionalization thus enables to partially circumscribe local constraints by externalizing them.

Many ports are reaching a stage of regionalization in which market forces gradually shape regional load centre networks with varying degrees of formal linkages between the nodes of the observed networks. Port authorities have a role to play in shaping efficient hinterland networks. But they have to start from the knowledge that their impact on cargo flows and on hinterland infrastructure development is limited to that of facilitator.

A large number of port authorities promote an efficient intermodal system in order to secure cargo under conditions of high competition. Port authorities can add value by setting up task forces together with various stakeholders (carriers, shippers, transport operators, labour and government bodies) to identify and address issues affecting logistics performance. These issues can relate to the bundling of rail and barge container flows in the port area and the development of rail and barge shuttles. The market players bear the market risks. Apart from port authorities, also branch associations are adopting a role as facilitator in dealing with inland transport issues (for example, Alfaport in Antwerp and Deltalinqs in Rotterdam).

Many ports fear the creation of logistics poles causes port benefits to ‘leak’ to users in inland locations. This fear and port users’ focus on logistics networks are clear invitations to port managers to consider co-operation with inland ports in the field of traffic management, land issuing, hinterland connections and services, environmental protection and research and development (R&D). A well-balanced port networking strategy should enable a port authority to develop new resources and capabilities in close co-operation with other transport nodes and with mutual interests served. Sometimes very simple co-ordination actions can substantially improve inland freight distribution, with benefits for all parties involved. Advantages of more co-operation with inland locations include:

- Increasing regional productivity by a more efficient connection with inland locations;
- Stronger support for the cargo handling function of the port because of better use of space and increased possibilities for a successful modal shift;
- Stronger position to attract investment and subsidies because of an integrated hinterland product;

- Expansion in the hinterland, and possibility to capture a market share of competitor ports;
- Retention of customers in the hinterland;
- Better insight and level of service in the local markets;
- Increased potential for intermodal services, even on shorter distances;
- More attractive hinterland services because of an increased flexibility, reliability and frequency;
- Further strengthening of the geographic concentration of logistics companies, including advantages for both seaport and inland port;
- Simplified custom procedures.

Table 3. A selection of initiatives of European and North American port authorities in establishing links with inland ports

Port authority	Project	Aim
Europe		
Antwerp	Trilogiport – Liège Other planned locations	Joint development of a 100 ha logistics platform along the Albert Canal. Status: Joint entity under the legal status of an 'economic interest grouping'
Lisbon	Puerta de Atlantico – Mostoles	Development of a logistical platform in Mostoles in the outskirts of Madrid. Status: Contract signed, January 2008
Rotterdam	EIT – European Inland Terminals	Minority shareholding in inland terminals in immediate hinterland via separate holding. Status: abandoned
Barcelona	tm-concept (Terminal Maritima)	Joint partnerships to set up dry ports / logistics zones in hinterland. Status: tmT (Toulouse), tmZ (Zaragozza), tmM (Madrid) are operational. New projects in Perpignan, Montpellier and Lyon
Marseille	Inland port Lyon	Development of Lyon as a multimodal satellite port of Marseille. Status: Société d'économie mixte founded in 1997. Port authority is one of shareholders. Joint barge and rail services between Lyon and Marseille

HHLA – Hamburg	Rail terminals	HHLA ha participations in rail terminals (Melnik, Budapest, etc.) to support its rail products via Potzug, Metrans and HHCE
North America		
New York / New Jersey	Port Inland Distribution Network	Network of rail and barge services to inland and port terminals. Status: barge service to Albany abandoned in 2006.
Virginia	Virginia Inland Port	Setting of an inland rail terminal at Front Royal. Status: Virginia Inland port operational
Los Angeles & Long Beach	Alameda corridor	Joint governance of the Alameda Corridor Transport Authority. Rail link between the satellite rail terminals of downtown Los Angeles (BNSF, UP) and on-dock and near dock rail facilities. Status: operational with more than 10,000 TEU per day

Source: the authors

Still, port authorities are quite reluctant to engage in advanced forms of strategic partnerships with inland ports (through strategic alliances, (cross-)participation, joint-ventures or even mergers and acquisitions) as they fear that they will lose added value and employment by ‘giving away’ activities, that they will lose captive cargo (port related companies in the hinterland are less dependent on one port for their maritime import and export), or that they lose clients as these might consider the cooperation with one specific hinterland location as a market restriction or distortion. In practice, mainly private market players are involved in setting up these types of cooperative networks. But informal programs of co-ordination between port authorities and inland ports are now slowly developing. Marseille (in relation to Lyon), Le Havre (in relation to Rouen and Paris), New York (in relation to the eastern seaboard) and Antwerp (in relation to Liège) are some examples (see table 3). Large load centres generally have a broad financial base to engage in a well-balanced port networking strategy, although substantial differences exist even among the largest container ports. Smaller ports and new ports have to rely solely on very simple co-ordination actions to substantially improve inland freight distribution, with benefits for all parties involved. In spatial terms this implies that regional load centre networks are most likely to be developed around large load centres, whereas smaller ports either become part of these large regional load centre networks or remain isolated in a spatial and organizational sense.

