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PORT COMPETITION AND HINTERLAND CONNECTIONS

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The International Transport Forum was created under a Declaration issued by the Council of Ministers of the ECMT (European Conference of Ministers of Transport) at its Ministerial Session in May 2006 under the legal authority of the Protocol of the ECMT, signed in Brussels on 17 October 1953, and legal instruments of the OECD. The Forum's Secretariat is located in Paris.

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1. INTRODUCTION

Maritime freight transport has experienced strong growth and profound change over recent decades. Freight volumes and container traffic in particular have grown with the intensification of global trade and the geographical dispersion of production. The industrial organization of the sector has evolved rapidly. These changes have rendered the ports business environment more challenging. Many agents along the supply chain have engaged in horizontal and vertical integration of activities. This has lead to more efficiency in the movement of cargo, but has reduced the number of players, with an attendant risk of abuse of market power. The market power of the ports *vis-à-vis* shippers and shipping companies has become correspondingly weaker.

The rapid expansion of trade has led to fast growth of throughput in many ports. As a result, in many large gateway ports, local communities are increasingly concerned about the negative impacts of port activity, including local pollution and congestion. The greenhouse gas emissions generated by freight traffic are also a growing policy concern. This paper explores the economic framework in which potential regulatory intervention to address the issues of competition, air pollution, congestion, greenhouse gas emissions, and financing and provision of infrastructure should be considered. It begins with an overview of the main changes in the sector, emphasizing how they have affected the role of ports and of other players in the supply chain (Section 2). Section 3 asks if ports' current responses to the changing environment are appropriate, or whether ports could and should play a more active role in shaping the supply chain. It is argued that there may be ways for ports to strengthen their positions within the supply chain, but that their actions may not always serve the public interest, even when ports effectively pursue a mix of public and private goals. Section 4 examines the policy issues that result. We first look at local authorities' scope for reducing negative local impacts, and conclude that some agents along the supply chain are sufficiently influential to affect policy design and potentially defeat its aims. At the same time purely local regulation of these impacts is likely to ignore the benefits of trade that occur outside the local economy. These observations highlight the need for better regulation at a national or multilateral level. Unfortunately, there is little evidence of systematic national – let alone transnational – policy frameworks towards ports or towards supply chains in general. This is problematic, given the emergence of large transnational conglomerates that have created agile and footloose supply chains with sufficient power to withstand or evade attempts to regulate them at national level.

2. THE CHANGING INDUSTRIAL ORGANIZATION OF SUPPLY CHAINS AND THE IMPACT ON PORTS

This section briefly discusses three of the major changes in the way maritime-based freight transport is organized: containerization, the emergence of global supply chains, and the rising importance of transshipment container terminals. The impact of these changes on the role and power of ports in the supply chain is then discussed.

2.1. Containerization, larger vessels, and expanding hinterlands

Containerization was a major technological innovation that revolutionized the nature of maritime-based freight transport of manufactured goods. It caused a substantial degree of standardization of port services, implying that ports cannot rely on specialization to maintain market share and generate revenues as much as they used to. With containerization, ports in the same region become closer substitutes, and hence are more exposed to competition from other ports and other routes. This tendency is reinforced by two other factors. First, the use of ever larger container vessels[1] implies that fewer port calls are required for the same freight volume. This move to larger ships reduces shipping lines' dependence on particular ports and intensifies competition among ports for the remaining calls (assuming each port can handle the larger vessels[2]). Second, the emergence of intermodal rail and barge corridors has extended gateway ports' geographical reach. The extension of hinterlands leads to more overlap among ports' hinterlands and hence to stronger competition.

These technological factors imply that the exposure of ports to competition has increased. At the same time, there has been widespread adoption by governments of new public management principles and the ensuing devolution of port management has resulted in a more commercial approach to the management of port operations (Brooks and Cullinane, 2007); this has led to intensified port competition as well. This is not to say that all ports behave like private firms as, in many cases, they pursue a mix of private and public objectives and there is considerable public sector involvement in infrastructure supply. The change in port behavior has been facilitated by a rather passive policy context; in section 3, the question to be tackled is: is a more active public policy towards port and supply chain developments now required?

Port competition is intense, but ports are not "perfect substitutes", i.e. they are not interchangeable perfectly or without cost. First, gateway ports still have a strong position in at least some of their service area, as hinterlands do not overlap completely. Second, the intensifying effect of containerization on port competition may be muted by congestion in ports or in their hinterland transport networks. When a port or its hinterland facilities are more strongly congested than is the case for competing ports, the quality of that port's service may be lower in that it takes more time to access and egress the port and the reliability of service declines, and this weakens its competitive position. The interaction between port competition and congestion is discussed in more detail later in this section. Third, switching ports is costly, although more from a terminal operator's point of view than from the perspectives of shipping lines or manufacturer-controlled supply chains. There is no consensus in the literature on the degree of inertia in port choice from shipping lines' point of view. It is widely accepted that supply chains are increasingly footloose, but it is less clear which elements of inertia remain.

2.2. The emergence of global supply chains

The second driver of change that directly affects the role of ports is the development of global supply chains. These chains link strongly dispersed production and sourcing sites to more geographically concentrated consumption regions. What matters from the point of view of shippers and customers is the performance of the supply chain in terms of price, service quality and reliability. This focus on the chain as a whole is reflected in efforts of the players in various segments to consolidate, vertically integrate or otherwise enter into long-term contracts, in order to drive costs down but also to increase the level of coordination and synchronization. Such concentration and restructuring carries a risk of generating excessive market power for some of the actors in the chain. It has also increased volatility, meaning that small deviations from expected or planned processes have large consequences for system performance. Volatility increases uncertainty and induces logistics providers to build in redundancy by using more than one of a set of routing options, so as to mitigate route risk. This trend further weakens the shipper or customer's reliance on a specific port.

The increase in levels of concentration, along several dimensions, is quite spectacular. In 1980, the top 20 of the world's shipping lines controlled 26% of TEU-slot capacity; by 2007 their share had increased to 81% (Notteboom, 2008).[3] Many of these top 20 further concentrate effort by engaging in alliances. Shipping lines also vertically integrate, in some cases working towards "extended gates" where shipping lines take control of inland transport and inland terminals and depots. At the level of port terminal operations, the market share in terms of throughput of the top 10 players rose from 42% in 2001 to 55% in 2005. This raises concerns over increasing market concentration. Some terminal operators have extended vertically in the direction of "terminal operator haulage". With respect to vertical integration, the current picture is one of widespread experimentation with ways of organizing the supply chain (see Notteboom, 2008, for an overview). While it is not clear exactly which models will persist, the emerging picture is one of market dominance by a handful of large players at each segment of the supply chain, combined with fringe firms specialising in profitable niche markets. Despite the small number of players, competition in and for the market (within and between ports) is strong, and may be strong enough to alleviate concerns about market power in the supply chain in many circumstances. Concerns were expressed by participants that the market power of integrated, global transport and logistics companies is a concern for ports themselves. Finally, geographical concentration of flows is increasing as well. For example, the North-South imbalance among ports in Europe is growing larger, and this is largely because of more favourable hinterland transport conditions in the North.

It is noteworthy that many actors along the supply chain are involved in attempts to vertically integrate, but that ports as such have not strongly engaged in this trend. In combination with the technological trends discussed earlier, this further weakens ports' market and bargaining power.

2.3. The rising importance of transshipment hubs

A third key change is the changing role of transshipments. Gateway ports become more engaged in transshipments, and pure transshipment hubs have emerged. More than 20 of the 100 largest ports worldwide are transshipment hubs, in the sense that at least half of traffic is ship-to-quay-to-ship (Baird, 2007). This evolution is related to increasing vessel size and fewer port calls per service discussed before, and is taking place in many regions. Major gateway ports are increasingly profiling themselves as transshipment terminals, because the fragmentation of production tends to pull production out of (relatively expensive) gateway cities.

Shifting transshipment to pure transshipment hubs reduces the pressure on gateway port capacity, which can then focus on serving expanding hinterlands. There is no such hub in Northern Europe at present, so that some 30% of activity in gateway ports in the region concerns transshipment. While these ports may have little incentive to shed this traffic, it is less clear whether maintaining the current port configuration is optimal from a broader point of view. The idea to construct a hub at Scapa Flow (Orkney Islands) is thought superior by Baird (2008). At the same time, transshipment hubs in the Western Mediterranean are currently moving towards more direct calls, a trend that may extend to the Eastern Mediterranean. More in general, the hub-and-spoke model is attractive when the density of demand is low, but becomes less attractive as market volumes rise. Assuming continued growth of demand, this suggests that the pure hub port model may not remain viable as, ultimately, handling costs are lower for direct service than for transshipment connections.

2.4. Impacts on ports

One consequence of the three drivers of change in the organization of supply chains is that gateway ports have in many cases become a replaceable element of the chain, with relatively weak bargaining power. A port that provides service of a given quality at the lowest price does not necessarily gain market share, as other factors – that are not under the port's control – also affect port choice. The focus shifts from port performance to supply chain performance. Among the other factors, hinterland transport costs have become relatively important, as the cost per kilogram per km on the hinterland is 5 to 30 times as high (depending on the hinterland transport mode) as the maritime shipping cost (Notteboom, 2008). Routing choices, and to some extent port choices, are strongly dependent on hinterland transport conditions and reliability of the total route has become increasingly important to those in the supply chain making the routing decisions.

This is not to say that port price and "internal performance" are irrelevant. For example, Blonigen and Wilson (2006) find that port efficiency affects port choice. Also, efforts to improve the reliability of port services can have a substantial payoff and, consequently, reduce the incentives for shipping lines to acquire dedicated terminal capacity. Ports can increase their attractiveness by exploiting complementarities with other parts of the supply chain, for example through closer ties with inland distribution centers, as well as by making efficient use of capacity in the port and the hinterland where they can (De Langen, 2008).

One way of increasing effective port capacity is through technological and operational innovations within the port. Rodrigue (2008) claims that improvements are available to double the throughput of existing terminal facilities[4]. A second way to effectively increase port capacity is to move some functions into the hinterland. For example, ports' distribution function is being decentralized by the creation of truck based inland distribution centers in the nearby hinterland ("port regionalization", Notteboom and Rodrigue, 2005), so relieving pressure on port capacity. In sum, it seems that port capacity is not a major constraining factor in determining a port's attractiveness, as no excessive levels of congestion should systematically arise there. This assessment is reinforced by the observation that capacity use in ports is organized in a more coordinated way than in general purpose transport networks (as usage patterns are less fragmented), leading to better (though not necessarily optimal) congestion management.

2.5. Impacts on modal split and on congestion in the hinterland

Hinterland transport uses a mix of road freight, rail, and marine (barge and short sea shipping variants). Rail and barge operators require cargo consolidation in order to provide an economically viable service. The combination of increased concentration at the level of shipping lines and terminal operators and increased vertical coordination should therefore provide conditions favourable to development of rail and barge transport, in the sense that it promotes carrier haulage and not merchant haulage. Nevertheless, it is likely that the success of rail and barge will be limited to a fairly small number of corridors where densities of traffic are sufficient, and should not be expected to change drastically port impacts on hinterland road networks[5]. Short sea shipping is another potential competitor for road haulage. The "Motorways of the Sea" initiative in the European Union aims to stimulate sea-based hinterland services. The competitive position of sea-based hinterland transport depends to a large extent on the prevailing prices and infrastructure subsidies for other modes. Distortions in the pricing of infrastructure use may hamper its development, e.g. where road freight uses infrastructure at a price below marginal social cost. Furthermore, outside of Europe, the divergence of regulatory policies applicable to short sea shipping restricts its development by industry, with cabotage in US waters protected by the Jones Act.

It is noteworthy that inland distribution centers (port regionalization) increase pressure on hinterland road and rail networks in Europe, with adverse effects on congestion and air pollution. This form of port decentralization discourages a modal shift from truck to rail or barge (or from rail to short sea), an effect likely to persist in the long run given the land-use decisions involved. Ports tend to opt for regionalization because cheap land is available outside the port and externalities are not internalized, so that port regionalization is cheaper than increasing in-port capacity. If relatively cheap options to increase in-port capacity are available but ports nevertheless choose regionalization, there may be a role for public policy to stimulate the development of in-port capacity, preferably by bringing the costs of truck-based inland distribution centres in line with social costs through infrastructure pricing policies. Land-use policies may be used as well, but fragmentation of responsibilities and the risk of unexpected and unintended side effects make them less attractive.

The social costs of ports include not only congestion effects, but also local and global pollution. Global pollution matters because the decentralized port region model is likely to be more greenhouse gas-intensive than the centralized model and possibilities for carbon capture are smaller (e.g. plans to store carbon in gas fields in the Port of Rotterdam were mentioned during the discussion). There is considerable consensus that scale and integration of port and logistics activities support the development of rail alternatives to road haulage and are, therefore, more likely to be "sustainable" than decentralized and small scale development. Scale alone may not generate sustainable patterns, so that steering policy will be required.

The interaction between competing ports' pricing and investment strategies is studied in recent economic literature on competition between congestible facilities (De Borger et al., 2008; Zhang, 2008). A basic insight is that congestion in the port or in its hinterland increases costs and hence weakens a ports' competitive position. The hinterland congestion problem is particularly relevant. Figures for the Los Angeles/Long Beach ports presented in Zhang (2008) provide *prima facie* evidence that port growth and market shares suffer where congestion levels are high, and a survey of port managers by Maloni and Jackson (2005) highlights that their concerns on capacity expansion are mainly related to the hinterland, not the port. Hinterland congestion of course is not a pure port problem, as the networks serve a heterogeneous set of users and the share of port traffic often is fairly small. In fact, from the port and supply chain perspective, reliability – which is correlated with but different from congestion – may matter more than congestion itself.

It is clear that concerns about port and hinterland congestion are stronger when ports compete. Hence, calls for more capacity in the port or its hinterland to alleviate congestion are stronger in a competitive setting, and this may result in investment levels exceeding those where ports face less intense competition (Zhang, 2008). Whether these investments are closer in line with socially desirable levels is less clear, although the answer is likely to be yes. In general, one would expect private ports to invest more when there is competition than when the port is a pure monopoly, with oligopolistic market structures falling between those polar cases. However, since decisions in investments in port capacity frequently are at least partly made by public authorities, insights about private port behaviour provide little guidance. In this regard, De Borger et al. (2008) find that privately owned competing ports invest less in port capacity than ports that set commercial prices but whose capacity is publicly financed, because the public investor has broader objectives than just port profits.

Port and hinterland congestion may be expected to affect the degree of ports' market share Specifically, one might assume that growth in traffic and rising congestion in the hinterlands of large gateway ports would lead to an increase in the market share of smaller and less congested ports in the same port range. The evidence, however, shows that this has not so far been the case. To the contrary, prevailing patterns of concentration prevail or are strengthened. For example, the share of traffic handled by the large ports within the Northern European range is stable between 1975 and 2007 (but large upstream ports gain at the expense of large coastal ports; Notteboom 2008), and the Northern range has gained market share on the Mediterranean ports. Similarly, traffic on the US West coast remains strongly concentrated in the Los Angeles – Long Beach ports, with a reasonably constant 70% share of west coast container traffic over the last two decades. This is not to say that congestion has no impact on routing, and switching major container flows to smaller ports could have a large impact on local congestion. While up to now it appears that the benefits from further concentration still outweigh the decision-makers' costs, in some cases congestion does intensify the search for alternative routings. The US west coast is an example, where possibilities to substitute these routes with services via Panama and Suez to serve non-local markets are under consideration. Environmental constraints on capacity expansion nevertheless appear a more critical factor for growth in the ports of Los Angeles and Long Beach.

The geographical concentration of flows reflects the concentration patterns in supply chains just mentioned, and suggests that the costs of hinterland congestion generally do not outweigh supply chain benefits from increased concentration (internal returns to scale, or external sources such as agglomeration economies), at least from a supply chain operators' point of view. Whether the cost-benefit analysis is the same when broader social benefits (including congestion and other adverse effects incurred by non-port activities) are taken into account is a different question, to which the answer is unclear. On the one hand, concentration and centralization may be more amenable to managing congestion (and air emissions to the extent they are increased by congestion) than fragmentation of the supply chain but, on the other hand, the spatial concentration of the negative impacts of supply chain activity may excessively affect local communities. Irrespective of whether the local impacts are excessive or not, the concentration of negative impacts provokes strong resistance in communities adjacent to mega-gateway ports, and this may effectively constrain further growth. The benefits of concentration and scale need to be weighed against both the concentration of local environmental impacts and the potential costs of abuse of market power.

3. PORT AUTHORITIES' RESPONSES

De Langen (2008) argues that port authorities *can* and *should* become more strongly involved with hinterland access infrastructure and operations. They *can* become involved because port authorities control decision margins that affect the efficiency of hinterland access. Specifically, port authorities can provide infrastructure inside and outside of ports (for example, through the creation of inland terminals); they can manage infrastructure access to improve the efficiency of use of port and hinterland capacity (for example, Key Rail was created in Rotterdam to allocate slots for quayside access more efficiently); and they can improve data exchange among the various agents involved in moving a container from ship to hinterland. While it has been suggested that concession contracts can be used to stimulate the use of some of these innovations, many ports have awarded very long-term concessions without clauses for re-opening, and so their use is often constrained.

De Langen (2008) argues that port authorities *should* introduce better coordination along the supply chain because other private and public parties have weaker incentives to do so. There can also be social benefits from improved coordination. Landlord port authorities that pursue a mix of private and public goals have an interest in providing efficiency-improving coordination of parts of the supply chain, as coordination can contribute to their net revenues from land leases and throughput growth. Even if not all benefits accrue to the port directly, the partly public role of the port suggests they might be interested in generating broader benefits as well. It was pointed out, however, that the business model underlying this view is unclear on exactly which public objectives are included and how they are traded off against narrower commercial concerns. Moreover, the landlord port authority model followed in Rotterdam is not universally applicable due to differences in governance and political cultures. When the model does work, it may help narrow the gap between responsibility for the strong impacts that port activities have outside the port area and the rather narrow set of competencies of a port in a traditional landlord port model.

Concession agreements with terminal operators are one lever that port authorities might use to pursue objectives regarding modal split, environmental impacts, and the like. The Port of Rotterdam uses them to influence the use of port space and transport modes, setting targets for the rail, barge and road shares in container movements out of terminals in the new Maasvlakte 2 development. The Antwerp Port Authority, in collaboration with cargo handlers, has developed an alternative approach, acting as a facilitator to develop the use of the rail mode through "Antwerp Intermodal Solutions (AIS)". This role may be extended in an Antwerp Intermodal Agency. The power of concession agreements is limited by the practice of renegotiations, which introduces considerable flexibility in these agreements. Concession agreements are also not always amenable to influencing business-to-business processes and decisions affecting the choice of transport mode.

However, it should not be taken for granted that a port authority's interest coincides with the broader public interest. For example, port authorities can become actively involved with the development of inland dry ports, to help decongest the seaport and possibly its adjacent transport network, but this is not necessarily ideal to improve hinterland access in as it may merely relocate the congestion.

Notteboom (2008: 25) noted that the policy push to achieve changes in modal split in the EU, through gradual liberalization of barge and rail markets, new pricing approaches and subsidy and support programmes, has to date failed, in the sense that modal shifts occur only when transformations in the supply chain make them attractive to those involved, and not by simply declaring the policy objective. Policy removed obstacles, but the actual change came about through "market pull" instead of through "policy push". As the decentralization issue suggests, market pull does not always work in socially preferable directions, in particular when external costs are present[6].

Conflicts of interest may also arise because the port authority cares about negative side effects such as congestion and air pollution only to the extent that they affect its own performance. Port authorities' actions to limit such negative impacts do not necessarily reduce overall congestion and air pollution, and may indeed make them worse. The next section deals with policy-making to curb negative local impacts of port-related traffic in more detail.

4. PUBLIC POLICY FOR PORTS AND SUPPLY CHAINS

The overall principles for public policy towards ports and supply chains are no different from those for other sectors of the economy. Intervention may be indicated when market failures arise, e.g. to price external costs or preserve competition. Public investment may be merited where very long investment cycles make demand risk difficult for private investment to handle. A balance has to be struck in creating a climate for both competition and investment. High and increasing levels of concentration in the industry may generate substantial market power and suggests that vigilance against the abuse of market power is a growing policy imperative. Research is far from conclusive on the scale of the potential problem. As Slack (2007) points out, terminal ownership and access models are very diverse. There are even cases of shipping lines running terminals at which their own ships do not call. A more detailed understanding of market power is required to draw conclusions and this will be the subject of a companion report (OECD ITF 2009). Industry concentration also has an impact on the treatment of congestion (the external component of congestion costs is smaller than in a more competitive environment), and on the possibilities to shape public policy (see section 4.1). On a general level, policy towards supply chain activities currently is *ad hoc*. The adoption of more systematic, transparent and uniform policy frameworks is desirable. Given the extended geographical reach of supply chains and of some players in the market, and given that some of the policy issues (e.g. greenhouse gas emissions) are global, such policy frameworks need to be defined at central rather than local levels of government, and involve inter-governmental or multilateral consultation. While these recommendations seem straightforward, they are not always reflected in current policy (section 4.2).

4.1. Local authorities

Local communities near mega-port sites are confronted with the adverse impacts of increased port throughput. Port-generated traffic contributes to congestion on transport networks, and to safety risks, noise, and local air pollution[7]. As incomes in these communities grow, sensitivities to these side effects grow as well. From a public policy point of view, the question is: are these side effects excessively high? The answer is yes, in the sense that congestion and air pollution are external costs, i.e. they constitute real costs for local communities (as well as for port traffic) that are often ignored in decisions regarding port and hinterland traffic volumes.

There is thus a case for policy intervention, and the standard prescription is to find least cost ways of reducing these external costs to socially desirable levels. In some cases, e.g. for congestion, this means internalizing external costs through charges that reflect these costs. In other cases, technology regulation or defensive expenditures may turn out more effective than the use of charges. The internalization principle should not be applied to port traffic in isolation, and because the external costs mentioned are just one of many market distortions, it is not obvious which structure and level of charges or other policies would maximize benefits. Even if the "optimal" policies were known, it is not clear whether they are a practical – politically feasible – option.

The experience with policy-making to contain negative local side effects in the Los Angeles–Long Beach port region, described in Giuliano and O'Brien (2008), provides insight on how citizen concerns about such externalities shape policy outcomes. A study on the health impacts of pollution from diesel engines, and the experience with the port shutdown in 2002, changed the local public perception of the ports and stimulated regional policy to contain negative impacts. As a result, there is currently no public support for further port expansion. The policies introduced to deal with these have had mixed success.

Specifically, the contrast between the failure of Assembly Bill 2650 and the success of the PierPass Program – both of which had the objective of stimulating the use of extended gate hours to reduce port traffic's impact on hinterland road congestion[8] – suggests that, in order to be successful, any attempt to implement measures that reduce negative impacts must take account of the interests of port related businesses and, in this particular case, labour union demands and terminal operators' interests. Assembly Bill 2650 was passed in 2002, and prohibited truck queuing for more than 30 minutes at terminal gates. Terminals could respond by extending gate hours, but instead chose to introduce truck appointment systems. The impact on the time distribution of port traffic was negligible.

The PierPass Program started in 2005 and successfully spread port traffic over more of the day, most notably shifting a significant share of the traffic to evening hours. The program is a form of cooperation between terminal operators, made possible by a Federal Maritime Commission ruling exempting this discussion from antitrust policies in the public interest, and implying that revenues from the program accrue to operators (with no public financial records). The PierPass fee is calculated on the basis of the incremental costs to terminal operators of operating a second shift, and bears no relation to marginal external costs. The program can also be seen as pre-empting the establishment of a new public authority charging for environmental impacts and using the revenue for mitigation. In this sense, the threat of regulation was sufficient to provoke a response.

The PierPass program gave the "dominant" players in the port-related business environment (including ports, terminal operators, shipping lines, port workers' unions, and large freight-generating clients) the opportunity to shape policy to serve their interests, so that the incidence of policies' costs is on more weakly represented and organized parties, mainly truckers. There seems to be a strong positive correlation between market power (*vs.* price-taking) and influence on policy (*vs.* "policy taking").

It was noted in section 2 that concentration in the logistics industry is increasing, and that the position of individual ports in exerting influence on traffic flows is weakening. The Los Angeles–Long Beach examples suggest that strong economic power translates into strong influence on local policy. One interpretation is that this makes ambitious environmental and transport policy in port regions difficult, especially where one port can potentially be replaced by another. However, a more nuanced view seems warranted as the examples also show that there has been a response to increased local demand for action. The powerful players have strong influence on the nature of policy measures, but that does not mean these measures will necessarily be ineffective. Hence, there is some scope for "self-regulation", also in the presence of limited rivalry among ports and terminal operators. To enable private parties to overcome competitive concerns, communication and coordination on the specific issue being regulated is required. Such self-regulation will not produce the textbook ideal of regulation, but is preferable over a situation where a regulator proposes measures, the regulated parties insist the market works without intervention, and the compromise result is poor and ineffective regulation. Whatever the merits of the Los Angeles – Long Beach policy, it is not clear if the model of "self-regulation" at the local level can be exported to regions where port competition is more intense than along the US West coast. The San Pedro Bay ports serve a huge and affluent hinterland with much better connections to the main markets than neighbouring ports. Port rivalry is stronger in Europe.

While the incidence of costs of policies to reduce external costs may not meet common equity criteria, the current policy-making constellation does provide some balance between business interests and local community objectives. A more powerful local community may give insufficient weight to business interests, leading to 'nimby-ism'; but ignoring local community interests may impose excessive costs on port regions.

4.2. Higher level authorities

There is at present a mismatch between levels at which policy is initiated and the scale at which regulated parties operate. The fragmentation and decentralization in governance contrasts with the wider geographic reach of (at least partially integrated) large conglomerates. Local governments are not very powerful vis-à-vis these conglomerates. Higher level (national) governments are better placed to handle them, and in some cases transnational approaches are desirable. There is also a risk that leaving port policies in the hands of local governments leads to the dominance of local issues over economic benefits of wider interest. This holds true for maritime transport in particular, as for example in Asia trade is seen as a primary engine of growth, and any regulation that slows it down as an impediment to growth. For global issues, such as climate change, a supranational approach clearly is desirable. Climate change policy as it relates to ports needs to be shaped at the highest level[9].

High level policy responses may also be needed for other goals, such as avoiding any negative consequences of strong concentration in supply chains. Horizontal concentration is strong in several segments of the supply chain, and close scrutiny of mergers and acquisitions is warranted. Vertical integration raises additional concerns for competition, as fully or semi-integrated companies control several segments of the chain. The markets in which these companies operate are hard to define and their boundaries are vague. Baird (2008) labels global logistics companies as "new empires", with strong control over trade routes and prices, and sufficient power to withstand or bypass fragmented policy approaches. Here too, a systematic high level approach seems warranted.

On a more strategic policy level, higher level authorities need a vision on the likelihood and the desirability of continued growth in volumes and geographical span of supply chains. Until recently, the general expectation was one of further fast growth of freight volumes within the current geographical pattern of "globalization". This expectation has triggered massive investments in transport infrastructure. However, it is not straightforward that this expectation will be realized. Rodrigue (2008) argues that containerization has matured so that future growth rates are likely to be lower than in the recent past. In addition, the medium term economic outlook implies moderate growth, translating in limited or even negative growth in traffic.

High energy prices also affect the organization of the supply chain. Some European and US manufacturers are re-relocating manufacturing closer to home market from overseas locations, in response to rising transport costs due to higher energy prices (Wall Street Journal Europe, 17 June 2008, US jobs return home as shipping costs from Asia rise; Financial Times, 27 June 2008). Cross-border security concerns are another factor in deciding on where to produce and upward pressure on overseas wages and in some cases on the value of local currencies may very well induce further re-relocation and restructuring of global supply chains. This evolution puts pressure on domestic transport systems, indicating that returns to infrastructure investment depend strongly on highly flexible production and trade patterns. The Asian trade model of the past two decades, characterized by Chinese imports of intermediate goods from other parts of Asia and exports to Western countries, is under pressure as well, reliant as it is on cheap transport. The share of Chinese exports based on imported intermediate goods has declined from 57% in 2001 to 44% in 2007 (Morgan Stanley Research, 2008).

The strategic policy stance with respect to the development of supply chains also depends on the wider, normative economic perspective adopted. For example, it is sometimes argued that supply chains are too stretched out geographically, and that there is excessive growth in transport. There are several reasons why this may be the case. For example, ports aim to maximize throughput, and can do so by charging low prices for the use of infrastructure and dredging that is often publicly provided. The consequence is that shippers and supply chain operators do not face the full cost of infrastructure, let alone the full social cost of their decisions. Transport infrastructure pricing structures that do not reflect marginal costs, including externalities, in the hinterland exacerbate these problems. More cost-based pricing approaches are likely to improve the balance between overall costs and benefits of port and supply chain activity, and may result in growth rates below those observed in recent decades.

5. CONCLUSION

The supply chain industry is subject to increasing vertical and horizontal concentration. This arguably has lead to more efficiency in the movement of cargo, and possibly the concentrated model is more favorable in some respects towards sustainable development than a more fragmented landscape in the sense that it facilitates the development of rail and the internalization of port congestion costs to some extent. These benefits of concentration in terms of sustainable development would be smaller if hinterland transport prices were more in line with marginal social costs, for all modes. A downside of concentration is that there are fewer players, which increases the risk of abuse of market power, and requires close oversight by competition authorities.

From the ports point of view, the main consequence of developments in supply chains is that their market power has declined. Ports operate in an increasingly competitive environment within their range as well as in their function as nodes in supply chains increasingly prone to switch routings (route competition). From the perspective of welfare economics, there is little reason to deplore the weakening of ports' influence, as the economic benefits depend on supply chains' performance more than on a particular port's performance. However, when countries think of their ports as instruments for defending strategic economic interests, the weaker influence of ports vis-à-vis shipping lines becomes an issue of concern. The round table heard divergent views on how ports should respond to their weakening market power, with some supporting increased involvement with hinterland activities, and others doubting the social desirability of such an extended role for ports. Given the competitive context, ports need sufficient operational independence to respond to changing demands from their customers, in order to retain market share.

The growth in port throughput has triggered strong reactions from local communities, and in some cases (such as Los Angeles and Long Beach) policies to mitigate negative impacts have been implemented. Large supply chain players clearly influence policy design, and although this does not mean that policy is impossible or necessarily ineffective, it does suggest that local authorities are not always sufficiently powerful to handle port-related policy issues. Similarly, experience with policy efforts to change the modal distribution of hinterland transport in the EU suggests that the attainment of targets requires that the policy needs to be compatible with business interests. Concession agreements between ports and their clients have some potential to reduce local congestion and environmental impacts, but this is a piecemeal approach that intrinsically lacks transparency.

The current diversity in governance models and management arrangements in the port and supply chain business poses a problem for the development of systematic responses to negative impacts. In order to deal with these impacts, higher level authorities need to be involved and appropriate incentive structures are required. This holds for local impacts and to a stronger extent for regional or global effects. Local effects such as congestion and air pollution affect local communities and not just the port area. Local governments may be in a relatively weak bargaining position to design and enforce policy, particularly when port competition is strong, leading to ineffective policy. When local authorities are in a strong position, they may ignore part of the economy-wide benefits of port activity in policy design. A higher level response thus is called for. High-level, transnational responses are ideal for dealing with climate change, but there is little agreement on which supranational agency is best placed to handle this problem.

While the general principles for port and supply chain policies are fairly obvious (ensure a level playing field in the provision of infrastructure and in the handling of externalities between ports and between modes), these principles are far from systematically applied. A failure to price the social costs of hinterland transport use and land development may result in many ports preferring to develop inland distribution centres rather than more efficient port organization in response to increasing traffic. When the implicit subsidy to road is larger than for rail, this also undermines the performance of rail investments even in major hinterland corridors such as Los Angeles' Alameda corridor. Unfortunately, piecemeal, and not very effective policy is the norm. Globalisation increases the case for measures (such as road pricing) to internalize congestion costs on hinterland roads and develop explicit policy towards market power in logistics businesses[10].

NOTES

1. The capacity of the world cellular container fleet increased by more than factor 4 between 1991 and 2006, and the share of ships with more than 4 000 TEU increased from 8% to 47% (Wilson, 2007: 11).

2. Accessibility is an issue for upstream ports such as Antwerp and Hamburg, and both ports respond by engaging in dredging programmes.

3. Increased concentration partly replaces the weakening impact of conferences (which set rates for specific routes), so that the effect of concentration on market power may be weaker than indicated by the percentage change.

4. Examples of such innovations are on dock rail facilities, barge services or high volume container flows between dock and storage areas, as well as better stacking through operations research, etc. In addition, if information collected for security purposes were no longer proprietary, then it could be put to productive use in ports and along the supply chain.

5. It was mentioned during the discussion that this is corroborated by the Australian experience with comprehensive pro-rail policies, which were made ineffective by innovations in road freight alternatives. Subsequently, policy shifted to support for specific projects.

6. In addition, the increased levels of concentration makes designing effective policies harder, as powerful private entities may have considerable political bargaining power or can develop strategies to bypass policies.

7. Port traffic also contributes to regional and global pollution (e.g. greenhouse gas emissions), but these are ignored here.

8. Interestingly, the programme focussed on moving traffic to the off-peak, not on changing the modal split.

9. Such a broad and high-level approach may also help attain abatement goals at the lowest economic cost.

10. To be addressed in a subsequent Round Table on Integration and Competition in Transport and Logistics Businesses.

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THE RELATIONSHIP BETWEEN SEAPORTS AND THE INTERMODAL HINTERLAND IN LIGHT OF GLOBAL SUPPLY CHAINS: EUROPEAN CHALLENGES

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SUMMARY

Antwerp, March 2008

ABSTRACT

The seaport-hinterland interaction plays an increasingly important role in shaping supply chain solutions of shippers and logistics service providers. Scarcity concerns, combined with concerns over the reliability of transport solutions, have led seaports and hinterland corridors to take up a more active role in supply chains. This contribution looks at port developments and logistics dynamics in Europe and proposes some steps towards a further integration between seaports and the hinterland. The key point put forward in this paper is that the competitive battle among ports will increasingly be fought ashore. Hinterland connections are thus a key area for competition and coordination among actors.

The paper approaches port-hinterland dynamics from the perspective of the various market players involved, including port authorities, shipping lines, terminal operators, transport operators (rail, barge, road and short sea) and logistics service providers. The paper will address the impact of horizontal and vertical relations in supply chains on the structure of these chains and on the relationships between seaports and the intermodal hinterland. Who takes or should take the lead in the further integration of ports and inland ports, and what actions have been taken so far by the market players in this respect, will be examined. The incentives for market players to vertically or horizontally integrate will be analyzed against the backdrop of the nature of the market in which the various players operate.

1. INTRODUCTION: GATEWAYS AND HINTERLANDS

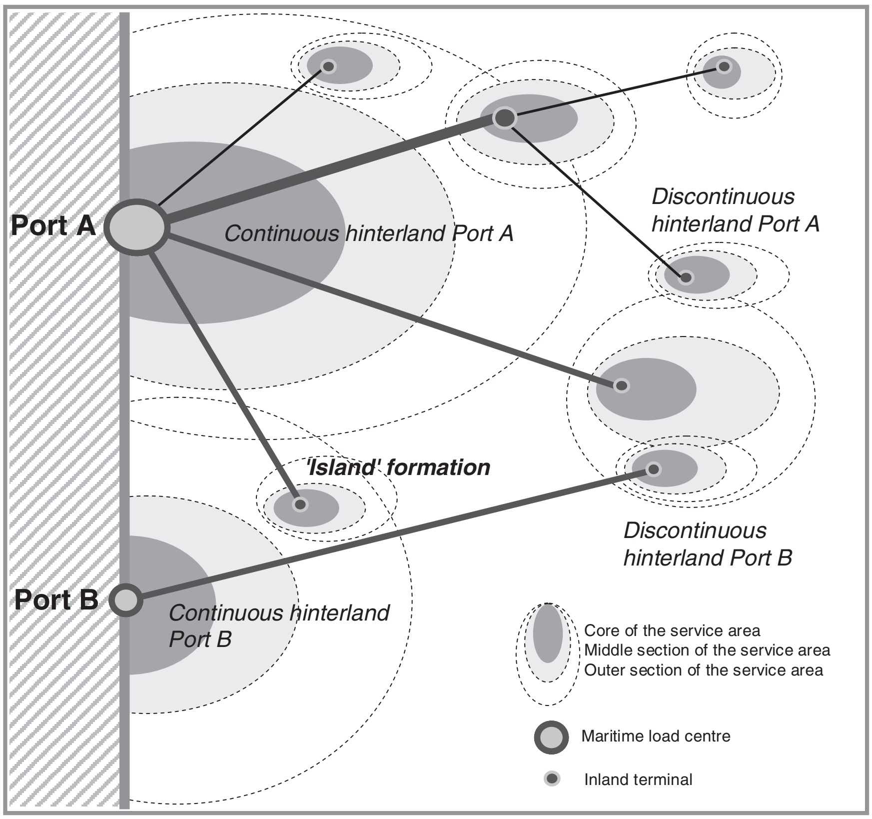
A hinterland is the area over which a port draws the majority of its business. It is very hard, or even not feasible, to delimit the hinterland of a port; the hinterland varies with respect to commodity (cf. bulk versus containers), the time (cf. seasonal impact, economic cycles, technological changes, changes in transport policy, etc.) and transport mode. Moreover, market dynamics make it dangerous to have a static concept of port hinterlands as being god-given and everlasting.

Literature on gateway-hinterland relationships acknowledges that containerisation has expanded the hinterland reach of ports and has thus intensified interport competition (see, e.g., Hayuth, 1981, and Starr and Slack, 1995). The expanding hinterland coverage and the associated shift from *captive* hinterlands to *shared* or *contestable* hinterlands has changed the perception of port markets from being monopolistic or oligopolistic to competitive. As a result, most European container ports now act as *gateways* to often extensive inland networks. These gateways are nodal points where intercontinental transport flows are trans-shipped onto continental areas and vice versa (Fleming and Hayuth, 1994; Van Klink *et al.*, 1998).

A number of factors have facilitated the rise of gateways that vie for contestable hinterlands.

First, containerisation and the deployment of ever larger container vessels have gone hand in hand with a concentration of vessel calls in a limited number of load centres, especially on the main long-distance routes where economies of scale at sea are most apparent. Price-fixing systems ensured that the reduction of port calls had no negative price impacts on the customer base (Gilman, 1997). For example, shipping lines put port equalisation systems in place to compensate inland customers for the longer inland transport distances they might incur when sending or receiving cargo via container load centres.

Figure 1. **Discontinuous hinterlands and corridor-based "island" formation**



Source: Notteboom and Rodrigue (2005).

Second, the development of intermodal corridors by rail and barge, and of inland terminals, allowed for a deep hinterland penetration via shuttle trains and barges. The full liberalisation of barge transport in Europe from 2000 and the advanced stage of liberalisation in European rail (which started in 1991 and whose stage of completion depends on the member state considered) proved to be instrumental to increasing the efficiency of transport services on inland corridors. The rise of intermodality and associated transport corridors had a major structuring effect on the hinterland reach of seaports. Not only did intermodality give ports incentive to expand their hinterland reach, but hinterlands also became more discontinuous in nature, especially beyond the immediate hinterland of the port (Figure 1). Such a process can even lead to the formation of "islands" in the distant hinterland for which the load centre achieves a comparative cost and service advantage vis-à-vis rival seaports (Notteboom and Rodrigue, 2005). Conventional perspectives based on distance decay are ill-fitted to address this new reality. Hence, high-volume intermodal corridors typically offer a more favourable relation between transport price, lead time and distance than the conventional continuous inland transport coverage. A port's service area in terms of rail and barge now consists of sets of overlapping service areas of individual inland terminals. The size of each of the inland service areas depends on the service frequency and tariffs of intermodal shuttle services by rail and or barge, the extent to which the inland terminal acts as a gateway and the efficiency and price of pre- and end-haul by truck. The more intermodality serves as a weapon in port competition, the more ports become dependent on the intermodal carriers offering services along the intermodal corridors. High volatility of intermodal markets, in terms of organisational and operational factors, is thus not very conducive to creating a stable and sustainable competitive position of a port vis-à-vis the hinterland segments served through the corridors.

The rise of corridors is highly relevant to any policies aimed at generating a modal shift from road haulage to inland navigation, rail and short sea shipping. Intermodal solutions based on barge or rail prove to be competitive on a number of high-density traffic corridors (e.g. the Rhine axis and some Alpine routes) or in specific niche markets, but cannot serve as a Europe-wide alternative to road haulage.

2. GLOBAL SUPPLY CHAINS, PORT SELECTION AND HINTERLAND CONNECTIONS

Academic literature on port selection identifies a multitude of service-related and cost factors that influence shipping lines' and shippers' decisions: see, e.g., Murphy *et al.* (1992); Murphy and Daley (1994); Malchow and Kanafani (2001); Tiwari *et al.* (2003); Nir *et al.* (2003); Chou *et al.* (2003); Song and Yeo (2004); Lirn *et al.* (2004); Barros and Athanassiou (2004); and Guy and Urli (2006). The traditional view on port selection primarily considers stand-alone physical attributes of a port, such as:

- physical and technical infrastructure (nautical accessibility profile, terminal infrastructure and equipment, hinterland accessibility profile);
- geographic location (vis-à-vis the immediate and distant hinterlands and vis-à-vis the main shipping lanes);
- port efficiency;
- interconnectivity of the port (sailing frequency);
- quality and costs of auxiliary services such as pilotage, towage and customs;
- efficiency and costs of port management and administration (e.g. port dues);
- availability, quality and costs of logistic value-added activities (e.g. warehousing);
- availability, quality and costs of port community systems;
- port security/safety and environmental profile;
- port reputation;

  and, very relevant in the context of this paper,
- reliability, capacity, frequency and costs of inland transport services by truck, rail and barge.

The focus on stand-alone physical attributes when assessing the competitiveness of a port does not mirror the reality of (global) supply chains. The container facilitated the adoption by multinational enterprises of flexible multifirm organisation structures on a global scale. Many of the world's largest enterprises manage extensive networks of globally dispersed inputs. The broad geographic distribution of sourcing and production (back end) versus less broad geographic distribution of sales (customer end) is reflected in trade patterns, supply chain management needs and shipping requirements. Service expectations of customers are moving towards a push for higher flexibility, reliability and precision. Average product life cycles and supply chain cycles have decreased. There is growing demand from the customer for "make-to-order" or "customised" products, delivered at maximum speed, with maximum delivery reliability, at the lowest possible cost. The focus is on supply chain excellence, with superior customer service and lowest cost to serve.

As a result, European ports are increasingly competing not as individual places that handle ships but as crucial links within (global) supply chains (Robinson, 2002; Carbone and Gouvernal, 2007; Notteboom and Winkelmans, 2001). The need for a more supply chain oriented approach to port selection is echoed in recent work. More than ever, the supply chain has become the relevant scope for analyzing port competitiveness. This implies that a port's competitiveness becomes increasingly dependent on external co-ordination and control by outside actors. Port choice becomes more a function of network costs. Port selection criteria are related to the entire network, in which the port is just one node. The ports that are being chosen are those that will help to minimise the sum of sea, port and inland costs, including inventory considerations of shippers. Along the same lines, Magala and Sammons (2008) and Sammons and Magala (2007) argue that port choice is to be considered as a by-product of a choice of a logistics pathway. Port choice becomes more a function of the overall network cost and performance.

The supply-chain focus on port competition holds clear implications on the role of hinterland connections. Port hinterlands have become a key component for linking elements of the supply chain more efficiently – namely, to ensure that the needs of consignees are closely met by the suppliers in terms of costs, availability and time in freight distribution. Through a set of supply/demand relationships involving physical flows, efficiencies and thus economies are achieved through the principle of flow (Hesse and Rodrigue, 2004).

In this setting, the out-of-the-pocket costs of transporting goods between origins and destinations and the port (including cargo handling costs) constitute just one cost component in supply chain routing decisions. The more integrated supply chain decision-making becomes, the more the focus is shifted to the generalised logistics costs. The implications on port and modal choice are far-reaching: shippers or their representatives might opt for more expensive ports or a more expensive hinterland if the additional port-related and modal out-of-the-pocket costs are more than offset by savings in other logistics costs. These other costs typically consist of:

- time costs of the goods (opportunity costs linked to the capital tied up in the transported goods and costs linked to the economic or technical depreciation of the goods);
- inventory costs linked to the holding of safety stocks;
- indirect logistics costs linked to the aggregated quality within the transport chain and the willingness of the various actors involved to tune operations to the customer's requirements, e.g. in terms of responsiveness to variable flows, information provision and ease of administration (see also Ojala, 1991).

These three cost categories have gained in significance as more and more high-value products are being shipped worldwide (i.e. impact on time costs) and as market players show increasing concerns over perceived inefficiencies in segments of the chain as well as reliability issues. There are two major points to be made in relation to this shift.

First, growing concerns on capacity shortages in ports and inland infrastructure have made supply chain managers base their port and modal choice decisions increasingly on reliability and capacity considerations next to pure cost considerations. Port congestion along the US West Coast and in many European ports, e.g. in the summer of 2004, has demonstrated how scarcity of port facilities and intermodal throughput capacity can impact a broader economic system. Freight transport has become the most volatile and costly component of many firms' supply chain and logistics operations. Managers have to deal with delays in the transport system, rising oil prices, complex security issues and labour and equipment shortages and imbalances. Each of these problems adds risk to the supply chain, and the problems are likely to worsen before they improve. Managers in the logistics industry, including the port and maritime industry, are spending more and more of their time handling freight transport missteps and crises. Scarcity in markets can lead to more efficient use of resources, which is positive. But when scarcity reaches a continuous high level, logistics players start to consider capacity problems as the new normal. They can adjust their logistics networks by increasing time buffers in the system (a measure which comes at an extra cost) or by finding alternative routes with lower "resistance" to their needs in terms of costs and reliability. Seaports on inefficient or capacity-tight corridors obviously are in a disadvantageous position.

Second, the logistics actors and transport operators have designed more complex networks that need a high level of reliability. The current development and expansion of global supply chains and the associated intermodal transport systems relies on the synchronisation of different geographic scales. The efficiency of transport systems can be seriously hampered if, despite low transport costs, shipments would be delayed significantly. But when the synchronisation level increases, the sea-land network as a whole becomes less stable (Rodrigue, 1999). This leads to extra costs to find alternative routes. In view of reducing the risk of major disruptions, logistics players tend to opt for a flexible network design offering various routing alternatives. This "not all eggs in one basket" approach implies that a specific port-corridor combination is seldom in a position where the market will forgive major flaws in system performance.

The multitude of port selection factors and modal choice criteria implies that modelling port-related hinterland flows and associated port market shares remains a very difficult exercise. For example, Veldman *et al.* (2005) developed a logit model for the routing of western European container flows in the context of the assessment of the economic impact of a river deepening project. Variables in the model include the hinterland transport cost and the transit time of routing via port p and hinterland mode m, a maritime resistance cost of port p and the quality of service aspects of port p related to the frequency of services offered. The model attempts to explicitly incorporate many dimensions of a generalised logistics cost approach. But, obviously, one should always take into account the assumptions and simplifications that lie at the heart of a model when interpreting the model results.

To add to the complexity, it is worth mentioning that the competitive position of a port vis-à-vis a specific hinterland region cannot always be narrowed down to cost and quality factors only (Van Klink and Van den Berg, 1998). Historical, psychological, political and personal factors can result in routing of container flows that diverges from a perfect market-based division. Bounded rationality, inertia and opportunistic behaviour are among the behavioural factors that could lead to a deviation from the optimal solution (Notteboom, 2001).

Given all of the above considerations, it becomes clear the success of a port will depend on the ability to integrate the port effectively into the networks of business relationships that shape supply chains. In other words, the success of a seaport no longer exclusively depends on its internal weaknesses and strengths. It is more and more determined by the ability of the port community to fully exploit synergies with other transport nodes and other players within the logistics networks of which they are part. The synergies that can be envisaged relate to efficient capacity utilisation and efficient operational synchronisation and integration. To be successful the port community has to think along with the customer, trying to figure out what his needs are, not only in the port but throughout the supply chains and logistic networks.

3. TRADE PATTERNS, DISTRIBUTION NETWORKS AND LOCATIONAL SHIFTS IN EUROPE

The previous sections provided a conceptual approach to the issue of port competition and hinterland connections. From this section onwards, this paper will discuss the European situation in more detail. Europe's economic development and external trade forms the starting point for understanding port competition and hinterland connections in Europe. A closer look at external trade data and GDP data provided by Eurostat (Annexes 1 and 2) leads to the following conclusions:

First, rising external trade of European countries seems to go hand in hand with increasing concerns over trade imbalances. The extra-EU trade of the European Union has increased significantly over the last decade in terms of the volume and the value of the goods exchanged. Only a handful of countries (i.e. Germany, the Netherlands, Ireland and Sweden) realise rather substantial trade surpluses, while a lot of countries (including the United Kingdom, Greece and Spain, to name but a few) are facing substantial trade deficits relative to total external trade volumes.

Second, intra-EU trade represents two-thirds of the EU's trade total, meaning that despite the globalisation trend intra-European trade remains very significant. The volume of intra-EU trade increased significantly with the consecutive rounds of enlargement of the EU, since the newest member states are typically strongly geared to the EU market. The share of intra-EU trade varies widely from one member state to another. For small open economies such as the Benelux countries, the Czech Republic and Denmark, the shares of intra-EU trade in total exports are very substantial. On the import side, the overall picture is mixed: the Netherlands, Greece, Italy and the United Kingdom are among the countries with a strong reliance on non-EU imports, while for most other countries the share of non-EU imports ranges between 20% and 30%.

Third, the western European markets are becoming mature. The total market volume in Europe's most important countries and in traditional market sectors such as consumer goods and automotive are showing moderate growth rates, which contrast with the boom in these markets of the 1970s and 1980s. GDP growth rates in the core of the EU are expected to reach between 1.5% and 2.5% in coming years (see Annex 2). Greece, Luxemburg and Ireland are some of the fastest growers among the former EU-15 countries. After the crisis that followed the dissolution of Comecon, the central and eastern European countries (CEECs) quickly redirected their trade towards the EU markets. Economic development in newer EU member states in central and eastern Europe and in the Baltic is expected to continue its strong growth path in the near future, with annual GDP growth rates typically between 5% and 7%. The enlargement of the European Union from 15 to 25 members states in 2004 meant a 20% rise in population (an additional 75 million citizens, according to Eurostat) but only a 5% rise (€500 billion) to real GDP. The economic gap remains substantial. However, at the current growth rates, more advanced countries such as the Czech Republic could reach the GDP per capita level of western European countries in fifteen years.

In trade, two categories of CEECs can be identified: Hungary, the Czech Republic and Slovakia are increasingly exporting more technology-driven or high-skill products. By contrast, countries like Latvia remain focused on low-skill or labour-intensive products. As the EU market has expanded and will add some high growth markets it is not unlikely that international companies will be keen to invest in the new Europe. This might imply, for instance, a move of global plants to the European Union. This tendency will generate larger bidirectional east-west flows within the European Union of raw materials and consumer products. The east-west flows require extensive infrastructure to be in place (road, rail, inland waterways and short sea). A large part of this transport will be on inland waterways, especially the Danube River. Germany, the Czech Republic, Poland, Slovenia and Hungary have access to elaborate rail networks while road networks in the eastern European countries are less developed. Transport in eastern European countries will therefore favour rail. A rise in multimodal transport infrastructure is expected on the frontiers between eastern and western Europe, particularly on the borders of Germany, which has well-developed infrastructure for both road and rail.

Given the trends outlined above, the traditional "blue banana" is approaching the shape of a boomerang as a result of extensions to central and eastern Europe and significant investment in the Mediterranean (Spain in particular), as Figure 2 shows. The expansion of the "blue banana" goes hand in hand with a strong development of trade flows in the Baltic area, central Europe and the Latin arc (stretching along the coastline from southern Spain to northern Italy).

Figure 2. **The "blue banana" and its extensions**

Source: Cushman & Wakefield, Healey & Baker.

The enlargement of the European Union and the strong economic growth of regions situated somewhat at the periphery of the internal market might have implications for the design of European distribution networks. When it comes to European distribution of EU countries' overseas goods, no generally applicable distribution structure exists. Companies can opt for direct delivery without going through a distribution centre, distribution through European distribution centre (EDC), distribution through a group of national distribution centres (NDCs) or regional distribution centres (RDCs) or a tiered structure in which one EDC and several NDCs/RDCs are combined to form a European distribution network. The choice between the various distribution network configurations depends on, among other things, the type of product and the frequency of deliveries. In the fresh food industry, for example, worldwide or European distribution centres are rare because the type of product (mostly perishable) dictates a local distribution structure. In the pharmaceuticals industry, EDCs are common but regional or local distribution centres are not present, because pharmaceutical products are often manufactured in one central plant and delivery times are not very critical (hospitals often have their own inventories). However, in the high tech spare parts industry, all of the distribution centre functions can be present because spare parts need to be delivered within a few hours and high tech spare parts are usually very expensive (which would require centralised distribution structures).

Before the creation of the EU, the distribution structure of most companies was based on a network of NDCs in the major countries in which the companies were present. Over the last fifteen years or so many barriers for cross-border transactions between countries within the EU have decreased. As a result many companies have consolidated their distribution operations into one central EDC covering all EU countries. The rise of EDCs has meant longer distances to the final consumers, and in some market segments local market demand has led companies to opt for RDCs. A certain degree of decentralisation of European distribution structures has taken place. At present, the tiered structure consisting of one EDC in combination with some smaller local warehouses, merge-in-transit concepts or cross-docking facilities offers the best results for many companies in terms of high level of service, frequency of delivery and distribution cost control. Companies today often opt for a hybrid distribution structure of centralised and local distribution facilities. For instance, they use an EDC for medium- and slow-moving products and RDCs for fast-moving products. These RDCs typically function as rapid fulfilment centres rather than holding inventories. The classical or multicountry distribution structures are being replaced by merge-in-transit, cross-docking or other fluid logistics structures.

The geographic centre of gravity within the expanded EU has slightly moved eastwards from the Benelux region to Germany, and this is causing some companies to reconsider their use of EDCs. The relatively recent waves of EU enlargement might further promote a two-tiered European distribution structure consisting of an EDC together with RDCs in northern Europe, UK/Ireland, southern Europe, eastern Europe and Italy/Greece. Favourite regions for locating such RDCs include northern Germany and Finland for northern access, Hungary, southern Germany and Austria for central access, northern Italy and the north Adriatic region for southern access, and the Czech Republic and Poland for eastern access. The new European Union is much larger, making it more difficult to deliver all EU countries out of one EDC within two to three working days. Northern ports, in particular Hamburg, are likely to benefit the most from the recent waves of EU enlargement, whereas new development opportunities arise for secondary port systems in the Adriatic and the Baltic Sea.

Some observers argue that growth of investment in EDCs in north-western Europe might slow. At the moment, this region still offers the best access to the EU core markets and infrastructure. The majority of EDCs still opt for a location in the Benelux or northern France. Next to dedicated transport service companies, companies in the automotive, food, retail, chemicals, electronics and pharmaceuticals industries are the main investors in distribution activities. Flanders, northern France and the Netherlands remain the top locations for EDCs, but more and more regions are vying for a position as attractive locations for RDCs and potentially EDCs.

Supply chains across Europe are being redesigned to respond to varying customer and product service level requirements. The variables which affect site selection are numerous and quite diverse and can be of a quantitative or qualitative nature: centrality, accessibility, size of the market, track record regarding reputation/experience, land and its attributes, labour (costs, quality, productivity), capital (investment climate, bank environment), government policy and planning (subsidies, taxes) and personal factors and amenities. Many companies fall back on intuition and rules of thumb in selecting an appropriate site.

In order for the established EDC regions to retain their attractiveness, it is primordial to keep labour costs within acceptable margins, to overcome the land scarcit issue and to guarantee a smooth (congestion-free) transfer through the maritime gateways and associated inland corridors. North-western Europe has to deal with the likelihood that no new major corridor infrastructure will be developed in the foreseeable future (the Betuweroute for rail in the Netherlands being one of the last major projects). The focus will thus be on stretching existing capacity on the corridors via advanced traffic management systems and effective cargo bundling and cargo coordination systems. In eastern Europe the focus is more on developing the much-needed corridors in the first place, a need that is reflected in the list of priority axes and projects of the Trans-European Transport Network (TEN-T) of the European Commission. Efficient long-distance corridors can have a downside for well-established EDC regions: they make it easier for logistics service providers to move distribution facilities inland closer to the customer base without having to sacrifice good accessibility to the maritime gateways.

4. THROUGHPUT DYNAMICS IN THE EUROPEAN CONTAINER PORT SYSTEM

To accommodate maritime trade flows, both extra-EU and intra-EU, Europe is blessed with a long coastline reaching from the Baltic to the Mediterranean and Black Sea. The European port system cannot be considered as a homogenous set of ports. It features large established gateway ports, hub ports, and a whole series of medium-sized and smaller ports, each with specific characteristics in terms of location qualities, hinterland markets served and commodities handled. This unique blend of different port types and sizes combined with a vast economic hinterland shapes port competition in the region. There is no lack of port competition in Europe. Battles are fought on many fronts: maritime and hinterland access, terminal capacity, and, above all, accommodation of supply chains.

With a total maritime container throughput of around 90 million TEU in 2007, the European container port system ranks among the busiest in the world. Growth has been particularly strong in the last few years, with an average annual growth rate of 10.5% in 2005-2007, compared to 6.8% in 1985-1995, 8.9% in 1995-2000 and 7.7% in 2000-2005. Europe counts many ports. For example, there are about 130 seaports handling containers, of which around 40 accommodate intercontinental container services (ESPO/ITMMA, 2007). In the US and Canada there are only 35 seaports involved in containerisation and only 17 of them are involved in the deep-sea container trade.

Table 1. **The top 15 European container ports** (1985-2007, in 1000 TEU)

in 1000 TEU

R		**1985**		**1995**		**2000**		**2005**		**2006**		**2007**	*R*
1	Rotterdam	2655	Rotterdam	4787	Rotterdam	6275	Rotterdam	9287	Rotterdam	9690	Rotterdam	10791	*1*
2	Antwerp	1243	Hamburg	2890	Hamburg	4248	Hamburg	8088	Hamburg	8862	Hamburg	9890	*2*
3	Hamburg	1159	Antwerp	2329	Antwerpen	4082	Antwerpen	6488	Antwerpen	7019	Antwerpen	8177	*3*
4	Bremen	986	Felixstowe	1924	Felixstowe	2793	Bremen	3736	Bremen	4450	Bremen	4912	*4*
5	Felixstowe	726	Bremen	1518	Bremen	2752	Gioia Tauro	3161	Algeciras	3245	Gioia Tauro	3445	*5*
6	Le Havre	566	Algeciras	1155	Gioia Tauro	2653	Algeciras	2937	Felixstowe	3080	Algeciras	3415	*6*
7	Marseille	488	Le Havre	970	Algeciras	2009	Felixstowe	2700	Gioia Tauro	2938	Felixstowe (**)	3200	*7*
8	Leghorn	475	La spezia	965	Genoa	1501	Le Havre	2287	Valencia	2612	Valencia	3043	*8*
9	Tilbury	387	Barcelona	689	Le Havre	1465	Valencia	2100	Barcelona	2317	Le Havre	2641	*9*
10	Barcelona	353	Southampton	683	Barcelona	1388	Barcelona	2096	Le Havre	2310	Barcelona	2610	*10*
11	Algeciras	351	Valencia	672	Valencia	1310	Genoa	1625	Genoa	1657	Zeebrugge	2021	*11*
12	Genoa	324	Genoa	615	Piraeus	1161	Piraeus	1450	Zeebrugge	1653	Marsaxlokk (**)	1900	*12*
13	Valencia	305	Piraeus	600	Southampton	1064	Marsaxlokk	1408	Southampton	1500	Genoa	1855	*13*
14	Zeebrugge	218	Zeebrugge	528	Marsaxlokk	1033	Southampton	1395	Marsaxlokk	1485	Southampton (*)	1800	*14*
15	Southhampton	214	Marsaxlokk	515	Zeebrugge	965	Zeebrugge	1309	Piraeus	1399	Constanza	1411	*15*
	TOP 15	10450	TOP 15	20841	TOP 15	34698	TOP 15	50067	TOP 15	54217	TOP 15	61111	
	TOTAL Europe	17172	TOTAL Europe	33280	TOTAL Europe	51000	TOTAL Europe	73729	TOTAL Europe	79840	TOTAL Europe	89990	
	Share R'dam	*15%*	*Share R'dam*	*14%*	*Share R'dam*	*12%*	*Share R'dam*	*13%*	*Share R'dam*	*12%*	*Share R'dam*	*12%*	
	Share top 3	*29%*	*Share top 3*	*30%*	*Share top 3*	*29%*	*Share top 3*	*32%*	*Share top 3*	*32%*	*Share top 3*	*32%*	
	Share top 10	*53%*	*Share top 10*	*54%*	*Share top 10*	*57%*	*Share top 10*	*58%*	*Share top 10*	*58%*	*Share top 10*	*58%*	
	Share top 15	*61%*	*Share top 15*	*63%*	*Share top 15*	*68%*	*Share top 15*	*68%*	*Share top 15*	*68%*	*Share top 15*	*68%*	

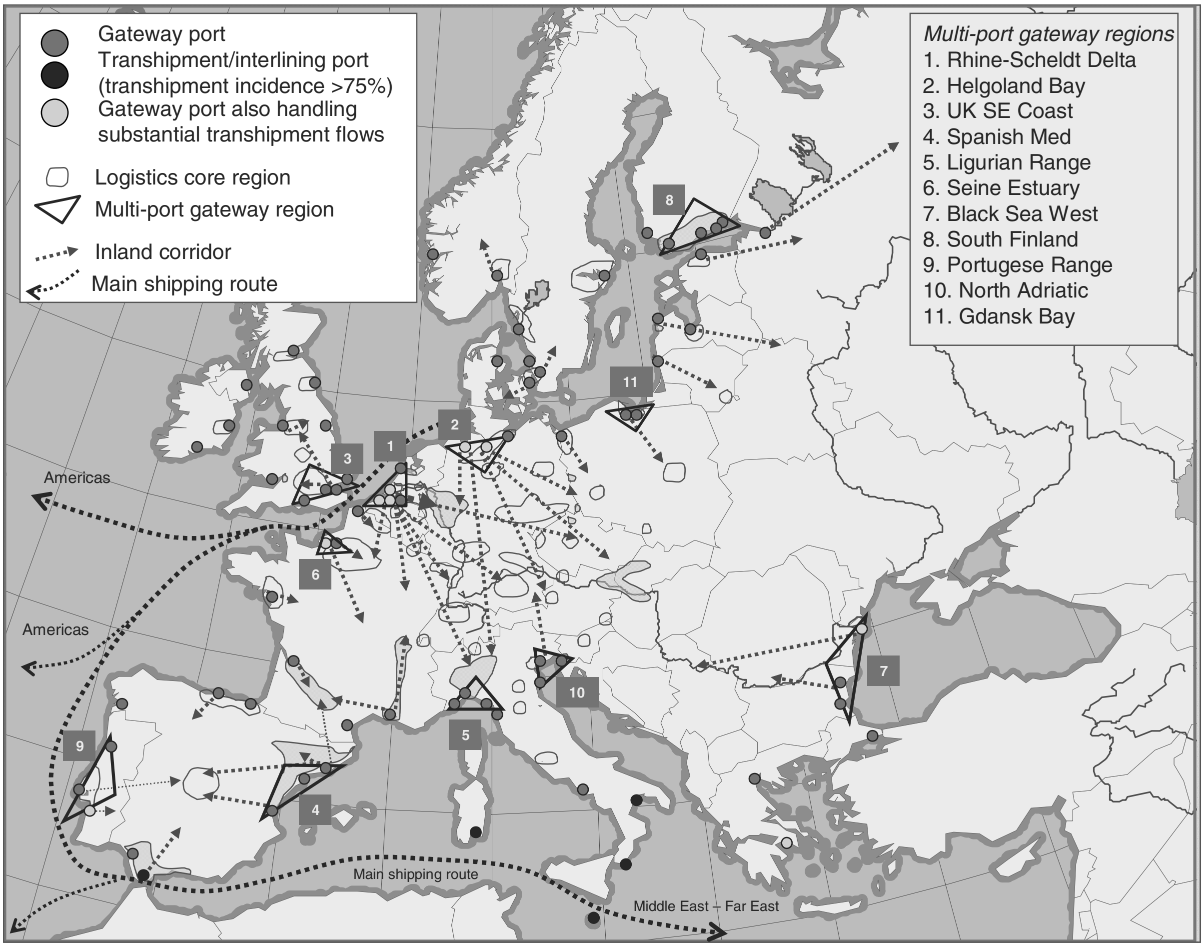
(*) Estimate based on growth first 8 months

(**) Estimate

Source: Author, based on traffic data from respective port authorities.

Table 1 provides an overview of the fifteen largest container load centres in Europe. Three of these ports (Gioia Tauro, Marsaxlokk and Algeciras) act as almost pure trans-shipment hubs with a trans-shipment incidence of 75% or more, while other load centres can be considered as almost pure gateways (e.g. Valencia, Genoa, Barcelona) or a combination of a dominant gateway function with sea-sea trans-shipment activities (e.g. Hamburg, Rotterdam, Le Havre, Antwerp and Constanza). About two-thirds of the total container throughput in the European port system passes through the top fifteen load centres, compared with 61% in 1985. One-third of all containers is handled by the top three ports, compared with 29% in 1985. It is worth noting that the dominance of market leader Rotterdam has somewhat weakened, while upstream ports Antwerp and Hamburg strengthened their position (from 7.1% and 6.7%, respectively, in 1985 to 9.1% and 11% in 2007). Concentration studies indicate that the cargo concentration index in Europe is rather high compared to the US/Canada and Asia, but has slightly decreased in the last decade, implying an increasing number of European ports is present on the competitive scene (Notteboom, 2006). This is in sharp contrast to North America, where more and more cargo is being channelled through only a few ports. The European port scene is therefore becoming more diverse in terms of number of ports involved and the scope of port functions and services, leading to more routing options being open to shippers.

Figure 3. **The European container port system and logistics core regions in the hinterlands**



Source: Notteboom – ITMMA.

Comparisons of container throughput figures are typically based on individual ports. This might be misleading when analysing the gateway function of specific port regions. An alternative approach consists in grouping load centres within the same gateway region together to form multiport gateway regions. The locational relationship to nearby identical traffic hinterlands is one of the criteria that can be used to cluster adjacent load centres. In cases there is no coordination between the ports concerned, the hinterland is highly contestable, as several neighbouring gateways are vying for the same cargo flows. The often complex linkages in the governance and management of port areas and terminals within the same multiport gateway region has received quite a lot of attention in academic literature. A good example is the port governance book edited by Brooks and Cullinane (2006) discussing the situation in many gateways and hubs, also in Europe. Charlier (1996) and Notteboom (2007) paid special attention to the Rhine-Scheldt Delta in the Benelux.

Figure 3 provides an overview of the main multiport gateway regions in Europe, as well as transshipment hubs and stand-alone gateways. Table 2 gives the associated container volumes, while Figure 4 contains pie charts for 1985 and 2007. The following conclusions can be drawn:

- The Rhine-Scheldt Delta and the Helgoland Bay ports, both part of the so-called Le Havre-Hamburg range, together represent 40% of the total European container throughput. The market share of the Rhine-Scheldt Delta is quite stable, while the northern German ports have gained market share, mainly because of Hamburg's pivotal role in feeder flows to the Baltic and land-based flows to the developing economies in east and central Europe.

- The Seine Estuary, the third region in the Le Havre-Hamburg range, suffered a long decline in its market share. The tide was turned only very recently as a result of the "renaissance" of Le Havre after the opening of the first Port 2000 terminals, combined with port productivity improvement. Le Havre's revival goes hand in hand with the ambition of the port to stretch its hinterland reach beyond the Seine basin (its core hinterland) and even across the French border, mainly supported by rail services.

- Among the major winners, we find the Spanish Med ports (from 3.9% in 1985 to 6.3% in 2007) and the Black Sea ports (from virtually no traffic to a market share of 1.7% in 2007). These ports have particularly benefited from the extension of the "blue banana" as outlined earlier (see later in this paper for a more detailed analysis).

- The Gdansk Bay ports and the Portuguese port system have been less successful so far. The Polish load centres are still bound by their feeder port status, competing heavily with main port Hamburg for the Polish hinterland. Portuguese ports Lisbon and Sines are trying very hard to expand business by developing a modest trans-shipment role as well as tapping into the market surrounding Madrid through rail corridor formation and dry port development (e.g. Lisbon's Puerta del Atlântico logistics platform in Móstoles on the outskirts of Madrid).

- Ligurian and northern Adriatic ports are typically challenged by the physical limitations to terminal capacity extensions (i.e. the locked-in geographic situation of the respective coastal port cities) and by the limited success so far in attracting a lot of business from the Alpine region and southern Germany.

- Many of the load centres along the south-eastern coast of the United Kingdom faced capacity shortages. To avoid delays, many shipping lines opted for the trans-shipment of UK flows in mainland European ports (mainly the Rhine-Scheldt Delta and Le Havre) instead of calling at UK ports directly. With the prospect of new capacity getting onstream soon (e.g. London Gateway, Bathside Bay and Teesport) there is hope for more direct calls and potentially a slight increase in market share. Much will depend on whether the UK economy remains strong and is not affected too much by the economic hiccups of its main trading partner, the US.

- Except for Piraeus, the larger stand-alone gateways in Europe have lost market share, for various reasons. For example, despite its proximity to the economic centres along the Rhône corridor and southern France, Marseille suffered from labour disputes and its rather remote location vis-à-vis the main shipping route (high diversion distance).

- Trans-shipment hubs in the Mediterranean have substantially increased their role in the container market. After a steep increase in market share from 5.1% in 1995 to 11.2% in 2000, the market position further evolved to a peak of 12.2% in 2005. However, the last few years have brought a small decline to 11.4%. A more detailed discussion of the mechanism underlying this observation follows later in this paper.

Table 2. **Container throughput figures for the main multiport gateway regions in Europe, the European trans-shipment hubs in the Mediterranean and a number of important, stand-alone gateways** (1985-2007, in 1000 TEU)

R	1985		1995		2000		2005		2006		2007	*R*
Main multi-port gateway regions in Europe												
1	RS Delta	4241	RS Delta	7747	RS Delta	11388	RS Delta	17327	RS Delta	18749	RS Delta	21463	*1*
2	Helgoland Bay	2145	Helgoland Bay	4430	Helgoland Bay	7110	Helgoland Bay	11871	Helgoland Bay	13382	Helgoland Bay	14802	*2*
3	UK SE Coast	1508	UK SE Coast	3543	UK SE Coast	5080	UK SE Coast	5722	UK SE Coast	6405	UK SE Coast (*)	7100	*3*
4	Ligurian Range	986	Ligurian Range	2051	Ligurian Range	2949	Spanish Med	4490	Spanish Med	4942	Spanish Med	5700	*4*
5	Seine Estuary	701	Spanish Med	1398	Spanish Med	2742	Ligurian Range	3528	Ligurian Range	3683	Ligurian Range (*)	4070	*5*
6	Spanish Med	676	Seine Estuary	1090	Seine Estuary	1610	Seine Estuary	2280	Seine Estuary	2295	Seine Estuary	2800	*6*
7	North Adriatic	376	South Finland	562	South Finland	773	South Finland	1120	South Finland	1221	Black Sea West	1561	*7*
8	Portugese Range	266	Portugese Range	470	Portugese Range	670	Portugese Range	916	Black Sea West	1182	South Finland	1395	*8*
9	South Finland (*)	200	North Adriatic	468	North Adriatic	606	Black Sea West	902	Portugese Range	1013	Portugese Range	1138	*9*
10	Gdansk Bay	83	Gdansk Bay	142	Gdansk Bay	206	North Adriatic	663	North Adriatic	688	North Adriatic (*)	788	*10*
11	Black Sea West	n.a.	Black Sea West	n.a.	Black Sea West	143	Gdansk Bay	470	Gdansk Bay	540	Gdansk Bay	711	*11*
Transhipment/interlining hubs in West and Central Med												
	Med Hubs	393	Med Hubs	1711	Med Hubs	5732	Med Hubs	9017	Med Hubs	9251	Med Hubs	10293	
Some important stand-alone gateways												
	Marseille	488	Piraeus	600	Piraeus	1161	Piraeus	1395	Piraeus	1399	Piraeus	n.a.	
	Gothenborg	317	Marseille	498	Marseille	722	Marseille	908	Marseille	941	Marseille	987	
	Piraeus	197	Gothenborg	461	Gothenborg	686	Gothenborg	788	Gothenborg	812	Gothenborg	n.a.	
	Bilbao	150	Liverpool	406	Liverpool	540	Liverpool	626	Liverpool	645	Liverpool	n.a.	
	Liverpool	133	Bilbao	297	Bilbao	434	Bilbao	504	Bilbao	523	Bilbao	555	

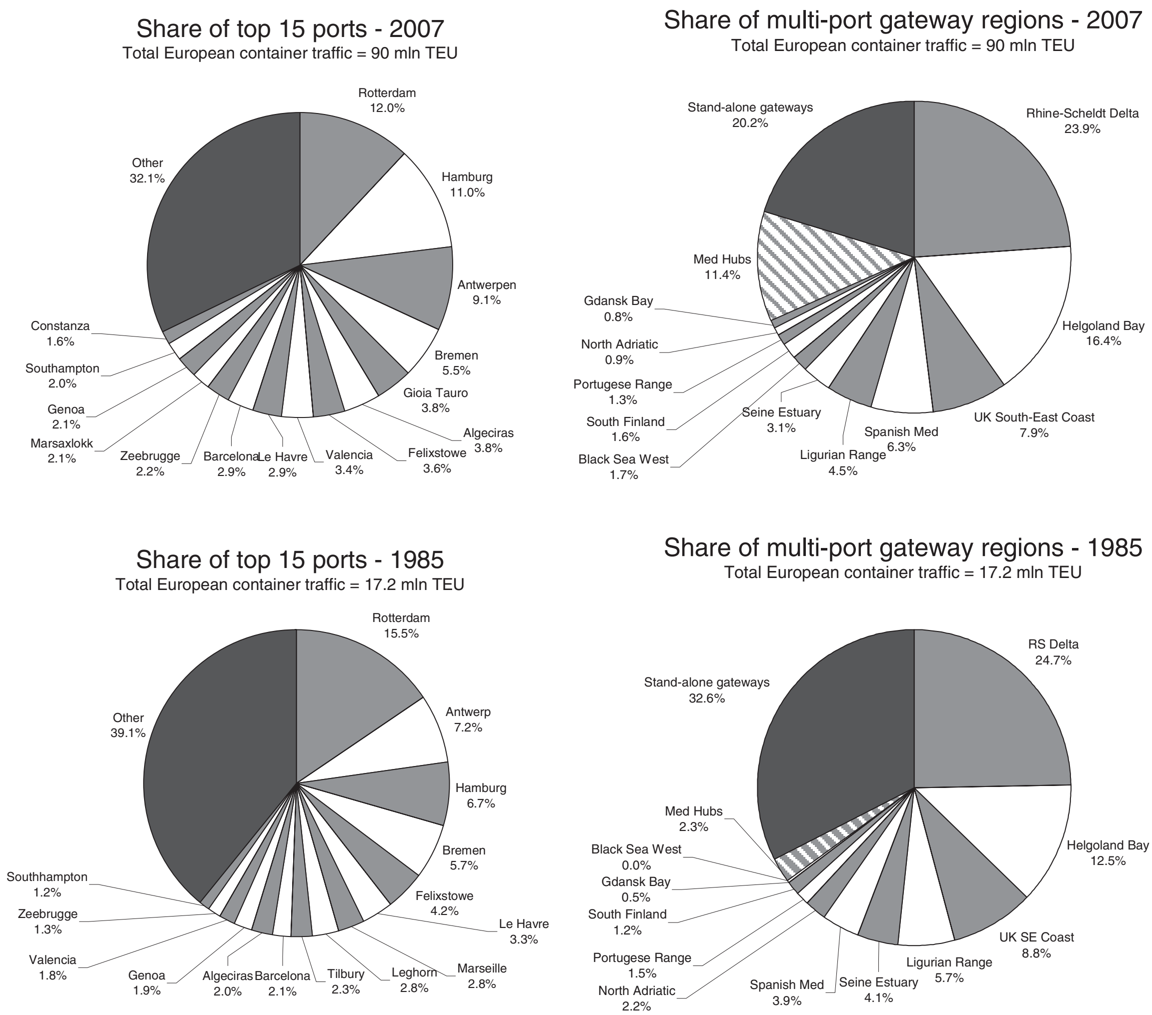
(*) Estimate

Notes:

Rhine-Scheldt Delta: Rotterdam, Antwerp, Zeebrugge, Amsterdam, Ghent, Zeeland Seaports, Ostend
Helgoland Bay: Hamburg, Bremen/Bremerhaven, Cuxhaven, Emden, Wilhelmshaven
UK South East Coast: Felixstowe, Southampton, Thamesport, Tilbury, Hull
Spanish Med: Barcelona, Valencia, Tarragona
Ligurian range: Genoa, Savona, Leghorn, La Spezia
Seine Estuary: Le Havre, Rouen
Black Sea West: Constanza, Burgas, Varna
South Finland: Helsinki, Kotka, Rauma, Hamina, Turku
Portugese range: Lisbon, Leixoes, Sines
North Adriatic: Venice, Trieste, Ravenna
Gdansk Bay: Gdynia, Gdansk

Source: Author, based on traffic data from respective port authorities.

Figure 4. **Breakdown of container throughput in the European container port system: an individual port perspective (left) versus a gateway region perspective (right)**



Source: Author, based on data from the respective port authorities.

5. KEY HINTERLAND DEVELOPMENTS FOR THE COMPETITION IN AND BETWEEN GATEWAY REGIONS

5.1 The immediate hinterland as the backbone for port rivalry in a gateway region

While corridor development to distant hinterlands attracts more and more attention, local or immediate hinterlands remain the backbone of ports' cargo bases. Even large European gateways such as Rotterdam and Antwerp have a high proportion of container flows that is generated by the port city and its immediate region. About 40% of containers leaving or arriving at Antwerp by truck are coming from or going to markets within a 50 km radius of the port. The most significant distance class for Rotterdam is the 150-200 km radius. This is directly related to the port's role as a cargo generating location linked to the strong manufacturing base of the immediate hinterland.

A major concern in many ports is the strong reliance of more local container volumes on trucks. While road haulage has always played a major role in shaping competition among load centres of the same multiport gateway region for the immediate hinterland, intermodal transport is slowly but surely acquiring a strategic role as well, particularly as a means to create cargo islands (see Figure 1). Logistics sites in the immediate hinterland typically value the flexibility a multiport gateway system offers in terms of available routing options for import and export cargo. In a logistics world confronted with mounting reliability and capacity issues, routing flexibility is one of the keystones for the logistics attractiveness of a region. For example, the logistics attractiveness of large parts of Belgium and the Netherlands for EDCs is partly due to the reality of having several efficient gateways at one's disposal.

A port with a strong local cargo base will sooner or later be tempted to increase the inland penetration of its intermodal offer so as to broaden its capture area. From that moment on the existing dense network of direct shuttles to nearby destinations might be complemented by indirect inland services to more distant destinations built around one or more inland hubs. Extensive cargo concentration on a few trunk lines opens possibilities for economies of scale in inland shuttles (through the deployment of longer trains or larger inland barges) but even more likely are higher frequencies. Containers for the more distant hinterland benefit from a port's strong local cargo base, as local containers often provide the critical mass for allowing frequent deep-sea liner services.

5.2 Gateway regions increasingly vie for distant contestable hinterlands

In line with the first section of this paper, port competition in Europe has intensified as inland corridor formation has allowed load centres to access formerly captive hinterlands of other ports. Moreover, the rise of economic centres in eastern and central Europe creates opportunities for different multiport gateway regions and stand-alone gateways to develop water-based and land-based transport networks to these areas. Major contestable hinterlands are increasingly being served not by the ports of one gateway region, but by several multiport gateway regions (Table 3). The Black Sea port region, Constanza in particular, could develop into a new gateway region to Europe. Constanza is strategically located at the eastern end of the pan-European waterway transport Corridor VII, which links the North Sea and Black Sea, as well as pan-European transport Corridor IV, linking Berlin and Istanbul by land. From the Suez Canal to Constanza is only 950 nm, compared with 3400 nm to Rotterdam, and many shipping lines have introduced direct services from the Far East with vessels in the range of 2000 to 3500 TEU (e.g. Bosporus Express of CMA-CGM and Tiger Service of MSC). The trend for Constanza to develop further into a major gateway for the region worries its Bulgarian competitors, but also opens up opportunities for landlocked countries such as the Czech Republic, Hungary and Austria to connect developing gateways in the east.

The multiplication of corridors brings about a change in the relationship between gateways and their hinterlands. On the one hand, the inland penetration strategy is part of maritime gateways' objective of increasing their cargo base. On the other hand, interior regions are recognising that it is in their interest to establish efficient links to as many gateways as possible. For example, the Czech Republic is upgrading its trans-European travel corridors intensively (in particular, the fourth corridor connecting Germany with south-eastern Europe (Istanbul). This strategy not only prevents these regions from becoming captive to one specific gateway, it also improves the locational qualities of these interior economic centres. Hence, linking up to more gateways implies more routing options and flexibility for shippers and logistics service providers who want to set up business in the region. The performance profile of each of the corridors in terms of infrastructure provision (capacity), transport operations (price and quality of the shuttle services) and the associated logistical control (i.e. the management in a supply chain context) is a key attribute for this kind of competitive play among various multiport gateway regions.