VII. SUPPLY CHAINS RECONCILING INLAND TERMINALS WITH GLOBAL FREIGHT DISTRIBUTION

In an environment of intense global competition, there are limited options to reduce costs other than through a set of freight distribution strategies. Improving supply chains leads to cost, quality and efficiency improvements, thus freight distribution strategies are a strong factor of competitiveness. Within this framework, inland terminals are becoming a fundamental part in the reconciliation between transportation infrastructure, and supply chain management. The development of inland terminals makes sense in a supply chain context for several reasons.

First of all, for a number of supply chains inland locations might possess the best resources to meet the demand linked to some activities (see discussion earlier). These activities can relate for example to those that cannot be reconciled with a high quality of life, such as distribution activities generating substantial road traffic.

Secondly, inland terminals can tackle the potential congestions in large gateway ports by shifting a part of the distribution function from seaport terminals to rail hubs and barge terminals in the immediate hinterland. As such inland terminals can make it easier for load centres to preserve their attractiveness and to fully exploit their potential economies of scale. The corridors towards the inland terminal network in fact create the necessary margin for further growth of the sea-borne container traffic. These inland terminals acquire an important satellite function with respect to the seaports, as they help to relieve the seaport areas of potential congestion. Rodrigue and Notteboom (2009) used the term '*bottleneck-derived terminalization*' in this context. Terminal operators must maintain a level of service to their users, particularly maritime shipping lines. In case of delays and capacity constraints the supply chain adapts with volume, frequency and scheduling changes and may seek alternatives if possible. Inland terminals can serve as an alternative to seaports.

The use of inland terminals to relieve pressure on seaport terminals can take many forms. For example, Rotterdam is planning to develop a series of so-called container transferia in the vicinity of the port near the main transport corridors to the hinterland service areas. At a container transferium, trucks would be loaded and discharged and inland barge shuttles would secure a frequent and reliable connection between the transferium and the large container terminals in the port. The container transferia would also provide space for additional services such as empty depots, distribution centres and customs. The first container transferium would be built near the A15, the main highway to Germany. The concept has been identified by the Dutch government as a key project in the so-called Urgency Program to relieve congestion in the Randstad, the economic heart of the Netherlands. While the Rotterdam Port Authority and the government are promoting the concept, the eventual operation of a Container Transferium will be the task for private operators. A second example concerns the San Pedro Bay Ports – Los Angeles and Long Beach. These gateways have limited options for expansion and terminal operations are increasingly facing constraining environmental regulations. About one third of all the long distance freight carried out of the San Pedro Bay ports is carried through the Alameda Corridor, a 20-mile-long rail high capacity freight expressway linking the port cluster to the transcontinental rail terminals near downtown Los Angeles. Since coming online in 2003, the number of trains going through the corridor has grown relatively on par with the containerized traffic at the port cluster. A significant factor impeding its growth is the transloading function assumed by the nearby distribution centres, an indication that the terminalization of the concerned continental supply chains cannot be easily by-passed, even with alternative inland distribution opportunities.

Thirdly, inland terminals add value to the market players in different ways. Shippers increasingly integrate inland ports in their logistics planning both for import cargo (integration in the production line) and export cargo (depot function for empty boxes). Shipping lines are increasingly using inland terminals in view of streamlining box logistics (e.g. reduction of empty hauls) and deepsea terminal operators develop links with inland terminals to increase their impact on hinterland flows.

Leading terminal operating companies are developing diverging strategies towards the control of larger parts of the supply chain. The door-to-door philosophy has transformed a number of terminal operators into logistics organizations and or organizers/operators of inland services. The European case provides a good illustration. Maersk Line wants to push containers into the hinterland supported by its terminal branch APM Terminals and its rail branches. HPH-owned ECT in Rotterdam has followed an active strategy of acquiring key inland terminals acting as extended gates to its deepsea terminals, e.g. a rail terminal in Venlo (the Netherlands), DeCeTe terminal in Duisburg (Germany) and TCT Belgium in Willebroek (Belgium). DP World is working in partnership with CMA CGM to streamline intermodal operations on the Seine and Rhône axes, while the large terminals of Antwerp Gateway (open since 2005) and London Gateway (future) are both linked to inland centres in the hinterland. DP World has set up Hintermodal in joint venture with the intermodal transport organizer Shipit to give concrete content to the concept of terminal operator haulage from the Antwerp Gateway terminal to the hinterland. The terminal operator haulage concept is aimed at a more active involvement of the terminal operator in hinterland connections by establishing closer relationships with shipping lines and inland operators. Terminal operators can play an instrumental role in bringing together intermodal volumes of competing lines and as such create a basis for improved or even new intermodal services. Eurogate has created a north-south axis connecting the rail activities of subsidiary Sogemar in the south to its extensive BoXxpress network in the north. The major private terminal of Melzo, owned by Eurogate and located in the suburbs of Milan, is where the Hannibal services between northern Europe and Gioia Tauro and La Spezia are routed. Singapore-based PSA is the only global terminal operator which has not presented a clear inland strategy yet, though they are working on it.

Thus, terminal operators are expected to increase their influence throughout supply chains by engaging into inland transport. They seem to do so mainly by incorporating inland terminals as extended gates to seaport terminals and by introducing an integrated terminal operator haulage concept for the customers. Customs can qualify an inland terminal as an extension of a deepsea terminal, so custom clearance can be done there. The terminal operator typically remains responsible en route between the deepsea terminal and the inland terminal. The advantages of the extended gate system are substantial: customers can have their containers available in close proximity to their customer base, while the deepsea terminal operator faces less pressure on the deep-sea terminals due to shorter dwell times and can guarantee a better planning and utilization of the rail and barge shuttles. However, the success of both extended gates and terminal operator haulage largely depends on the transparency of the goods and information flows.

With the increasing role of inland terminals in supply chains, a process of *warehousing-derived (buffer) terminalization* is unfolding, where the function of warehousing, in whole or in part, is shifted to the terminal (Rodrigue and Notteboom, 2009). The terminal becomes the main buffer instead of the distribution centre, which functionally makes the terminal a component of the supply chain, no longer as a factor of delay, but as a storage unit. Box 1 provides an example for the EDC of the Japanese firm JVC. It gives the supply chain a higher level of flexibility to lower their warehousing costs as well as to adapt to unforeseen events such as demand spikes or delays. An ‘inventory in transit’ strategy coupled with an ‘inventory at terminal’ one can reduce significantly warehousing requirements at distribution centres.

Box 1. Example - the extended distribution center system of JVC Belgium

JVC Belgium was set up in 1999 and is responsible for the European distribution of the products of the Japanese electronics producer JVC. The European Distribution Centre is located in Boom, halfway between Antwerp and Brussels in Belgium. JVC Belgium uses inland barges to transport the containers with imported electronics (mostly with an Asian origin) to the EDC in Boom. The containers are handled at the inland terminal TCT Belgium, part of ECT/Hutchison. The terminal maintains a daily barge connection to Rotterdam and three daily sailings to Antwerp. Over the years, JVC has developed a simple and effective system for the transport of containers between Rotterdam and Boom. Instead of giving shipping lines a separate transport order for each container, the company follows the four day rule: each container discharged in Rotterdam should be at TCT Belgium within three days. Every morning TCT Belgium informs JVC about the number of containers that are waiting at the inland terminal or will be arriving later that day. JVC picks the containers they like to have in their warehouse that day and these are subsequently delivered by truck in the morning to the warehouse. Trucks take empties on the way back to the inland terminal facility. In the afternoon, the truck bays at the EDC are solely used for supplying the regional distribution centres in the European Union. The warehouse management system of JVC considers full containers stacked at TCT Belgium to be in stock like any other inventory within the walls of the warehouse. If a full container load of a specific product needs to be delivered to a regional distribution centre somewhere in Europe, JVC might leave the stock in the warehouse and send directly a full container stationed at TCT Belgium, since it has to be moved anyway.

The streamlined supply system of JVC Belgium makes optimal use of the free storage time at the deepsea terminal in Rotterdam and at the inland terminal. Free time in Rotterdam is limited to around 5 days, while free time at TCT Belgium amounts to 21 days. By imposing the four-day rule to shipping lines, JVC Belgium guarantees the dwell time at the deepsea terminal never exceeds the free time. In other words, JVC has successfully externalized a significant share of its warehousing costs through an optimal combination of deepsea and inland terminals.

Source: based on Rodrigue and Notteboom (2009)

VIII. INLAND TERMINALS IN EUROPE AND NORTH AMERICA: OPERATIONAL CONSIDERATIONS

The last section in this paper focuses on operational issues and practices in European and North-American inland terminals. The discussion on Europe will focus on both barge and rail terminals, while the North-American discussion is limited to rail since the barge option represents a very small market in the US and Canada.

A. Rail terminals and networks in Europe

European rail logistics are highly complex. A geographically, politically and economically fragmented Europe prevented the realisation of greater intermodal scale and scope economies (Charlier and Ridolfi, 1994). For a long time, there were no obvious drivers for change in the intermodal rail industry other than the (former) national railway companies. These national railway companies lacked commitment and commercial attitude. Major complaints related to their perceived bureaucratic attitude, unannounced rate changes, long lead time required to make bookings, poor documentation management, limited tracking and tracing possibilities, limited cost-effective integration in door-to-door transport chains and the fact that in most cases no service guarantees were given. Until 1993, cross-border rail traffic of maritime containers in Europe was the exclusive right of Intercontainer. The rail liberalisation process (see e.g. Bologna, 2004 and Debrie and Gouvernal, 2006 on this issue) should lead to real pan-European rail services on a one-stop shop basis. All over Europe, new entrants are emerging while some large former national railway companies have joined forces (cf. Railion). The emergence of a new generation of rail operators not only made incumbent firms act in a more commercial way, but also led to an improvement in the endogenous capabilities of the railway sector which in time could make rail a more widespread alternative in serving the European hinterlands, at least if some outstanding technical and operational issues facing cross-border services can be solved.