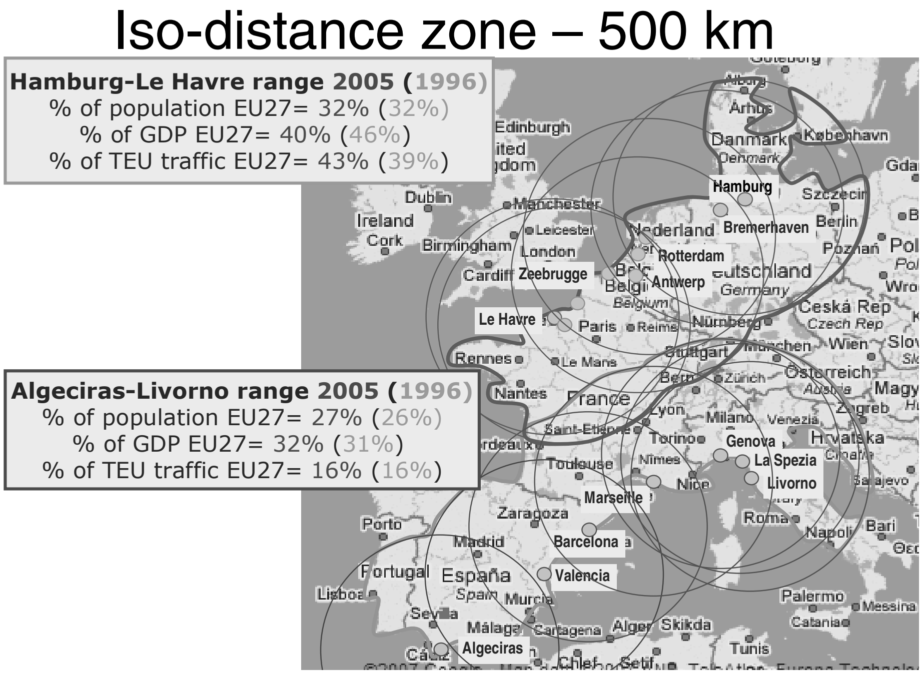
Table 3. **The position of major multiport gateway regions vis-à-vis important contestable hinterland areas in Europe**

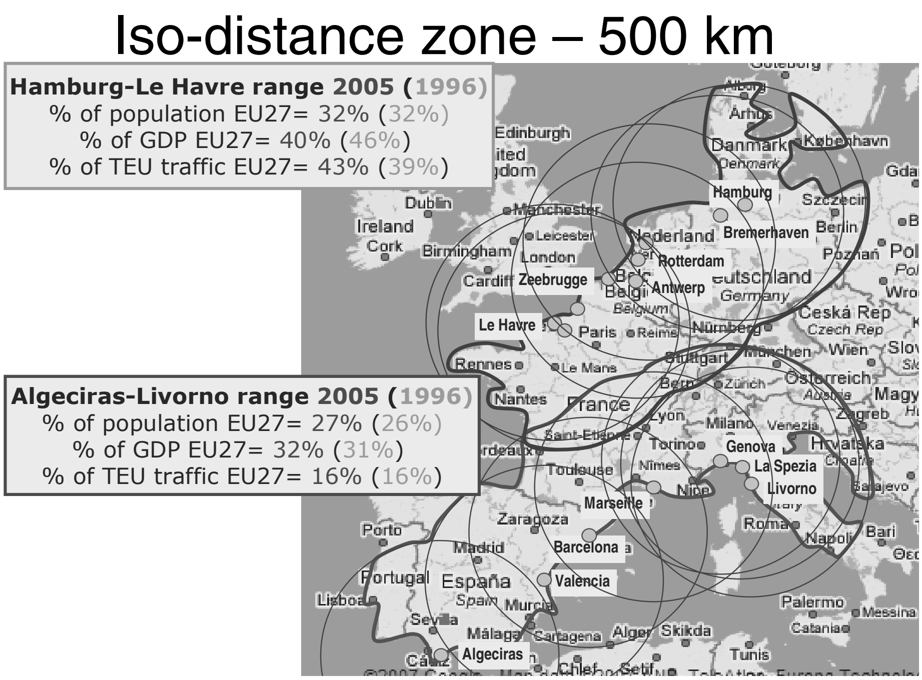
	West Germany (Ruhr area, Baden-Württemberg, ..)	South Germany Alpine countries	Madrid and surroundings	Southern Poland Czech Republic Hungary	Northern Italy	Southern France
Rhine-Scheldt Delta	+	+	-	+ (Rott.) / °	+	+ (Antw.) / -
Helgoland Bay	+	+	-	+	+	-
Spanish Med			+			- / + (Barc.)
Ligurian Range		x / °			+	x
Seine Estuary	°	-				+
Black Sea West		°		° / +		
Portugese Range			°			
North Adriatic		x / °		x / °	+	
Gdansk Bay				x / °		

+ = major hinterland region for gateway region, successful intermodal services
x =potentially major hinterland region for gateway region, but success limited
- = minor hinterland region for gateway region
° =potential hinterland region for gateway region, intermodal services planned or started-up recently

5.3 The North-South balance in perspective

Figure 5: **The relative shares of iso-distance zones for the Hamburg-Le Havre range and the Algeciras-Livorno range** (1996 versus 2005)





Source: Compiled on the basis of Eurostat GDP and population statistics (NUTS II level) and traffic figures provided by the respective port authorities.

The dominance of ports in the Le Havre-Hamburg range (particularly the Rhine-Scheldt Delta and Helgoland Bay) in Europe is very apparent when looking at throughput statistics (see earlier). This observation fuels a decades-old debate on what some see as an "unhealthy" balance between North and South. Evidence provided in Figure 5 demonstrates the imbalance not only exists, it has even grown stronger in the last decade despite an increasing degree of participation by mainland Med ports in international shipping networks. While the share of the immediate hinterlands of the northern range ports in the GDP of the EU27 decreased in 1996-2005, the container cargo share increased significantly. The joint market share of the Le Havre-Hamburg range ports in liner services between the Far East and Europe is estimated at 76%, compared to 24% for western Med ports (Milà, 2008). In the 1980s the Europe-Far East trade was still totally concentrated on northern range ports. The more local gateway function of mainland Med ports versus the sometimes European-wide gateway position (including trans-shipment flows and land-based intermodal corridors) of ports such as Hamburg, Rotterdam and Antwerp is a major cause of the observed imbalance.

In theory, mainland Med ports offer transit time advantages over the northern European ports for accommodating cargo flows between Asia/Middle East and large parts of southern and central Europe (time savings for vessels of up to five days). In practice, only Spanish Med ports have been successful (in large part due to the strong economic growth in Catalonia) while Italian and French Med ports lag behind in growth (see figures outlined earlier).

Italy is somewhat a special case for intra-Med trade. While France and Spain are mainly involved in north–south trade, Italy could also represent a gateway for trade with eastern Europe (Ferrari *et al.*, 2006). However, Cazzaniga and Foschi (2002) demonstrate that northern Italian ports collect only a very small portion of the merchandise of the area extending from Bavaria to Hungary. Even worse, significant flows of Italian cargo sail not from Italian ports but from ports in the Rhine-Scheldt Delta and Helgoland Bay. There has been improvement, though. Cazzaniga and Foschi (2002) indicate that northern Italian ports increased their market share in total northern Italian container flows on the Far East trade from 70% in 1995 to 81% in 2001 while the market share of the northern ports fell from 30% to 19% (no later figures are available). About half of the flows between northern Europe and northern Italy) goes by rail (the share is still increasing) and the remainder by truck. Note that rail has a market share of 25% in Genoa and La Spezia. The percentages of cargo shipped via northern Europe are thus showing a tendency to decrease, but some observers argue this process is far too slow considering that many shipping lines now have direct mainline vessel calls in the Med.

Gateway ports in the western Med have indeed improved their connectivity in the global shipping networks, which gives these ports the opportunity to benefit from a higher critical mass and the economies linked to larger vessels. But so far, they seem to be having difficulties in substantially extending their hinterland reach north through rail services (Gouvernal *et al.*, 2005). While Spanish ports face a major technical problem in setting up rail shuttles to France (i.e. the difference in gauge), the North-South paradox for northern Italian cargo is mainly linked to a weaker intermodal organisational performance for intra-Italian rail products, and existing (but converging) differences in port efficiency between northern ports and northern Italian ports. Moreover, a smaller critical rail volume makes it hard to maintain frequent rail services, which sometimes disappear soon after introduction.

Several initiatives are under way with the objective of improving the position of the Med ports. Next to major terminal expansion plans in ports such as Barcelona, Valancia, Marseille and Genoa, western Med ports' latest investment strategies include a range of logistics platforms both in seaports and in strategic inland locations (e.g. the "tm concept" of the Barcelona port authority, discussed later in this paper), but at the moment the inland operations are mostly modest, generating only small volumes. To attract Asian trade distribution to the region, the ports of Barcelona, Marseille and Genoa have joined their marketing efforts under the umbrella of the association Intermed. The range of actions also includes corridor formation. Next to south-north corridors (mainly rail) included in DG TREN's TEN-T program, the FERRMED association aims at the development of a reticular and polycentric railway axis reaching from southern Spain all the way to the core economic regions in the Benelux and Germany and further north to Stockholm. The FERRMED axis aims to offer an alternative to the high-volume Rhine-Rhône-Occidental Mediterranean axis.

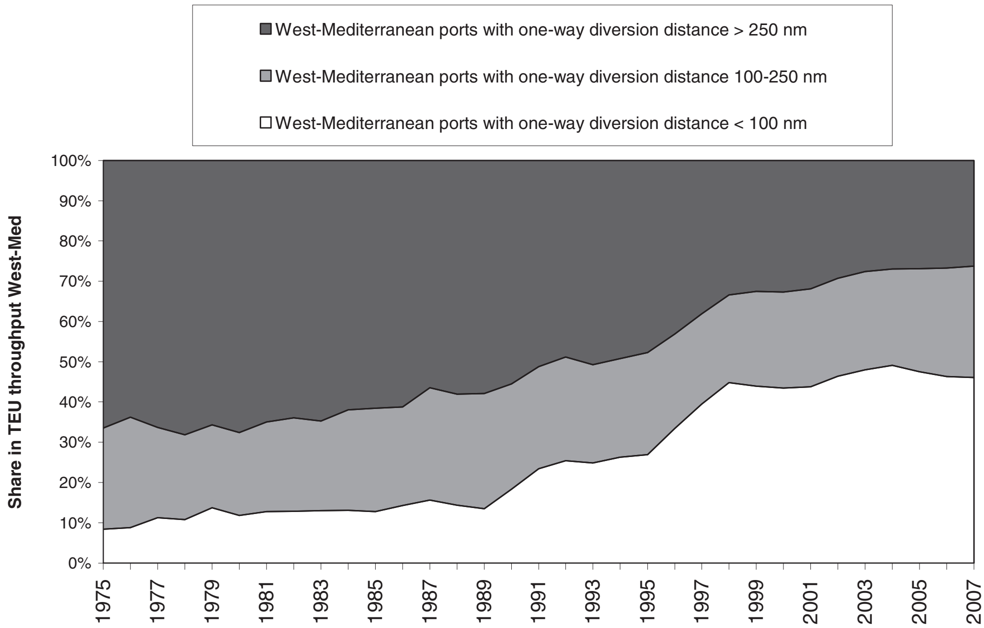
All these initiatives are taken in a market environment where northern range ports are also very active in intensifying their intermodal networks, mainly to inland service areas in France, Germany, the Alpine region and eastern and central Europe. The range and diversity of the intermodal service offer of the large load centres in the north are still far bigger and more established than their Mediterranean counterparts. As it is highly unlikely this gap is going to be bridged in the foreseeable future, the presence of northern load centres in south European container markets remains a market-driven reality.

5.4 Transshipment hubs under scrutiny and the impact on inland freight distribution

Not all ports in Europe are gateways. A number of terminals mainly rely on their role as turntables or hubs in extensive maritime hub-and-spoke/relay/interlining networks. In the Mediterranean, extensive hub-feeder container systems and short sea shipping networks have emerged since the mid 1990s to cope with the increasing volumes and to connect to other European port regions (Figure 6). Terminals are typically owned, in whole or in part, by carriers which are efficiently using these facilities. Marsaxlokk on Malta, Gioia Tauro, Cagliari and Taranto in Italy and Algeciras in Spain act as turntables in a growing sea-sea trans-shipment business in the region. These sites were selected to serve continents, not regions, for trans-shipping at the crossing points of trade lanes, and for potential productivity and cost control. They are typically located far away from the immediate hinterland that historically guided port selection.

The market share of the trans-shipment hubs in total European container throughput peaked in 2005 (12.2%) but since then has started to decline, reaching 11.4% as volume growth in mainland ports allowed shipping lines to shift to direct calls. While some shipping lines still rely on the hub-and-spoke configuration in the Med, others have decided to add new line-bundling services calling at mainland ports directly. Maersk Line, MSC and CMA-CGM are modifying their service patterns, giving increasing priority to gateway ports. In reaction, mainly Italian trans-shipment hubs are reorienting their focus, now serving central and eastern Med regions. Algeciras (stronghold of APM Terminals of the AP Moller Group) relies a lot on east-west and north-south interlining and is facing competition from newcomer Tangermed where APM Terminals has also set up business recently. The net result of the above developments has been a slight decline in the market share of the western Med hubs in recent years (Figure 6). The trans-shipment business remains a highly "footloose" business. This has led some trans-shipment hubs such as Gioia Tauro and Algeciras to develop inland rail services to capture and serve the economic centres in the distant hinterlands directly, while at the same time trying to attract logistics sites to the ports.

Figure 6. **The market shares of ports in the western Mediterranean**
Ports grouped according to the diversion distance from the main shipping route (1975-2007)



Source: Aggregation by author based on statistics of respective port authorities.

The creation of "offshore" hubs does not occur in all port systems. Northern Europe up to now has not had any real trans-shipment hub, let alone an offshore hub. Hamburg, the northern European leader in terms of sea-sea flows, has a trans-shipment incidence of merely 40%, far below the elevated trans-shipment shares in the main southern European hubs (85% to 95%). It is generally expected that the trans-shipment shares of future newcomers Flushing and Wilhelmshaven might slightly exceed 40%. The only somewhat concrete plan for a real northern European offshore hub relates to a proposed trans-shipment facility at the natural deep-water harbour at Scapa Flow in the Orkney Islands. Baird (2006) argued that alternative port sites such as Scapa Flow could provide superior and more competitive locations from which to support the fast expanding trans-shipment markets of northern Europe. Nevertheless, market players have not adopted the idea of bringing a northern offshore hub into reality.

The dynamics in the trans-shipment business have implications on freight distribution patterns in Europe. A hub and spoke-based network means less cargo concentration in mainland destination ports and, as such, a more dispersed or fragmented inland transport system. Alternatively, traffic growth can lead to an undermining of the position of trans-shipment hubs in favour of a limited number of large-scale mainland ports, each connected to intermodal corridors. This brings us back to the discussion on inland services of the Med ports as outlined in the previous section.

5.5 The challenge of the periphery

The geographic literature on development patterns in seaport systems suggests an increasing level of port concentration as certain hinterland routes develop to a greater extent than others in association with the increased importance of particular urban centres (Taaffe *et al.*, 1963). The geographic system would evolve from an initial pattern of scattered, poorly connected ports along the coastline to a main network consisting of corridors between gateway ports and major hinterland centres. These models thus suggest that large ports, which invested early in container infrastructure, would attract more and more container traffic. The resulting port concentration would cause degradation of minor ports in the network. In the 1980s, some authors suggested cargo concentration would reach a limit, allowing smaller ports or new ports to acquire a place in the market (Barke, 1986, and Hayuth, 1981). The challenge of the periphery supports the transition from a single gateway situation to a multiport gateway region. Many gateway regions in Europe have witnessed a recent multiplication of load centres or will do so in the future. The main challengers in each gateway region are listed in the last column of Table 4.

Table 4. **Evolution of the share of the market leader in the multiport gateway region** (%, 1985-2007)

	1985	1995	2007	Trend for market share of leader	Main challengers in the periphery
RS Delta	62.6	61.8	50.3	Decreasing, leader unchanged (Rotterdam)	Zeebrugge (+), Amsterdam (-), Flushing (?)
Helgoland Bay	54.0	65.2	66.8	Increasing, leader unchanged (Hamburg)	Wilhelmshaven (°), Cuxhaven (x)
UK SE Coast	48.1	54.3	47.3	Fluctuation, leader unchanged (Felixstowe)	London Gateway (°), Bathside Bay-Harwich (°) Dibden Bay (X), Teesport (?)
Spanish Med	52.2	49.3	53.4	Fluctuation, change in leader (Valencia overtook Barc.)	-
Ligurian Range	48.2	30.0	45.6	Fluctuation, change in leader (Genoa overtook Leghorn)	-
Seine Estuary	80.8	89.0	94.3	Increasing, leader unchanged (Le Havre)	-
Black Sea West	n.a.	n.a.	90.4	Increasing, leader unchanged (Constanza)	-
South Finland	n.a.	60.3	40.9	Decreasing, change in leader (Kotka overtook Helsinki)	Kotka (+)
Portugese Range	57.9	58.4	48.7	Recent decrease, leader unchanged (Lisbon)	Sines (+)
North Adriatic	50.5	41.3	41.3	Fluctation, change in leader (Venice overtook Ravenna)	Trieste (+)
Gdansk Bay	100.0	99.6	86.4	Decreasing, leader unchanged (Gdynia)	-

(+) (some) terminal(s) already in operation; strong results
(-) (some) terminal(s) already in operation; moderate results
(°) Terminal under construction
(?) No container terminal yet, planning phase
(x) Container terminal was planned, but plans abandonned or rejected

Source: Based on data from respective port authorities and specialized press.

Centrifugal forces that support the so-called "peripheral port challenge" include (a) the new requirements related to deep-sea services (e.g. good maritime and inland accessibility, availability of terminal and back-up land and short vessel turnaround times), (b) strong growth in the container market and (c) potential diseconomies of scale in the existing load centres in the form of lack of space for further expansion or congestion (see, e.g., Hayuth, 1981, Slack & Wang, 2002, Notteboom, 2005, Frémont & Soppé, 2007). The markets also exert a range of centripetal forces favouring a sustained strong position of established large load centres vis-à-vis medium-sized and new terminals. First, the planned additional terminal supply in small and medium-sized ports is typically overshadowed by massive expansion plans in established larger ports. For example, Notteboom (2007) demonstrated that in the best case scenario, the market share of the small and medium-sized ports in the Le Havre-Hamburg range could increase from 7.1% in 2006 to approximately 16% past 2015, with 75% of the capacity bring added by the large load centres. Major shifts in existing port hierarchy are unlikely. Second, new entrants in the terminal market often have to overcome major issues such as the need to secure hinterland services, relative inexperience in dealing with stakeholder-related procedures linked to large terminal projects and weak cargo-generating and cargo-binding potential (typically as a result of a lack of associated forwarders' and agents' networks). New trans-shipment hubs generally face less of these problems given their remote locations, their weak reliance on hinterland connectivity and their strong link with one or few shipping line(s) that will use the facilities as turntables in their liner networks (operational push instead of market pull).

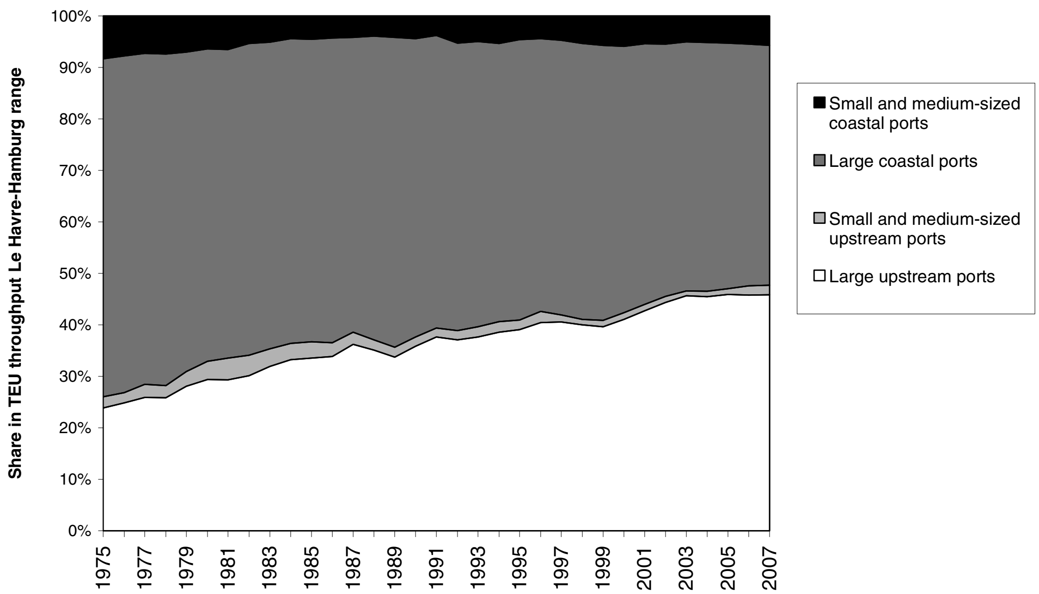
The hinterland connectivity issue deserves special attention. Large load centres to a varying extent experience a virtuous cycle. The concentration of large deep-sea container volumes in one place makes it easier to build up an extensive network of intermodal services and this in itself attracts even more cargo (partly triggered by economies of scale and density). Small-scale container ports often lack the volumes needed to develop a network of frequent shuttle trains. This in itself can contribute to a perceived lower attractiveness of the port. To escape this imminent vicious cycle, smaller ports tend to shuttle substantial container flows to larger ports in the region (interport traffic) so as to link up with the extensive hinterland network available. The development of inland hubs in the immediate hinterland opens opportunities for smaller ports to use the extensive hinterland networks even without having to rely on the established load centres directly. The inclusion of such bundling points in the hinterland thus promotes the formation of a multiport gateway region and increases the complexity and range of possible routing patterns. The minimum cargo volume needed to set up a network of direct shuttles is affected by the level of cargo dispersion in the service area of the port. A port that only serves a dense local economic cluster will obviously face less difficulty in developing a regular inland service than a port handling containers for a large number of final destinations dispersed over a vast hinterland.

5.6 Port competition and the role of upstream ports

With demand growing for a good nautical accessibility and a fast turnaround time for the ever larger container vessels, one could assume that the days of upstream ports are counted (see, e.g., Baird, 1996). While in the Med trans-shipment hubs with a low diversion distance have succeeded in gaining a position in the market, the northern European port system seems to have been going another direction. Large upstream ports, i.e. basically Antwerp and Hamburg, have gradually gained market share at the expense of coastal ports (Figure 7). Since 2003, however, the share has stabilised at around 46%, mainly due to the rise of Zeebrugge, the recent revival of Le Havre and a regained growth path in Rotterdam after several years of stagnation.

Although the discussion on downstream versus upstream load centres can not be generalised, there exists a competitive potential for upstream ports in northern Europe. First, the growing gap between inland transport costs and maritime freight costs supports direct calls at an upstream port, certainly when the port's immediate hinterland has a strong cargo-generating power (as is the case for Antwerp and Hamburg) and when the upstream port succeeds in outperforming downstream ports in terms of terminal productivity, prices and integrated value-added services, all this in order to compensate for the extra sailing time. Antwerp and Hamburg have become "must call" ports in the eyes of quite a number of shipping lines. A relatively high proportion of container traffic is handled for a multitude of smaller shippers. Major freight forwarders use these ports as major groupage centres. Merchant haulage is particularly strong in Antwerp, where small and large forwarders controlling about 70-75% of the inland movements, attracting shipping lines to this cargo base. Draft limitations remain the worst threat to the position of upstream ports mainly on the Europe-Far East trade. Both Antwerp and Hamburg have responded to the realities in the liner market by engaging in extensive dredging programmes to guarantee access for the largest generation of post-panamax vessels.

Figure 7. **Evolution of the market shares in the Le Havre-Hamburg range**



Source: Aggregation by author based on data of respective port authorities.

The future outlook will largely depend on the balance of power between two principles: "cargo follows ship" versus "ship follows cargo". Shipping lines are entirely prepared to call at upstream ports Antwerp and Hamburg in large part because of their high cargo generating performance and the savings they can make in onward inland transport distances. This demonstrates that the design of liner services is a function not only of carrier-specific operational factors, but also of shippers' needs (for transit time and other service elements) and of shippers' willingness to pay for better service.

6. THE ROLE OF RELEVANT ACTORS IN THE STRUCTURING OF HINTERLAND NETWORKS

6.1 Co-operation, logistics integration and market pull in the intermodal offer

As mentioned earlier, the ultimate success of a port will depend on the ability to integrate the port effectively into the networks of business relationships that shape supply chains. In other words, the success of a seaport is increasingly determined by the ability of the port community to fully exploit synergies with other nodes and other players within the logistics networks of which they are part. A study by Song and Panayides (2008) revealed that the most important parameters contributing to port/terminal integration in supply chains relate to technology, value-added services, the relationship with clients and liner operators, the facilitation of intermodal transport and channel integration practices. Many of these factors go beyond the narrow geographic limits of the port, thereby confirming the need for an increasing focus on the notion of the *borderless mainport* (Van Klink, 1995) and on *port regionalisation* as the newest phase in the functional development of load centres and port systems (Notteboom and Rodrigue, 2005). Regionalisation expands the hinterland reach of the port through a number of strategies linking it more closely to inland freight distribution centres. The port regionalisation phase is characterised 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 or logistics pole. The port system consequently adapts to the imperatives of distribution systems as supply chain management strategies finally permeate to transport operations and transport infrastructure.

This plea for creating synergies beyond the port perimeter and across market players is particularly relevant in the context of hinterland connections. In an attempt to expand the port's cargo base, to generate revenue and to add value for customers, ports have all adopted ways of moving cargo as efficiently as possible through the port and on to intermodal corridors. No port has been able to achieve these outcomes alone. They are all dependent on the development of an innovative range of relationships and network formations with transport operators, logistics service providers and other transport nodes. Co-ordination and co-operation are needed to form an integrated intermodal service that complies with the requirements imposed by the supply chains that pass through the port. Van Der Horst and De Langen (2008) made a detailed analysis of the co-ordination problems in hinterland chains of seaports and the arrangements to resolve these problems. They distinguished four main categories of arrangements to improve co-ordination: the introduction of incentives (e.g. a bonus or penalty), the creation of an interfirm alliance (e.g. through the introduction of standards for quality and service or a joint capacity pool), alteration of the scope of the organization (e.g. through vertical integration or the introduction of a chain manager) and collective action (e.g. through governance by a port authority or a concerted action by a branch association; see also De Langen and Chouly, 2004).

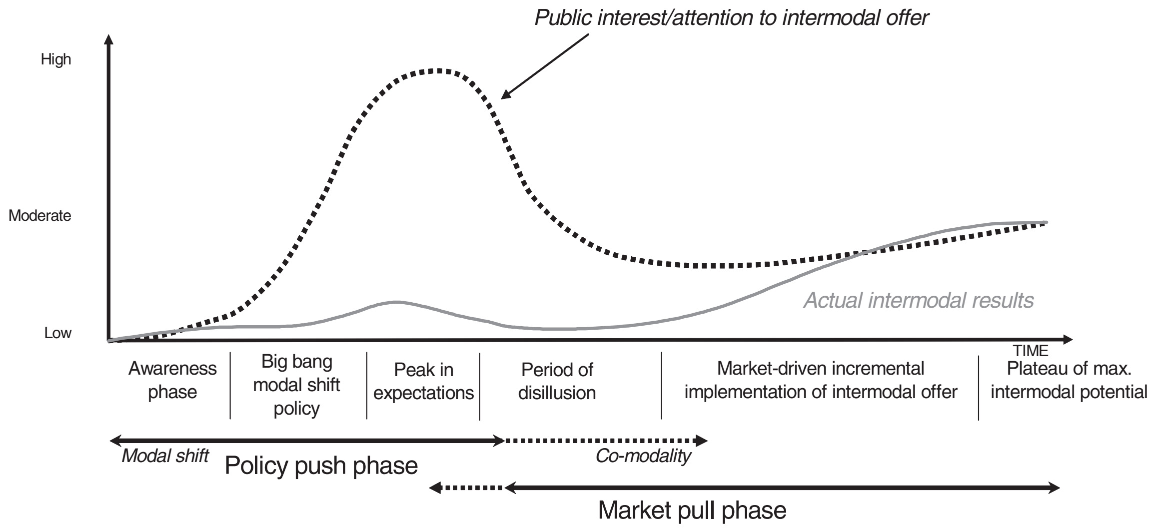
The dynamics in contemporary port-hinterland relationships are thus not taking place in a vacuum, but are articulated by the joint strategic and operational decisions of the actors involved. The need for co-ordination is also rooted in a belief that the private interests of individual companies will not lead to the creation of efficient and extensive pan-European intermodal networks (Stone and Verbeke, 1997). Companies cannot be expected to be the promoters of an intermodal network system that leads to higher efficiency at the macro level rather than the level of the firm.

The call for co-operation and co-ordination is materialising against the backdrop of large scale consolidation and vertical integration in the logistics industry. Most actors have responded to the globalisation and outsourcing trends by providing new value-added services in an integrated package, through vertical integration along the supply chain, and by significantly expanding the scale of operations via a series of mergers and acquisitions. The observed vertical integration strategies of the market players have blurred the traditional division of tasks within the logistics chain but at the same time improved the co-ordination between segments of the chain; see, e.g., Robinson (2002) and Notteboom and Winkelmans (2001). Customers' need for a wider array of global services and for truly integrated services and capabilities (design, build and operate) triggered a shift from transport-based 3PLs to warehousing and distribution providers, and at the same time opened the market to innovative forms of non-asset-based logistics service provision, i.e. 4PL (fourth party logistics). Mergers and acquisitions have permitted the emergence of large logistics operators that control many segments of the supply chain. Through vertical and horizontal integration of their activities, market players such as shipping lines, forwarders, transport operators and logistics groups seek to reduce costs, improve efficiency, generate revenue and deliver value and a "one-stop shop" service to the customer. The provision of integrated services does not always need to coincide with the ownership of the related assets. In many cases, the integration is achieved through close partnerships with other players.

All the actors involved approach hinterland issues from their respective viewpoints and objectives. Logistics service providers and transport operators have their specific operational and commercial reasons to get involved in the shaping of hinterland networks. Notwithstanding potential objective struggles and varying levels of logistics integration, they have some shared interests when it comes to hinterland issues. First, logistics service providers, shipping lines, terminal operators and transport operators are facing major challenges in the cost structure (e.g. pricing systems, fuel costs) and the reliability and synchronisation of inland transport services. Second, all these market players expect government regulation and liberalisation to support their efforts to create efficient hinterland transport networks.

In the 1990s, European and national policy makers showed a strong inclination to almost "force" a modal shift, backed by the liberalisation (or at least the start of it) of the barge and rail markets, new pricing tools and extensive subsidy and supporting programs (e.g. PACT). The market players reacted only moderately to the incentives in this "policy push" phase, even at the peak of the modal shift hype (Figure 8). As a result, the modal split trends remained almost unchanged. Recent years have seen a more bottom-up approach mirroring a clear market-driven interest from the users and suppliers of intermodal services (market pull) and more initiatives aimed at better co-ordination. The market players are spontaneously launching new intermodal initiatives or jointly tackling existing obstacles, while at the same time the push component on the policy side has somewhat softened. In more recent policy documents, the European Commission has adopted the idea of "co-modality" so as to move away from the "road against all other modes" connotation associated with the modal shift concept.

Figure 8. **Policy push and market pull in achieving a modal shift and co-modality**



Source: Author, combining insights from the Gartner Group on the hype cycle of emerging technologies and Button (2007) on transport policy development (big bang versus incremental).

The transition to more of a market pull environment has allowed some ports to achieve a partial modal shift in hinterland transport in recent years, but rail and inland navigation still have not reached their maximum potential (see modal split figures in Annex 3). For example, container transport by barge is slowly becoming more important in navigation areas outside the Rhine and the Benelux countries, with positive effects on barge traffic in ports such as Hamburg, Le Havre and Marseilles. Container transport by rail has seen spectacular development in German ports and Zeebrugge, while other ports both small and large are implementing strategies (backed up by infrastructure and rail liberalisation) to significantly increase the market share of rail in the modal split after years of stagnation or relative decline. As mentioned earlier, smaller ports and new terminals often find themselves confronted with a vicious circle in the organisation of hinterland transport, which complicates a further modal shift in many ports around Europe and could impede the development of new multimodal corridors.

The following sections will discuss the impact of horizontal and vertical relations in supply chains on the structure of these chains and on the relationships between seaports and inland ports. They will identify who takes or should take the lead in the further integration of ports and inland ports and what actions have been taken so far by the market players in this respect. It will analyse, in particular, the roles of shipping lines, terminal operators, land transport operators and port authorities.

6.2 Shipping lines and the hinterland

In recent years, substantial takeover activity has occurred on the shipping lines' side, where mergers have created a handful of gigantic companies controlling several hundred ships. The top twenty carriers controlled 26% of the world TEU-slot capacity in 1980, 41.6% in 1992, 54% in 1999 and 81.4% in 2007. AP Moller-Maersk started the latest consolidation wave with the takeover of P&O Nedlloyd in August 2005. TUI AG (Hapag-Lloyd's parent company) responded with the purchase of

CP Ships, while French line CMA CGM acquired the shipping interests of Bolloré (including Delmas, OTAL, Setramar and Sudcargos). Maersk Line had a market share of more than 16% in 2007 based on the number of TEU slots deployed worldwide, and has more than double the fleet size of runner-up MSC and more than three times the fleet size of CMA CGM. Between them, these three carriers controlled more than 33% of the cellular TEU capacity in 2007 (according to ASX Alphaliner). This obviously gives them enormous bargaining power vis-à-vis terminal operators and port authorities. Some industry observers argue that further consolidation in the liner shipping industry can be expected. In March 2008, TUI announced that it might consider selling Hapag-Lloyd, with NOL/APL as the most likely buyer. However, a further massive consolidation would be unlikely to escape the scrutiny of regulatory bodies such as the European Commission.

Container shipping lines are well aware of the growing importance of the land leg. Scale increases in vessel size and alliance co-operation have lowered ship system costs, but at the same time intermodal costs share an increasing part of the total cost. The portion of inland costs in the total costs of container shipping typically ranges between 40% and 80%. The shift from vessel costs to land-side costs is enhanced by transport price evolutions. For example, the freight rate and additional charges (including BAF, CAF and THC, but excluding administrative and time costs) on a port-to-port basis with a post-Panamax vessel between Shanghai and the Rhine-Scheldt Delta amount to some €0.12 per FEU-km (€2300 for 11000 nm), while inland haulage by truck from northern European ports usually ranges from €1.50 to €4 per FEU-km depending on distance and weight. By barge the price ranges between €0.50 and €1.50 per FEU-km (excluding handling costs and pre- and end-haul by truck; CCS figures). The price difference per FEU-km between inland transport and long-haul liner shipping ranges from a factor 5 to a factor 30, further supporting the notion that inland logistics could be one of the most vital areas still left to cut costs.

Moreover, shipping lines have to meet shippers' requirements in terms of frequency, punctuality, reliability and geographic coverage (Slack *et al.*, 1996). Shipping lines are facing poor schedule reliability, mainly caused by port terminal congestion (Notteboom, 2006b). Drewry (2006b) reports that on the Far East-Europe trade only 44% of the vessels made it on schedule. Among the late arrivals, 50% were one day late, 20% two days late, roughly 10% three days late and the remaining 20% four or more days late. Maersk Line recorded an average worldwide schedule integrity of 70%. MSC is amongst the poorest performers with only 41%. In an effort to better control costs and operational performance and as a measure to remedy the effects of ever-decreasing schedule integrity, container shipping lines have been very active in securing (semi-)dedicated terminal capacity in strategic locations in recent years. Nowadays a substantial number of container terminals in North and South Europe feature a shipping line among their shareholders (in most cases as a minority shareholder). In particular MSC and CMA CGM, the world's second and third biggest container shipping lines, are very active in this field, with involvements in 15 and 10 container terminals, respectively. Maersk Line's parent company, AP Moller-Maersk, operates a large number of container terminals in Europe (and abroad) through its subsidiary APM Terminals. APM Terminals is involved in the management of container terminals in the ports of Aarhus, Bremerhaven, Rotterdam, Zeebrugge, Dunkirk, Gioia Tauro, Algeciras, Constanza and Le Havre.

But the ambitions of many shipping lines do not stop at the terminal. Much literature has addressed the involvement of container shipping lines in inland transport and logistics (see, e.g., Konings, 1993, Baird & Lindsay, 1996, Graham, 1998, Cariou, 2001, Frémont, 2006). A number of shipping lines stick to the shipping business and try to enhance network integration through structural or ad hoc co-ordination with independent inland transport operators and logistics service providers. They do not own inland transport equipment. Instead they use trustworthy independent inland operators' services on a (long-term) contract basis. Other shipping lines combines a strategy of selective investments in key supporting activities (e.g. agency services or distribution centres) with subcontracting of less critical services. With only a few exceptions, the management of pure logistics services is done by subsidiaries that share the same mother company as the shipping line but operate independently of liner shipping operations, and as such also ship cargo on competitor lines (Heaver, 2002). A last group of shipping lines are increasingly active in the management of hinterland flows. The focus is now on the efficient synchronization of inland distribution capacities with port capacities.

A number of shipping lines, such as Maersk Line, have gone fairly far in providing rail services. Maersk Line owns European Rail Services (ERS) and has a shareholding in BoxXpress (joint venture with Eurogate). ERS operates a vast network of shuttle trains mainly out of the port of Rotterdam to inland destinations across Europe. Started at 3 shuttles a week in 1994, ERS now offers 200+ shuttles a week and handled a rail volume of 620,000 TEU in 2006. CMA CGM and MSC are moving along the same path. For example, Rail Link, the CMA CGM rail subsidiary, was founded in 2001 and handled 51,000 TEU in 2006 on links from Marseille/Fos, Lyon, Dourges and Le Havre to destinations in France, the Benelux and Germany. Carriers often buy capacity from national railway companies. They often complain about the elevated traction cost and the long preparations and negotiations with the railway companies needed to install fast direct rail services.

In the past, barge services were solely maintained by independent barge operators (Charlier and Ridolfi, 1994), but recently a few deep-sea carriers have become directly involved in inland navigation. For example, CMA CGM set up River Shuttle Containers a few years ago and now offers barge services on the Seine and the Rhône-Saône (volume of 59,736 TEU in 2006). MSC and Maersk also offer barge services from Le Havre. These shipping lines develop their own rail, barge and truck products through their own companies or through strategic partnerships with major third party operators, to safeguard quality and efficiency.

The inland strategy of shipping lines also includes inland terminals and inland depots. Inland terminals and rail and barge services are combined to push import containers as fast as possible from the ocean terminal to an inland location, from where final delivery to the receiver is later initiated. The push concept is initiated by the shipping line, yet prioritised based on the required delivery date. Export containers are pushed from an inland location to the ocean terminal, initiated by the shipping line, yet prioritised based on available inland transport capacity and the ETA of the mother vessel. The function of inland terminals thus changes to a distribution node, where containers will be accumulated until customer required delivery (customer pull process). Rodrigue and Notteboom (2008) provide an extensive analysis of this *extended gate* concept.

In order to streamline such as an inland distribution system, shipping lines and alliances between them seek to increase the percentage of carrier haulage on the European continent. The share of carrier haulage is about 30% on average, but large differences can be observed among routes and regions: the UK is a typical example of a strong carrier base, while merchant haulage remains very dominant in the Benelux and especially in Switzerland. Carrier haulage has a positive influence on the modal split (see Table 5 for an example), as it provides shipping lines with a better overview of the flows so that intermodal bundling options come into play. If the inland leg is based on merchant haulage then the carrier often loses control of and information on its boxes.

Table 5. **Modal split for Maersk volumes**

	Maersk Intermodal volumes in ..					
	Rotterdam			Bremerhaven		
	Road	Rail	Barge	Road	Rail	Barge
Carrier haulage	25%	42%	32%	35%	64%	0%
Merchant haulage	65%	27%	9%	68%	32%	0%

Source: Maersk Line data 2006 and Q1 2007.

Carriers face important barriers in further improving inland logistics. Land-side operations are management intensive and generally involve a high proportion of bought-in services. Moreover, inland movements generate some under-remunerated activities such as the repositioning of empty units, network control and tracking. Other important barriers relate to volume and equipment-type of imbalances, (unforeseen) delays in ports and the inland transport leg, as well as the uncertainty of forecasts. Carriers have very little room to increase the income out of inland logistics. If the carrier haulage tariffs edge above the open market rates, the merchant haulage option can become more attractive. The resulting competitive pressures partly explain the weak level of price contention between carrier and customer when it comes to charges in the inland leg.

Carriers are using IT solutions to meet the challenges in inland logistics and to manage global container flows taking into account the effects of global trade imbalances. Operators also try to get information on other lines' regular flows, so as to know where useful surpluses and/or deficits may arise. Moreover, they have learned to lessen equipment surpluses/deficits through container cabotage, interline equipment interchanges, chassis pools and master leases. Container cabotage makes it possible to considerably cut the costs related to the repositioning of empty containers: carriers will build up relationships with inland transport operators which move their equipment to where it is needed free of charge. In return the inland operator gets free one-way use of the box. Master leases allow carriers to pick up/drop off equipment at will, placing the repositioning problem to the leasing company. The pick up/drop off charges reflect imbalances. Equipment interchange agreements are often, but not always, maintained among some liner conference members and some members of the same strategic alliance (e.g. New World Alliance). So-called "grey box" agreements are quite rare: the concept has not proven workable partly because many carriers attach too much importance to company branding via the equipment used.

Customer requirements and behaviour often impede carriers from minimising inland logistics costs. Shippers often insist on receiving/loading containers early in the morning and at the end of the week. This logistics requirement of the customers leads to money-wasting peaks in inland logistics costs. Late bookings are costly as well, because instead of going by train or barge, they must go by truck to catch the ship, for no extra revenue.