On the operational side, launching new rail services remains very costly and finding the necessary critical mass is not an easy task, especially when facing a fragmented cargo base controlled by many forwarders. This has opened the door to an increasing involvement of major shipping lines, terminal operators (mainly in Italy and Germany) and port authorities (for example Barcelona and Marseille). Direct shuttle trains constitute the backbone of rail services out of European ports. These shuttle trains can only be exploited in a profitable way on a number of high-density traffic corridors such as the Rhine axis and the trans-Alpine route. Some rail operators have resolved the problems related to the fluctuating volumes and the numerous final destinations by bundling container flows in centrally located nodes in the more immediate hinterland. Numerous hub-and-spoke railway networks emerged in the 1990s (see e.g. Notteboom, 2001; Kreutzberger, 2005). The nodes within these networks were connected by frequent shuttle trains with capacities for a single train combination ranging from 40 up to 95 TEU. An example was the Qualitynet of Intercontainer-Interfrigo (ICF) with Metz-Sablon in the north-east of France as a master hub linking up the Rhine-Scheldt delta ports with the rest of Western Europe.

Such hub-and-spoke networks now appear to be vulnerable, as the volumes on the spokes can be affected by (1) newcomers entering the market in the aftermath of European rail liberalization and (2) increasing intermodal volumes in seaports. New railway operators often engage in cherry picking by introducing competing direct shuttle trains on a spoke of an established hub-and-spoke network of a competitor. This has a negative affect on cargo volumes on the spoke and might lead to a collapse of the whole hub-and-spoke system. This is what happened to ICF's Qualitynet in 2004. ICF launched its new strategy in December 2004. The intermodal traffic of the former Qualitynet hub in Metz are now handled by a set of direct shuttles trains to less destinations. For East- and Southeast Europe, services are centered around the hub in Sopron (Hungary).

At present, a wide array of rail operators together make up the supply of hub-based networks, direct shuttles and inter-port shuttles out of the large load centres. Hamburg's rail connections outperform all other ports in numbers (i.e. more than 160 international and national shuttle and block train services per week) and in traffic volumes by rail (i.e. over 1 million TEU in 2005). Rotterdam and Antwerp each have between 150 and 200 intermodal rail departures per week. Smaller container ports in the range tend to seek connection to the extensive hinterland networks of the large load centres by installing shuttle services either to rail platforms in the big container ports or to master rail hubs in the hinterland.

Rail terminals in Europe are typically build and operated by large railway undertakings. Before European rail liberalization the respective national railway companies established national networks of rail terminals. The entry of new players in the wake of the rail liberalization process meant that major rail centers are now witnessing a multiplication in the number of rail terminal facilities, with each terminal being operated by a specific rail operator.

The largest rail facilities have bundles of up to 10 rail tracks with lengths of maximum 800m per track. The limitation in track length is linked to the existing limitation in the length of freight shuttle trains (max. 750m). DB in Germany is setting up experiments to increase the length of the trains on certain corridors (up to 1000m or even 1200m), but this initiative is still in a pioneering stage. Rail hubs are typically equipped to allow simultaneous batch exchanges (direct transhipment) through the use of rail-mounted gantry cranes that stretch over the rail bundles. However, rail hubs also typically feature a small stacking area to cope with synchronization problems between rail shuttles and to allow containers to be feedered by trucks.

B. Barge terminals in Europe

Barge container transport in Europe has its origins in transport between Antwerp, Rotterdam and the Rhine basin, and in the last decade it has also developed greatly along the north-south axis between the Benelux and northern France (Notteboom and Konings, 2004). Antwerp and Rotterdam together handle about 95% of total European container transport by barge. Volumes on the Rhine have increased from 200,000 TEU in 1985 to some 1.8 million TEU in 2006 leading to higher frequencies and bigger vessels (figures Central Commission for Navigation on the Rhine). At present the liner service networks offered on the Rhine are mainly calling at 3 to 8 terminals per navigation area (Lower Rhine, Middle Rhine, Upper Rhine). The inland vessels used on the Rhine have capacities ranging from 90 to 208 TEU, although some bigger units and push convoys of up to 500 TEU can be spotted occasionally. Rotterdam has a strong position on barge traffic from/to the lower Rhine and middle Rhine, whereas Antwerp and Rotterdam are equally strong on the upper Rhine.

The number of terminals in the Rhine basin is steadily increasing. This is the result of new terminal operators arriving on the market and of new terminals appearing along the Rhine and its tributaries. The growing realization of the potential offered by barge container shipping has led to a wave of investment in new terminals over the past ten years, in northern France, the Netherlands and Belgium. The Benelux and northern France now have more than 30 container terminals, about as many as in the Rhine basin. In 1991 there was still no terminal network on the north-south axis (only two terminals). The next step is to establish a network of liner services connecting the various terminals outside the Rhine basin on a line bundling basis.

Barge services and inland terminals are also being developed outside the Rhine-Scheldt-Meuse basins. The barge container market is booming on the Rhône (55,807 TEU in 2005) and on the Seine (159,000 TEU in 2007 via barge services operated by Logiseine, River Shuttle Containers, Marfret, MSC and Maersk). Hamburg is slowly developing barge services on the Elbe, with annual volumes in 2006 exceeding 140,000 TEU compared to only 30,000 TEU in 2000. And there are even initiatives to introduce small-scale barge services on the Mantova–Adriatic waterway in Northern Italy.

Some have raised concerns regarding a possible over-supply of inland terminals. The cycle theory states that once a phase of maturity is reached, rationalization commonly leads to the closing of the least productive elements. Governments (local, regional, national, supranational) promote the use of inland navigation as an alternative to road (modal shift). Especially in the 1990s and the first half of this decennium, start-up premiums for services and infrastructure subsidies were readily available. For example, the first EU Marco Polo programme supported modal shift actions and could co-finance up to 30% of the start-up costs for a new service for a period of three years. At present, the market mechanism guides the European barge terminal sector. The decreasing financial support of public authorities has resulted in an increased pressure towards a rationalization phase driven by mergers and acquisitions in the inland terminal business and the consolidation of flows in larger facilities.

The bulk of the barge services is controlled by independent barge operators. They have always shown a keen interest in the exploitation of inland terminals. About two thirds of all terminals in the Rhine basin are operated by inland barge operators or the logistics mother company of a barge operator. The remaining terminals are operated/owned by stevedoring companies of seaports, inland port authorities (e.g. Port Autonome de Strasbourg) or logistic service providers.

The leading barge container carriers are increasingly trying to achieve a functional vertical integration of the container transport chain by extending the logistical services package to include complete door-to-door logistical solutions. In the 1990s, three logistics holdings got a strong grip on the barging market. Wincanton controlled 33% of containers moved by barge in the Rhine basin in 2004. Wincanton is the mother company of Rhenania with subsidiary Rhinecontainer (375,000 TEU in 2004). Rhenus Logistics, mother company of Contargo (including SRN Alpina and CCS), reached a market share of 22% and Imperial Logistics Group, mother company of Alcotrans, 15% (Zurbach, 2005). Alcotrans transported around 220,000 TEU on the Rhine in 2006. The Contargo network, comprising of 19 inland container terminals in Germany, the Netherlands, France and Switzerland, handled some 840,000 TEU in 2006. The integration of leading barge operating companies in the structures of highly-diversified logistics groups further strengthens the functional integration in the logistics chain.

At the operational side, we address two important issues: (1) the consolidation or bundling of cargo in seaports and (2) operational considerations in the development and implementation of inland barge terminals.

We start with the first issue. In the seaports of Rotterdam and Antwerp, Europe's biggest load centres for inland waterway traffic, barge container transport is increasingly being confronted with operational problems hampering its image as a reliable transport mode. Due to the enormous increase in deepsea container traffic in these two ports, coupled with the fact that deepsea vessels are granted priority over barges when they have to be handled alongside the same quay, barge container transport is confronted with increasing waiting times (waiting times of up to 48 hours were no exception). This results in the disruption of barge's sailing schedules and unexpected costs. The resulting uncertainty and unreliability of barge services means that trucks are often chosen unnecessarily. Another problem faced by barge container transport is the fragmentation of container flows in seaports. Barge operators sailing between Rotterdam/Antwerp and terminals along the Rhine typically call at a large number of terminals in both seaports (so-called terminal shopping), which results in a low number of container moves per terminal and a significant amount of time spent in port. On the Rotterdam/Antwerp market, the number of terminals called at is lower, resulting in higher call sizes and a lesser amount of time spent in port. A possible solution to the problem of low call sizes and time losses in seaports is the consolidation of barge container flows at a limited number of seaport terminals. This, however, increases inter-terminal transport and handling costs for the stevedore. Given the fact that handling costs take up a large share of the total port-to-door transport costs, particularly for short port-to-door distances, this would significantly hamper inland navigation's competitive position vis-à-vis other transport modes.