The danger of cost under-recovery on second moves is another serious problem in inland logistics. For example, where the line issues a B/L to Antwerp but the vessel only calls at Rotterdam, it pays the full cost of moving the cargo to Antwerp. Less ports of call means more second moves and more substituted service, and as such possibly large landside container interchanges between adjacent ports. For instance, large volumes of containers are exchanged over land between Rotterdam and Antwerp.

The formation of global alliances has taken intercarrier co-operation to new heights, with members sharing inland logistics information, techniques and resources as well as negotiating collectively with suppliers (terminals, rail operators, feeders, barge operators, etc.).

6.3 (Independent) terminal operators and the hinterland

Against the background of supply chains, competitive forces are shifted to groups of spatially dispersed but functionally integrated terminals in different ports. Large global terminal operators have emerged in container handling in order to offer the customers a more differentiated service range. The extensive terminal networks can also be considered an effective means of counterbalancing the power of carrier combinations, realising economies of scale and optimising the terminal function within supply chains. Partly in response to the financial and operational needs of modern terminal activities, the container terminal operating industry has witnessed an increased amount of consolidation in recent years. Whereas a few years ago the container handling sector was still rather fragmented and characterised by about 10 large players, the picture looks drastically different today. The market share of the top 10 players in terms of throughput increased from 42% in 2001 to 55% in 2005 (Drewry, 2003 and 2006). Recent examples are the acquisition of CSX World Terminals in 2005 and P&O Ports in 2006 by Dubai-based DP World, and PSA's stake of 20% in Hutchison Port Holding's global terminal portfolio. The worldwide container handling industry is now dominated by four worldwide operating companies (PSA, HPH, DP World and APM Terminals), representing some 42% of total worldwide container handling. As far as the concentration of market power is concerned, the current situation in the terminal operating sector is somewhat comparable to that of the liner shipping industry, where the four largest shipping lines also control some 40% of the market (see earlier). The industry structure has become so concentrated as to raise a fundamental question about whether market forces are sufficient to prevent the abuse of market power. EU competition law has already affected Hutchison's expansion within northern Europe, and it is likely that any future moves by PSA or DP World will also be carefully scrutinised by regulatory authorities. More and more financial suitors, such as banks, hedge funds, private equity groups and investors, are entering the terminals business (for example, Babcock and Brown, Macquarie Infrastructure and American International Group, to name a few).

The consolidation in the container handling industry has had a major impact on port competition. The large terminal operators are becoming more footloose in spatial terms as the network approach loosens their former strong ties with particular seaports. In many cases, global terminal operators in upstream ports have extended their operations to medium-sized or new coastal container ports in order to offer the customers a more differentiated product range. In developing a global expansion strategy, HPH, PSA, APM Terminals and DP World try to keep a competitive edge by building barriers to prevent competitors from entering their domains or to keep them from succeeding if they do. These barriers are partly based on the building of strongholds in selected ports around the world and on advanced know-how on the construction and management of container terminals. It is increasingly difficult for new entrants to challenge the top global terminal operating companies.

Global terminal operators are increasingly hedging the risks by setting up dedicated terminal joint ventures. The relation between PSA and MSC provides a good example. The recent linkages include the MSC Home Terminal in the Belgian port of Antwerp (50-50 joint venture), a BOT arrangement in the Portuguese port of Sines and the MSC PSA Asia Terminal in the Pasir Panjang area in Singapore (50-50 joint venture). Another modern form of enhanced co-operation in the container terminal industry consists of offering long term contracts to shipping lines with gain sharing clauses. Shipping lines can thus choose the most interesting offer received for the particular node. Shipping lines can and sometimes do make a totally different choice for the next node (footloose behaviour).

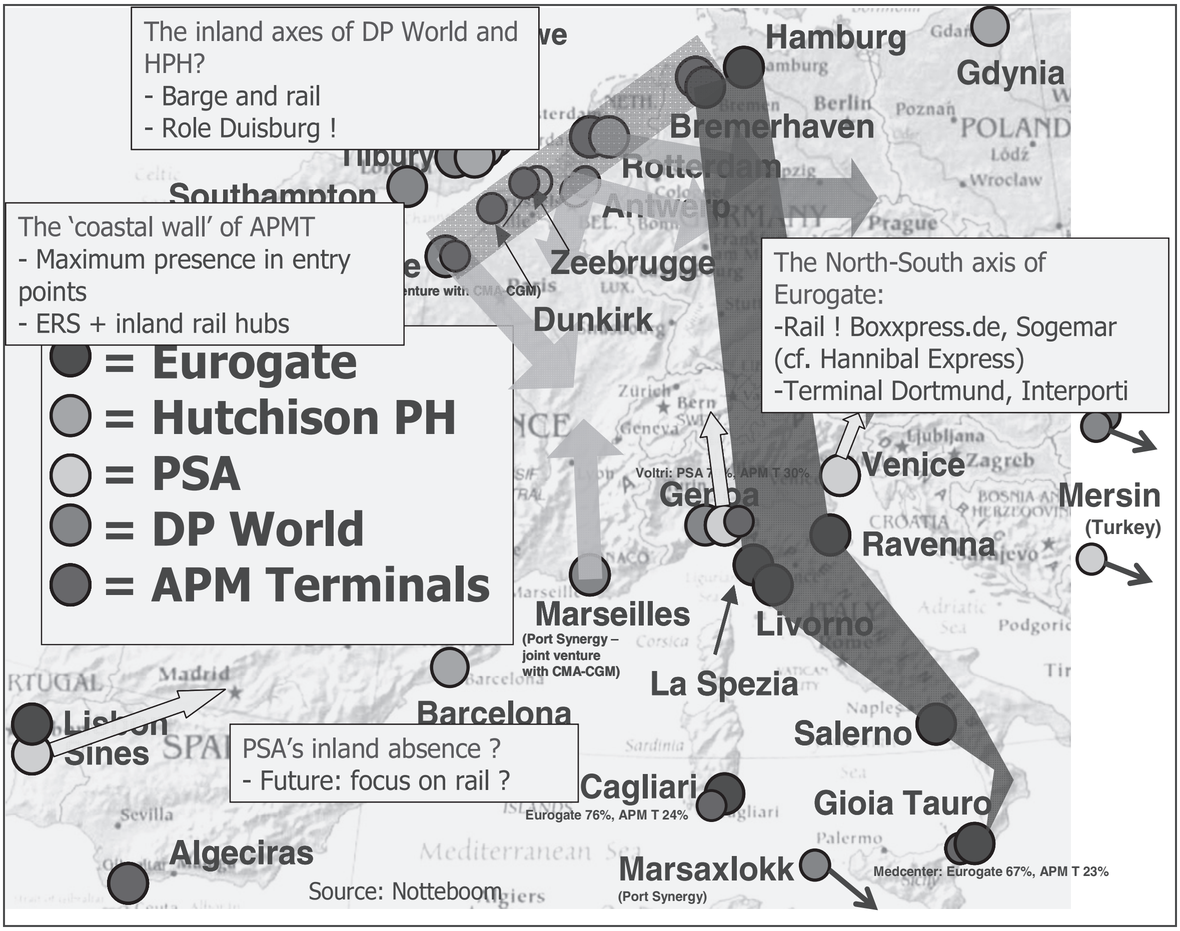
As terminal operators are urged towards better integration of terminals in supply chains, and shipping lines are acquiring container terminal assets worldwide, leading terminal operating companies are developing diverging strategies towards the control of larger parts of the supply chain. The door-to-door philosophy has transformed a number of terminal operators into logistics organisations and/or organisers/operators of inland services.

As discussed earlier, 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 deep-sea terminals, e.g. a rail terminal in Venlo (the Netherlands), DeCeTe terminal in Duisburg (Germany) and TCT Belgium in Willebroek (Belgium).

DP World is following a similar strategy. It 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 organiser Shipit to give concrete form to the concept of *terminal operator haulage* from Antwerp Gateway to the hinterland. The terminal operator haulage concept is aimed at 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 thus 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. While the intention is to offer a trans-European land bridge to its customer base, the volumes actually crossing the Alps remain low (see discussion earlier on the north-south balance). Singapore-based PSA is the only global terminal operator which has not presented a clear inland strategy yet, though it are working on one. A first indication is the ambition of its terminal in Sines to provide direct rail services to the cargo base in the Madrid area. PSA shows an increasing awareness that the additional volumes generated by its Deurganckdock terminal in Antwerp and future new terminals in Zeebrugge and potentially also Flushing will put strong pressure on the inland segment of the chain. The exact nature of their future involvement in the provision of inland services or the operations of inland terminals remains to be seen.

Figure 9. **Terminal operators and the hinterland: the hinterland strategy of the main European container terminal operators**



Source: Notteboom – ITMMA.

In summary, terminal operators are expected to increase their influence throughout supply chains by engaging in inland transport. They seem to be doing 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 deep-sea terminal, so custom clearance can be done there. The terminal operator typically remains responsible en route between the deep-sea 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 deep-sea terminal operator faces less pressure on terminals due to shorter dwell times and can guarantee better planning and utilisation 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. Unfortunately, terminal operators often lack information on the onwards inland transport segment for containers that are discharged at the terminal. Close co-ordination with shipping lines, forwarders and shippers is needed to maximise the possibilities for the development of integrated bundling concepts to the hinterland.

6.4 Rail transport operators

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). Until 1993, cross-border rail traffic of maritime containers in Europe was the exclusive right of Intercontainer. In the past, ICF initially concentrated its strategy on the intermodal container flows within the blue banana. The ongoing rail liberalisation process 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 rail operating industry is still somewhat hindered by the shelter-based strategies of former national railway companies in a number of countries and the high entry costs. Rail operators continue to face profitability issues. Launching new rail services is very costly and finding the necessary critical mass is not an easy task, surely when facing a fragmented cargo base controlled by many forwarders. This has opened the door to increasing involvement by major shipping lines, terminal operators (mainly in Italy and Germany) and port authorities (cf. 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. The nodes within these networks were connected by frequent shuttle trains with capacities for a single train combination ranging from 40 to 95 TEU. An example was the Qualitynet of Intercontainer-Interfrigo (ICF) with Metz-Sablon in north-eastern France as master hub linking up the Rhine-Scheldt Delta ports with the rest of western Europe.

Such hub-and-spoke networks were revealed to be vulnerable, as the volumes on the spokes could be affected by (a) newcomers entering the market in the aftermath of European rail liberalisation and (b) increasing intermodal volumes in seaports. New railway operators often “cherry-pick” by introducing competing direct shuttle trains on a spoke of a competitor’s established hub-and-spoke network. This has a negative affect on cargo volumes on the spoke and can lead to collapse of the whole hub-and-spoke system. That 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 is now handled by a set of direct shuttle trains going to fewer destinations. For eastern and south-eastern Europe, services are cantered 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 interport shuttles out of the large load centres. Hamburg’s rail connections outperform all other ports in numbers (more than 160 international and national shuttle and block train services per week) and in traffic volumes by rail (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.

The market evolution has led to increased competition among operators and a higher degree of choice available to customers. For a long time, there were no obvious drivers of change in the intermodal rail industry other than the (former) national railway companies. These companies lacked commitment and commercial attitude. Major complaints related to their perceived bureaucratic attitude, unannounced rate changes, the long lead time required to make bookings, the poor documentation management, the 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. The emergence of a new generation of rail operators not only made incumbent firms act more commercially, but also led to 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.

6.5 Barge operators

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. Data from the Central Commission for Navigation on the Rhine shows volumes on the Rhine increasing from 200,000 TEU in 1985 to some 1.8 million TEU in 2006, leading to higher frequencies and bigger vessels. At present the liner service networks offered on the Rhine are mainly of the line bundling type, with each rotation calling at three to eight 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 in 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 as new terminal operators arrive on the market and new terminals appear along the Rhine and its tributaries. The growing realisation 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 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. There are even initiatives to introduce small-scale barge services on the Mantua-Adriatic waterway in northern Italy.

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 logistics service providers.

The new millennium brought rising pressure on the existing co-operation agreements on the Rhine as more and more operators grew eager to start services independently of their partners. For instance, CCS withdrew from the Fahrgemeinschaft Niederrhein collective on 1 January 2000. In 2006, the Fahrgemeinschaft Oberrhein (OFG) nearly ceased to exist when Rhinecontainer and Haeger & Schmidt decided to step out of the OFG partnership and to start up the Upper Rhine Container Alliance (URCA). A major restructuring of the barge services within OFG took place once Interfeeder was taken over by Contargo in October 2006. Collaborative agreements are making their appearance in other navigation areas, such as shuttle services between the Antwerp and Rotterdam. Joint ventures, mergers and takeovers form a relatively new aspect, aimed at increasing the geographic scope of the services offered and at developing the operators' own barge transport networks. Danser Container Line, for instance, which offers services on the Rhine and Neckar and between Rotterdam and Oss, acquired Eurobarge from Nedlloyd Rijn & Binnenvaart in 1999. Eurobarge mainly operates barges on the Antwerp-Rotterdam route. Since January 2006, Danser Container Line has controlled the barge services of Natural Van Dam AG, an operator formerly owned by the logistics group Cronat from Basel. In 2000, Rhinecontainer acquired Container Exploitatiemaatschappij (CEM), a main player on the Antwerp-Rotterdam axis. In the same year, Combined Container Service (CCS) and SRN Alpina came under the same ownership when Rhenus (the parent company of CCS-SRN Alpina) acquired the Swiss holding company Migros. In 2004, Rhenus Logistics integrated CCS in its container transport division Contargo.

In addition, the leading barge container carriers are increasingly trying to achieve functional vertical integration of the container transport chain by extending the logistical services package to include complete door-to-door logistics 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 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 functional integration in the logistics chain.

Finally, a fairly new aspect of the vertical integration strategy followed by barge operators is the desire to fully exploit the complementarity with rail transport by forging closer links with existing rail companies, or, if required, even acting as rail operators themselves. The present market consolidation in European rail transport leaves a certain limited scope for barge operators to position themselves as rail shuttle operators, allowing them to overcome the restricted geographic coverage of the European inland waterway network. On top of barge operations via Rhinecontainer, the Wincanton group has set up its own railway company, Railcontainer, using main hubs in Neuss and Mannheim and co-operating with ERS, IFB, MSC and others. Rhenus Logistics offers similar services through the RheinRail Service of CCS.

6.6 Port authorities and the hinterland

Nowadays, landlord port authorities are viewed as independent commercial undertakings aiming at full cost recovery and rapid response to the customer. Port managers aim at making the port attractive to users by providing a competitive supply of services for carriers and shippers. Inland services are an integral part of that supply. However, the traditional tools in the hands of port authorities are confined to the port area itself: investment in docks/berths, concession policy and tariff policy as regards port dues. Given the local nature of revenue sources, port authorities tend to have a rather local focus and strongly promote activities within the port perimeter that could increase the local revenue base.

Landlord port authorities throughout Europe are facing some serious challenges with respect to the hinterland connections. In previous sections it was made clear that market players were very active in setting up inland services and broader hinterland networks. Market consolidation has resulted in large port clients that possess strong bargaining power vis-à-vis terminal and inland transport operations. Loyalty to the home port tends to fade as large players expand their reach over more than one port. In such an environment, it is up to port authorities to assure the overall efficiency and performance of the port-hinterland interface, as individual market players will primarily cater for the performance of specific sectors and or their network, not an individual port.

Port authorities thus 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.

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. A successful example of the task force approach is Antwerp Intermodal Solutions (AIS), a joint project by the Antwerp Port Authority and the cargo handling companies PSA HNN and DP World, with support from the rail track operator Infrabel. The project brought all parties round the table with a view to concentrating the rail volumes. This led to, among other things, the introduction of new rail links by market players. Most of them are common-user trains on which anyone can book container space, while a few are closed trains dedicated to one or more parties. The ultimate objective is for 15% of cross-border shipping containers to be carried by rail. Although AIS has an important role to play in creating new rail links to and from the port of Antwerp, the initiative lies with the rail partners. The port authority acts solely as facilitator. What AIS does is to concentrate the demand for container transport by rail, inviting the market players to react accordingly. The rail operators continue to bear the market risks associated with the new rail links. Apart from port authorities, branch associations are also adopting a role as facilitator in dealing with inland transport issues (e.g. Alfaport in Antwerp and Deltalinqs in Rotterdam).

Most port authorities still stand on the sidelines when it comes to inland terminal developments and the creation of logistics zones along hinterland corridors. However, the attitude of larger load centres seems to changing. Ports such as Rotterdam, Barcelona, Le Havre, Marseille and, more recently, Antwerp and Lisbon have become more active in this field (Table 6). There are a number of reasons for this change in attitude.

First, port authorities understand that with the creation of logistics poles, port benefits might leak to users in inland locations. A port strategy solely based on the local port area is not suited to address this threat adequately. An active port regionalisation strategy maximises the benefit from the reshaped networking among nodes.

Second, port users' focus on logistics networks makes a wider approach to port management imperative. As was outlined earlier, the success of a port will depend on its capability to fit into the networks that shape supply chains. In other words, the port community has to fully benefit from synergies with other transport nodes and other players within the networks of which they are part. This supports the development of a broader regional load centre network, serving the large logistics poles.

Third, port authorities face a wide array of local constraints resulting from external effects of port activities (e.g. road congestion, lack of available land, environmental issues). These external effects do not enhance community support. Ports must demonstrate a high level of environmental performance and sustainability not only to retain community support but also to attract trading partners and potential investors. A port with a strong environmental record and high level of community support is likely to be favoured. Inland locations can help the port to preserve its attractiveness and to fully exploit potential economies of scale. The corridors towards the inland terminal network can create the necessary margin for further growth of seaborne container traffic. Inland terminals thus acquire an important satellite function with respect to the port, as they help to relieve the seaport area from potential congestion.

Table 6. **A selection of initiatives of port authorities aimed at establishing links with inland ports and dry ports**

Port authority	Project	Aim
Antwerp	Trilogiport - Liège Other locations (future)	Joint development of a 100ha logistics platform along the Albert Canal Status: joint entity under the legal status of an 'economic interest grouping'
Lisbon	Puerta del Atlântico - 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: abandonned
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: Sociéte 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 has participations in rail terminals (Melnik, Budapest, etc..) to support its rail products via Polzug, Metrans and HHCE

Source: Port authority websites and specialized press.

The above elements constitute incentives to consider co-operation with inland ports in traffic management, land use, hinterland connections and services, environmental protection, and research and development. Notwithstanding these advantages, port authorities have always been rather reluctant to engage in advanced forms of strategic partnerships with inland ports, e.g. through strategic alliances, (cross-)participation, joint ventures or even mergers and acquisitions. Port managers fear losing added value and employment by "giving away" activities, losing captive cargo (as port related companies in the hinterland are less dependent on one port for their maritime import and export) and losing clients who might consider co-operation with one specific hinterland location as a market restriction or distortion. More room is created for forms of indirect co-operation, for example through joint marketing and promotion, which are less binding and require less financial means. 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 spatially and organisationally isolated.

The interaction between seaports and inland locations leads to the development of large logistics poles consisting of several logistics zones. Seaports are the central nodes driving the dynamics in such poles. But at the same time seaports rely heavily on inland ports to preserve their attractiveness. A well-balanced port networking strategy does not imply a loss of port activity. It 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.

7. CONCLUSIONS AND AVENUES FOR FUTURE RESEARCH

Container shipping has been the fastest growing sector of the maritime industries for the last two decades. Organic growth resulting from increasing economic activity, trade liberalisation, globalisation and outsourcing is compounded by the fact that break-bulk cargo is increasingly carried in containers (substitution effect), by changes in carriers' scheduling strategies (for example an increased focus on trans-shipment) and by port development. The very core object of container port competition in Europe has become highly complex and dynamic due to structural changes, some of which were outlined in this paper. The organisational and institutional environment in which ports operate has changed dramatically in recent decades. The World Trade Organization's impact on free trade, deregulation in the transport industry and corporatisation and privatisation processes in ports and inland transport are among the main institutional factors affecting port hierarchy. Logistics integration, scale increases in vessel size, the emergence of global terminal operators and structural changes in logistics and distribution networks are just some of the key organisational trends affecting port operations and spatial characteristics within Europe. Logistics market developments and the discontinuous nature of complex logistics networks necessitate a more functional approach to port competition and hinterland connections.

The key point put forward in this paper is that the competitive battle among ports will increasingly be fought ashore. It was demonstrated that quite a lot of actors are trying to play a leading role in this battle, or even go a step further by vying for a position as general. Rising concerns about capacity issues have led market players to secure terminal and corridor capacity. As intermodality serves as a weapon in port competition, ports become dependent on the intermodal carriers. A highly volatile intermodal market, in terms of organisational and operational factors, is not very conducive to creating a stable and sustainable competitive position for a port vis-à-vis the hinterland segments served through the corridors. The success of the port is strongly affected by the ability of the port community to fully exploit synergies with other transport nodes and other players within the logistics networks of which they are part. This observation demands closer co-ordination with logistics actors outside the port perimeter and a more integrated approach to port infrastructure planning. A large number of port authorities promote or should promote an efficient intermodal system in order to secure cargo under conditions of high competition. This includes, for example, facilitating the introduction of new shuttle services in close co-ordination with the market players. Port authorities can be catalysts in improving the port-hinterland interface and the structuring of hinterland networks, even though their direct impact on the routing of cargo flows is limited.

A special role is reserved for terminal facilities. Terminals, both in seaports and in inland ports, are expected to increase their role in supply chains, given increasing levels of vertical integration in the market and increasing pressure on capacity. Terminals will take up a more active role in supply chains in the future by increasingly confronting market players with operational considerations through the imposition of berthing windows, dwell time charges, truck slots, etc., all with the intent of increasing throughput, optimising terminal capacity and making the best use of the land.

The issue of port competition and hinterland connections is certainly not new. But, with this paper, we hope to have demonstrated that the changing nature of the interplay between markets, port competition and hinterland connections demands new approaches in dealing with hinterlands. This paper does not give answers to all outstanding issues. It is more a kind of *status questionis* combining various perspectives on the matter. Given the changing market environment, the topic of port competition and hinterland connections still offers plenty of challenges for further research. This paper concludes with a few suggestions in this regard, classified under three themes.

Vertical integration and the risk of foreclosure. Vertical integration might create concerns on either raising the costs of rivals or reducing their revenue. Raising rivals' costs typically involves *input foreclosure*. Input foreclosure occurs when the integrated firm either stops supplying competing downstream firms (complete foreclosure) or does so at a higher price (partial foreclosure), resulting in both cases in an increase in the price of the upstream input post merger, raising the costs of competing downstream firms. This relaxes the competitive constraint on the integrated firm that has access to the input at a lower cost. The reduction of rivals' revenues typically involves *customer foreclosure*. Customer foreclosure occurs when, post merger, the downstream division of the integrated firm no longer sources supply from independent upstream firms. If this leads to a reduction in sales volume and that sales volume reduction leads to an increase in the average cost or marginal cost of upstream competitors, then the competitive constraint these firms exert on the upstream division of the integrated firm will be reduced, leading to greater market power upstream and higher input prices. As far as we know, no research has been done on the impact of vertical integration of shipping lines, terminal operators and other market players on the risk of foreclosure in the provision of hinterland services.

Inland terminals. Inland terminals and dry ports are crucial for the further development of hinterland networks under conditions of high-volume growth. However, the possibilities of deploying inland cargo centres to relief the problems in seaports are not limitless. An increasing number of inland locations are facing strict environmental regulations and a lack of spare capacity. It is clear that both the problem of limited expansion opportunities and the problem of overcapacity will eventually result in a worsening of the competitive position of inland ports and the commercial viability of intermodal transport services. While these issues have been well studied for seaports, the implications of a potential growing mismatch between the demand for intermodal services and the supply of inland terminal capacity needs more attention.

Reliability, port competition and hinterland connections. It was stated in the paper that port and modal choice is also affected by reliability and capacity issues next the pure cost considerations. While service integrity issues have received considerable attention in operations research in recent years, research on the impact of low reliability levels on port hierarchy and inland cargo distribution patterns has only just taken off.

ANNEXES

Annex 1: **External trade of the EU Member States and some non-EU states**

	Extra and intra EU-trade in 1000 million of ECU/EURO										
	Imports				Exports				Trade balance	Share of EU25 in	
	1995	2000	2003	2006	1995	2000	2003	2006	(Ex-Im) in 2006	Total imports	Total exports
EU (27 countries)		**993**	**935**	**1350**		**850**	**869**	**1157**	-193		
EU (25 countries)		**996**	**941**	**1354**		**858**	**883**	**1181**	-173	63.4	67.3
EU (15 countries)	**545**	**1033**	**993**	**1430**	**573**	**942**	**980**	**1310**	-120		
Belgium	126	192	208	280	136	204	226	292	12	71.4	76.3
Bulgaria		7	10	15		5	7	12	-4		
Czech Republic		35	46	74		32	43	76	1	80.0	84.0
Denmark	35	49	51	69	39	56	59	74	5	71.8	70.7
Germany	355	538	534	724	400	597	664	886	162	63.0	62.7
Estonia		5	6	11		3	4	8	-3	74.0	66.0
Ireland	25	55	48	58	34	84	82	88	30	68.2	63.5
Greece	20	36	40	50	8	13	12	17	-34	54.8	53.2
Spain	87	169	184	252	75	125	138	164	-88	60.6	70.5
France	221	367	353	426	230	355	347	391	-35	68.4	64.5
Italy	157	259	263	348	179	260	265	327	-21	55.3	58.2
Latvia		3	5	9		2	3	5	-4	76.3	72.3
Lithuania		6	9	15		4	6	11	-4	62.4	63.2
Luxembourg		12	14	21		9	12	18	-3	70.2	89.5
Hungary		35	42	61		31	38	59	-2	66.7	74.0
Malta		4	3	3		3	2	2	-1	67.6	50.2
Netherlands	127	236	234	332	140	252	262	368	37	49.5	78.9
Austria	51	78	88	112	44	73	86	112	0	78.7	70.2
Poland		53	60	100		34	48	88	-13	72.0	77.3
Portugal	25	43	42	53	17	26	28	35	-19	75.5	77.2
Romania		14	21	41		11	16	26	-15		
Slovenia		11	12	19		10	11	19	-1	76.7	66.7
Slovakia		14	20	37		13	19	33	-3	75.0	85.1
Finland	23	37	38	55	31	50	47	61	7	63.7	57.0
Sweden	50	79	74	101	62	94	90	117	16	69.5	59.8
United Kingdom	204	372	353	485	182	309	270	358	-127	58.0	62.7
Norway	25	37	35	51	32	65	60	97	46	68.7	79.3
Switzerland	61	91	89	113	62	88	93	118	5	78.5	61.0
United States	589	1362	1154	1528	446	845	640	826	-702	17.7	20.6
Japan	257	411	339	461	339	519	417	515	54	10.3	14.5
Canada	126	260	212	279	146	300	241	309	30	12.3	6.5
China (excl. Hong Kong)	101	244	365	630	114	270	387	772	141	11.4	18.8

Note: Imports are expressed in value terms and measured CIF (cost, insurance, freight). Exports are expressed in value terms and measured FOB (free on board).

Source: Based on external trade statistics of Eurostat.

Annex 2: **Real GDP growth rates - percentage change on previous year**

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
EU (27 countries)	**2.9**	**3**	**3.9**	**2**	**1.2**	**1.3**	**2.5**	**1.8**	**3**	**2.9 (f)**	**2.4 (f)**	**2.4 (f)**
EU (25 countries)	**3**	**3**	**3.9**	**2**	**1.2**	**1.3**	**2.4**	**1.8**	**3**	**2.9 (f)**	**2.4 (f)**	**2.4 (f)**
EU (15 countries)	**2.9**	**3**	**3.8**	**1.9**	**1.1**	**1.2**	**2.3**	**1.6**	**2.8**	**2.7 (f)**	**2.2 (f)**	**2.2 (f)**
Belgium	1.7	3.4	3.7	0.8	1.5	1	3	1.7	2.8	2.7 (f)	2.1 (f)	2.2 (f)
Bulgaria	4	2.3	5.4	4.1	4.5	5	6.6	6.2	6.1	6.3 (f)	6.0 (f)	6.2 (f)
Czech Republic	-0.8	1.3	3.6	2.5	1.9	3.6	4.5	6.4	6.4	5.8 (f)	5.0 (f)	4.9 (f)
Denmark	2.2	2.6	3.5	0.7	0.5	0.4	2.3	2.5	3.9	1.8	1.3 (f)	1.4 (f)
Germany	2	2	3.2	1.2	0	-0.2	1.1	0.8	2.9	2.5	2.1 (f)	2.2 (f)
Estonia	5.4	-0.1	9.6	7.7	8	7.2	8.3	10.2	11.2	7.8 (f)	6.4 (f)	6.2 (f)
Ireland	8	10.4	9.4	6.1	6.6	4.5	4.4	6	5.7	4.9 (f)	3.5 (f)	3.8 (f)
Greece	3.4	3.4	4.5	5.1	3.8	4.8	4.7	3.7	4.3	4.1 (f)	3.8 (f)	3.7 (f)
Spain	4.5	4.7	5	3.6	2.7	3.1	3.3	3.6	3.9	3.8 (f)	3.0 (f)	2.3 (f)
France	3.5	3.3	3.9	1.9	1	1.1	2.5	1.7	2	1.9 (f)	2.0 (f)	1.8 (f)
Italy	1.4	1.9	3.6	1.8	0.5	0	1.5	0.6	1.8	1.5	1.4 (f)	1.6 (f)
Latvia	4.7	3.3	6.9	8	6.5	7.2	8.7	10.6	11.9	10.5 (f)	7.2 (f)	6.2 (f)
Lithuania	7.5	-1.5	4.1	6.6	6.9	10.3	7.3	7.9	7.7	8.8	7.5 (f)	6.3 (f)
Luxembourg	6.5	8.4	8.4	2.5	4.1	2.1	4.9	5	6.1	5.2 (f)	4.7 (f)	4.5 (f)
Hungary	4.9	4.2	5.2	4.1	4.4	4.2	4.8	4.1	3.9	1.4	2.6 (f)	3.4 (f)
Malta	:	:	:	-1.6	2.6	-0.3	0.2	3.3	3.4	3.1 (f)	2.8 (f)	2.9 (f)
Netherlands	3.9	4.7	3.9	1.9	0.1	0.3	2.2	1.5	3	3.5	2.6 (f)	2.5 (f)
Austria	3.6	3.3	3.4	0.8	0.9	1.2	2.3	2	3.3	3.3 (f)	2.7 (f)	2.4 (f)
Poland	5	4.5	4.3	1.2	1.4	3.9	5.3	3.6	6.1	6.5 (f)	5.6 (f)	5.2 (f)
Portugal	4.9	3.8	3.9	2	0.8	-0.8	1.5	0.7	1.2	1.8 (f)	2.0 (f)	2.1 (f)
Romania	:	-1.2	2.1	5.7	5.1	5.2	8.5	4.2	7.9	6.0 (f)	5.9 (f)	5.8 (f)
Slovenia	3.6	5.3	4.1	3.1	3.7	2.8	4.4	4.1	5.7	6.0 (f)	4.6 (f)	4.0 (f)
Slovakia	4.4	0	1.4	3.4	4.8	4.8	5.2	6.6	8.5	8.7 (f)	7.0 (f)	6.2 (f)
Finland	5.2	3.9	5	2.6	1.6	1.8	3.7	2.8	4.9	4.4	3.4 (f)	2.8 (f)
Sweden	3.8	4.6	4.4	1.1	2.4	1.9	4.1	3.3	4.1	2.6	3.1 (f)	2.4 (f)
United Kingdom	3.4	3	3.8	2.4	2.1	2.8	3.3	1.8	2.9	3.1	2.2 (f)	2.5 (f)

Note: (f) = estimate/provisional figures

Source: Based on Eurostat data.

Annex 3: **Modal split for inland transport of containers (selection of container ports)**

		Road	Rail	Barge
Amsterdam (Ceres Paragon)	2004	60	5	35
	2005	57	2	41
	2006	54	3	43
	2007	50	7	43
Antwerp	1998	64.5	7.8	27.7
	2000	60.6	10.1	29.3
	2002	59.5	9.3	31.2
	2007	59.8	8.0	32.2
Bremerhaven (Eurogate)	2002	53.1	44.4	2.5
	2005	43.0	53.0	4.0
	2006	39.6	56.3	4.1
Constanza	2000	56.0	44.0	0.0
	2002	53.0	47.0	0.0
	2004	61.6	38.4	0.0
	2005	33.9	65.8	0.3
	2006	47.6	47.3	5.1
Dunkirk	2002	82	14	4
	2002	72	25	3
	2005	88	8	4
	2006	88	8	4
Hamburg	1998	70.1	29.7	0.2
	2000	70.0	28.7	1.3
	2002	69.6	28.7	1.7
	2005	67.4	30.5	2.1
	2006	69.0	28.7	2.3
	2007	68.9	29.0	2.1

		Road	Rail	Barge
Le Havre	1995	82.5	16.9	0.6
	1998	84.6	14.3	1.3
	2000	85.1	12.2	2.7
	2002	85.4	11.7	2.9
	2005	87.4	6.2	6.4
	2006	86.8	5.1	8.1
Marseilles-Fos	2000	82.7	16.9	0.4
	2002	82.1	15.6	2.4
	2005	82.0	12.0	5.6
	2006	81.9	12.1	6.0
Rotterdam	1998	51.3	14.5	34.2
	2000	48.0	13.0	39.0
	2002	59.0	9.0	32.0
	2003	59.0	10.0	31.0
	2004	60.0	9.0	31.0
	2005	60.0	9.0	31.0
Zeebrugge	1990	70.5	26.9	2.6
	2000	79.8	17.7	2.5
	2002	78.3	20.5	1.2
	2005	62.0	36.6	1.4
	2006	61.2	37.6	1.2

Source: Data from respective port authorities and Schiffahrt Hafen, Bahn und Technik (2/2007)

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RESPONDING TO INCREASING PORT-RELATED FREIGHT VOLUMES: LESSONS FROM LOS ANGELES/LONG BEACH AND OTHER US PORTS AND HINTERLANDS

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SUMMARY

Los Angeles/Long Beach, March 2008

ABSTRACT

Rapid growth in international trade over the last two decades has generated both benefits and costs. Costs have become increasingly visible in metropolitan areas – growing congestion, air pollution – and local communities are demanding solutions. Congestion and air pollution associated with increased international trade have become so severe in the Los Angeles region that port-related trade is facing increased regulation by both state and local agencies. Historically US ports have been remarkably autonomous. Their role as economic development engines is well-recognized by local leaders. Thus recent regulatory efforts represent a significant change in public policy.

This report begins with an overview of trends in port-related trade and its impacts on US metropolitan areas, and discusses changing public perceptions of port-related trade as impacts have increased. Using Southern California as a case study, the report examines responses by the ports, terminal operators, and allied industries to a changed regulatory regime. Two examples are discussed in detail: 1) a state regulation requiring appointments or extended hours at terminal gates; and 2) the OFFPeak extended gate hours program. We use a political economy framework to explain outcomes. I describe the main economic actors and their competitive positions, and we explain the key aspects of the US regulatory system affecting these actors. Those with significant market power within the international trade supply chain were successful in staving off several regulatory attempts to force changes in operating practices. When regulations were imposed, they were able to structure responses to protect their economic interests. Results suggest that "dominant actors" – ports, terminal operators, steamship lines, and their major clients – will continue to be a strong influence in efforts to solve trade-related environmental problems.

1. INTRODUCTION

Economic restructuring and globalization have vastly increased the volume of both domestic and international trade. With the growth in trade, nodes in the global transport network – especially seaports and airports – are experiencing rapid growth of traffic volumes as well as economic activity. Large metropolitan areas, typically the location of the largest seaports and airports, are incurring significant costs as a result of this growth. Increased traffic congestion, noise, and air pollution are generating concern and opposition among local residents and governments. In addition, trade growth generates demand for expanded port facilities, generating competition for scarce coastal resources.

At the same time, the competitive environment in waterborne commerce is changing as scale economies drive development of ever larger ships and reduce transport costs, governance and regulatory structures change, and the global trade industry continues to restructure (e.g. Brooks and Cullinane, 2007; Olivier and Slack, 2006). With more flexibility in trade routes, competition among ports intensifies. Thus at a time when local support of increased trade is in decline, ports may be less able to address externalities while maintaining or growing their market share.

The purpose of this paper is to examine efforts to manage negative local impacts of growing international trade in the US and understand the successes and failures of regulatory efforts aimed at reducing these impacts. In a few metropolitan areas these efforts have resulted in a rapid and significant change in the regulatory environment facing ports, steamship lines, terminal operators, and other actors within the international trade supply chain. This changed environment is being driven primarily by local public concerns. The situation is particularly severe in Los Angeles: state and local agencies have engaged in many efforts to reduce air pollution and manage congestion at the ports and on the main rail and truck routes connected to the port complex. Therefore Los Angeles provides an excellent case study for examining responses to a changed regulatory environment.

This report begins with an overview of trends in port-related trade and its impacts on US metropolitan areas, and discusses changing public perceptions of port-related trade as impacts have increased. Using Southern California as a case study, the report examines responses by the ports, terminal operators, and allied industries to a changed regulatory regime. Two examples are discussed in detail: 1) a state regulation requiring appointments or extended hours at terminal gates; and 2) the OFFPeak extended gate hours program. The report concludes with some observations on how local environmental concerns are affecting international trade interests and what the implications may be for the competitive position of large US ports.

2. TRENDS IN PORT-RELATED TRADE AND IMPACTS ON US METRO AREAS

World merchandise trade growth has outpaced growth of world GDP for now several decades. The US share of world exports is 14.2 percent, and its share of imports is 21 percent (World Trade Organization, 2007). US total foreign trade as a share of GDP continues to increase, from 26% in 2000 to 27.2% in 2005, with goods making up nearly 80% of total trade (USDOT, 2007). Most freight transport in the US is domestic, but the foreign share continues to increase. In terms of value, freight imports and exports increased from 16.2% in 2002 to 19.0% in 2006.

Freight flows by all transport modes have increased. Total US ton-miles of freight increased from 3.2 billion in 1990 to 3.8 billion in 2001 (Bureau of Transportation Statistics, 2006), but truck and air transport have increased faster than other modes. In 2001, for example, of the total bill of \$579.6 billion the US spent on freight transportation, trucks carried 80.6%, i.e. \$467.2 billion (USDOT 2006, Table 3-7). Total US ton-miles of freight increased from 3,584 billion in 1990 to 4,357 billion in 2003. Over the same period truck ton-miles increased from 854 to 1,264 billion, and air ton-miles increased from 10.4 to 15.1 billion (USDOT 2006, Table 1-46B).

Foreign trade is concentrated; the top eight foreign gateways account for 34% of total 2005 US foreign trade (see Table 1). These gateways include the major port complexes, airports, and land-border crossings with Canada and Mexico. The two largest gateways, Los Angeles and New York, are of course also the two largest metropolitan areas in the US.

Table 1: **Top 8 US Foreign Trade Gateways by Value, 2005**

Gateway	Total Foreign Trade (USD millions)
Los Angeles (Port of Los Angeles, Port of Long Beach, LA Airport)	331 946
New York (Port of New York and New Jersey, JFK Airport)	265 301
Detroit (bridges)	130 473
Laredo, Texas (land bridges)	93 677
San Francisco (Port of Oakland, SF Airport)	89 818
Houston (Port of Houston)	86 133
Buffalo/Niagara (bridges)	71 496
Seattle (Port of Seattle, Port of Tacoma)	68 780

Source: Calculated from USDOT 2007, Figure 3-17.

2.1. Impacts of Trade on US Metro Areas

The growth of international trade has had both positive and negative impacts on metropolitan areas. The positive impact is economic growth which results in more jobs and tax revenues to local governments. It is the economic growth benefits that historically have been the basis of local support for port development (Erie, 2004). Port-related trade relies on an extensive network of warehousing, secondary processing, logistics, shipping, customs, and other services, and hence has a large multiplier effect. For example, it is estimated that port-related trade in the Los Angeles region accounts for about 585,000 jobs, or about 1 in every 12 jobs in the region (Chang, 2005). In the New York/New Jersey greater metropolitan area, port-related trade is estimated to account for about 233,000 jobs and about $5.8 billion in federal, state and local tax contributions in 2004 (Lahr, 2005). Husing (2004) notes that the logistics sector provides well-paid and stable blue collar jobs, in contrast to other growing sectors such as retail trade. It therefore plays a critical role in regions with large shares of low-skilled workers such as Los Angeles.

Although local economic benefits are significant, the bulk of benefits of international trade are dispersed throughout the US in the form of lower prices for consumer products. These economic benefits come with large external costs that are concentrated on local populations. The most visible external costs include congestion on the surface transport system, truck involved crashes, air pollution, and noise and other impacts on neighborhoods. Congestion and air pollution problems are briefly described here.