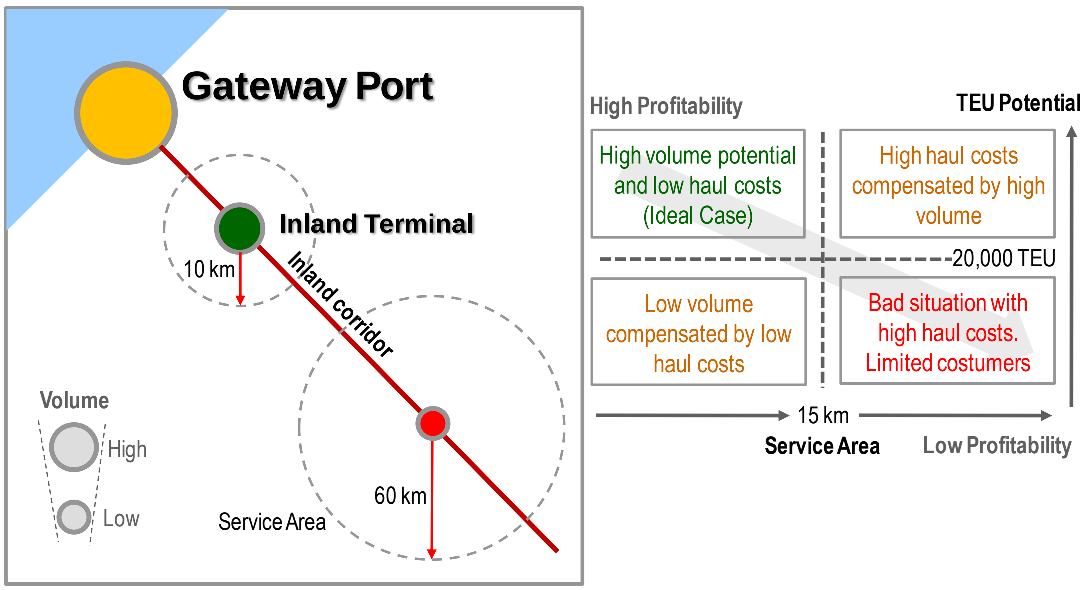
A core problem is the lack of transparency on barge flows in seaport areas. Both in Rotterdam and Antwerp relevant parties are now brought together by the port authorities to obtain a better insight on the barge-related flows moving in the respective ports. The ultimate aim is (a) to give advice to barge operators through existing barge traffic systems on the optimal terminal loading sequence and (b) to create a good market environment for the bundling of small batches of containers so that the average call size of barges increases. In some cases the barge operators or inland terminal operators have taken matters in their own hands. The long barge turnaround times and delays at the port of Rotterdam in 2006 was jointly addressed by deepsea terminal operator ECT (part of Hong Kong-based Hutchison Port Holdings) and the

Dutch association of inland terminal operators VITO. The partnership resulted in the allocation of a barge crane at the ECT Delta Terminal to the handling of inland ships of VITO members. In return, VITO stationed a planning staffer at the Delta Terminal in charge of a more evenly supply of ships around the clock and provides more advance information to ECT on the containers to be discharged and loaded. VITO ensures that all the necessary information arrives via electronic data interchange (EDI) ahead of time. ECT takes the responsibility for the internal container transport between the deep-sea terminals and the barge terminal.

The second relevant issue relates to operational considerations in the development and implementation of inland barge terminals. The location decision and the associated market analysis are of strategic importance to the success of a terminal. A low bridge along the river or canal between a seaport and the planned inland terminal may limit the stacking height on the vessel (e.g. three layers instead of four), thereby decreasing the profitability of the liner service. Next to these air draft considerations, the draft of the canal or river is obviously also a major concern since it will define the maximum deployable vessel scale. Planners have to follow a realistic approach when estimating the market potential of an inland terminal at a certain location. This implies they should take into account (a) the ‘modal shift’ potential in the area (i.e. the willingness of companies to shift from truck to barge), (b) existing and future competing inland terminals that might limit the market potential of the terminal under consideration and(c) the traffic evolution and modal split expectations in the associated seaports. A location near a few big shippers which bring in the critical mass has proven to be an important success factor to inland barge terminals. Inland terminal operators need to develop a door-to-door product and an extensive service package for the customers. This requires e.g. good arrangements with shipping lines and local trucking companies. The costs for pre- and endhauls by truck are considerable and explain why the range of the service area of inland terminals is often rather limited. Planners also have to take into consideration that the market for pure continental barge services between two inland terminals is very small in Europe.

The profitability of an inland container terminal typically depends on two factors, namely its throughput and the size of its service area. As far as throughput is concerned, a minimum volume is required in order to be profitable (20,000 TEUs in case of Dutch inland terminals, figure 5). A high throughput enables a quick recovery of fixed investment costs (in infrastructure, superstructure and ICT systems), which take up a large share of the total terminal handling costs. The size of the service area has a large impact on the competitiveness of an inland terminal. In case the inland terminal is located in the vicinity of the seaport, the service area of the inland port (the market threshold) often covers a range of 10 km or less around the terminal, making the last trucking leg short and time responsive. Far away from the seaports (>300 km), service areas of inland terminals in some cases stretch up to a range of 60 km. Larger service areas imply high haul costs (pre- and end-haulage), which seriously hampers a terminal's ability to attract new business, confer longer delivery times and increase the risk of competition with other inland terminals. All this impedes the acquisition of possible new customers. The expected terminal profitability is highest for terminals with a high throughput and a small service area.

Figure 5. Service area of inland barge terminals (European situation) and a matrix of inland terminals based on TEU potential and service area (applicable to Dutch inland terminals)



Inland barge terminals are advised to follow a low-cost orientation in the start-up phase. In practice this implies that an inland barge terminal can best handle cargo with reach stackers until the terminal reaches a volume between 5,000 and 10,000 TEU. At these volumes it is worthwhile to consider buying a gantry crane designed to handle vessels (via the outreach of the crane), stack containers (in between the 'legs' of the crane) and handle trucks (via the outreach at the landside of the crane). Terminals on the Rhine typically handle 25,000 to 35,000 TEU per crane per year, so above this throughput figure the terminal operator will have to consider adding an additional crane.

Most inland terminal operators use individual barges to guarantee frequent services with the relevant seaport(s). For a regular service on a short to medium distance one needs at least two barges (limitation of risk). Barge services that connect to other terminals as well will lead to a lower necessary critical mass per terminal given a desired service frequency and the unit capacity of the vessels. Such line-bundling services are very common on the Rhine and are also slowly developing in other navigation areas (see discussion earlier).