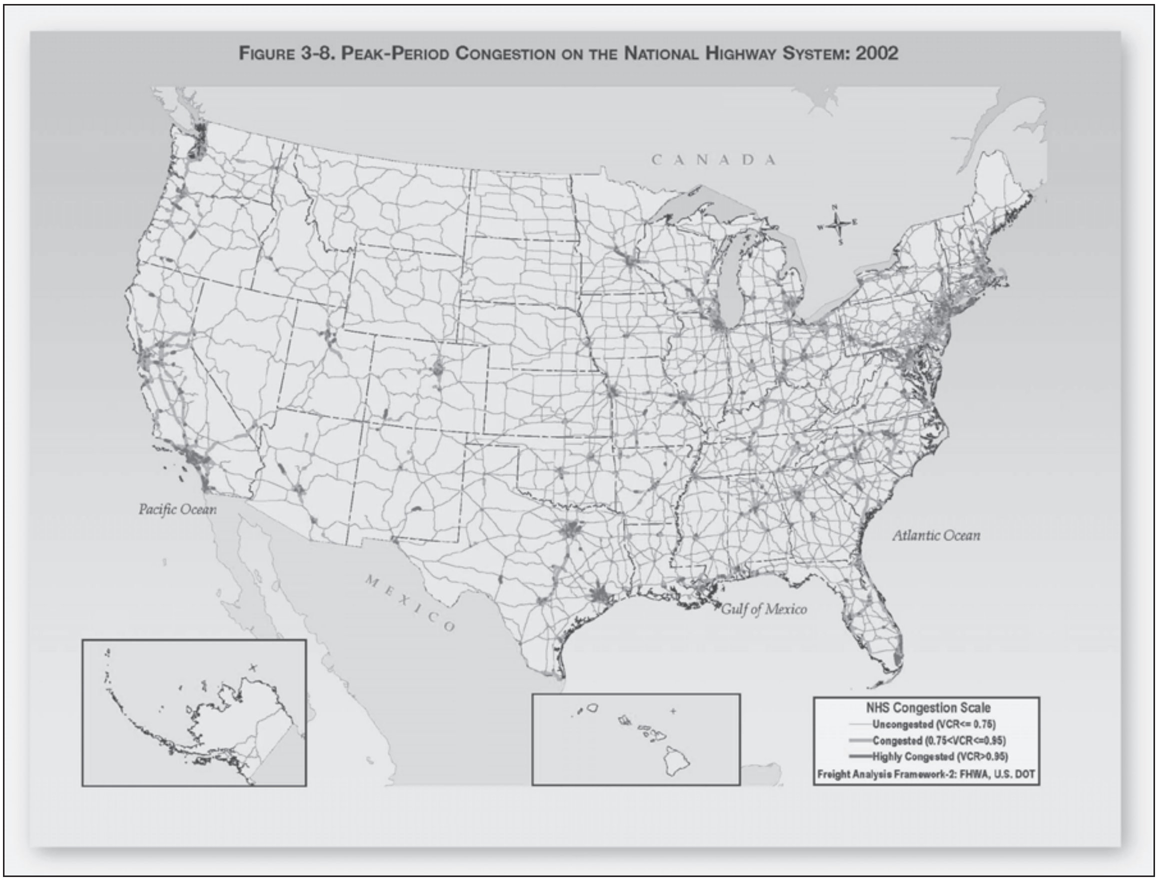
2.1.1. Congestion

Increasing congestion in US metropolitan areas is well documented by the Texas Transportation Institute annual reports that estimate congestion based on traffic volumes and road capacity. Hours of delay per traveler is highest in the largest metropolitan areas (3 million population or more), and has increased dramatically: from 21 in 1982 to 54 in 2005. Total delay cost for 2005 is estimated to be $78 Billion, compared to $15 Billion (constant 2005 dollars) in 1982. As demand continues to increase, peak spreading has occurred, with peak periods extending to several hours each day (Schrank and Lomax, 2007).

Increased demand is the result of growth in both passenger travel and freight transport. Although truck traffic accounted for just 8% of all highway vehicle miles traveled (VMT) in the US, heavy truck VMT have increased faster than passenger vehicle VMT (USDOT, 2007). Major freight nodes have experienced particularly large increases, contributing to congestion. Figure 1 shows 2002 peak period highway congestion on the US National Highway System. Highly congested roadways are concentrated along the New York/New Jersey coastal corridor, Los Angeles, San Francisco, Houston and Chicago, the major US intermodal hub.

In the Los Angeles region, it is estimated that the ports generate about 35,000 daily truck trips, and the ports are seen as a major contributor to highway congestion. Heavy-duty truck (HDT) miles in the Los Angeles region (i.e. those trucks with five or more axles) have increased faster than total vehicle miles traveled. The major routes serving port-related trade carry very large HDT truck shares: 12 to 14% of total daily traffic, compared to 2 – 3% for other highways in the region.[1] High volumes of trucks add to congestion problems and contribute disproportionately to incident related delays (Haveman and Hummels, 2004; California Highway Patrol, 2003). The drayage trucking industry is a particular problem: low compensation is associated with using older, less maintained trucks and possibly less qualified truck drivers (Monaco, 2004)

Figure 1: **Peak Period Congestion, 2002, US National Highway System**



Source: Provided by Federal Highway Administration; used with permission.

The New York/New Jersey (NY/NJ) port complex also generates significant truck traffic. Container traffic of the Port of New York/New Jersey in 2001 generated 13,000 trucks travels per day. Unlike Los Angeles/Long Beach, where more than half of all container traffic has destinations outside of Southern California, most NY/NJ container traffic (75%) is destined for local markets. Thus options for rail traffic are quite limited. Freight movements across the harbor are limited to two bridges, George Washington and Verrazano, handling crossings of more than 30,000 trucks per day. Road congestion is therefore expected to increase by 50% by 2020 (Rodriguez, 2003).

2.1.2. Air Pollution

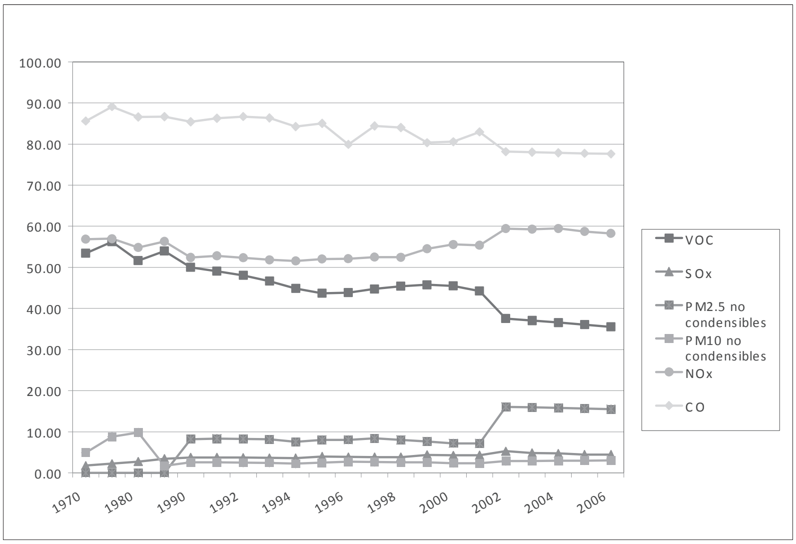
Perhaps the most serious impact of increased trade is air pollution. The transport sector accounts for a large portion of some air pollutants. Freight transport accounts for about 27% of all NOx emissions. While freight transport accounts for about one third of PM10 mobile source emissions, most particulate emissions are from non-mobile sources. See Table 2.

Table 2: **NOx and PM10 Emissions Shares by Freight Transport Mode, 2002**

Mode	**NOx**		**PM 10**	
	All mobile sources	**All sources**	**All mobile sources**	**All sources**
Heavy-duty trucks	33.0	17.9	23.3	0.5
Freight Rail	7.5	4.1	4.1	0.1
Marine vessels	8.8	4.8	8.5	0.2
Air	0.1	0.0	0.1	0.0
Total	49.4	26.8	36.0	0.8

Source: Adapted from Table 5-12, USDOT 2007.

Figure 2: **Contribution of Road and Non-Road Vehicles to Emissions, 1970-2006**



Source: Calculated from US EPA, 2007

Heavy duty trucks are by far the major freight transport source of NOx and PM10, largely because trucks carry about three fourths of all US freight tonnage. Constantly improving emissions control technologies has resulted in greatly reduced emissions rates per mile, but increased VMT has offset some of these gains. Figure 2 shows the share of various pollutants contributed by all vehicles, from 1970 to 2006. While shares of most pollutants have declined, contributions to NOx and PM 2.5 have increased since the early 2000s.

The Los Angeles region is perhaps the most extreme example, as the region is a non-attainment area for several criteria pollutants. Transportation sector emissions have grown at an average rate of about 2% annually (not including international bunker fuels) since 1990 compared to .8% for non-transportation sectors. The ports are the largest single source of emissions, largely because the local air district, SCAQMD (South Coast Air Quality Management District), does not have jurisdiction over ships or trains. Ships use high sulfur content "bunker fuel", the cheapest form of diesel. Adding to the problem are the unique characteristics of the port drayage segment of the trucking industry which result in an older (and dirtier) heavy duty diesel truck (HDDT) vehicle fleet. NOx emissions are estimated at more than 100 tons per day, and the ports' contribution to pollution, notably PM10, is expected to increase with the growth in port trade (SCAQMD, 2005).

The Los Angeles region is not alone, however. Lena *et al.* (2002) document high volumes of truck traffic in low income neighborhoods near the Ports of New York and New Jersey. They calculate estimates of emissions, and conclude that low income residents experience higher exposure levels.

3. THE LOS ANGELES REGION: CHANGING RESPONSES TO PORT-RELATED TRADE

We turn now to the Los Angeles region, where over the past eight years changes in the political and regulatory environment have been extraordinary. In his study of the Los Angeles region, Erie (2004) states that international trade creates a policy dilemma because the benefits are dispersed and the costs are concentrated. The dilemma is particularly strong for local public officials, who are dependent upon trade for economic development and tax revenue, but at the same time must respond to legitimate citizen concerns. The rapid increase in international trade and the associated congestion and environmental effects has raised the visibility of trade and has led to growing public perceptions that the local costs of trade are no longer acceptable. An additional concern is the demand for landside infrastructure – port expansion, highway and rail capacity enhancements – in densely developed urban areas to support trade growth.

The Los Angeles region is the second largest in the US, with estimated 2006 population of 18.6 million and employment of 7.3 million (Southern California Association of Governments, 2007). Figure 3 provides a map of the southwest portion of the region. The ports are located about 20 miles due south of downtown Los Angeles, within the most densely developed part of the region. The main expressways connecting the ports with inter-modal facilities and distribution networks are the I-110 and I-710. The Alameda rail corridor is located between the two expressways, and connects the ports with the main railroad yards just east of downtown Los Angeles.

Public perceptions of the ports and trade they represent have shifted from generally positive to quite negative. After decades of relative independence from state or local control, port-related trade is the target for regulation of truck traffic, truck emissions, ship fuels, and cargo equipment. The ports have been unsuccessful in moving any new expansion project through the environmental review process since 2000, and the two railroads serving the ports have been unable to move forward with expansion of near-dock rail facilities.

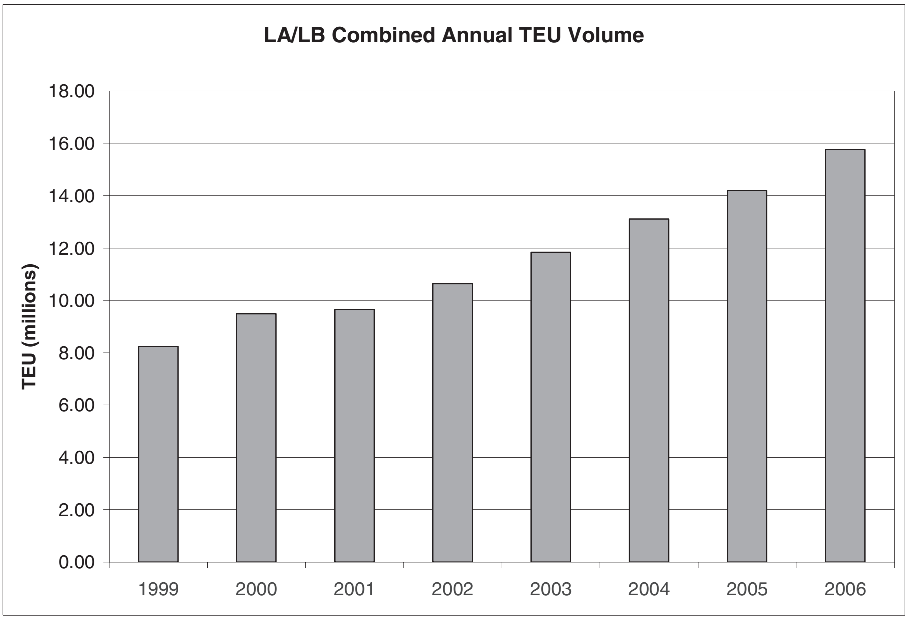
Figure 3: **Map of San Pedro Bay Ports Area**

3.1 Explaining the shift in public perceptions

What explains this dramatic change? The first explanation is the rapid increase in container trade that has taken place (see Figure 4), largely due to rapidly growing East Asian trade. The two ports moved 15.8 million twenty-foot equivalent units in 2006, nearly double the 1999 combined volumes. Combined TEU volumes have increased an average of 1 million TEU per year. To put this growth in perspective, the next largest west coast port, Oakland, had a total 2006 volume of 2.4 million TEU, and the increase over the same period was 700,000 TEUs. The growth rate of the Los Angeles/Long Beach complex has exceeded that of any other West Coast port. Continued growth is explained by scale economies in international shipping, the large local consumer market, good connections to the US national market, and extensive supporting industries.

A near doubling of port traffic volume has resulted in a significant increase in truck traffic, adding to an already congested highway network. For the general public, trucks are the most visible aspect of port-related trade. The Alameda Corridor, a 20 mile, $2.4 Billion rail cargo facility opened in 2002, yet truck traffic on highways continued to increase. Although the Alameda Corridor was not intended to increase the rail modal share or operate near capacity for many years, public perceptions suggested such expectations, and the Corridor came under criticism for not solving the truck traffic problem (Agarwal, Giuliano and Redfearn, 2004). A major study of the I-710 also took place in the early 2000s. The study was based on an expected tripling of port trade by 2020, and the analysis generated alternative plans for greatly increasing capacity of the facility, some of which required the taking of adjacent properties. The study generated significant local opposition that in turn caused state and local transportation planners to temporarily suspend I-710 expansion plans.

Figure 4: **Growth of San Pedro Bay Ports Container Volumes**



Source: Ports of Los Angeles and Long Beach

The port shutdown of 2002 also raised public awareness of port-related traffic. The breakdown in contract negotiations between the ILWU (International Longshore and Warehouse Union) and the PMA (Pacific Maritime Association) resulted in a 9 day shutdown of all west coast ports. While ships queued in the harbor, the I-710 and other main port trucking facilities experienced greatly reduced truck volumes and congestion. For the public, the shutdown illustrated how much truck traffic was generated by the ports (Giuliano *et al.*., 2005).

A second explanation for the shift in public perceptions is air pollution. The SCAQMD Multiple Air Toxics Exposure (MATES) II Study was released in 2000 and provided detailed documentation of local health impacts. It assessed potential disproportionate cancer burdens and found that 71% of all cancer risk from air pollution comes from diesel exhaust (SCAQMD, 2000). A widely circulated map from the report showing diesel emissions concentrations was used to demonstrate that a "diesel death zone" existed around the ports. The MATES Study was followed by several reports from a longitudinal children's health study that documented a significant relationship of school absences, asthma and other lung diseases with exposure to particulate concentrations (Coussens, 2004). The California Air Resources Board (CARB) estimates 750 premature deaths per year from particulate exposure associated with ports and international goods movement activities, and 2,400 premature deaths from all goods movement in California (CARB, 2006). These numbers have been widely circulated.

The Los Angeles region has long been known for its poor air quality, and the health impacts of pollution are widely known. However, research on fine particulates impacts and recent increases in some emissions categories have raised public awareness and concern, in turn placing growing pressure on political leaders to solve the air pollution problem. As noted earlier, state and local air quality regulators do not have jurisdiction over ships or trains. Thus as emissions from on-road vehicles have decreased, the share of emissions from ships and trains has increased. Port-related emissions are consequently viewed as a growing problem.

Air quality has become the key issue for any proposal to expand port capacity. In 2000 the Natural Resources Defense Council (NRDC) filed a lawsuit against the Port of Los Angeles over the construction of the China Shipping Terminal. The settlement included $10 million to clean up diesel trucks. It also required use of yard equipment powered by cleaner burning fuels, and testing of new alternate marine power technology, cold ironing (Giuliano and O'Brien, 2007). Cold ironing uses electric power so that ships can turn off engines while in port. The success of the NRDC China Shipping settlement effort provided a model for dealing with subsequent expansion efforts, which have been consistently opposed on environmental grounds.

3.2 Legislative Response

Local public concerns with port growth and its associated impacts have led to steadily increasing efforts to regulate activities related to trade operations. These efforts have focused primarily on air pollution, because of the precedent of regulation based on human health impacts. In California, the state has air pollution regulation authority, with certain provisions from the federal government that allow it to impose standards more stringent than the federal standards. Therefore local efforts to control trade activity involve persuading state legislators to take action. Table 3 lists state legislative efforts to address port-related impacts between 2000 and 2006. The first successful bill was AB 1775, which called for covering coke both in transport and in open storage.[2] Table 3 illustrates that in just a few years, ports became a legitimate target for state regulatory legislation.

The first effort to change operational practices was Assembly Bill (AB) 2650, passed in 2002. US ports typically service truck pick-ups and deliveries only during regular weekday hours. Outside pressure to extend truck gate operating hours had been growing for several years; it seemed an obvious solution for spreading truck trips over more hours of the day. AB 2650 prohibited truck queuing of more than 30 minutes at terminal gates. In order to avoid penalties, terminal operators could either operate full gate service 70 hours or more per week, or implement a truck appointment system. Justification for the bill was based on air quality: reduced truck queues at terminal gates would reduce diesel emissions. AB 2650 did not result in the adoption of extended gate hours, as will be explained later in this paper.

AB 2650 was followed by several legislative efforts to impose emissions regulations on port or port related operations, and to establish container fees to fund congestion or emissions mitigation. AB 2042 would have established an air quality baseline for the two ports. No project would be allowed that increased pollution levels beyond the baseline. AB 2041 would have established a regional governing body, the Port Congestion Management District, and authorized a charge for cargo moved at the San Pedro Bay Ports between the peak hours of 8 AM and 5 PM. Fee revenue would be spent on freight-related congestion mitigation projects. The bill was adamantly opposed by marine terminal operators (MTOs) and other port trade interests. Ultimately terminal operators set up their own extended gate program, OFFPeak, in return for the sponsor withdrawing AB 2041. By 2004 port-related trade had become a highly visible and contentious political issue.

Table 3: **California State Legislative Activity Associated with Mitigating Port-related Trade Impacts, 2000-2006**

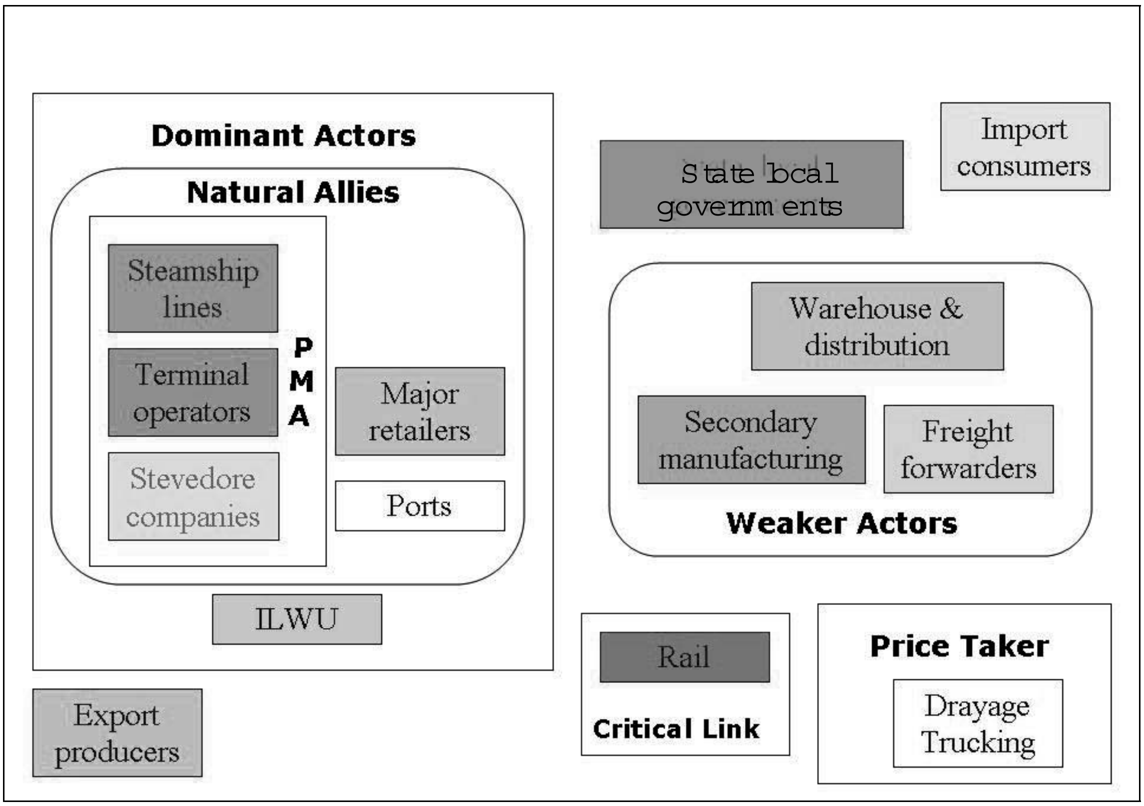
Year	Bill	Status	Description
2000	AB 1775	Passed	Required covers on coke piles and on coke in transport
2001	Karnette	Died in committee	First proposal for cargo fee
2002	AB 2650	In committee	Reduced queue time at terminal gates; reduced turn times
2002	AB 2650 revised	Passed	Reduced queue times at terminal gates
2004	AB 2042	Passed by Legislature; vetoed by Governor	Established baseline for "no net increase" in emissions
2004	Senate Bill (SB) 1397	Passed in Senate; died in Assembly	SCAQMD authority to regulate locomotive emissions
2004	AB 2041	Passed by Legislature; withdrawn by sponsor (Lowenthal)	Port management congestion district + container fee for environmental mitigation, infrastructure, security
2005	SB 760	Not passed	$30/TEU mitigation fee in LA/LB
2005	SB 761	Passed in Senate; died in Assembly	Truck turn time maximum 60 minutes
2005	SB 762	Passed in Senate; died in Assembly	Joint Powers Authority to license, limit, and regulate trucks at the port
2005	SB 763	Passed	Priority berthing for vessels using low sulfur fuels
2005	SB 764	Passed in Senate, died in Assembly	Caps on port emissions to 2001 levels
2005	SB 848	Died in committee	Collective bargaining for truckers
2005	AB 1101	Died in Assembly	Regulate ports, distribution centers as stationary sources
2006	SB 927	Passed by Legislature; vetoed by Governor	$30/TEU mitigation fee in LA/LB
2006	SB 1829	Passed in Senate; died in Assembly	Limits trucks wait time to 30 minutes in line and 30 minutes inside the terminal
2006	SB 1601	Died in Senate	Require best available technology to reduce NOx emissions through lease agreements

There are three additional observations to be drawn from Table 3. First, cargo fees to fund mitigation efforts outside the ports had almost no support in 2001, but by 2006 were avoided only by veto of the Governor, reflecting a growing political consensus that the costs of mitigation should be borne by trade interests. Second, more aspects of port operations are the subject of regulatory proposals, for example mandating priority berthing for vessels using low sulfur fuels, or requiring ports to negotiate emissions technology changes via terminal lease agreements, suggesting changing perceptions of the role of government in addressing trade-related externalities. Finally, efforts to improve conditions for drayage truckers (reduced truck turn times, collective bargaining) were unsuccessful throughout the period, reflecting a lack of political support for this constituency.

3.3 Institutional Relationships in Goods Movement

Understanding responses to the changed regulatory environment requires an understanding of the institutional relationships within the port-related trade supply chain. We have developed a conceptual model of institutional relationships, as shown in Figure 5. We adopt a political economy approach, explaining relationships and outcomes in the context of market power and political influence.

Figure 5: **Conceptual Model of Port-related Supply Chain**



3.3.1 Dominant Actors

We identify steamship lines, ports, terminal operators, their major customers, and the Longshore labor union as the "dominant actors" in the supply chain. They are dominant in the sense that they have both significant market power within port-related trade and substantial political influence within the US. All but the ILWU are "natural allies," in that they have sufficiently aligned objectives to promote cooperation in many circumstances. Public ports in California are granted operating authority by the state under the 1911 California Tidelands Trust Act. Operating authority comes with certain protections on funds and limits on local regulatory oversight. The ports are managed by governing boards whose members are appointed by their respective mayors, and who have significant authority over port management. This lack of direct accountability has historically insulated the ports from political pressure (Erie, 2004). The ports operate as landlords (tenant terminals have long-term lease agreements), and their primary focus is a stable and adequate source of lease revenues.

Tenant marine terminal operating companies (MTOs) are either owned by or have long-term contractual agreements with the steamship lines. The steamship lines are foreign flag carriers, and are subject only to international maritime agreements with respect to operating practices. MTOs serve specific customers or product lines. They manage the movement of cargo between ships and the landside shippers who serve steamship line customers – foreign manufacturers, wholesalers and retailers. These entities are interdependent and share common economic interests. Major customers in Asia-Pacific trade include the large discount retailers, e.g. Wal-Mart and Target. Major customers can influence ship schedules, rates, and cargo handling. For example, MTOs may offer special pickup times, or allow longer dwell time of cargo on the docks for preferred customers.

Federal oversight for US ports and port operations is provided by the Federal Maritime Commission (FMC). The FMC is an independent regulatory agency which administers the Shipping Act of 1984 and the Ocean Reform Shipping Act of 1998. The Shipping Act allows terminal operators anti-trust immunity under certain conditions: to enter into agreement with each other to discuss rates, conditions of service or cooperative working arrangements. Thus the US regulatory structure facilitates collaborative actions among steamship lines, MTOs, and ports.

The presence of large scale economies in international trade has led to the concentration of trade in a few very large ports. Ever larger ships require deeper ports and larger dockside operations, which imply infrastructure investments that need high volumes and long-term contracts to cover costs. On the landside, more trade volume generates supporting activities – third party providers, secondary manufacturing, freight distributors, and high quality rail transport – that further reinforce the advantages of large ports. These dominant actors therefore have significant market power within the international supply chain.

3.3.2 The Longshore Union

Represented on the west coast by the International Longshore and Warehouse Union (ILWU)[3], longshore labor is arguably the most powerful (and highest paid) unionized labor force in the US. The ILWU contract covers wages and benefits, working conditions, and allocation of labor. It also controls the size of the labor force. As trade volumes have grown, longshore labor has enjoyed favorable bargaining conditions, and hence has been able to retain significant control over dock operations.

Unlike many other industries, the terminal operators have been given authority by the FMC (see above) to act cooperatively in dealing with longshore labor. They do so through the Pacific Maritime Association (PMA), whose members include terminal operators, stevedore companies, and steamship lines. Labor contracts are the outcome of bilateral negations between the PMA and the ILWU, hence the same labor provisions apply at all west coast ports. Once an ILWU contract is in place, terminal operators (MTOs) have few options for economizing on longshore labor. The ILWU's market power derives from its potential to disrupt west coast trade. As long as high labor costs can be passed on, PMA members have little incentive oppose union demands.

3.3.3 Drayage Trucking

In contrast, the drayage trucking industry has little influence within the international supply chain. The truck drayage industry is composed mainly of owner-operator drivers who contract with small trucking companies. These are low-skill, low-pay jobs. Drivers receive a lump sum based on the cargo hauled and the distance traveled which must cover all costs including fuel, insurance, registration and maintenance. With easy entry and an apparently still plentiful supply of labor, drayage is a price taking industry segment.

Truckers have no formal means of influencing the behavior of MTOs (or of the trucking companies who contract with them). Because they are considered private contractors and not employees, drivers are subject to federal anti-trust laws prohibiting cooperative action that could impede interstate commerce. In Los Angeles drayage truckers are mainly Spanish speaking immigrants, most of whom are reticent to political action or other forms of influence.

3.3.4 Other Actors

There are many other participants in international trade: railroads, third party providers, customs brokers, etc. Two Class I railroad companies serve the San Pedro Bay ports, Union Pacific and BNSF. By virtue of the importance of the rail network in distributing goods throughout the US, the railroads also have significant market power. Other industry segments are more fragmented, and to date have had little apparent influence in port-related activities.

4. TWO EXAMPLES: AB2650 AND OFFPEAK

The combination of favorable competitive conditions and supportive national regulatory environment allow ports, MTOs and steamship lines considerable control and flexibility in responding to local efforts to mitigate congestion and air pollution impacts. We illustrate with two examples, AB 2650 and the OFFPeak fee program. The summaries presented here are based on comprehensive evaluations of each program.[4]

4.1 AB 2650

As noted in Section 3, AB 2650 was the first attempt to change dock operational practices. It went into effect in July 2003. It imposed a penalty of $250 on marine terminal operators for each truck idling more than 30 minutes while waiting to enter the terminal gate. Because the bill targeted ports of a certain size, only three were subject to the regulation: Los Angeles, Long Beach and Oakland. Terminals could avoid fines by extending full service gate hours to 70 per week (65 hours at the Port of Oakland), or by offering a gate appointment system to trucks to drop off or pick-up cargo containers. The bill had some important caveats – the penalty applied only to: 1) trucks idling (not waiting with engine off); 2) trucks with an appointment; 3) wait time to the entry of the terminal property (not the pedestal within the entry where trucks receive permission to enter the docks). AB 2650 had no jurisdiction over queuing within the terminal.

No terminal chose to comply with AB 2650 by instituting extended gate hours, or even modifying existing extended hours; most implemented an appointment system. Although the legislation included some guidelines, terminal operators had great flexibility in structuring appointment systems. Appointments were implemented with different appointment providers, policies for making appointments, and gate procedures. Appointments are made via a proprietary web-based information system. The terminal operator determines which service is to be used, and the trucking companies and others pay to access the service based on volume of transactions. Trucking companies typically service all terminals, so using the appointment systems required subscribing to each of the information systems used by the terminals they service. No terminal made special arrangements for trucks with appointments once they were inside the terminal.

4.2 Results from AB 2650

The stated purpose of AB 2650 was to reduce emissions from truck idling at terminal gates. In order for an appointment system to be effective in reducing truck idling, appointments must be used, and appointments must be associated with a reduction in truck wait times.

4.2.1 Use of Appointment System

Terminal operators were not required to report on use of the appointment system. Ex-post surveys of MTOs on use of appointments yielded estimates from almost none to 30% or more, with most responses at the low end of the range. Monthly data from three terminals showed different patterns, as shown in Figure 6. Only one terminal had a large share of appointments; this was due to a strategy of using appointments as a way of managing truck moves on the dock. We also obtained limited data from a fourth terminal; appointments were 1-3% of total moves. While an appointment system can potentially reduce transaction times, the generally low rates of appointment utilization imply limited impact.

Appointment systems can only be effective if truckers use them. If appointments reduce trip times by reducing wait time or making sure cargo is released and ready for pickup, truckers have every incentive to make them, since they are paid by the load, not by hour. We examined the impact of appointments by comparing transaction time data from one MTO for transactions conducted with and without appointment times. Since the greatest share of appointments at any terminal is for picking up an import container, our comparison is limited to import pickup transactions. Figure 7 gives the cumulative distribution of transaction times for all import pickup transactions, and for import pickup with appointment transactions. It can be seen that transactions with appointments are longer than transactions without appointments. The group means are 52.6 minutes for all transactions and 84.6 minutes for transactions with appointments; the difference is statistically significant. In a survey of 27 trucking companies, the average estimate of transaction time with appointment is longer than without appointment, consistent with the Figure 7 data. Our conservative conclusion is that we have no evidence that appointments are associated with time savings. However, longer transaction times could simply mean that appointments are more likely to be used for the most complex transactions.

Figure 6: **Appointments as Share of Total Gate Moves**

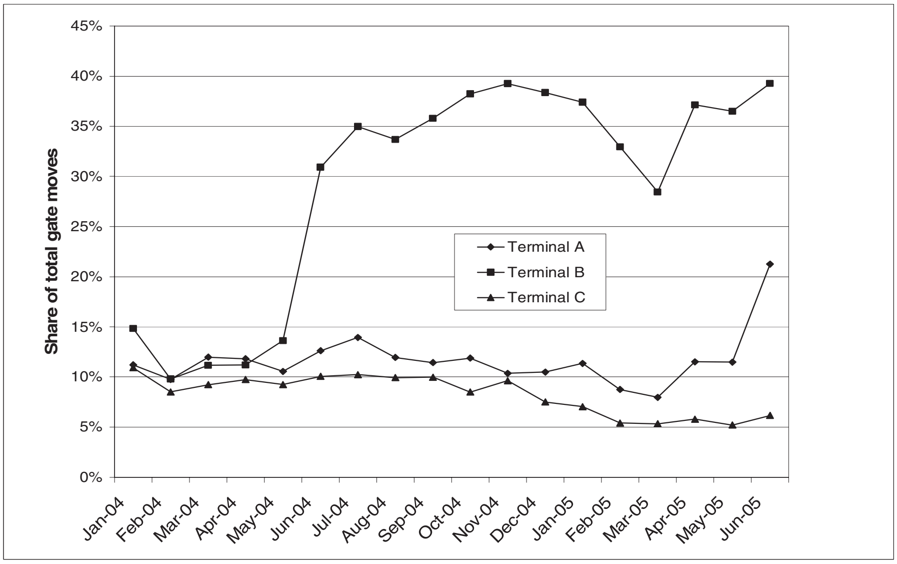
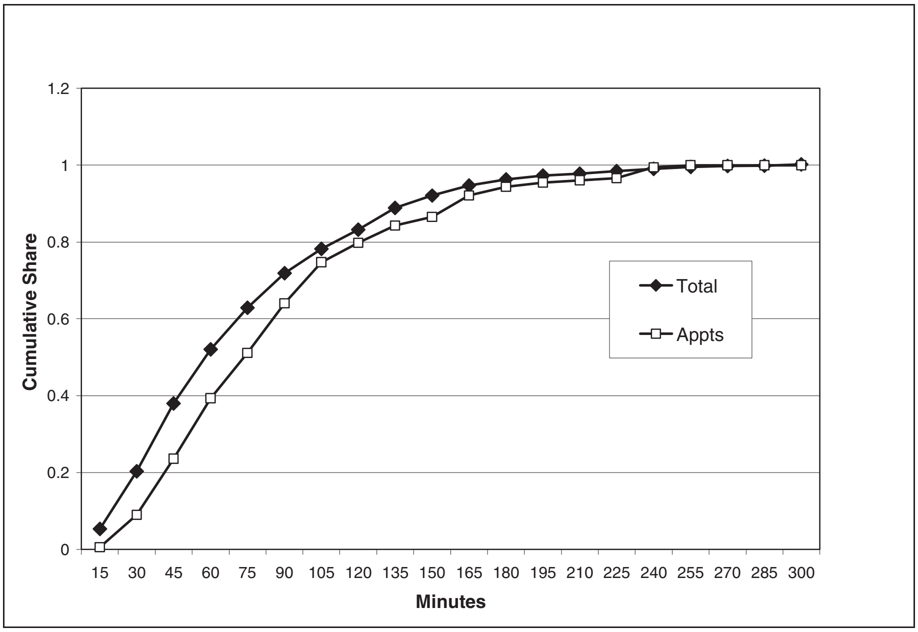


Figure 7: **Cumulative Distribution, Import Transactions**



We conducted simulations to evaluate conditions under which an appointment system would generate time savings sufficient to measurably reduce queuing and truck idling, based on plausible rates of appointment use. We found that reducing wait time on the docks would have the greatest impact, holding appointment share constant. For the average transaction, time spent at the terminal is a larger portion of total transaction time than time spent waiting to enter the terminal, so has the greatest potential for reducing total transaction time. We also found that a much larger proportion of appointment use would be required to generate significant time savings. For example a transaction time savings of 10 minutes for 30% of all import moves would generate a total transaction time reduction of about 6%.

4.2.2 Trucking Response

Why were appointments so little used? Our survey revealed an overall perception that the appointment system did not improve conditions for truckers. The majority stated that it did not improve their ability to meet customer demands, nor did it reduce turn times (the time required to complete a transaction at the docks, including waiting to enter the terminal and completing the transaction within the terminal). No firm gave an unequivocally positive response. Respondents were also asked to rate the effectiveness of the appointment system at each terminal in reducing turn times on a scale of one to five, with 1 = not effective and 5 = exceptionally effective. Terminals are not given high marks: mean scores range from 1.4 to 2.3.

Written comments, as well as the open-ended discussion conducted with respondents after completion of the survey, provide some explanations for their negative assessment. First, truckers expected that appointments would reduce transaction time by assuring that containers and/or chassis were ready and available for pick-up. However, this was not the case; practices "inside the gate" did not change as a result of the appointment system. Second, some respondents noted that the real constraints are limited gate hours and limited dock labor. If container volumes are increasing and the container processing rate remains constant, transaction time will increase, with or without appointments. Others noted the difficulty of using several different appointment systems. Finally, respondents cited the difficulties of making and keeping sequential appointments, because any delay with an earlier transaction cascades to all other later transactions.

4.2.3 Conclusions on AB 2650

We have no evidence to suggest that the appointment system reduced queuing at terminal gates and hence HDT emissions. Data from terminals and information from interviews supports a finding of no impact for two reasons: 1) the majority of terminals did not view appointments as an effective operational strategy, and few efforts were made to offer any priority to those with appointments; 2) trips with appointments made up a very small share of all trips at most terminals, and hence could not have had a significant impact on queuing even if such trips were granted priority. Our estimates of potential turn time savings from appointments suggests that a large proportion of trips would have to use appointments, and appointment trips would have to be given some priority in order to realize significant time savings. It is only under these conditions that an appointment system would reduce truck queuing enough to result in lower truck emissions.

4.3 OFFPeak

As noted in section 3 above, the OFFPeak program was established in order to avoid implementation of AB 2041. The stated intent of OFFPeak is to spread port truck traffic across more hours of the day in order to reduce peak period truck traffic and related congestion. In June 2004, MTOs filed an amendment to the existing West Coast Marine Terminal Operator Agreement with the FMC to give the MTOs the authority to develop and implement an off-peak services program. The amendment was approved in early August 2004.

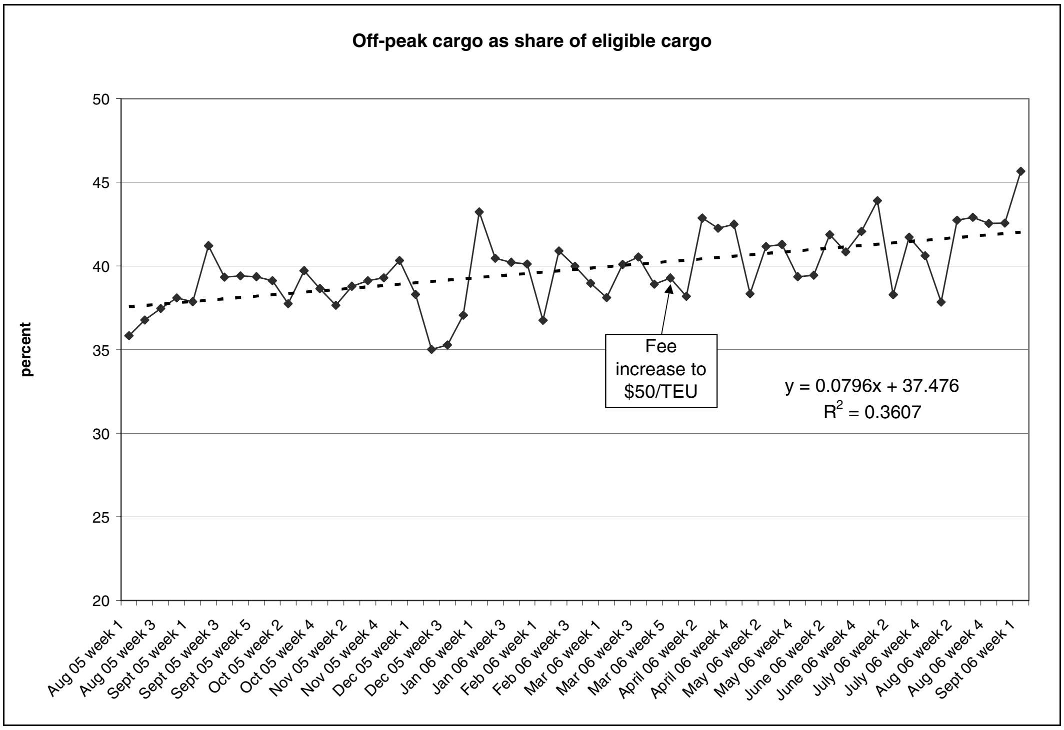
The MTOs established a special purpose non-profit entity called PierPASS, Inc. to act on behalf of the MTOs and coordinate the program. An independent financial consulting firm was hired to estimate expected costs and revenues of the program, and the peak fee was based on the financial analysis. The Traffic Mitigation Fee (TMF) was set at $40/TEU, and later increased to $50/TEU. The fee is imposed on eligible cargo from 8 AM to 5 PM, Monday through Thursday. Exempt cargo includes empty containers, cargo transshipped to other ports, domestic cargo, and cargo subject to Alameda Transportation Corridor fee. No off-peak operations are available on Friday. Fee revenue, discounted by PierPASS operating expenses, is returned to the MTO of origin. The program includes a sunset clause after 3 years.