The utility of providing logistics services on the terminal will depend on the main focus: a terminal with a strong orientation towards shipping lines (carrier haulage) will typically not really need warehousing and other logistics services, while a terminal with a strong focus on shippers (merchant haulage) might have to develop logistics services. A relatively new development is the interconnection of the terminal planning system with the IT systems of main customers (shippers and or shipping lines) in view of increasing the visibility of the flows.

C. Rail terminals and networks in North America

Intermodal rail is of primordial importance to support long distance trade corridors and inland ports in North America. It accounts for close to 40% of all the ton-miles transported in the United States, while in Europe this share is only 8%. Rail freight in the United States has experienced a remarkable growth since deregulation in the 1980s (Staggers Act) with a 77% increase in tons-km between 1985 and 2003. The North American rail transport system shows a high level of geographical specialization with seven large private rail carriers servicing large regional markets. Rail companies have their own facilities and customers and thus have their own markets along the segments they control. Each rail system is the outcome of substantial capital investments occurring over several decades with the accumulation of impressive infrastructure and equipment assets. However, such a characteristic created issues about continuity within the American rail network. Mergers have improved this continuity but a limit has been reached in the network size of most rail operators. Attempts have been made to synchronize the interactions between rail operators for long distance trade with the setting of intermodal unit trains. Often bilateral, trilateral or even quadrilateral arrangements are made between rail carriers and shipping companies to improve the intermodal interface at the major gateways or at points of interlining between major networks. Chicago is the largest interlining center in North America, handling around 10 million TEU per year. Its location is at the junction of the Eastern, Western and Canadian rail systems and de facto North America's main inland port.

The main growth factors for rail activity in recent years have been linked with a growth in international containerized trade, particularly across the Pacific, a growth in the quantity of utility coal moving out of the Powder River basin and a growth of the Canadian and Mexican transborder trade. Intermodal and coal represent the two most important sources of income for most rail operators; container traffic represented approximately 80% of all rail intermodal moves. Long distance intermodal rail transport corridors have favored the setting of what are known as landbridge serviced originating from major port gateways.

The main North American landbridge links two major gateway systems; Southern California and New York/New Jersey via Chicago. Landbridges are particularly the outcome of cooperation between rail operators eager to get lucrative long distance traffic and maritime shippers eager to reduce shipping time and costs, particularly from Asia. The two largest North American railroads, UP and BNSF, derive a sizable share of their operating revenue from long distance intermodal movements originating from the Pacific Coast and bound towards the eastern part of the continent.

Long distance intermodal rail corridors are also planned in a latitudinal fashion to Mexico. Kansas City Southern de Mexico (KCSM, a subdiary of Kansas City Southern; KCS) is building an USD 80 million intermodal terminal next to the port of Lazero Cardenas. KCSM plans to establish a new International Intermodal Corridor stretching 1,300 miles across Mexico to the border crossing at Laredo, Texas. At Laredo, the Kansas City Southern system that connects to major American rail hubs, namely Chicago and Kansas City, takes over (Randolph, 2008). KCS has also invested in the development of a new rail terminal at Richards Gabaur in Kansas City, a project supported by the setting of a logistics pole in a former military base. NAFTA rail corridors and the setting of inland hubs is thus a strategy that goes hand to hand, each element reinforcing the other.

However, due to road congestion, infrastructure capacity issues and a surge in fuel price the advantages of the landbridge are being challenged, particularly for long distance trade. For instance, shipping a forty foot container from New York to Korea cost about USD 3,000 if the all-water maritime route through the Suez Canal is used and USD 9,000 if shipped by rail to a West Coast port and then across the Pacific. Thus, this form of rail intermodalism appears to have reached a phase of maturity. Still, the market segment of domestic (North American) rail intermodalism is expected to grow substantially as the only available alternative to long distance trucking. This will lean on the setting of a variety of inland terminals acting as load centers for the respective market areas.

The United States alone has about 2,270 rail facilities performing some form of intermodalism by being able to move freight from rail to trucks. Although this appears to be a large number, only about 20% of these facilities handle a significant intermodal volume and less than 10% of them are true intermodal container terminals. The rest are local facilities fulfilling specific industrial, resources or manufacturing needs for bulk and break-bulk shipments. Thus, the North American system of operational intermodal rail terminals handling COFC and TOFC traffic accounts for about 206 facilities covering major inland markets.