4.3.1 Use of OFFPeak

The OFFPeak program was launched in July 2005. The stated program targets for off-peak container moves was 20% by the end of the first year, 35% by the end of the second year, and more than 40% by the time the program was scheduled to sunset 3 years later. Results of the program were immediate; some off-peak shifts were moving 30% of the day's eligible containers, surpassing the first year goal. By December 2005, PierPASS claimed to have diverted 1 million truck trips to the off-peak, and by June 2006 the figure was 2 million truck trips.

Figure 8 gives weekly shares of off-peak cargo based on data provided by PierPASS, Inc., from July 2005 to September 2006. Figure 8 includes only cargo *eligible* to pay the fee, about 55-60% of all truck moves, excluding Friday cargo moves. From 7/05 to 9/06 (57 weeks of data), the average share of off-peak cargo is 39.8%. The share is increasing over the period. We estimated a simple regression on the series; the estimated average rate of increase is about 8%/week. The immediate response to the program is evident, with the early weeks in the range of 35%. Given the many exemptions to the fee, we estimate diversion to be in the range of 22-30% of all truck moves.

Figure 8: **Weekly Share of Off-Peak Cargo**



4.3.2 Impacts on the Highway System

Given the increased use of off-peak hours, we would expect some temporal redistribution of truck traffic. We compared the temporal distribution of truck traffic for weekdays in May, August and December, 2004 (before OFFPeak) and 2006 (after OFFPeak). Figure 9 shows hourly distribution of heavy truck volumes, before and after OFFPeak, for I-710, one of the main truck corridors. It can be readily seen that mid-day volumes decreased and late afternoon/evening increased. Figures 9 also suggests that there were small shifts of truck traffic out of AM and PM peaks, but large shifts out of the mid-day period and into the evening period.

OFFPeak was also intended to shift truck traffic to weekends. Again using the I-710 data, we compared truck volumes on weekends before/after OFFPeak. Total weekend truck volume increased after OFFPeak, with most of the increase taking place in the early morning hours. Daily average truck volumes before/after OFFPeak were about 5000 and 5300 respectively. Before and after volumes were 6400 and 8000 on Saturdays and 3700 and 3500 on Sunday.

We employed simulation modeling to estimate impacts of OFFPeak on the region's transport system. The "before" year is 2004; the "after" year is 2006. Over this period, container volume increased by about 2.7 million TEU, and we adjusted our simulation data accordingly. No adjustments were made for overall regional growth. We simulate four scenarios, each with four different time period simulations: AM peak, mid-day, PM peak, and night. Scenario 1 is the before OFFPeak baseline. Scenario 2 estimates what would have happened had port volume increased while the hourly distribution of port truck traffic remained unchanged. Scenario 3 estimates the impact only of the OFFPeak time distribution shift, holding port traffic constant. Scenario 4 estimates the combined effects of port growth and truck traffic distribution shift.

Figure 9. **I-710 Average Hourly Distribution of Heavy Truck Traffic, Before and After OFFPeak**

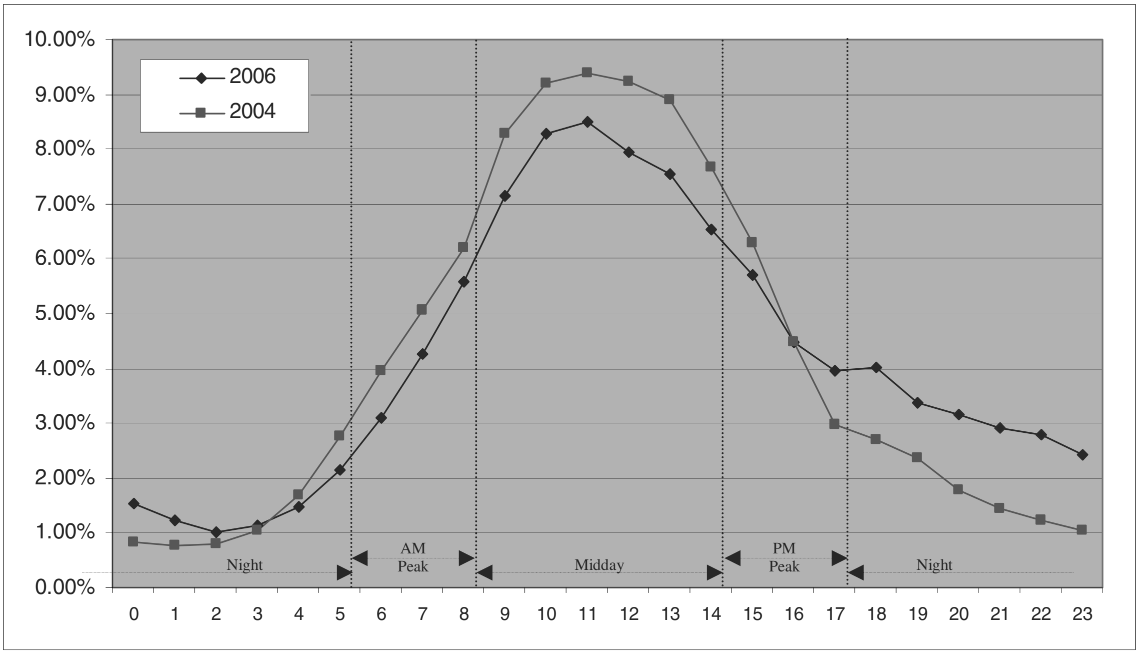


Table 4 provides comparisons across the scenarios for vehicle hours traveled. For example, in the AM peak, port growth leads to a 1.04% increase in VHT relative to the baseline, and the OFFPeak shift leads to a 1.08% decrease in VHT. When we combine growth and the OFFPeak shift, we get a 0.45% increase. That is, the OFFPeak shift offsets some of the increase in AM peak VHT. The separate effects of growth and OFFPeak are given in the last two rows; about half of the growth effect is offset by the OFFPeak effect

Table 4. **Scenario Result Comparisons (Percent change), Port sub-area only**

Scenario	Time Period			
	AM peak (6-8 a.m.)	**Mid-day (9 a.m.–2 p.m.)**	**PM peak (3-6 p.m.)**	**Night (7 p.m.-5 a.m.)**
VHT				
1 vs 2 growth effect only	1.04	21.64	3.17	0.22
1 vs 3 PP effect only	-1.08	-10.95	0.71	1.21
1 vs 4 growth + PP effect	0.45	0.97	1.95	1.15
2 vs 4 PP effect, given growth	-0.58	-17.00	-1.181	0.925
3 vs 4 growth effect, given PP	1.54	13.38	1.23	-0.06

The mid-day changes are much larger, consistent with the greater OFFPeak mid-day shift (about 8% reduction), and the greater share of truck traffic in the mid-day. Results suggest that the OFFPeak shift has almost entirely offset the port growth effect. The PM peak results are similar to AM peak: changes are small, but the OFFPeak shift tends to offset the growth effect. Night is the only period when OFFPeak contributes to VHT. Despite the large average shift (about 10%), the effect is small, because truck traffic accounts for a smaller share of total traffic at night. Results suggest that the OFFPeak shift has about four times the effect of the port growth effect. This does not affect average speeds, because there is little congestion on the network during night hours.

4.3.3 Terminal Operator Response

Terminal operators were generally positive in their assessment of OFFPeak. They agreed that the program was brought about by political pressure, not by congestion and increased cargo volumes at the terminals. Only 2 respondents said the fee revenue was not adequate to cover costs. Given the extra pay associated with second or third shift work, it might be expected that lack of labor would not be a problem. However, the ILWU controls the number of longshore workers, both "regular" and casual. Additional longshore workers would be drawn from the casual pool in the short run. Nine respondents reported some type of labor difficulty.

Terminal operators saw the OFFPeak structure as the best possible solution under the circumstances: it allowed MTOs to control implementation of extended gates with limited oversight, it eliminated competition between MTOs on peak service parameter, it assured that the fees would be returned to MTOs to offset off-peak costs, and it restricted access to financial and operating data.

Terminal operators also recognized that they were able to accommodate significant growth in container volumes by shifting more activity to the night shift.

4.3.4 Drayage Trucking

Apart from the terminal operators themselves, the greatest impact of OFFPeak has been felt by the port drayage industry. Spreading out gate moves over a longer period should translate to shorter transaction times for truckers, as less time would be spent waiting for a container to be available. It is also possible that the additional gate hours would allow truckers to make additional turns, thereby increasing the truck driver's income. However, the trucker's work day is regulated by federal hours of service mandates. It is therefore possible that OFFPeak would require significant modifications to the driver's schedule to accommodate a second shift. Trucker response should also depend on whether extra pay is provided for off-peak hauls.

Four trucker surveys have been conducted since the inception of OFFPeak, two by the California Trucking Association and two by PierPASS, Inc. The surveys are of limited comparability, and, as might be expected given the different agendas of the two organizations, show conflicting results regarding overall satisfaction with OFFPeak, effects on turn times and pay, and willingness to work night shifts or weekends. Our comparisons of the surveys yield the following observations:

- Two-thirds of work start times are between 5 and 10 AM, suggesting that most drivers have not replaced a first shift with a second shift, but have modified start time to work additional hours.
- The average number of trips per week has not changed, suggesting that turn times have not been shortened.
- No more than one-third of those working at night receive extra pay for doing so.

4.3.5 Other Stakeholders

Other key stakeholders make it clear how limited a role they have played in the development of OFFPeak. The Ports have been interested observers but have not been involved in establishing the fee structure. Distribution centers, warehouses, and exporters have modified their own operations in response to OFFPeak, adding second shift staff, or allocating more space to off-peak storage. Unlike the terminal operators, these stakeholders do not enjoy the benefit of the traffic mitigation fee as a means of covering off-peak operating costs. Their options are to pass along the costs where feasible and move as much port-related activity to the evening as possible.

We conclude that the OFFPeak program achieved its objective of shifting truck traffic out of peak periods. In doing so, it offset about two years of port growth. Shifting truck trips to less congested time periods benefited drayage truckers, as trips were being made at faster speeds. However, travel time benefits were likely not as large as the costs of working less convenient hours (generally without extra pay). The traveling public received benefits from less daytime truck volume. The ports and MTOs likely benefited from increased trade volume, and certainly benefited from having the fee contribute to the added costs of off-peak operation. We surmise that extended operations contributed to the ports' ability to process more cargo. The direct costs of OFFPeak are paid by cargo owners, but we do not know the ultimate incidence of these costs.

4.4 Conclusions from AB 2650 and OFFPeak

Outcomes of AB 2650 and the OFFPeak program were quite different. Although the intent of AB 2650 was to increase use of extended gate hours, terminal operators chose to implement appointment systems as the means of compliance. With few exceptions, appointment systems were structured to meet requirements, not to promote efficiencies either at the gates or on the docks. Consequently, appointments were infrequently used and had no measurable impact on truck transaction times. In contrast, OFFPeak was successful in shifting truck moves to night hours and hence reducing congestion on the highway system. We explain these different outcomes in the context of our conceptual model.

First, AB 2650 was imposed from the outside, without the endorsement of the dominant actors. These actors were able to influence the bill to make it as benign as possible. The earlier version of the bill that included a limit on turn times was opposed by the PMA and the Long Beach Board of Harbor Commissioners. The turn time limit was removed as a condition of withdrawing their opposition. The exemptions in AB 2650 made it difficult to enforce, and limited surveillance made documenting an excessive wait time unlikely. Even if a violation occurred, a fine of $250 was small relative to the costs of extended gate hours. The option of an appointment system provided a low cost means of compliance that would have no serious effect on dock operations. AB 2650 also served as a powerful signal to the dominant actors that they were no longer exempt from regulatory legislation.

In contrast, OFFPeak was developed and implemented by MTOs, with the tacit approval of ports and steamship lines. The experience of AB 2650 motivated MTOs to become proactive. AB 2041 was introduced in February 2004, and by July 2004 the FMC discussion agreement had been amended to allow establishment of common gate hours and fees. The discussion agreement allowed MTOs to implement a significant operational change that resulted in a best possible outcome. The success of the program allowed the dominant actors to take credit for reducing congestion and vehicle emissions.

Second, winners and losers reflect market power positions. Dominant actors were winners in AB 2650 in the sense that they were able to avoid any costly changes in operations. Drayage truckers were losers, as, contrary to their expectations, turn times did not improve. Terminal operators have no incentive to employ practices that would reduce delays for truck drivers. Rather, their incentive is to serve their customers and manage dock operations within the constraints of longshore work rules and contract provisions.

The MTOs, ports and steamship lines were clear winners in OFFPeak for the reasons given above. The program protects terminal operators in several ways: 1) establishment of a common fee and operating practices eliminates competition on these dimensions of service; 2) control of both fee rate and revenue minimizes the chance of financial losses; 3) the separate, non-profit entity limits information available to the public, making it difficult if not impossible to determine whether MTOs are generating excess profits from cooperative price setting. The major retailers were not harmed; most terminals were already operating special gate hours for major customers, and distribution systems of these retailers were already structured for 24 hour operation. Longshore labor was also a winner. OFFPeak hours were determined by the ILWU shift schedule, and second shift work comes with significant shift premiums and guarantees.

Actors without market power have not benefited from OFFPeak. Drayage trucking was not consulted in the development of OFFPeak, despite the obvious impacts it would have on this industry segment. Fewer longshore crews at night and gaps in service during shift changes have resulted in delays for truckers which are typically not compensated by additional pay. During the formation of OFFPeak, truckers attempted to claim some of the program revenue, arguing that they should be compensated for night work and longer hours, just as longshore workers are. They were summarily ignored; dominant actors knew they would not be able to exert enough political pressure to achieve such an outcome. Similarly, distribution centers and warehouses had limited input in the development of OFFPeak. Like the drayage truckers, they were left to absorb the additional costs of the program.

5. CONCLUSIONS

The outcomes of AB2650 and OFFPeak provide many insights on the response of port-related trade interests to a rapidly changing political and regulatory environment. AB 2650 demonstrated that political support was sufficient to impose regulations on port operations in order to reduce environmental impacts. While an established regulatory framework for reducing stationary and mobile source emissions has been in existence for many years, these are aimed directly at emissions. AB 2650 indirectly targeted emissions by regulating specific operating practices, greatly increasing government involvement and authority. AB 2650 also represented a significant change in perceptions regarding the responsibilities of port-related trade. Highway congestion and local air pollution problems became in part the responsibility of trade interests to solve. Again, there is some historical precedent – ports have been responsible for reducing pollution impacts on local waters for decades in the US – but the important dimension is the scope and scale of perceived responsibility.

OFFPeak illustrates the capacity of the dominant actors to respond to increased pressures for solving congestion and environmental problems. It represents a significant shift in strategy. The growing evidence of particulates on health effects, together with port activity being a major source of particulate emissions has made it virtually impossible for political leaders not to embrace an aggressive mitigation strategy. International trade proponents have no choice but to actively participate. Without operational changes that are viewed by those outside the industry as minor, no credible case could be made for supporting growth in port activity, or for the public infrastructure investments to accommodate that growth. Thus the question is one of how externalities can be addressed with the least cost to the dominant port interests. Some basic principles seem to emerge: direct all operational changes, maintain control of revenue streams, and cooperate to achieve outcomes that are mutually beneficial.

Both case studies suggest that the incidence of costs associated with these programs reflects the institutional relationships within the port-related supply chain. Costs were borne by those with weaker positions, notably drayage trucking and the smaller wholesalers and distributors, who had no part in the design of appointment systems or extended gate hours, but were faced with adapting their own business operations.

The case studies also demonstrate the key role US regulatory policy. The FMC agreement process, which allows MTOs substantial authority to collaborate, made it possible to establish the OFFPeak program. Agreement amendments are subject to permissive review requirements: proposed agreements must only be listed in the Federal Register for 45 days, and unless objections are placed with the FMC, the amendment goes into effect. Parties who may be affected by an amendment may be unaware of the filing until after the fact, as the only source of information is the Federal Register. The US regulatory framework, in which MTOs, steamship lines, and stevedore companies may cooperate for many different purposes, both supports and reinforces the market power of the dominant actors, giving them a relatively free hand in controlling port activities. The US regulatory framework also supports and reinforces the weakness of drayage trucking by subjecting this sector to anti-trust prohibitions on cooperative service practices or rate setting.

5.1 Is Los Angeles Unique?

To what extent does the Los Angeles experience help us understand the larger issue of a changed regulatory environment? Is Los Angeles the harbinger of the future, or is the situation so unique that there are few conclusions to be drawn? Los Angeles is in some ways indeed unique: international trade constitutes a large share of the regional economy; the ports' container volume is more than double that of the next largest complex (New York/New Jersey); it has the worst air quality and traffic congestion among US metropolitan areas. It is also capable of handling the world's largest ships and has the nation's largest network of supportive industries.

On the other hand, environmental concerns continue to grow throughout the US and the world, and Los Angeles has long been recognized as a source for precedent setting. Cargo handling equipment provides just one example. Reducing emissions from cargo handling equipment began in the 1990s in Los Angeles. Since then, these practices have been adopted at the ports in Seattle, Houston, and New York/New Jersey.

Air pollution and traffic congestion associated with truck traffic are growing concerns in other metropolitan areas. Feasibility studies for short-sea shipping have been conducted for Oakland, the upper west Pacific coast ports, as well as Los Angeles (Le-Griffin and Moore, 2006). The New York/New Jersey ports considered an inland distribution network that would shift truck traffic to rail and barge, and funded a demonstration of the barge service (Port Authority of New York and New Jersey, 2006). Efforts to shift truck traffic to rail have been examined for Oakland and for New York/New Jersey, and New York/New Jersey is engaged in a major expansion of on-dock and near-dock rail.

We have not yet seen the passage and implementation of regulations such as AB 2650 in other US metropolitan areas, but efforts to do so are increasing. Appointment systems have been proposed in both Seattle and New York/New Jersey. Truck idling bills have been introduced in Illinois, Rhode Island, Connecticut and New Jersey. New Jersey Assembly Bill A2646, introduced in October 2006, would prohibit the idling or queuing of heavy duty diesel trucks at marine terminals for more than 30 minutes, would fine terminal operators $250 per infraction, and would exempt terminals if extended gate hours are offered. The bill has to date remained stalled in committee.[5] The Port of New York and New Jersey 2006 Strategic Plan calls for extended gate hours and an OFFPeak type fee program, though no actions have yet been taken to implement these plans.

Finally, the utility of FMC agreements for controlling mitigation strategies is becoming evident outside Los Angeles. As of this writing, port interests at PANYNJ have submitted a draft amendment for the purpose of coordinating policies and programs associated with measures to reduce congestion at the ports, and Seattle is using the existing west coast agreement to develop methods for managing local truck traffic.

5.2 Implications

Results from Los Angeles lead to some broader considerations on the role of ports in an era of global industry restructuring and rising environmental concerns. Olivier and Slack (2006) note the emergence of the transnational corporation in the global supply chain, and argue that global trade flows will increasingly follow the logic of logistics chains based on terminals and their forward and backward linkages. This new logic weakens the ability of ports to influence global trade flows. Hall (2007) argues that changing patterns of globalization have changed the relationship between port and hinterland: the benefits of increased trade impose substantial local costs that the port has a responsibility to address, since localities themselves have little control over trade-related externalities. Hall's perspective is borne out in Los Angeles, where there is a growing expectation that ports take an active role in addressing externalities. Indeed, the San Pedro Bay ports have moved from a position of passive lease agents to active self-regulators. We see similar efforts by ports to lead air pollution and congestion mitigation efforts in New York and New Jersey and in Seattle.

Mitigation costs to port-related trade, however, can be substantial. In Los Angeles the OFFPeak fee is $50 per TEU. In their continuing effort to address congestion and pollution, port interests have agreed on additional fees of $15 per TEU for upgrading the drayage truck fleet and $30 per TEU for surface transport infrastructure (the latter again in response to pending state legislation). Whether anticipated trade growth can be sustained with fees approaching $100 per TEU remains to be seen. Los Angeles demonstrates the fundamental dilemma facing large US trade nodes: growing local demand for relief from port trade externalities vs an increasingly competitive international trade industry.

NOTES

1. Calculated by the authors from 2002 California State Department of Transportation, District 7 traffic volume data.

2. Coke is a solid by-product of petroleum refining.

3. On the east coast, labor is represented by the International Longshoremen's Association (ILA).

4. On AB 2650, see Giuliano, O'Brien and Maggadino, 2005; Giuliano and O'Brien, 2007. On OFFPeak, see Giuliano and O'Brien, 2008; Giuliano *et al..,* 2008.

5. http://www.njleg.state.nj.us/bills/BillsByNumber.asp

ACKNOWLEDGEMENTS

This report is based on research supported by grants from the METRANS Transportation Center, University of Southern California, with funding from the US Department of Transportation and California Department of Transportation. Support from OECD to write this report is gratefully acknowledged. Elena Maggiore, PhD student in Public Policy, provided assistance. All errors and omissions are the responsibility of the authors.

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ASSURING HINTERLAND ACCESS: THE ROLE OF PORT AUTHORITIES

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SUMMARY

Rotterdam, March 2008

ABSTRACT

We argue that port authorities (PAs) should contribute actively to better hinterland access. We discuss different types of PA involvement as well as some reasons for such involvement. The analysis applies to landlord PAs with public goals. Landlord PAs take the initiative for the expansion and redevelopment of port infrastructure. Traditionally PAs have acted as landlords, but they are increasingly operating outside the landlord model.

The main argument for more active PA involvement is the fact that co-ordination in port clusters and transport chains does not emerge spontaneously. Better co-ordination could lead to more efficient transport and supply chains. Since the main revenue drivers of PAs are throughput and land value, PAs have incentives to invest to improve co-ordination in port clusters and supply chains.

More active involvement would be particularly advantageous in hinterland transport, the main bottleneck in international door-to-door transport chains. PAs could contribute to efficient hinterland access by investing in infrastructure and terminals not only inside the port area, but also outside it. PAs could also improve hinterland access by setting infrastructure access rules, investing in a port community system, setting conditions in terminal concessions and assuring sufficient competition between firms in all parts of the supply chain. These PA roles may not be relevant in all ports, but could provide a challenging perspective for PAs that wish to explore a more active role in improving hinterland access.

1. INTRODUCTION

We use several theoretical insights to explore the role of port authorities (PAs) in hinterland access. The paper is explorative and contains some initial ideas for further discussion and scrutiny. Further analysis is pertinent, since the pressure on hinterland transport systems is increasing. Furthermore, it has become clear that, in many ports, initiatives to improve hinterland access do not emerge spontaneously (for example, through market forces or public investments), but may require the active involvement of the PA.

Following this introduction, the traditional role of the landlord PA is first briefly reviewed. Second, we provide a new perspective on the role of PAs, with the focus on their contribution to improving co-ordination in port clusters and supply chains. This new perspective is relevant for the subsequent discussion of the role of PAs in improving hinterland access. Third, we briefly review the existing literature on port hinterlands. This review suggests a number of challenges for improving hinterland access. Fourth, we discuss the involvement of the PA in hinterland transport. A short conclusion section ends the paper.

2. THE ROLE OF LANDLORD PORT AUTHORITIES

Most large container ports worldwide are organised according to the landlord model, in which a publicly owned PA plays a central role (Baird, 2002). Landlord PAs increasingly operate as autonomous organisations with a commercial focus (see the overview provided in Brooks and Cullinane, 2007). Figure 1 shows schematically the increasing autonomy of PAs in selected countries.

PAs normally invest in (the dredging of) maritime access channels, breakwaters, berths and quays, sites for terminals, sites for manufacturing and logistics activities, and road and rail infrastructure. PAs provide sites for tenants and port access for ships. Consequently, the main revenue streams are land rents and port dues. In general, landlord PAs do not aim for profit maximisation, but have other objectives, such as maximising throughput, contributing to overall economic development and enabling trade (Brooks and Cullinane, 2007). Nevertheless, many PAs are self-sustaining and thus need to generate sufficient return on investment to finance new investments. Landlord PAs usually have the *planning initiative* for expanding or redeveloping a port area and maritime infrastructure**.** Table 1 shows PA involvement in port planning in four countries.

Figure 1: **Examples of the increasing autonomy of PAs**

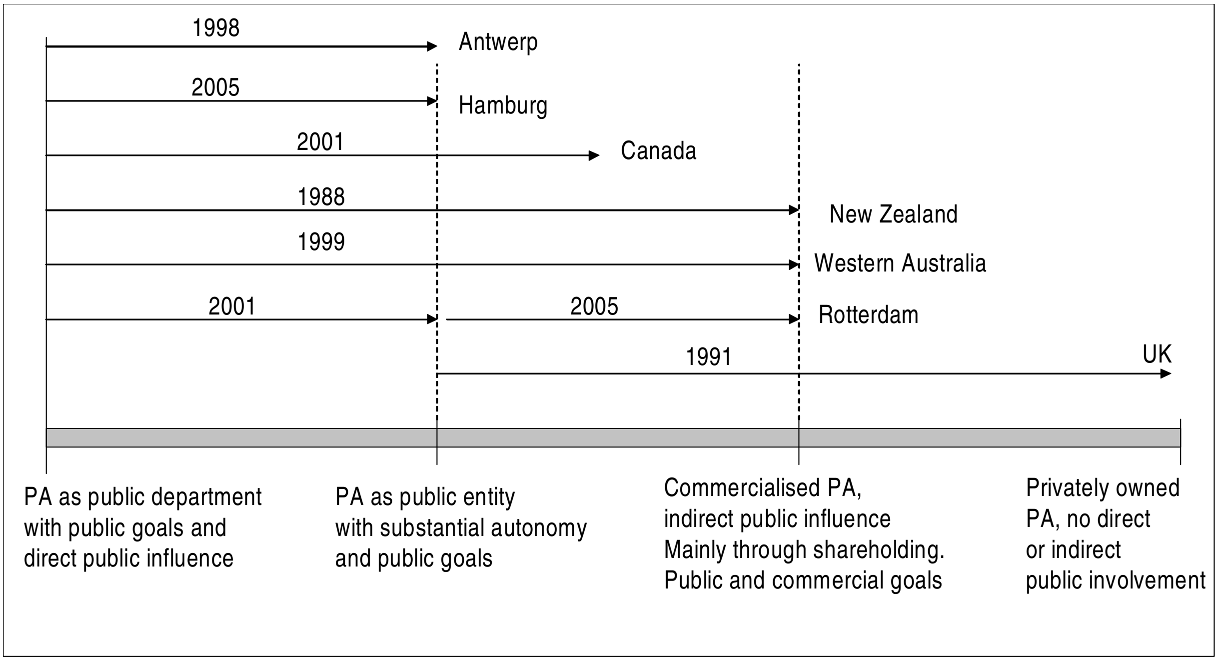


Table 1: **PA involvement in port planning**

Country/port	**Arrangements**
Belgium	The PA develops port plans that have to be approved by the Flemish Ministry and comply with relevant regional, national and international regulations. The special law for ports gives the PA the right to expropriate land (under specific conditions) to enable effective port planning.
The Netherlands	The PA develops port plans and seeks their approval from the municipal and national governments. Expansion plans have to comply with the relevant regulations.
New Zealand	Public agencies are in charge of port planning; the port company is responsible for running an efficient port business. They are clearly stakeholders in the planning process and provide information on the requirements of additional capacity.
Canada	The PA develops a land use plan for the port land it manages. The Ministry of Transport is responsible for major port development initiatives.

These countries have different institutional structures and consequently the PA has a different role in each. However, the PA either has the planning initiative (Belgium, the Netherlands) or is the main partner in planning initiatives formally taken by public authorities[2] (New Zealand and Canada).

Figure 2 illustrates four activities of landlord PAs.[3]

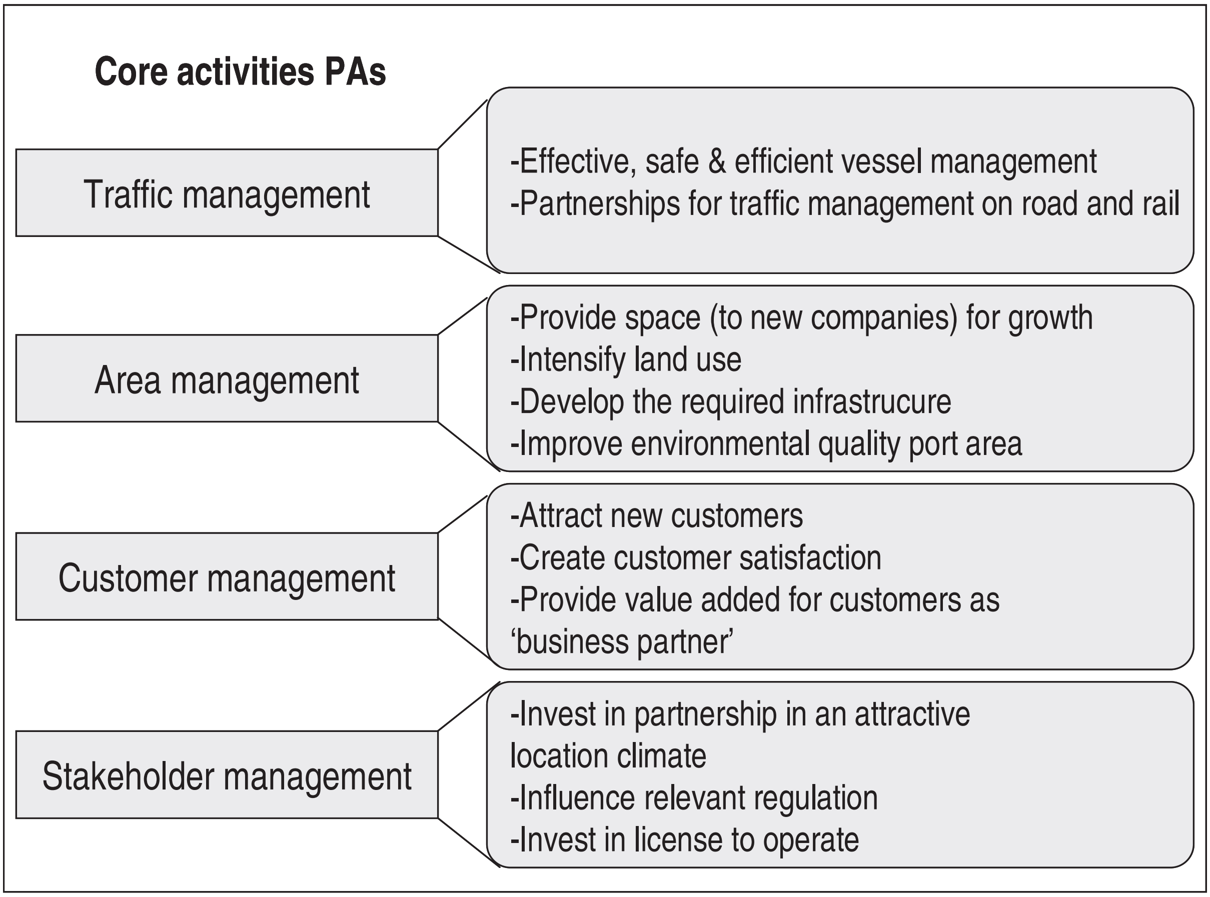
Traffic management is a core activity for many PAs. Their focus is on the management of vessel movements in the port. The PA is often the harbourmaster in the port area. This activity may also encompass monitoring and preventing pollution from ships in the port, as well as monitoring of the security of ships and cargo.

Area management refers to all activities designed to develop the port area, such as the construction of road and rail infrastructure in the port area, the maintenance of public areas and the planning of land use in the port area.

Customer management refers to all contacts with customers, including signing contracts with new customers, granting concessions to private operators and (joint) port marketing.

Stakeholder management refers to all activities that ensure that the port maintains its licence to operate. Contacts with stakeholders who directly influence the attractiveness of the port stand to the fore and are maintained through, for example, customs, security and inspection procedures, and infrastructure policies.

Figure 2: **Four core activities of landlord PAs**



3. THE ROLE OF PAs IN ENHANCING CO-ORDINATION

The involvement of PAs increasingly exceeds the traditional landlord model. PAs not only lease land and provide safe access to the port, but also actively invest to improve the efficiency of the transport chain and the competitiveness of the port. Such investment leads to the growth of the two key *revenue drivers* of PAs: land value and port throughput. The central argument for an active role of the PA is the contribution to effective *co-ordination*. More co-ordination is required both in *port clusters* and in *international transport chains.*[4]

3.1. Co-ordination in port clusters

A *port cluster* consists of all the economic activities in the port region related to the arrival of ships and cargoes (De Langen, 2004). Although it differs from case to case, the relevant port region generally includes the primary port area, some adjacent municipalities and a number of transport and logistics firms. Physical proximity is a defining characteristic of a cluster; the port cluster is a more localised concept than the port hinterland, which may stretch several hundreds or even thousands of kilometres inland. Co-ordination between firms in the cluster (cargo handling firms, forwarding firms, logistics service providers, transport firms and so on) contributes to the competitiveness of the cluster as a whole. This competitiveness is explained by the presence of external economies (such as a high-quality labour market and knowledge spillovers) in clusters (Marshall, 1890). To some extent, these external economies arise spontaneously.[5] Firms and other organisations in a cluster also *invest* to create or enlarge cluster externalities, for instance through joint investment in education. Such investment does not always arise spontaneously, however, because the benefits cannot be internalised by a particular firm or group of firms, but is spread over all the firms in the cluster (Schmitz, 1999). Thus, the collective action problem (Olson, 1971) arises in clusters (De Langen and Visser, 2004). Even when the collective benefits of co-operation exceed (collective) costs, co-operation may not develop spontaneously. This tendency towards insufficient shared investment applies to various types of investment, including in education, innovation and marketing (De Langen and Visser, 2004).[6]

Landlord PAs have incentives to make such investment. Since landlords are self-sustaining, these costs are passed on to port users (tenants and shipping lines). Such an arrangement can be beneficial for the port users, because the collective goods contribute to the quality of the port.

3.2. Co-ordination in international transport chains

At least five arguments can be put forward to explain why co-ordination problems arise in transport chains:

1. The unequal distribution of the costs and benefits of co-ordination. If one actor in the chain has to invest (for example, in ICT systems) while others obtain the benefits, co-ordination may not arise spontaneously. Gain-sharing mechanisms that redistribute benefits may fail owing to high transaction costs and the risk of free-rider behaviour.

2. A lack of resources on the part of at least one firm in the chain. This issue is especially relevant for co-ordination problems involving relatively small firms.

3. Strategic considerations. These can also impede co-ordination. Firms may be reluctant to improve co-ordination if competitors also benefit. This situation is likely to arise in a fragmented market characterised by fierce competition.

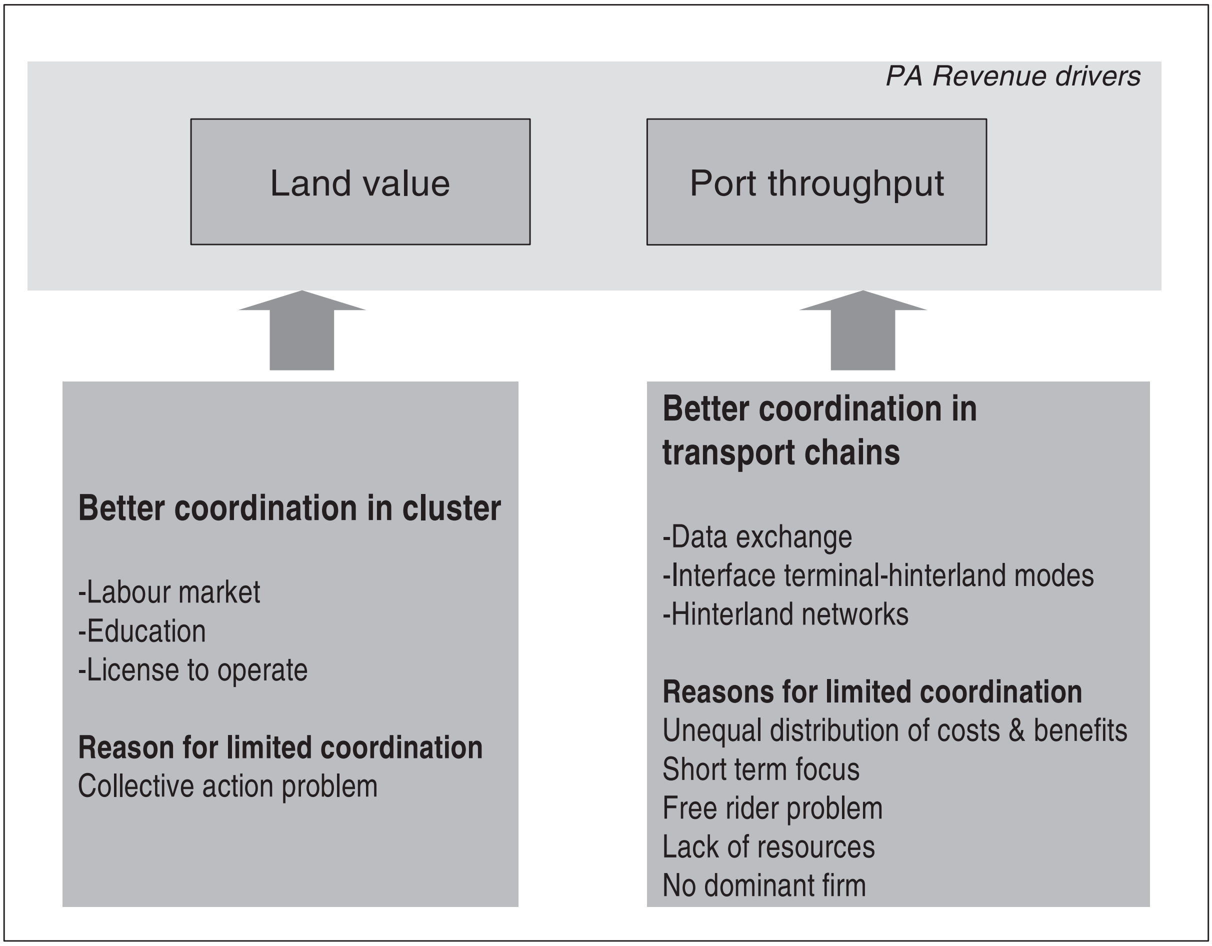
4. The lack of a dominant firm. A firm with supply-chain power will have a major impact on the structure of a transport chain (see, for example, Groothedde, 2005). A lack of supply-chain power reduces co-ordination.

5. The risk-averse behaviour and short-term focus of firms in hinterland chains. Firms that expect that co-operative initiatives designed to improve co-ordination will be time-consuming may be reluctant to put any effort into such initiatives.

These reasons explain why the efforts and investments of firms to improve co-ordination are in some cases limited. Firms generally focus on internal processes and put less effort into resolving the co-ordination problems of the chain as a whole. This attitude is more marked if actors expect co-operation to be difficult to achieve. Thus, previous experience in co-ordination also determines a firm's attitude.

A PA has incentives to invest in co-ordination within transport chains, because if the chains are more efficient, more throughput ensues. Figure 3 summarises the reasons for a PA role in enhancing co-ordination in port clusters and transport chains.

Figure 3: **The role of the PA in co-ordination in port clusters and transport chains**

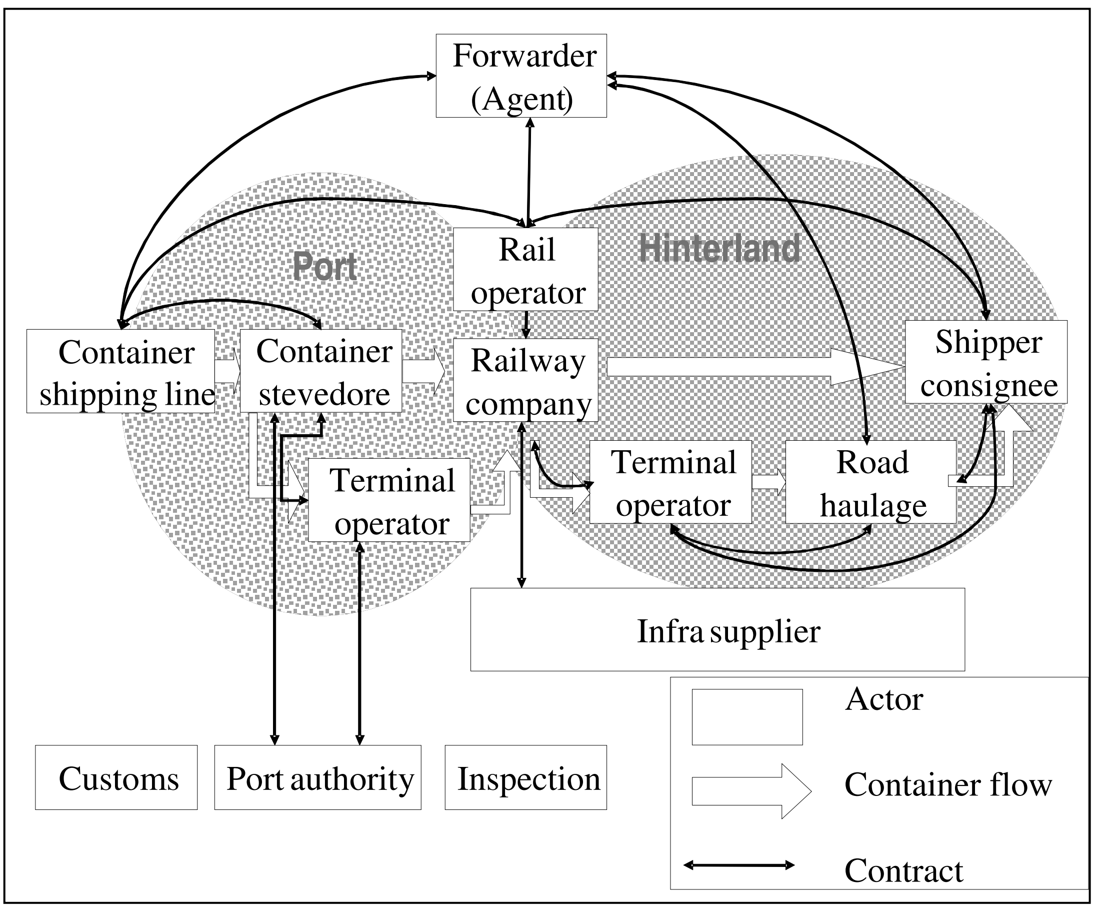


This role of a PA is relevant with regard to hinterland access. Before discussing the involvement of PAs in hinterland access (in section 5), we briefly review some insights with regard to port hinterland.

4. PORT HINTERLANDS

Now that ports are links in a global logistics chain (Robinson, 2002), port competition is no longer between ports, but between transport chains (Notteboom and Winkelmans, 2001). In fact, in most door-to-door transport chains, the costs of hinterland transport are higher than the maritime transport and port costs combined. Most ports mainly serve contestable hinterlands[7] and thus depend crucially on the quality of hinterland transport services. The quality of a port's hinterland access depends on the behaviour of many actors, including terminal operators, freight forwarders, container operators and the PA. As an illustration of the variety of firms involved in hinterland transport, Figure 4 shows the relevant actors in the rail hinterland chain.

Figure 4: **Relevant actors in the rail hinterland chain**



Source: Van der Horst and De Langen, 2008.

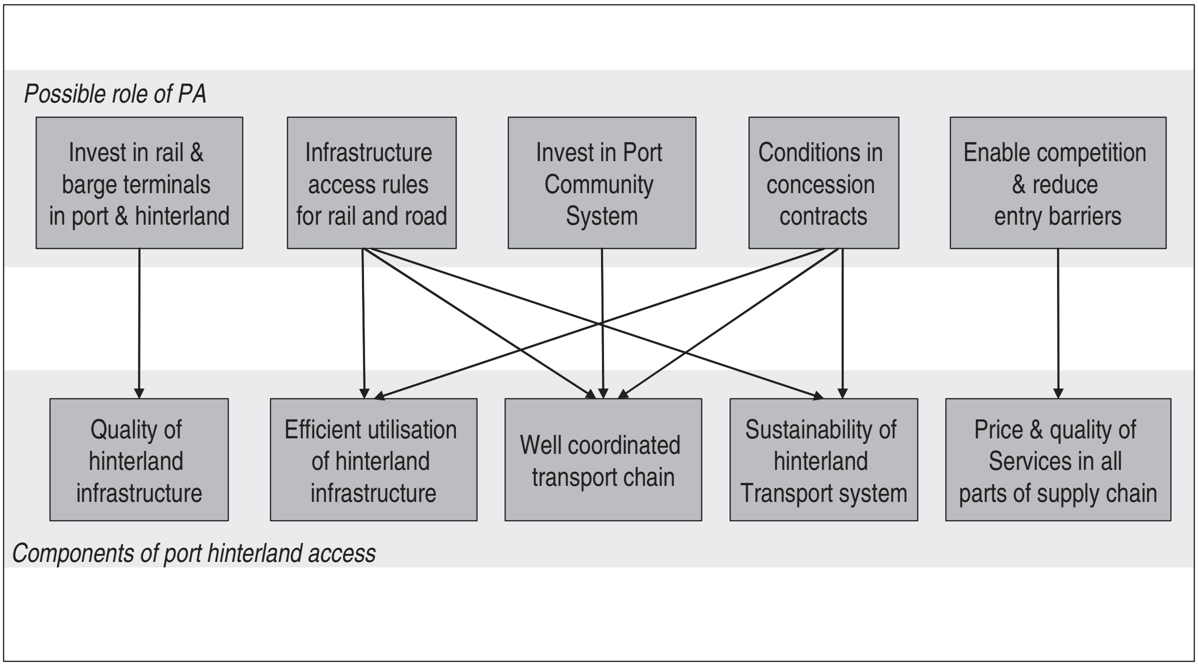
On the basis of the overview and other relevant literature (such as Robinson, 2002; Notteboom and Rodrigue, 2005; and De Langen and Chouly, 2004), five conditions for efficient hinterland access of seaports can be identified:

1. The transport infrastructure to the hinterland needs to be well developed;
2. The transport infrastructure needs to be used efficiently;
3. The transport chains need to be well co-ordinated;
4. The hinterland transport system needs to be sustainable;
5. The services provided by private firms (terminal services, barge services and so on) need to be attractive.

5. THE ROLE OF PAs IN IMPROVING HINTERLAND ACCESS

Figure 5 shows the five conditions for efficient hinterland access described above, and five options for the PA to influence the conditions. Each option is discussed in further detail below. These options are explorative and may not be relevant in all cases.

Figure 5: **Conditions for efficient hinterland access and options for PA involvement provide infrastructure**



5.1. Investments in rail & barge terminals

In many seaports, the PA takes the initiative for infrastructure-expansion projects in the port area, because other firms or public organisations lack the incentive or the legitimacy to do so. There may also be arguments for an active involvement of a PA in such expansion projects *outside* the port area. The key argument is that such investments outside the port area can contribute significantly to the utilisation of the infrastructure *inside* the port area. The active involvement of a PA is only required when such investments do not arise spontaneously. Private firms may not have the administrative power to invest in new infrastructure (for example, dry ports or rail tracks to the port), while regional authorities in the hinterland may not have an incentive to take the planning initiative for such facilities: local residents do not benefit from such facilities, but importers, exporters and logistics service providers that may largely be located outside the region do benefit.

Examples of PAs that have taken the planning initiative outside the port area:

- The PAs of Los Angeles and Long Beach have been involved from the start in the Alameda Corridor project, aiming to make substantial improvements in the rail connections from both ports.

- The Port of Barcelona has invested in rail tracks to improve the connection of the port to the European hinterland.

- The Port of Rotterdam Authority has taken the initiative to develop a *container transfer point* outside the port area, where trucks can deliver containers for the port. The containers are transported to the deep-sea terminals by barge, thus reducing highway traffic.

These examples suggest that PAs may need to monitor the structure of hinterland transport chains and look beyond their boundaries for investments to relieve bottlenecks and improve the efficiency of existing hinterland transport infrastructure.

5.2 Infrastructure access rules

PAs are in most cases involved in and responsible for the development of infrastructure in the port. PAs may also have to contribute to the efficient *utilisation* of hinterland infrastructure. The use of infrastructure is often inefficient, because users co-ordinate their activities insufficiently, if at all.[8] Setting rules for infrastructure access may improve efficiency and thereby enhance port competitiveness.

Table 2 gives examples of cases where insufficient co-ordination leads to suboptimal infrastructure use, along with tentative infrastructure access rules that could enhance efficiency.[9] Such rules involve either allowing trucks, trains and barges to use the infrastructure only if they meet certain criteria,[10] or devising tariff structures that provide discounts when the criteria are met and penalties when they are not.

These examples show that infrastructure access rules may have benefits with regard to sustainability, efficiency of infrastructure use and co-ordination of transport chains. While most PAs set access rules for seagoing vessels (for example, regarding safety or waste disposal), they do not do so for trucks, trains or barges. Given the central role of the PA in the port (regarding, for example, contracts with terminal operators, investments in a port community system, communication with all relevant stakeholders), partnerships between the PA and the owners of the infrastructure to design and implement infrastructure access rules may be appropriate. Examples of PAs that have developed access rules include Los Angeles, Long Beach and Rotterdam, which allow only environment-friendly trucks in the port area.

Table 2: **Cases of insufficient co-ordination reducing utilisation of infrastructure**

Co-ordination problem	Potential solution through infrastructure access rules
Too many calls of barges with small call sizes per terminal	Only allow barges in the port if they call at a limited number of terminals
Peak load on rail terminals in ports	Only allow trains on rail tracks when the rail terminal operator confirms the capacity is available to handle these trains in their allocated slots (real time)
Unused rail tracks because of insufficient planning	Penalise train operators (substantially) for not using a track
Peak loads in the arrival and departure of trucks at deep-sea terminal	Only allow trucks onto port access routes if they have reserved a slot at the terminal
Peak loads in road transport causing road congestion in port region	Only allow (empty) trucks onto port access roads outside rush hours
Insufficient exchange of (container) data causes inadequate planning	Only allow trucks, trains, barges and ships into the port area if they have provided all the necessary information

Source: Based on Van der Horst and De Langen (2008).

5.3. A port community system

An effective port community system can contribute to co-ordination in the transport chain. In ports, data exchange between a variety of firms is required (Fabbe-Costes *et al.*, 2006). For instance, terminal operators can plan better when shipping lines provide container data. Similar benefits can be gained by forwarding companies and hinterland transport companies. In most cases, the same data is useful for a variety of firms as well as government functions such as customs. A port community system can provide systems for data exchange. Since the data of customs clearance are an integral part of a logistics EDI system, the inclusion of customs in the system design is essential (Lee *et al.*, 2000).

The benefits of data exchange are especially relevant in hinterland transport chains. Whereas maritime transport and the port sector are concentrated and the average firm size is large, many small firms such as forwarders and trucking companies are involved in hinterland transport. These firms do not often have the resources or incentives to invest in dedicated data-exchange systems. Consequently, trucks often arrive at terminals without prior notification or they may arrive with the wrong information, and so forth. Similarly, hinterland transport companies may arrive to collect containers that have not yet been cleared by customs. Many ports have a port community system in one form or another. Examples include Rotterdam, Antwerp, Hamburg, Barcelona and Singapore. In all these cases, the companies in the port as well as the PAs are involved.

5.4. Conditions in concession contracts

The World Bank infrastructure database (2008) shows widespread use of concessions in port development. Most concessions are granted for specific terminals. Public PAs (or occasionally other public agencies) invest in general port infrastructure and select terminal operating companies for a concession to operate a terminal and pay a concession fee to the PA.[11] Notteboom (2007) rightly argues that granting concessions and setting the conditions in the concession are key instruments that PAs can use to influence port development.

Such concessions can contain conditions aimed at improving the hinterland transport system. For instance, PAs may set a minimum share of barge and rail in the concessions, or define service levels for the services to hinterland modes, such as on-the-dock loading of trains and barges. PAs may also consider requiring concession holders to use the port community system. Thus, conditions in concessions for terminal operators may be instruments to improve hinterland sustainability, transport chain co-ordination and infrastructure use. Barcelona and Rotterdam are two examples of PAs that stipulate conditions regarding hinterland services in their concessions.

5.5. Assuring competition in transport chains

Finally, the door-to-door transport chain is only competitive if there is sufficient competition in all of its parts. For instance, if a train operator does not face any competition, the overall transport chain will be less competitive; firms without competitors may increase prices and/or reduce service. Competition in the port can also be expected to lead to more specialisation and innovation, with benefits for the port as a whole (De Langen and Pallis, 2006).

The issue of entry barriers is relevant in this respect. In most seaports they are substantial and include economic, regulatory and geographic barriers (De Langen and Pallis, 2007). In some cases, port reform has introduced a limited number of private port operators but has not lowered entry or exit barriers for additional firms. Thus, while the scope for private involvement in the provision of port services has increased substantially, the issue of entry barriers is still pertinent.

Lowering entry barriers is desirable because it enhances the contestability of markets, increases the level of intra-port competition and facilitates faster implementation of new technology and business models (Geroski *et al.*, 1990). Thus, to encourage competition in the port, a policy to reduce entry barriers may be required. This issue is relevant for hinterland access, especially with regard to rail transport, since in many seaports the number of competing rail operators is limited. The same may apply to rail and barge terminals in the port.

6. CONCLUSIONS

This paper explores the role of port authorities in hinterland access. Landlord PAs have become more autonomous and taken the initiative in expansion and redevelopment of port infrastructure. PAs have traditionally acted as landlords, but now increasingly operate beyond the landlord model. The main argument for more active involvement by PAs is the fact that co-ordination in clusters and in the transport chain does not always arise spontaneously, for various reasons. More co-ordination can lead to more efficient supply chains and more competitive clusters. Consequently, PAs have incentives to invest in ways to improve co-ordination in port clusters and supply chains. Such active involvement could be particularly beneficial in hinterland transport, the main bottleneck in door-to-door chains. PAs may contribute to efficient hinterland access by investing in infrastructure and terminals not only inside the port area, but perhaps also outside it. PAs may also improve hinterland access by setting infrastructure access rules, investing in a port community system, setting conditions in terminal concessions and assuring sufficient competition in all parts of the supply chain. Such involvement may not be appropriate for all PAs; however, over the last few years, the PAs of some leading ports, including Los Angeles, Long Beach, Barcelona and Rotterdam, have expanded their involvement in hinterland access.

NOTES

1. This paper reflects the personal positions of the author and does not represent the views of the Port of Rotterdam Authority or Erasmus University Rotterdam. It draws on previous papers with various co-authors. Correspondence to: Erasmus University Rotterdam, Department of Port, Transport and Regional Economics, PO Box 1738, 3000 DR Rotterdam, The Netherlands. E-mail: delangen@few.eur.nl

2. An advantage of a system where public, autonomous PAs have the planning initiative is that they can be given instruments to enable effective port planning that cannot be given to private firms. In the case where private initiative leads, regulations are required to ensure that public interests are served. In the UK, such regulations make port development difficult (Gilman, 1999). Private planning initiatives are effective only when there is a level playing field.

3. A PA may not engage in all these activities, but taken together they provide a good overall picture of PA involvement.

4. A previous study (De Langen and Chouly, 2006) used the concept of a *hinterland access regime* to analyse co-operation to improve hinterland access. In such a regime, the co-operation between all relevant organizations in the port cluster stands to the fore. In this paper, we focus on the role of the PA.

5. For instance, the availability and quality of labour are relatively high in clusters, because workers migrate to a cluster to reduce search costs and the risks of unemployment. Furthermore, the high demand for skilled labour provides a basis for a relatively advanced education infrastructure.

6. Because firms in clusters benefit from collective investments and cannot readily be excluded from such benefits, these investments can be considered as *collective goods* (Antonelli, 2000).

7. A contestable hinterland consists of a region where there is no single port with a clear cost advantage. Consequently, several ports have a share of the market.

8. This can be explained by unequal distribution of costs and benefits, lack of resources or unwillingness to invest by at least one relevant firm, strategic considerations of infrastructure users, a lack of supply-chain power (see, for example, Groothedde, 2005) and risk-averse behaviour and a short-term focus by firms in hinterland chains (see Van der Horst and De Langen, 2008, for a more detailed analysis).

9. These co-ordination problems do not occur in all ports. In the US, for instance, the large rail operators own most of the rail tracks and the issue of access to them may not arise.

10. Obviously, governments have general infrastructure access rules, such as a driving licence and a safe vehicle. The argument here is for additional rules aimed at improving efficiency of infrastructure use and sustainability, and at providing more co-ordination in hinterland chains.

11. The responsibility for investment varies: in some cases, the public PA invests in quays and the terminal area, while in others this is the private terminal operator's role.

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THE IMPACT OF HINTERLAND ACCESS:

CONDITIONS OF RIVALRY BETWEEN PORTS

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SUMMARY

Revised, Vancouver, March 2008

ABSTRACT

This paper examines the interaction between hinterland access conditions and port competition. Competition between ports is treated as competition between alternate intermodal transportation chains, while the hinterland access conditions are represented by both the corridor facilities and the inland roads. We find that when ports compete in quantities, an increase in corridor capacity by a region will increase its port's output, reduce the rival port's output, and increase its port's profit. On the other hand, an increase in inland road capacity by a region may or may not increase its port's output and profit, owing to various opposing effects. Essentially, while more road capacity reduces local congestion delays and moderates the negative impact of the port's output expansion, it induces greater local commuter traffic and may moderate the effect by which a rise in cargo traffic reduces local commuter traffic, both of which reduces the port's output and profit. Similarly, inland road pricing by a region may or may not increase its port's output and profit. Finally, case examples for selected ports and regions are discussed.

Keywords: Seaports; Corridor; Hinterland; Intermodal transport chain; Competition; Capacity investment; Road pricing

Acknowledgement: I would like to thank Sarah Wan for very helpful discussions on some of the data used in this paper, and Robin Lindsey for helpful comments.

1. INTRODUCTION

Port competition has been driven by two separate but related developments in the shipping industry. First, *containerization* has helped lower transport costs, shorten transport times and improve schedule reliability and security, and hence has made large-scale global sourcing and production possible, stimulating the demand for sea shipping (e.g. Notteboom, 2006; Levinson, 2006). Furthermore, as described by, among others, Luo and Grigalunas (2003) and Cullinane and Song (2006), containerization has dramatically increased competition among ports. The intermodal movement of freight by containers through ports has reduced port-handling costs and increased the reach of markets served from a given port. Whereas a port used to be able to count on an exclusive "hinterland" for freight movements, these hinterlands may now be reached by freight movements through competing ports. As a result, ports have lost their monopolies over their hinterlands, with port hinterlands increasingly overlapping with one another. As argued by van Klink and van den Berg (1998), gateway ports are in a unique position to, on the one hand, stimulate intermodal transport and, on the other hand, use the intermodal systems to enlarge their hinterlands. In the commercially famous Le Havre-Hamburg range, for instance, major ports vigorously vie with one another for interior hinterland shipments that have alternative routing possibilities. The second development has been the *devolution of public responsibility in ports* through privatization and commercialization of activities (e.g. Cullinane and Song, 2002; Brooks, 2004). Fleming and Baird (1999) argue that private ports lead more naturally to port competition than public ports.

While both containerization and port commercialization intensify port competition, the dramatically increased cargo movements are certainly stressing ports and their hinterlands' transportation systems. It has been widely recognized that congestion is acute at many ports around the world, and tremendous efforts have been extended to the resolution of the problem at both the policy and research levels (see, e.g., Heaver, 2006; De Borger *et al.*, 2008; Yuen *et al.*, 2008). In comparison, relatively little attention – especially in academic research – has been paid to the hinterland access conditions and their impact on the port and port competition. In a port "transport supply chain", users incur delay costs not only at ports, but also at other parts of the chain, and hence overall congestion is dictated by the weakest link (or node). A survey conducted by Maloni and Jackson (2005) suggests that US port managers' greatest concern in port capacity expansion planning is the capacity constraint imposed by local roads. Heaver (2006) further describes how the shipping developments, including containerization, change the bottleneck of this intermodal system, which has over time shifted from stevedoring on the ship to the ship/port interface (e.g. terminal/berth investment, crane and yard productivity) and, more recently, to the port/inland interface (e.g. hinterland connection, inland transportation)[1].

In this paper, we investigate the impact of hinterland access conditions on the port and port competition. There have been many empirical studies on the productivity and efficiency of port operations (see, e.g., Turner *et al.*, 2004, and Cullinane and Song, 2006, for references). For example, Turner *et al.* (2004) collected fourteen years of data on twenty-six container ports in North America, used data envelopment analysis to compute the relative productivity measures of the ports, and then regressed the productivities on a number of explanatory factors in an attempt to determine which factors differentiated the more productive container ports from the less productive ports. They find that higher measures of port productivity were associated with greater numbers of Class 1 railroads serving the port, and conclude: "*This is clear support for the importance of rail service quality, perhaps including frequency of service, and rail service competition, to the success of container ports*[2]." Several authors further argue that hinterland access is one of the important factors that influence the competitiveness of a seaport when it competes with other seaports (Notteboom, 1997; Kreukels and Wever, 1998; Fleming and Baird, 1999). Distinct from these studies, this paper attempts to identify the channels through which hinterland access conditions may affect a port's competitiveness in an environment of competing ports. This is done largely through analysis of a theoretical model.

Our second objective in this paper is to link urban mobility with port competition. Congestion at large urban areas has become a major policy issue, and freight movements are a major contributor to urban congestion (they also create other social costs such as pollution, safety hazards and road damage). According to US GAO (2003), from 1993 through 2001, truck traffic on urban highways in the United States increased more than twice as much as passenger traffic. Given existing urban highway congestion, this implies that freight traffic was contributing to worsening congestion at a faster rate than passenger traffic. Berechman (2007) further finds that the additional highway traffic due to a (modest) 6.4% container throughput increase at the Port of New York would induce annual "social costs" that range from USD 0.66 billion to USD 1.62 billion – over 60% of which is from congestion costs (the time loss due to traffic conditions and drivers' discomfort, both of which are a function of increasing road volume-to-capacity ratios). On the other hand, congested roads could also hinder the port development. For instance, as to be shown later, the growth at the Ports of Los Angeles and Long Beach has been hindered by road congestion in the greater Los Angeles area. To tackle the urban mobility problem, options such as the investment in road capacity and road pricing have been actively discussed (debated) at both the policy and research levels[3]. Will these options adopted in the hinterland improve the port's traffic; and how do they interact with the port's competitiveness? These questions have not yet been addressed in the literature, but will be investigated in the present paper.

More specifically, we develop an analytical model in which we treat competition between ports as competition between alternate intermodal transportation chains: To the extent that a port can be a part of the cheapest, most reliable intermodal transportation chain, it will then out-compete other ports for a customer's business. In addition to the port, the hinterland access conditions form the other components of the chain. Here, the hinterland access conditions are represented separately by corridor facilities that are specific for seaport cargo – e.g. the designated rail lines connecting to ports such as the Alameda Corridor – and by inland roads that are used by both the freight trucks and local commuter cars. Basically, a capacity or pricing policy may change the congestion levels at corridor and inland road facilities, which in turn may affect ports' output/price decisions and profits. We shall also discuss, in both the theoretical analysis and case studies, how the presence of hinterland facility congestion and of port competition affects regions' strategic policies concerning hinterland transport facilities.

We find that when ports compete in quantities, an increase in corridor capacity by a region will increase its own port's output, reduce the rival port's output, and increase its own port's profit. Our analysis suggests that the rivalry between ports may, owing to the strategic effect, result in a higher level of corridor capacity investment than would be the case in the absence of rivalry, such as in an isolated, single port case. This over-investment result might be weakened if the ports compete in prices. Regarding inland road capacity, we find that under quantity competition, an increase in road capacity by a region may or may not increase its port's output and profit, owing to various opposing effects. Essentially, while more road capacity reduces local congestion delays and moderates the negative impact of the port's output expansion, it induces greater local commuter traffic and may moderate the effect by which a rise in cargo traffic reduces local commuter traffic, both of which reduces the port's output and profit. We further investigate the impact of inland road pricing by a region on port competition and find that it may or may not increase its port's output and profit. Finally, case examples for selected ports and regions are discussed to supplement the analytical study.

This paper is related to several studies in the literature. By taking into account the hinterland transportation network and assuming shippers minimize the total cost of moving containers from sources to markets, Luo and Grigalunas (2003) empirically estimate demand for major container ports. The intermodal transportation network in their model contains rail, highway and international shipping line sub-networks. They point out that because of the increasing importance of intermodal transportation, the traditional method for port demand estimation using hinterland delimitation is no longer valid for container port demand estimation. Ports will serve not only markets in their vicinity, but also compete for markets in areas far from the port, through the use of high-speed, low-cost rail connections. Their numerical results reveal that vast geographic market areas are serviced by major ports on both coasts, and hence demonstrate the potential for national competition between ports. Parola and Sciomachen (2005) present a discrete event simulation modelling approach, related to the logistics chain as a whole in the north-western Italian port system. They analyse the potentiality of the system by giving particular attention to land transport and the modal split re-equilibrium with the aim of evaluating the possible future growth of container flows[4]. Lirn *et al.* (2004) use, in part, a survey to explore the importance of various service attributes for transshipment port selection by global carriers. Lindsey (2007b) discusses various policy considerations concerning transportation infrastructure investments, pricing and gateway competition.

Our analytical model is perhaps most closely related to De Borger *et al.* (2008), who study a two-stage game where each government first decides on the capacities of the port and the hinterland network – both of which are congestible – so as to maximize its regional welfare, and then the private ports engage in a duopolistic pricing sub-game. In comparison, the present paper considers non-congestible ports, which allows us to abstract away the issue of port investment while focusing on the impact of hinterland access conditions on port competition. An innovation of the paper is to represent the hinterland access conditions by both the corridor facilities and the inland roads. The separation of inland roads from corridors allows us not only to be more realistic and to delineate the impacts of different hinterland access conditions, but also to investigate the interaction between urban road congestion, port-related freight traffic and the ports' pricing and output behaviour. The latter investigation is important because a growing large number of urban areas in the world are suffering road congestion, and solutions such as capacity investment and road pricing have been actively debated. Moreover, unlike De Borger *et al.*, we consider both the quantity competition and price competition, and compare the results from the two modes of port competition[5].

The paper is organised as follows. Section 2 provides background information for our analytical modelling. Section 3 develops the analytical model to examine the interaction between urban road congestion and port development, as well as to illustrate how hinterland access conditions impact on rivalry between ports. Section 4 discusses three case examples, namely: the Le Havre-Hamburg port range; gateway ports in Canada; and the Port of Shanghai, and describes the recent policy initiatives in these regions regarding hinterland/corridor infrastructure expansion and pricing. Finally, Section 5 contains a brief summary and discusses future research.

2. BACKGROUND

Cullinane and Talley (2006) define a port as "*a place that provides for the vessel transfer of cargo and passengers to and from waterways and shores.*" They note that a port is a "node" in a transportation system, connected to other ports and inland destinations by spokes or transportation routes or corridors. As indicated in the introduction, containerization has greatly facilitated just-in-time production and door-to-door transport services; as a consequence, a port becomes a part of the "network". On the part of inland connections, a seaport and its hinterland forms an intermodal transportation system in which the port serves both its local and interior (hinterland) regions. Consider the cargo flow to the hinterland (the reverse flow can be similarly analysed). Goods from the rest of the world (imports) are first shipped to a seaport, and then are transported to the hinterland region by trucking, rail, inland waterway or a combination of these modes. The modal split differs greatly between seaports depending on the geographical situation and existing infrastructure. For example, international cargos shipped to the Port of Rotterdam were distributed in 2005 to the hinterland by truck (60% of total freight), waterway (30.5%) or rail (9.5%). Similarly, other major gateways[6] – such as Antwerp, Hamburg, Los Angeles, Long Beach, Vancouver, Busan, Shanghai, Hong Kong and Singapore – serve their respective hinterlands by intermodal transportation systems.

An obvious consequence of this intermodal system is the network nature of multi-stage activities and the application of a total distribution cost approach. These imply that all members of the transport supply chain, including the port, would contribute to the "cost" of cargo shipments. This cost includes transit time and its reliability. Hummels (2001) finds that controlling for distance, each additional day spent in transport from/to a country reduces the probability that the US will source from that country by 1.0%-1.5%, while time cost in travel is on average equivalent to a 16% *ad-valorem* tariff[7]. In addition, firms (shippers or consignees) are required to increase their inventories so as to prevent the shortage of inputs in production and goods to sell if delivery times are uncertain due to congestion delays[8].

Both the gateway port and its hinterland's transport system are prone to congestion. Whilst congestion at major ports has been widely recognised, congestion at connected facilities in the hinterland, such as road, highway, rail and waterway, is less discussed. As seen earlier, the latter problem not only exists but also is getting serious. Here are two further road examples. First, road congestion in Vancouver is a major concern with rising container trucking as a significant contributor (Lindsey, 2007a, 2008). Truck traffic in the greater Vancouver area is anticipated to increase by 50% between now and 2021, generated primarily by port related activities (www.th.gov.bc.ca/gateway). Second, 80% of containers generated in the direct hinterland of Shanghai (Shanghai and neighbouring cities in Jiangsu and Zhejiang provinces) are transported by land to the Port of Shanghai, which has a seriously strained road system around Shanghai (Y. Zhang, 2007).

Indeed, hinterland accessibility plays an important role in port growth and competitiveness. We use the Ports of Los Angeles (LA) and Long Beach (LB) to illustrate this point. Table 1 (first row) reports the correlations between the annual percentage change of the combined LA/LB container throughput and the annual percentage change in various urban mobility indicators. The Texas Transportation Institute's annual Urban Mobility Reports reveal how congestion delays are changing in US urban areas. To measure travel delays, they adopt free-flow conditions at the speed limit as a baseline, below which congestion is considered "unacceptable". Since these urban mobility data take Los Angeles and Long Beach (along with Santa Ana) as a single region, the container throughputs of LA and LB, taken from their respective websites for 1995-2006, are added together.

Table 1. **Correlation of annual container throughput growth (market share, respectively) and changes in urban area mobility – Los Angeles/Long Beach, 1995-2006**

	Total delay (person-hrs)	**Delay per peak traveller (person-hrs)**	**Travel time index**	**Total congestion cost (USD)**	**Congestion cost per peak traveller (USD)**
LA+LB container throughput growth	-0.683* (0.029)	-0.649* (0.024)	-0.716* (0.020)	-0.684* (0.029)	-0.642* (0.045)
LA+LB container market share	-0.414 (0.235)	-0.353 (0.318)	-0.301 (0.398)	-0.405 (0.246)	-0.367 (0.297)

* = Significant at the 0.05 level (2-tailed); p-values in parentheses.

Table 1 shows that the growth of container throughput at these two ports is negatively and highly statistically significant, correlated with all the road congestion/delay measurements – namely, total delay, delay per peak traveller, travel time index, total congestion cost, and congestion cost per peak traveller – for the Los Angeles/Long Beach/Santa Ana area. This suggests that the growth at LA and LB might be hindered by urban road congestion; or alternatively, any improvements in urban area mobility might also significantly raise container throughput going through the two ports[9].

To see how hinterland accessibility affects port competitiveness, we further examine the correlations between the annual percentage change in *market share* of LA/LB and the annual percentage change in urban mobility indicators. For this purpose, the most relevant market may be the

US west-coast port range, which consists of six major seaports: namely, Seattle, Tacoma, Portland, Oakland, Los Angeles and Long Beach[10]. LA and LB are clearly the No. 1 and No. 2 container ports in the range, owing in large part to their having more corridor linkages to US inland markets than other west-coast ports (Rodrigue, 2007). These six ports accept about 85% of the US-bound containers from Asia[11].

As can be seen from Table 1 (second row), the changes in urban road congestion are found, like the effect on throughput growth, to be negatively correlated with the changes in LA/LB's market share. That is, when the congestion level rises, the combined market share of LA/LB in the west-coast port range falls; similarly, when the congestion level falls, their market share rises[12]. For instance, in 2004-2005, the two ports had to divert a large number of ships to other ports because of truck and rail congestion (*Journal of Commerce*, August 8, 2005). These observations suggest that urban area mobility conditions can affect the competitiveness of a port *vis-à-vis* other ports. If a port has good transportation connections and minimum inland congestion, freight may be moved through this port to destinations previously served exclusively through the less efficient ports.

It is noted that, while the Los Angeles/Long Beach/Santa Ana area has been among the most congested urban areas in the US, the combined market share of LA/LB in the west-coast port range has been maintained at around 70% over the years, amid the continuing growth of container traffic from Asia, especially China as it emerges as a world manufacturing power house. This stability is due in part to the ability of the region and ports to control any further increase in congestion. For instance, a "traffic mitigation fee" – USD 50 per twenty-foot equivalent unit (TEU) or USD 100 for all containers larger than a TEU – is imposed on containers exiting port terminals by truck during peak hours (defined as 3 a.m. to 6 p.m., Monday to Friday) by PierPASS, a programme (a non-profit corporation) developed by the Ports of Long Beach and Los Angeles to mitigate the problem of congestion on the highways serving the ports. With over one-third of truck traffic now being in the off-peak hours, the programme has contributed to a significant reduction in truck traffic on adjacent highways[13]. In addition, containers entering or exiting the ports can use the local highway system or the Alameda Corridor, a new rail link developed in recent years which eliminates all level crossings between the ports and the major rail terminals in central Los Angeles. The fee for the use of the Alameda Corridor is USD 18 per TEU. Thus, while congestion in the region remains at a high level, it may not be getting worse relative to that of competing ports[14].

3. AN ANALYTICAL MODEL

The above discussion suggests that urban road congestion might inhibit the port development but that at the same time, port-related freight might also contribute to urban road congestion. In this section, we develop an analytical model to examine this interaction, as well as to investigate how hinterland access conditions influence port competition. A central point is that competition between ports has changed from competition between individual ports in terms of port charges and services to competition between alternate intermodal systems, among which ports form an important component. Shipping lines, forwarders and shippers would seek the best system: To the extent that a port can be a part of the cheapest, most reliable intermodal transportation chain, it will then out-compete other ports for a customer's business. This point has been made by Notteboom (2007), who states, "*Port choice has become more a function of network costs, and port selection criteria are related to the entire* *network, in which the port is just one node*." Further, the issue of improving the intermodal connections in a transportation chain has also been recognised in the policy arena, including, in the context of port-inland transportation, the adequacy of landside connections to ports (e.g. Australian Government, 2005). This section will further illustrate how such competition impacts rival ports' outputs, prices and profits.

3.1. Basic framework

We consider the simplest model structure in which our question – what would be the effects of hinterland access conditions on the rivalry between ports? – can be addressed. There are two seaports, labelled 1 and 2, that share the same overseas customers and have each a downstream, congestible transport network to a common hinterland. This set-up follows the one in De Borger *et al.* (2008). Located in two separate regions, the two ports are competing with each other in the sense that their services are substitutes to users. They may be in the same port range – e.g. the ranges of north-west Europe or of the North American west coast – and so regions 1 and 2 could be two countries (e.g. Antwerp and Rotterdam, or Vancouver and Seattle) or two regions within the same country (e.g. Rotterdam and Amsterdam, or Bremen and Hamburg). Users of the ports and related transport networks include shipping lines, shippers, consignees, transport companies (e.g. railroads, trucking companies), third party logistics operators, freight forwarders, or some combination of these groups. For simplicity, we shall just use "shipping lines" to represent the users.

Each port charges shipping lines p_i per cargo unit (e.g. TEU) for port use, and faces demand $X_i(\rho_1, \rho_2)$, where ρ_i represents the generalised (total) user cost if shipping lines use port i for cargo shipment, $i = 1,2$. This "full price" faced by shipping lines is given by:

$$\rho_i = p_i + D_{Ci}(K_{Ci}) + D_{Li}(V_i, K_{Li}) + t_i, \qquad i = 1,2 \qquad (1)$$

where D_{Ci} and D_{Li} denote the delay costs occurred at the corridor and local road delivery respectively, and t_i the road toll.

Four important features about the above specification are worth noting. First, unlike the set-up in De Borger *et al.* (2008), we consider non-congestible ports. This simplification allows us to abstract away the issue of port investment while focusing on the impact of *hinterland access conditions* on port competition. Second, port charge p_i is an important element of the full price. For instance, in analysing waterborne containerised imports from Asia to the North American west-coast ports, Leachman (2008) finds that imposition of container fees without compensating improvements in container transit times would result in significant traffic diversion: Even a modest USD 30 per TEU fee assessed on imports at the San Pedro Bay Ports would result in approximately a 6% loss in both total and trans-loaded import traffic[15].

Third, in formulation (1), the hinterland access conditions are represented by: (a) transport facilities that are specific for the seaport cargo; and (b) those facilities that are subject to joint use with traffic other than the seaport cargo. Parts of (a) and (b), then, are further operationalised, in theoretical modelling, with the corridor and road conditions, respectively. In practice, cargo passing through a port may be shipped out by rail, inland waterway, road, or a combination of these modes. The modal split differs greatly between seaports, depending on the geographical situation and existing infrastructure. For example, in 2006 about 60% of Rotterdam's containers were shipped out by truck, while this percentage was 75% for the Port of New York/New Jersey. In general, rail and inland waterway are used for long-haul freight transport (e.g. greater than 500 km in the North American context) whereas trucks are used for the final delivery. Thus if a shipment is for a local port market, it would use road transport. On the other hand, if the shipment is for the hinterland, it would use a combination of modes: first with rail or inland waterway for the corridor leg and then by trucks for the final delivery. In either case, shipping lines may, in their inland transportation, encounter potential congestion, and hence delays, at both the corridors (rail, inland waterway) and local roads. Corridors may also be considered as inland terminals serviced by designated trains – the Alameda Corridor in Los Angeles mentioned above and the new rail corridor in the Netherlands are such examples.

Furthermore, compared to major rail/inland waterway corridors, the road would have much more local traffic – i.e. traffic other than the seaport cargo – such as local commuters. To capture these distinct features, we have in (1) considered that the corridor congestion is affected only by corridor capacity, denoted K_{Ci}, whilst the road congestion is affected by both road capacity, denoted K_{Li}, and total road traffic volume V_i. In the context of the Alameda Corridor mentioned in Section 2, therefore, investment in this new rail link represents an increase in corridor capacity K_{Ci}. While the Alameda Corridor diverts many containers to designated rail, there remain a significant number that leave the Ports of Los Angeles and Long Beach by truck, especially with freight destined for the local market. Such traffic (as well as the traffic of final delivery in the hinterland) may encounter road delays which will, as specified in (1), depend on both road capacity K_{Li} and total road traffic V_i.

Fourth, we further specify that the corridor delay cost falls as the corridor capacity (K_{Ci}) increases, i.e. $D_{Ci}^{'}(\cdot) < 0$. Since the road is used by both cargo shipments X_i and local commuters, we have $V_i = X_i + Y_i$, with Y_i denoting local traffic volume. The road delay cost satisfies:

$$\frac{\partial D_{Li}}{\partial V_i} > 0, \quad \frac{\partial D_{Li}}{\partial K_{Li}} < 0, \quad \frac{\partial^2 D_{Li}}{\partial V_i^2} \geq 0, \quad \frac{\partial^2 D_{Li}}{\partial V_i \partial K_{Li}} \leq 0. \tag{2}$$

Thus, increasing traffic volume (V_i) will increase road congestion, while adding capacity (K_{Li}) will reduce road congestion, and the effects are more pronounced when there is more congestion. Assumption (2) is quite general and holds for the two widely used delay functions:

(a) a "linear" delay function, in that D_{Li} is a linear function of the volume-capacity ratio (e.g. De Borger and Van Dender, 2006; De Borger *et al.*, 2005, 2007, 2008); and

(b) $D(V, K) = aV/(K(K-V))$, with a being a positive parameter, which is estimated from steady-state queuing theory (see, e.g., Lave and DeSalvo, 1968)[16].

We now turn our attention to local road traffic, Y_i: it depends on a "full price" ρ_{Li}, with the inverse demand function being $\rho_{Li}(Y_i)$. Here, the full price is the sum of the road toll and congestion cost:

$$\rho_{Li}(Y_i) = t_i + D_{Li}(X_i + Y_i, K_{Li}), \qquad i = 1,2 \tag{3}$$

Note that in the above full-price formulations (1) and (3), it has been implicitly assumed that a uniform toll is imposed on trucks and local vehicles. Further, equation (3) implicitly determines Y_i as a function of (t_i, X_i, K_{Li}): $Y_i = Y_i^*(t_i, X_i, K_{Li})$. It is straightforward, using (2) and $\rho^{'}(\cdot) < 0$ (downward-sloping demand), to show:

$$\frac{\partial Y_i^*}{\partial t_i} = \frac{1}{\rho_{Li}^{'} - (\partial D_{Li} / \partial V_i)} < 0, \qquad \frac{\partial Y_i^*}{\partial X_i} = \frac{\partial D_{Li} / \partial V_i}{\rho_{Li}^{'} - (\partial D_{Li} / \partial V_i)} < 0$$

$$\frac{\partial V_i}{\partial X_i} = 1 + \frac{\partial Y_i^*}{\partial X_i} = \frac{\rho_{Li}^{'}}{\rho_{Li}^{'} - (\partial D_{Li} / \partial V_i)} > 0, \qquad \frac{\partial Y_i^*}{\partial K_{Li}} = \frac{\partial D_{Li} / \partial K_{Li}}{\rho_{Li}^{'} - (\partial D_{Li} / \partial V_i)} > 0 \tag{4}$$

for i = 1,2. Inequalities (4) show that:

(a) an increase in road toll will reduce the local traffic;
(b) an increase in cargo traffic will decrease the local traffic;
(c) an increase in road capacity will increase the local traffic; and
(d) an increase in cargo traffic will, while reducing the local traffic, increase overall road traffic.

While effects (a)-(c) are as expected, effect (d) is somewhat less obvious.

As indicated above, each port's demand depends on both its full price ρ_i and the rival port's full price ρ_j:

$$X_1 = X_1(\rho_1, \rho_2), \qquad X_2 = X_2(\rho_1, \rho_2). \tag{5}$$

Solving the two equations in (5) for ρ_1 and ρ_2 yields:

$$\rho_1 = \rho_1(X_1, X_2), \qquad \rho_2 = \rho_2(X_1, X_2). \tag{6}$$

Using (1) and $Y_i = Y_i^*(t_i, X_i, K_{Li})$, equations (6) can be written as, for $i = 1,2$:

$$p_i = \rho_i(X_1, X_2) - D_{Ci}(K_{Ci}) - D_{Li}(V_i, K_{Li}) - t_i \equiv p_i(X_1, X_2; K_{Ci}, K_{Li}, t_i). \tag{7}$$

Consequently, each port's profit may be expressed as:

$$\pi^i = p_i(X_1, X_2; K_{Ci}, K_{Li}, t_i) \cdot X_i = \pi^i(X_1, X_2; K_{Ci}, K_{Li}, t_i), \ i = 1,2 \tag{8}$$

where the port operating costs are, for simplicity, assumed to be zero[17]. This assumption allows us to focus on potential channels linking hinterland accessibility with port competition through the demand side rather than the cost side. In effect, there has been an extensive empirical literature on the cost efficiency of port operations, some of which associated inland transport connections with the port operating costs. The reduction in per-unit port operating costs, owing to an improvement in hinterland access conditions, then enhances the port's competitiveness *vis-à-vis* its rival. As seen below, however, some of the mechanisms operating through the costs also appear through the demand-side interactions. Thus the zero-cost assumption is for simplicity of modelling and will not really affect the basic insights of our analysis.