Most intermodal terminals are clustered around major maritime gateways (Los Angeles, New York) and intermediary locations having strong inland logistical activities and inland ports

(Chicago, Memphis, Kansas City). The location of intermodal rail terminals is a balancing act between gateway location, market density, interlining and complementarity with trucking. In spite of a system controlled by only seven major operators, the great majority of inland load centers are serviced by a least two operators, which confers a level of competitiveness and offers options for regional shippers. For the western system, most load centers are serviced by both BSNF and UP, while for the eastern system, most load centers are serviced by both UP and CSX. A similar pattern is observed for the Canadian system with CN and CP. There are however a few notable exceptions serviced by only one intermodal terminal and with no nearby competitors such as for Halifax (CN), Salt Lake City (UP), Billings (BNSF), Albuquerque (BNSF), Amarillo (BNSF) and Prince Rupert (CN). On the opposite range of the spectrum several locations, particularly at the interface between regional systems, have three or more rail operators (Detroit, Chicago, St. Louis, Kansas City, Memphis, Dallas-Fort Worth, New Orleans and Atlanta). They are thus particularly prone to a more competitive inland terminal setting offering shipping options to both the east and the west coasts.

In the North American setting, inland ports must provide three fundamental services to containerized trade

- Repositioning. The American economy has a negative trade balance with most of its major trade partners, implying that it imports more than it exports, both in volume and value. This generates empty backhauls. Under such circumstances, an inland port must provide the physical and logistical capabilities to insure that empty containers are repositioned efficiently to other markets if local cargo cannot be found.
- Cargo rotation. Whether there are imbalances in container flows or not, an inland port must insure that the inbound and outbound flows are reconciled as quickly as possible. A common way involves a cargo rotation from imports activities where containers are emptied to exports activities filling containers. For container owners, let them be

maritime shipping or leasing companies, a rapid turnover of their assets is fundamental and will secure a continuous usage of the inland port.

- Support for trade. An inland port can also be a fundamental structure promoting the export sectors of a region, particularly for smaller businesses unable to achieve economies of scale on their own. Through lower costs and better accessibility, new market opportunities become possible as both imports and exports are cheaper.

CONCLUSIONS

The growing focus on inland ports is indicative of transport development strategies gradually shifting inland to address capacity and efficiency issues in light of global supply chains. The complexity of modern freight distribution, the increased focus on intermodal transport solutions and capacity issues appear to be the main drivers. While trucking tends to be sufficient in the initial phase of the development of inland freight distribution systems, at some level of activity, diminishing returns such as congestion, energy consumption and empty movements become strong incentives to consider the setting of inland terminals as the next step in regional freight planning. Also the massification of flows in networks, through a concentration of cargo on a limited set of ports of call and associated trunk lines to the hinterland, have created the right condition for nodes to appear along and at the end of these trunk lines.

Inland terminals have become an intermodal and freight distribution unit that comes into three major functional categories. They can be maritime barge terminals serviced from deepsea ports, intermodal rail terminals linked to gateways and distribution centers linking supply chains. Inland ports are commonly incorporating terminals (rail, barge or in rarer cases both) with distribution centers in operational characteristics mainly associated with satellite terminals or load centers.

Regional issues, namely how inland ports interact with their regional markets, remain fundamental as they define the modal characteristics, the regulatory framework and the commercial opportunities of these ports. The prospects for inland terminals remain positive with large continental markets like North America and Europe relying on a network of satellite terminals and load centers as a fundamental structure to support hinterland freight movements. This entailed the emergence of a regionalization of distribution and with it extended forms of supply chain management in which inland terminals play an active role. As congestion increases, inland terminals will be even more important in maintaining efficient commodity chains. It can also be expected that commodities, such as grain, chemicals and wood products, will play a greater role within containerized trade with inland terminals, again underlining unique regional characteristics. This implies a set of repositioning strategies where inland terminals play a fundamental role either to improve the efficiency of this repositioning, by providing better cargo rotation opportunities, or by acting as an agent that can help promote containerized exports. Inland ports will take part of the ongoing intermodal integration between ports and their hinterland through long distance rail and barge corridors. They are likely to be more important elements within supply chains, particularly through their role of buffer where containerized consignments can be cheaply stored, waiting to be forwarded to their final destinations.

Following previous stages in intermodal transport development, such as in port infrastructure, there is a potential of overinvestment, duplication and redundancy as many inland locations would like to claim a stake in global value chains. This appears to be the case in Western Europe where an abundance of inland terminals, particularly within the Rhine / Scheldt delta, is indicative of an over competitive environment and the waste of resources it implies. In

North America, because of a different ownership and governance structure, the setting of an inland port, at least the intermodal terminal component, is mostly in the hands of rail operators. Each decision thus takes place with much more consideration being placed on market potential as well as the overall impact on their network structure. The decision of a rail company to build a new terminal or to expand existing facilities commonly marks the moment where regional stakeholders, from real estate developers to logistics service providers, readjust their strategies. In some instances, local governments will come with inland port strategies adjusting to existing commercial decisions in the hope to create multiplying effects.

In light of the North American and European experiences, the question remains about how Asia-Pacific can develop its own inland port strategy and regionalism. The unique geographical characteristics of the region, particularly a high level of coastal development and its export-oriented economies, are likely to rely much on the satellite terminal concept and inland load centers in relative close proximity. For this context, the European example is more suitable. However, the setting of long distance intermodal rail corridors within China and through Central Asia is prone to the inland load center system common in North America. Yet, there are no clear frameworks in the setting of inland terminals as the region and supply chains they are embedded in dictates much of their functional and operational realities. What is the likely next phase in the evolution of inland freight distribution and which role inland terminals will play?

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