We consider situations where the ports make their strategic decisions taking both the corridor capacity (K_{Ci}) and the road capacity and toll (K_{Li}, t_i) as given. Infrastructure investments in corridors and roads are long-lasting and typically irreversible. Similarly, whether to impose road pricing, and if so, by which scheme, takes a long time to decide for political and implementation reasons, and once determined, it is hard to reverse. That is, investments in inland capacity and road pricing are usually longer-term decisions as compared to the ports' decisions on their charges or quantities. In other words, the ports compete with each other in price or quantity, taking K_{Ci}, K_{Li} and t_i as given.

Furthermore, as reflected in the above full-price approach, the two ports compete as parts of intermodal transport chains. The success of each chain is recognized to be dependent on each of the parts working to provide an efficient, reliable system, which in turn depends on each region's policies on inland infrastructure pricing and investment and on the charge of its port[18]. In what follows, we shall consider that the port and its hinterland belong to a single region which ensures their co-ordination in their decisions. One motivation for this is that to maintain their competitiveness and provide better service to their consumers, various forms of collaboration have become more popular between ports and inland transportation. For example, many ports use rail connections as a strategic tool to penetrate new markets and retain dominance over existing hinterlands (Debrie, 2004). Major European port operators, such as Eurogate and Hamburger Hafen, have been participating in rail services, whereas major stevedores in Australia, namely, P&O Ports and Patrick Co., have been involved in significant restructuring to control landside chains (Debrie and Gouvernal, 2006). We shall discuss the issue of the port and hinterland being separate regions in Section 5.

3.2. Quantity competition

Consider first that the two ports compete with each other by choosing quantities to maximize profits. In this case, the Cournot-Nash equilibrium is characterized by the first-order conditions:

$$\pi_1^1(X_1, X_2; K_{C1}, K_{L1}, t_1) = 0, \qquad \pi_2^2(X_1, X_2; K_{C2}, K_{L2}, t_2) = 0 \tag{9}$$

where the subscripts denote partial derivatives ($\pi_1^1 \equiv \partial\pi^1/\partial X_1$, etc.). Following standard practice in models of quantity competition, we assume the quantities are "strategic substitutes" (e.g. Bulow *et al.*, 1985; Tirole, 1988). In addition, regularity conditions are imposed so that the equilibrium exists, is unique and stable; consequently, the comparative-static exercises conducted below are meaningful.

We begin with the first comparative-static result concerning the effects of corridor capacity K_{Ci} (all the proofs are omitted to save space, but are available upon request from the author).

Proposition 1: *Under quantity competition, an increase in corridor capacity by a region will: (a) increase its own port's output; (b) reduce the rival port's output; and (c) increase its own port's profit.*

The rationale for Proposition 1 may be explained as follows. Note that the condition of quantities being "strategic substitutes" ensures a downward-sloping output "reaction function" for each port, which is defined by each equation in (9). An increase in the corridor capacity by (say) region 1 will increase its port's marginal profit ($\partial\pi_1^1/\partial K_{C1} = -D'_{C1} > 0$). With the rising marginal profit, port 1's reaction function shifts outward, i.e. it behaves more aggressively and produces more output for each output choice of its rival; whilst port 2's reaction function stays unchanged. This moves the equilibrium outputs (X_1^*, X_2^*) along port 2's reaction function, thereby increasing X_1^* and decreasing X_2^*.

Furthermore, the impact on port 1's (equilibrium) profit can be split into two parts:

$$\frac{\partial \pi^{1*}}{\partial K_{C1}} = \pi_2^1 \frac{\partial X_2^*}{\partial K_{C1}} + \frac{\partial \pi^1}{\partial K_{C1}} . \tag{10}$$

The second term on the right-hand side (RHS) of (11) represents a "direct effect" of the shift in port 1's profit function, whereas the first term is an "indirect effect" of the shift in its marginal profit, which in turn will change the equilibrium. Whilst the term $\partial \pi^1 / \partial K_{C1} = -X_1 D_{C1}^{'} > 0$ captures a direct advantage of corridor capacity investment by reducing corridor delay, the indirect effect is relevant only for ports that are competing. Since this effect works by indirectly influencing the behaviour of the rival port – port 2 becomes less aggressive by committing to a smaller quantity, which in turn improves port 1's profit as the outputs are substitutes – it is often referred to as the "strategic effect". Observe that this indirect, strategic effect augments the direct effect. Our analysis therefore suggests that the rivalry between multiple ports may, owing to the strategic effect, result in a higher level of corridor capacity investment than would be had in the absence of rivalry, such as in an isolated, single port case.

We now turn to examination of the comparative-static effects of road capacity and toll.

Proposition 2: *Under quantity competition, an increase in inland road capacity by a region may or may not increase its own port's output and profit, owing to various opposing effects. Similarly, inland road pricing may or may not increase its own port's output and profit.*

The intuition behind Proposition 2 is as follows. As indicated above, the output effect depends critically on the impact of an increase in capacity on own marginal profit. In the present road-capacity case and for port 1, this impact is, by (8) and (7):

$$\frac{\partial \pi_1^1}{\partial K_{L1}} = -\frac{\partial D_{L1}}{\partial K_{L1}} - \frac{\partial D_{L1}}{\partial V_1}\frac{\partial Y_1^*}{\partial K_{L1}} - X_1 \frac{\partial V_1}{\partial X_1}\frac{\partial^2 D_{L1}}{\partial V_1 \partial K_{L1}} - X_1 \frac{\partial D_{L1}}{\partial V_1}\frac{\partial^2 V_1}{\partial X_1 \partial K_{L1}} \tag{11}$$

The first term on the RHS of (11) is positive by (2) – more road capacity reduces local delays – but the second term is negative by (2) and (4), as more capacity induces greater local traffic. The third term is non-negative, given by (4) that $\partial V_1 / \partial X_1 > 0$ and $\partial^2 D_{L1} / \partial V_1 \partial K_{L1} \leq 0$, indicating that an increase in capacity would moderate the negative impact of own output expansion. The fourth (and final) term in (11) has the same sign as $\partial^2 V_1 / \partial X_1 \partial K_{L1}$, which can be either positive or negative for the general functional forms we are considering here, but is nevertheless strictly positive for linear local demand $\rho_{L1}(Y_1)$ and delay cost $D_{L1}(\cdot)$. In the linear case, essentially more capacity will moderate the reduction by local traffic in response to a rise in cargo traffic. Taken together, the above discussion shows that the sign of $\partial \pi_1^1 / \partial K_{L1}$ is generally undetermined. As a consequence, port 1's reaction function can shift outward or inward, leading, respectively, to an expansion or reduction of its (equilibrium) output.

A related consequence of the undetermined marginal-profit effect is that the output of port 2 may contract or expand following an increase in region 1's road capacity. Thus, the strategic effect of road capacity investment can be positive or negative on port 1's profit. As for the "direct" effect, it is given by:

$$\frac{\partial \pi_1}{\partial K_{L1}} = -X_1 \frac{\partial D_{L1}}{\partial K_{L1}} - X_1 \frac{\partial D_{L1}}{\partial V_1}\frac{\partial Y_1^*}{\partial K_{L1}} \tag{12}$$

As discussed in connection with (11), the first-term on the RHS of (12) is positive but the second term is negative. In other words, the benefit from more road capacity and hence less congestion is diluted by induced local traffic. As a result, the direct effect on the port's profit can, similarly to the strategic effect, be positive or negative.

Finally, the impact of road tolls on output and profit can be similarly discussed. For instance, the direct effect of tolls on port 1's profit is given by:

$$\frac{\partial \pi_1}{\partial t_1} = -X_1 - X_1 \frac{\partial D_{L1}}{\partial V_1} \frac{\partial Y_1^*}{\partial t_1}. \qquad (13)$$

The first term on the RHS of (13) shows the obvious negative effect of tolls on the generalised cost of shipments going through port 1. On the other hand, an increase in road toll reduces local vehicle traffic, which in turn will create more road space for freight traffic, leading to higher running speeds and reliability for trucks. Captured by the second term which is, by (2) and (4), positive, this latter effect benefits shippers and improves port 1's profit. The net impact on own profit is, at this general level, undetermined. Thus, road pricing on a region's roads may or may not benefit the region's port. On the other hand, if trucks have a much higher value of travel time than local commuting cars (US DOT, 2003), it might be possible that trucks overall benefit from a congestion toll, thus benefiting the port[19].

3.3. Price competition and related issues

The previous subsection considers quantity competition. What if the mode of port competition is in prices (rather than quantities)? In this case the profit function for each port is specified as:

$$\Pi^i = p_i X_i(\rho_1, \rho_2) = \Pi^i(p_1, p_2; K_{C1}, K_{L1}, t_1, K_{C2}, K_{L2}, t_2), \qquad i = 1,2 \qquad (14)$$

where the second equality follows from the use of (1) and $Y_i = Y_i^*(t_i, X_i, K_{Li})$, and the profit is written as a function of prices (rather than quantities). Treating capacities and tolls as parameters, each port chooses its price to maximize profit, and the resulting Bertrand-Nash equilibrium is characterized by the first-order conditions:

$$\Pi_i^i(p_1, p_2; K_{C1}, K_{L1}, t_1, K_{C2}, K_{L2}, t_2)(\equiv \partial \Pi^i / \partial p_i) = 0, \qquad i = 1,2 \qquad (15)$$

Following standard practice in models of price competition, strategy variables p_1, p_2 are assumed to be "strategic complements" (e.g. Bulow *et al.*, 1985; Tirole, 1988) and regularity conditions are imposed for the existence, uniqueness and stability of the equilibrium.

To highlight the main implications of price competition, we shall below focus just on the corridor transport part so that (15) becomes $\Pi_i^i(p_1, p_2; K_{C1}, K_{C2}) = 0$ (i.e. road transport is suppressed). The impact of an increase in corridor capacity on the equilibrium prices, output and profit is summarized in the following result.

Proposition 3: *Under price competition, an increase in corridor capacity by a region will increase its own port's price and reduce the rival port's price. Furthermore, the increase in corridor capacity has an undetermined impact on its own port's output, the rival port's output and its own port's profit, owing to various opposing effects.*

Proposition 3 indicates that an increase in the corridor capacity of region 1 will raise port 1's price while inducing port 2 to cut its price. These price effects can be explained as follows. Note that the prices being "strategic complements" ensures two upward-sloping reaction functions, defined by (15), in the p_1- p_2 dimension. An increase in the corridor capacity by region 1 will shift its port's reaction function outward, i.e. the increase in corridor capacity enables port 1 to charge a higher price for each price chosen by the competing port. Unlike the case of quantity competition (where port 2's reaction function stays unchanged), however, in this case port 2's reaction function shifts as well, and it shifts downward. As a result, at the new equilibrium, the price of port 1 rises whilst the price of port 2 falls.

Thus, an increase in corridor capacity yields two opposing effects on own profit: it reduces port 1's profit owing to the price drop at port 2 and the ensuing demand shift away from port 1 (recall the two ports produce substitutes) – a negative strategic effect. Caring for its port's profit, region 1 therefore has a strategic motive to invest in less road capacity. On the other hand, capacity investment improves port 1's profit via a reduction in its hinterland's road delays – a positive direct effect. The net impact on own profit is generally undetermined. Finally, the impact on port 1's (equilibrium) output is given as follows:

$$\frac{\partial X_1^*}{\partial K_{C1}} = \frac{\partial X_1(\rho_1^*, \rho_2^*)}{\partial K_{C1}} = \frac{\partial X_1}{\partial \rho_1}\frac{\partial p_1^*}{\partial K_{C1}} + \frac{\partial X_1}{\partial \rho_1}D'_{C1} + \frac{\partial X_1}{\partial \rho_2}\frac{\partial p_2^*}{\partial K_{C1}} \tag{16}$$

While the first and third terms on the RHS of (16) are negative – an increase in corridor capacity reduces own port's output via the price effects discussed above – the second term represents the positive impact of capacity via a reduction in region 1's corridor delay. As a result, the overall impact on own output is undetermined. The impact on the rival port's output can be similarly seen,

$$\frac{\partial X_2^*}{\partial K_{C1}} = \frac{\partial X_2}{\partial \rho_1}\frac{\partial p_1^*}{\partial K_{C1}} + \frac{\partial X_2}{\partial \rho_1}D'_{C1} + \frac{\partial X_2}{\partial \rho_2}\frac{\partial p_2^*}{\partial K_{C1}} \tag{17}$$

with the first and third terms on the RHS of (17) being positive but the second term being negative.

The above analysis suggests that a region's motive for investing in corridor capacity so as to improve its own port's competitiveness (in terms of port throughput and profit) may be weakened if the nature of port competition is in prices rather than quantities. Which model of competition is "correct" for ports? In general, this depends in large part on the production technology of an industry under consideration (here, the port industry). In Cournot competition, firms (here, ports) commit to quantities, and prices then adjust to clear the market, implying the industry is flexible in price adjustments, even in the short run. On the other hand, in Bertrand competition, capacity is unlimited or easily adjusted in the short run. In reality, some industries behave like Bertrand and others like Cournot; as such, which model of oligopoly is applicable to a particular industry is an empirical question. While there is an extensive literature on the empirical evidence of the relevance of certain oligopoly models to a particular industry (see, e.g., Bresnahan, 1989; Brander and Zhang, 1990), no such study has been conducted for ports. Such a study would be helpful in assessing the impact of hinterland access conditions in the context of port competition[20].

In the above analysis of price competition, there are no capacity constraints at the ports. This is consistent with our formulation of the ports being non-congestible (which allows us to abstract away from considering port investment and focus on hinterland access conditions). With capacity constraints, a reasonable formulation of port competition, given in De Borger *et al.* (2008), is a two-stage game where ports first invest in port capacity and then compete over prices. Note that the timing sequence in this two-stage game recognises that investment in port capacity takes time and cannot be changed quickly relative to the ease and rapidity with which prices can be adjusted. In the second stage, the Bertrand equilibrium, given port capacity, has the ports pricing such that they produce to capacity (or near capacity if the port delay-cost function is convex). Taking the pricing behaviour into account, the equilibrium of the two-stage game involves, under certain rationing and other conditions, each port investing in capacity equal to its Cournot quantity. This is the Kreps and Scheinkman (1983) result that "*quantity precommitment and Bertrand competition yield Cournot competition*." One interpretation, then, of our quantity-competition model is that it is a reduced form of the more complicated two-stage (capacity; price) game in which hinterland access conditions (corridor and road capacities, road congestion tolls) are treated as exogenous factors.

4. CASE EXAMPLES

In this section we discuss three case examples, namely: the Le Havre-Hamburg port range; major gateway ports in Canada; and the Port of Shanghai, and describe the recent policy initiatives in these regions regarding hinterland/corridor infrastructure expansion and pricing.

4.1. The Le Havre-Hamburg port range

The Le Havre-Hamburg (LHH) port range constitutes a number of ports in France, Belgium, the Netherlands and Germany. Among these ports, Rotterdam, Hamburg, Antwerp, Bremen, Le Havre and Zeebrugge are ranked No. 1 to No. 6 container ports, all of which handled more than 1 million TEUs in 2006 (Table 2). The other three major ports in this range, namely, Amsterdam, Dunkirk and Ghent, are relatively minor in container business, handling container throughput of 306 000, 205 000 and 39 000 TEUs, respectively, in 2006. Like the west-coast port range in North America, the LHH range has seen a rapid growth in container traffic, due in large part to the Asian economic booms. As shown in Table 2, container throughput for the top six ports as a whole has seen 89% growth between 1985 and 1995, and 159% growth between 1995 and 2006.

Within the Le Havre-Hamburg range there is strong competition among the ports. The competitive dynamics may be approximated by the changes in market share of each port over time. With a comparatively low tidal range, quick and easy access both to the North Sea and to the productive Rhine hinterland, Rotterdam has been until recently the leading container port in Europe[21]. However, this position has been gradually eroded over time, especially during the past decade (Table 2). Whilst Rotterdam grew 102% between 1995 and 2006, this rate is below the regional average of 159%, and only half of the rates enjoyed by its two main rivals, Hamburg and Antwerp. As a result, both Hamburg and Antwerp (and lately, Bremen) have gained market share at the expense of Rotterdam, and Rotterdam has lost its dominant position in container market share[22]. Also note that Hamburg has become the second largest container port in this range since 1987 (it used to be No. 3 behind Antwerp) and that Zeebrugge has, like Hamburg, enjoyed a very rapid growth, albeit starting from a low level of container traffic.

Table 2. **Container throughput for the Le Havre-Hamburg port range, selected years (1 000 TEU)**

	1985	1995	2006	Growth (1995-85)	Growth (2006-95)
Rotterdam	2 715	4 787	9 690	76%	102%
Hamburg	1 159	2 890	8 862	149%	207%
Antwerp	1 243	2 329	7 018	87%	201%
Bremen	998	1 524	4 450	53%	192%
Le Havre	566	970	2 121	71%	119%
Zeebrugge	218	528	1 653	142%	213%
Total	*6 899*	*13 028*	*33 794*	*89%*	*159%*

Source: Calculations based on the Port of Rotterdam – Le Havre-Hamburg range container throughput time series data.

Fleming and Baird (1999) note that there is a long history in port rivalries on the LHH port range. According to the authors (p. 387):

"*The 19th century heavy industrialization of north-western Europe brought economic and commercial linkages that were stronger than the political divisions, so that, from 1870 to the outbreak of World War I, French, Belgian, Dutch and German ports were vying for the hugely productive industrial hinterlands of the Ruhr and Rhine valleys, Lorraine, Luxembourg, the Saar, the Sambre-Meuse valley of Belgium and the coal mining districts of north-eastern France, all part of what geographers labelled the heavy industrial triangle with apexes in the French Nord, the German Ruhr and French (but German from 1871 to 1918) Lorraine. Rivalries for the commerce of this region were fierce and governments were very much involved, using various strategies to support their ports. The Dutch, for over a century, blocked Antwerp's easy access to the Rhine. The Belgians retaliated by building the 'Iron Rhine,' a very early rail connection from Antwerp to the Rhine and Ruhr. In the era of economic nationalism between World Wars I and II, the Germans favoured Bremen and Hamburg, setting artificially low rail freight rates to interior industrial regions. The French, after World War II, used the same rail rate strategy to favour Dunkerque on shipments to and from the Lorraine metallurgical district*."

Fleming and Baird (1999) further describe more recent policy developments (pp. 387-388): "*Governments are still involved and each container port tends to complain about their rivals' 'unfair' state subsidies. Actually, unlike UK ports, all the main continental container ports regard provision and maintenance of access channels as essential infrastructure to be funded by the state. … Although the port authorities both in Antwerp and Rotterdam take pride in their 'autonomies' in port management, there is no doubt that Belgian national interests and Dutch national interests are very much entwined in the fortunes of these two huge ports. This is inescapable and it explains, in large part, the determination of each port to hold on to 'market share' and to re-equip for new business. … German ports may have lost the national subsidies and preferential treatment of the late 1980s but the Lander-level governments still have a strong interest and influence in Bremen's and Hamburg's port activities.*" As a result, "*Throughout the entire Le Havre-Hamburg range there is much complaining recently about 'distortions of competition', each port suggesting that its rivals in adjoining states are using the public sector to give unfair competitive advantage* (p. 388)."

Like the North American west-coast ports, the LHH ports recently encountered high pressure through port and inland congestion. Facing the dramatic container traffic growth of the last two decades, the dense and intricate network of river, canal, rail and highway, developed post-World War II, began to choke. Antwerp, Rotterdam and Hamburg have expanded, or will expand, their port capacities, in response to the port congestion problem (Quinn, 2002). On the hinterland accessibility, we first note that the modal splits in 2005 among road, waterway/barge and rail for the three main competitors – Rotterdam, Antwerp, and Hamburg – are, for Rotterdam, 60%; 30.5%; 9.5%, respectively, for Antwerp, 60%; 32.4%; 7.6%, and 66.1%; 13.6%; 20.3% for Hamburg. Thus, for the three ports, road is the dominant mode of transport to access the hinterland. Both Antwerp and Hamburg have been trying to promote hinterland access modes other than road. Antwerp completed the Antwerp Intermodal Network project at the end of 2006. This project aims to shift transport from road to rail and barge over distances less than 250 km, so that the pressure on road traffic can be relieved. The increase in barge volume attributed to this project is around 249 761 TEUs in 2006.

At a wider level, as a measure to smooth the intermodal connectivity, the European Community recently proposed a standardization and harmonization programme concerning intermodal loading units: While the standardized containers (e.g. TEU) were usually used for sea mode, swap bodies were usually used for land modes. This programme is estimated to provide European industry and transporters with efficiency gains, and a reduction of up to 2% in logistics costs (European Commission, 2004). Another example is the Trans-European Networks (TENs) project, which aims to promote competitiveness and cohesion within Europe by improving the transportation infrastructure of different regions to a desired level and enhancing urban accessibility (Vickerman, 2007). These initiatives may help enhance the competitiveness of LHH ports *vis-à-vis*, for example, Mediterranean ports[23].

4.2. Canada

Vancouver and Montreal are Canada's two major maritime freight gateways, ranked Nos. 1 and 2 in container throughput in the country. Both cities have heavy truck volumes, including freight traffic to and from the US; and nationwide, freight shipments are concentrated along a few widely separated corridors so that substitution possibilities are limited. As discussed in Lindsey (2007a, 2008), both urban areas (as well as Toronto) have serious and growing congestion, and as gateway cities, both have a strong incentive to facilitate freight transport. The master plan of the city of Montreal sets out several priorities for transportation, including facilitating freight movements to maintain the city's competitive position as a freight hub, while limiting the environmental impact of road freight transport, upgrading selected highways and building new ones (Lindsey, 2008).

Now consider Vancouver, British Columbia. As Canada's largest container port, its container throughput has grown at an annual rate of 12% since 1980 – the corresponding figure for Montreal is 6% – which is also faster than the growth rate of other US west-coast ports. Asian countries are again the driving force for Vancouver's container growth, with China accounting for 62% of the Asian share in 2006. Despite several major expansions, congestion is still a key concern, both at the port and on the local roads. The latter is caused by trucks moving freight between terminals and around the region. It is also caused by local consumption of these containers: about 20% of container volumes moving through the Port of Vancouver is local traffic and thus relies on trucks for final delivery. The rapidly growing truck traffic contributes to congestion delays that not only impede passenger transport but also disrupt freight supply chains. The British Columbia Trucking Association has estimated the cost of congestion to freight movements in the greater Vancouver regional district (GVRD) as CAD 500 million a year (Lindsey, 2008).

Container traffic in Vancouver is expected to triple by 2020, despite the opening of the new container facilities at the Port of Prince Rupert, north of Vancouver. Vancouver's current share of the North American west-coast ports – Vancouver, Seattle, Tacoma, Portland, Oakland, Los Angeles and Long Beach – is 8.5%, but the goal is to reach a 12% share by 2020. Congested port terminals and roads could hinder such development. For instance, while a passenger could choose between various means of transport (and different times of day) for his/her travel, goods sometimes could only be delivered by roads based on a tight schedule. Since Vancouver is the main gateway to Canada, it needs to develop and maintain an efficient road network.

As a result of increasing port and road congestion, governments and port operators have been looking for solutions, which include capacity expansion and congestion pricing. In early 2006, the province of British Columbia embarked on an ambitious Gateway Program, administered by the provincial Ministry of Transportation in consultation with TransLink (the Greater Vancouver Transportation Authority, which has authority for roads and public transportation in the GVRD as well as responsibility for long-range transportation and land-use planning) and local municipalities. The Gateway Program includes a set of major transport infrastructure projects, primarily for expanding capacity at the port and related rail and road facilities in the province. The centerpiece is the Port Mann/Highway 1 Project to twin the Port Mann Bridge crossing the Fraser River, and toll the Port Mann Bridge. The tolling is intended to facilitate freight traffic by reducing non-commercial vehicle traffic, and it is hoped that it will become a part of a comprehensive regional approach to road pricing. The Program treads a fine line between the goals of accommodating freight transport and improving Vancouver's competitiveness *vis-à-vis* other gateway ports, and reducing congestion and emissions. The Federal Government's Asia-Pacific Gateway and Corridor Initiative, launched in October 2006, is providing additional funds[24].

4.3. Shanghai[25]

The Port of Shanghai has enjoyed a 30-40% annual growth rate in containers handled for over a decade, rising to be the World's No. 2 container port. Its container volume is largely driven by international trade, as exports/imports contribute nearly 90% to the total container throughput in Shanghai. About 87% of containers handled are generated in the hinterland of Shanghai, with the remaining 13% being transshipment.

An important hinterland for Shanghai is the west-to-east Yangtze River, the so-called golden waterway. The Yangtze River is a natural corridor that links the interior regions of China to the Pacific coast, and Shanghai is used as the gateway for these interior regions to trade with the rest of the world. Apart from a strong direct hinterland in the Yangtze River Delta, there is a vast indirect hinterland in the middle and upper reaches of the Yangtze River that will drive future growth in Shanghai. The feeder fleet used in the Yangtze River has largely been outdated, however. In 2003, there were around 2 000 shipping companies operating more than 68 000 vessels on the trunk of the Yangtze River. These vessels are built by different shipyards without a unified standard. In fact, there are more than 300 types of vessel operating on the river and most of these vessels have small tonnage, low speed and poor operating efficiency. The outdated fleet caused inefficiency in the operation of port facilities, as much newer facilities, built to handle modern container ships, are ill-equipped to operate with ships of old and different types. The passing capacity of the ships' lock in the Three Gorges had also been severely limited as the lock had to deal with many vessels of different sizes.

In the national strategy of developing mid- and western China, the development of the water transportation system along the Yangtze River received high priority. To improve the efficiency of water transportation along the golden waterway, China's Ministry of Communication has developed plans for the standardization of river vessels. At the end of 2003, the new standard on container ships and truck ro/ro ships was announced. The new standards on other types of river vessel were announced in 2004. It is planned that standardization of river vessels will be carried out in two stages (in two five-year plans) and by 2020 the standardization rate should reach 90% for river vessels navigating on the trunk of the Yangtze River.

Another plan to improve gateway operations in the Port of Shanghai is to establish a river-coast direct shipping route from inland ports in the Yangtze River to the Yangshan deepwater port in the East China Sea – which is the newest container terminal of the Port of Shanghai – to avoid "double transshipping[26]". Indeed, in May 2006, the first express route from Wuhan (a major city west of Shanghai) to Yangshan was opened, so that it now takes two days for the containers generated around Wuhan to arrive at the Yangshan port for further transshipping to Europe. Without the river-coast direct shipping, it would take five days. As the number of containers handled in Wuhan in recent years has grown at 30% annually, establishment of this express route would significantly enhance the effectiveness of Shanghai as the gateway for the regions in the middle reaches of the Yangtze River. In 2006, construction of the first special river-coast direct shipping vessel, the so-called Yangshan-class container ship, started in Shanghai. The Yangshan-class ship has a capacity of 400 TEU, and is suitable for navigation between Wuhan and Yangshan.

Both the standardization and river-coast direct shipping initiatives would improve efficiency of the gateway operations for the Yangtze River's middle reaches. On the other hand, it is also under plan that seagoing vessels should be able to sail into the Yangtze River in its lower reaches. This necessitates the upgrading of waterway conditions, especially the water depth. There is a three-stage plan for deepening the waterway in the lower Yangtze River. The first-stage work started in 1998 and was completed in 2002, providing an 8.15-metre water depth at the entrance to the Yangtze River course. The second-stage work started in 2002 and finished in 2005. In November 2005, the Ministry of Communication announced that the Yangtze River's 10-metre deepwater course had reached Nanjing, which indicated that the 430 km waterway from Shanghai to Nanjing now was accessible to the 3rd and 4th generation container ships. The third-stage work started in 2006 and, upon its completion, would deepen the water depth further to 12.5 metres.

These initiatives would significantly improve the hinterland access conditions for the Port of Shanghai, which will enhance its further development into a premier container port in Asia.

5. CONCLUSION AND FUTURE RESEARCH

In this paper we have examined the interaction between hinterland access conditions and port competition. Competition between ports is treated as competition between alternate intermodal transportation chains, while the hinterland access conditions are represented, separately, by the corridor facilities and by the inland roads. We found that when ports compete in quantities, an increase in corridor capacity by a region will increase its port's output, reduce the rival port's output and increase its port's profit. On the other hand, an increase in inland road capacity by a region may or may not increase its port's output and profit, owing to various opposing effects. Essentially, while more road capacity reduces local delays and moderates the negative impact of the port's output expansion, it induces greater local commuter traffic and may moderate the effect by which a rise in cargo traffic reduces local commuter traffic, both of which reduce the port's output and profit. Similarly, inland road pricing by a region may or may not increase its port's output and profit. Finally, case examples for selected ports and regions are discussed to supplement the analytical study.

The paper has also raised a number of other issues and avenues for future research. Below we discuss two such issues.

5.1. Port/hinterland interactions and organisational co-ordination

In our analysis, we have considered that the port and its hinterland belong to a single region, which ensures co-ordination in their decisions. For a given intermodal transportation chain, however, the port, the corridor and the inland road may belong to different, separate parties (regions or organisations). Each party tries to maximize its own interest, which may not be the same as the interest for the entire chain. An example of breakdown in co-ordination between the port and hinterland is given in Y. Zhang (2007), who notes: "There has been a lack of co-ordination between water transport and land transport along the Yangtze River. With the development of the new highway system in China, an increasing number of bridges have been built to cross the Yangtze River. On the trunk of the waterway some 2 800 km in length, there is one bridge every 30 km on average. Such a high density of bridges provided convenience for the north-south land traffic, but has serious impacts on the west-east water traffic. Since the 1980s, there have been dozens of new docks capable of handling vessels of 5 000 tonnage built along the Yangtze River. The bridges on the river, however, have only allowed vessels of 3 000 tonnage to sail beneath."

This perhaps more realistic structure naturally raises questions about the nature of interactions among the parties, their co-ordination concerning congestion pricing and capacity investment, and about their impact on rivalry between ports. Assuming a single, isolated intermodal transportation chain, Yuen *et al.* (2008) investigate the effects of congestion pricing implemented at a gateway port on its hinterland's optimal road pricing, road congestion and social welfare. A. Zhang (2007) is similar to Yuen *et al.* (2008) in that he addresses the interaction and co-ordination issue in facility pricing in a gateway-hinterland intermodal system. Unlike Yuen *et al.*, however, he investigates the impact of the hinterland's highway congestion pricing on the gateway, and considers both pricing and capacity investment. Both papers demonstrate the important need for co-ordination among the multiple parties in order to achieve efficiency for the entire chain. Extending this line of research to the setting of competing ports – such as the one analysed in this paper – provides an important feature of future research.

5.2. Overlapping and captive hinterlands

In our analysis we have followed the set-up in De Borger *et al.* (2008) whereby the two seaports compete for a common hinterland. This set-up of (completely) overlapping hinterlands may be justified, as discussed earlier, by the emergence of container trade; it also allows us to focus on the issue of port competition. In many markets, however, both overlapping and captive hinterlands may exist. For example, in their observation about ports in the Le Havre-Hamburg range, Fleming and Baird (1999) note: "*While these ports vie with one another for interior hinterland shipments it should be noted that each has a competitive advantage in its* local *hinterland to which it has best access. It is the 'discretionary' shipments which have alternative routing possibilities that stir the competitive fires. … Le Havre's hinterland is primarily French*." Another example is the Port of Shanghai: Both the (direct) Yangtze River Delta and the indirect hinterland in the middle and upper reaches of the Yangtze River are captive hinterlands for Shanghai, whilst transshipping markets along the north-south coastline (about 13% of Shanghai's container throughput) are subject to competition with other Chinese or East Asian seaports.

Although the captive hinterlands are not subject to immediate competition, they play an important role in the competition between ports. A larger captive hinterland for a port would: (a) allow for (all other things, such as load factor and ship size, being equal) more frequent services by shipping lines; (b) allow shipping lines to use larger ships, deriving economies of scale; (c) increase ships' load factors, so the port is more likely to be chosen as a "load centre", or as a scheduled stop on a route (Heaver, 2006); (d) facilitate the growth of third-party LSPs (logistics services providers) and forwarders at/near the port, which would in turn facilitate the port's role in the logistics supply chain; and (e) allow more value-added "clusters" (transport product, logistics product and port-related manufacturing product) to be developed, further attracting more liners, LSPs and forwarders (De Langen, 2002, 2004). All of these elements would make the port more competitive in bidding for the overlapping market. For instance, a larger captive hinterland for a port results in higher traffic density which in turn will, among things, lower freight rates[27].

If both the overlapping and captive markets are considered, then important interactions between the two markets and their impact on port competition need to be analysed. An earlier paper by Basso and Zhang (2007) has analysed a somewhat similar problem in the context of airports. They did not consider either the hinterland markets, or the intermodal nature of transportation chains. Nevertheless, their model might be adapted, after incorporating features of the model developed in the present paper, to an analysis of seaport competition with both the overlapping and captive hinterlands.

NOTES

1. See also the earlier work by Jansson and Shneerson (1982).

2. Dresner (2007) has documented the dramatic shift of container traffic from the Port of Baltimore to the Port of Norfolk over the past twenty years. This shift is attributed to a number of factors, including railroad preference for Norfolk over Baltimore. It was claimed that the railroads prefer to concentrate their business at ports other than Baltimore for economic reasons. Norfolk Southern, one of the two Class 1 railroads serving Baltimore, prefers to concentrate its business at its home port in Norfolk. The other Class 1 railroad, CSX, prefers to concentrate much of its business in New York. Since most of the container traffic is not destined for local markets at either Norfolk or Baltimore, the availability of high-quality rail services at Norfolk is conducive to its competitiveness.

3. There is an extensive literature on urban road pricing (see Small and Verhoef, 2007, for a literature survey, and recent studies by Lindsey, 2007a, 2008, on related issues).

4. A similar study has been carried out by Kim *et al.* (2007), who consider a multimodal transportation problem of determining the transportation flow quantity (i.e. volume of container cargos) and the transportation mode in each trade route, with the objective of minimizing the sum of shipping and inland transportation costs. The model is then fitted using the container cargo data in Korea.

5. As can be seen below, there are a few other modelling differences as well, including the linear demand and delay functions used in De Borger *et al.* (2008), as opposed to the more general demand and delay functions in the present paper.

6. A "gateway" may be defined as a coastal metropolis with port access to both its hinterland and the rest of the world, which captures a substantial share of total regional and international trade volumes (Berechman, 2007).

7. The average ocean travel time is suggested to be twenty days.

8. Gausch and Kogan (2001) find that halving inventories could reduce unit production costs by 20%.

9. The causality may be reversed: container throughput growth could contribute to congestion. It could also be the case that container throughput growth and the urban mobility indicators are correlated with a third variable, e.g. time. Further empirical investigation is thus needed.

10. These ports might also compete with the Canadian west-coast ports, namely, Vancouver and in the future, Prince Rupert.

11. Due to the strong growth of imports from Asia, congestion has become a major problem for these ports and respective inland facilities. The ensuing delays have imposed substantial costs on

carriers and shippers (see, e.g. *Bloomberg News*, December 4, 2005).

12. Unlike the effect on throughput growth, however, none of the correlation coefficients are statistically significantly different from zero.

13. The revenue generated by the PierPass fees is refunded to terminals that operate an effective off-peak programme to compensate them for the extra cost of longer hours and the labour costs related to overtime or night and weekend shifts.

14. As long as the change in congestion level is marginal, shippers and forwarders are reasonably certain about the congestion they are going to encounter: i.e. the delays will be "expected". Thus they are able to incorporate the waiting time caused by congestion into their shipping schedules (e.g. assign more time to that leg of movement during peak hours). Even though the level of congestion is high, shippers and forwarders may still be willing to use LA/LB, because they are able to follow their schedules by planning ahead of time. In this case, shippers and forwarders may still achieve a given level of delivery reliability.

15. See also Luo and Grigalunas (2003), who provide an estimate of the impact on port demand and inter-port competition due to hypothetical changes in port use fees at selected ports.

16. Queuing at junctions is the dominant source of delay in many urban areas (Santos, 2004).

17. Since there is no congestion at the port, port capital cost is not relevant in this case. Further, note that our results will continue to hold for constant (but non-zero) operating costs.

18. More generally, Carbone and De Martino (2003) place such an environment in the context of supply chain management. The contribution of a port to a supply chain (to which it belongs) depends on its infrastructure, connectivity and ability to add value; for example, by providing punctual and frequent service for shippers, by disseminating important information (e.g. product location) to other members of the supply chain, and by providing a secure environment for the cargo. Rivalry between intermodal transport chains has also been examined in Zhang *et al.* (2007) in the context of the air cargo market.

19. Here, we have considered a flat toll, as opposed to a variable (peak/off-peak) toll, which is more effective in combating road congestion. Recent research in the US has shown that truckers have little scope for adaptation to variable tolls because of rigid delivery schedules imposed by shippers and consignees (Holguin-Veras, 2006). Thus, consideration of a variable toll might lead to a similar result, that is, a congestion toll on a region's roads may or may not benefit the region's port.

20. Quinet and Vickerman (2004, p. 263) remarked: "*The general idea which emerges from the theoretical analysis is that when transport capacities are high, or can be enlarged through the transfer of capacity from other locations, and the services provided are not differentiated, then competition is likely to be of a Bertrand type, based on price. ... If, on the other hand, capacity is difficult to increase, then competition is likely to be of a Cournot type, based on quantities. This is the case found, for example, in rail, maritime or inland waterway transport*."

21. Its two main rivals, Antwerp and Hamburg, are inland ports. In order to reach the ports from the sea, vessels have to sail up the river before arriving at the upstream ports, incurring higher operating and time costs than reaching Rotterdam, which sits right on the coastal line. The 2003

data shows that the deep-sea call efficiency ratios (TEUs handled as a percentage of two-way capacity of vessel called at port) of Antwerp and Hamburg were 27.7 and 22.7 respectively, while this ratio was about 18.5 for Rotterdam (Notteboom, 2006), suggesting that both Antwerp and Hamburg have to be more capable of handling the sudden arrival of large container volumes.

22. It is notable that Rotterdam has increased its transhipment function in recent years. Its relative shares of containers accessing hinterland and transhipped are, respectively, 83.4% and 16.6% in 2002, but 76.1% and 23.9% in 2006.

23. Heaver (2006) notes that the advent of same-day-of-the-week liner services has sharpened the competition among ports on a route. For example, a line may substitute a port on one coast for a port on another if the profit contribution to a vessels' route is enhanced by substituting one for the other within the time cycle available under the constraint of same-day service. Ports that operate on the same schedule offer a more similar service so that Bertrand undercutting forces prices lower.

24. For more information about the two programs, see www.th.gov.bc.ca/gateway/ and www.apgci.gc.ca.

25. This subsection is based largely on Y. Zhang (2007).

26. As most vessels in the Yangtze River cannot sail by sea, containers generated in different regions along the Yangtze River, carried by river vessels to Shanghai for transhipping to international destinations, cannot directly dock in the Yangshan deepwater port. These containers must be unloaded in the Waigaoqiao Port (another major terminal at the Port of Shanghai), which is located along the bank of the Yangtze River, and then transshipped by coastal barges for about 70 nautical miles to the Yangshan Port for further transhipping. This double transhipping not only extends overall shipping time for customers, but also puts great stress on already strained capacity at the Waigaoqiao Port.

27. In effect, Y. Zhang (2007) concludes: "*Based on the examination of the regional development along the Yangtze River, it is concluded that, with direct and indirect hinterlands of such grand scale and foreseeable development on the hinterland, Shanghai should aim for efficient gateway operations, strengthening its connections to its hinterlands and providing best service to its clients along the golden waterway for domestic/international transshipping, rather than competing with other international shipping centres in the Asian Pacific for international/international transshipping*."

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PRINTED IN FRANCE
(74 2009 02 1 P) ISBN 978-92-821-0224-4 – No. 56729 2009

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PORT COMPETITION AND HINTERLAND CONNECTIONS

This *Round Table* publication discusses the policy and regulatory challenges posed by the rapidly changing port environment.

The sector has changed tremendously in recent decades with technological and organisational innovation and a powerful expansion of trade. Although ports serve hinterlands that now run deep into continents, competition among ports is increasingly intense and their bargaining power in the supply chain has consequently weakened. Integration of supply-chain operations on a global scale has greatly increased productivity but raises issues of both competition and sustainability.

Concentration among shipping lines and terminal operators may generate market power. National competition authorities have the power to address this but might not fully appreciate the international dimension. Greater port throughput meets with increasing resistance from local communities because of pollution and congestion. In addition, local regulation is warranted but made difficult by the distribution of bargaining power among stakeholders. Higher-level authorities could develop more effective policies.

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