International Transport Forum

Traffic Planning in Port-Cities

Discussion Paper

169 Roundtable

Peter Hall
Simon Fraser University, Vancouver

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OECD

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Introduction

Conflict over environmental, congestion, pollution and other impacts resulting from container traffic has emerged as a new arena of tension in the relationship between ports and cities (Hall, 2014). This paper examines the question of traffic planning and management in port-cities. As container terminals in seaports around the world have converged in terms of their management practices and dockside productivity, hinterland connectivity and landside productivity have become relatively more important factors in differentiating which ports perform better. This is not to deny or minimise the perennial challenges with over-capacity, horizontal integration and market uncertainty in ocean shipping, or the challenges with ever-larger container ships and ownership, governance and technology changes in marine terminals. Indeed, precisely because carriers and terminal operators are seeking to secure access to competitive hinterlands so that they can exploit the latent economies of scale, they are imposing volume-, movement- and time-based challenges on the immediate urban hinterlands of ports.

The paper identifies the actors, interests, relationships and elements of the transportation system in the immediate hinterland of container ports, from the terminal gates through to sub- and ex-urban warehouses, terminals and other freight handling locations, including the modal, technological, planning, governance and labour dimensions. The paper begins by identifying the key actors relevant to traffic planning in port cities, highlighting their shared and conflicting interests (see section *Actors and interests*), and their relationship to each other as they organise and influence connectivity patterns in the port hinterland (see section *Why the metaphor matters*). Traffic and connectivity issues in the port-hinterland are complicated because the impacts are spatially uneven and cross jurisdictional boundaries (see section *Spatial unevenness, scales and jurisdictions*). This is unavoidable; all container ports (except pure transshipment hubs in remote locations) are systems of activity that are intimately tied to the urban economy. They compete with other urban actors for land, labour and infrastructure, as well as for the attention of governing authorities and legitimacy in the public eye.

The standard economic advice when one activity spills over to impose costs on third parties is to internalise such negative externalities through pricing, regulatory and related interventions (see section *The potential and limitations of "internalisation"*). Typically, these interventions are focused at and around the marine terminal, because this is where the negative impacts are most readily visible, but also because the terminal operator and port authority are coherent institutional actors with some ability to enact internalisation policies. There are important examples of emerging good practice in this regard, particularly on the west coast of North America, which the paper reviews.

Internalisation strategies have their limits. Traffic planning for container ports is a wicked problem (Rittel and Webber, 1973) with difficult-to-define domain boundaries and a complex mix of actors and interests. A wicked problem "cannot be definitively described. Moreover, in a pluralistic society there is nothing like the undisputable public good; there is no objective definition of equity; policies that respond to social problems cannot be meaningfully correct or false; and it makes no sense to talk about 'optimal solutions' to social problems unless severe qualifications are imposed first. Even worse, there are no 'solutions' in the sense of definitive and objective answers" (Rittel and Webber, 1973: 155).

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This definition applies to traffic planning in port cities in large part because ports deliver a mix of external benefits and costs that are unevenly distributed, and difficult to measure and attribute. The relationship between ports and cities is not confined to the marine terminal and its direct traffic system. Hence it is not always feasible to fully internalise the costs of port activity at the terminal, in the same way that it is neither possible nor desirable to fully internalise the costs and benefits of any (urban) economic activity. The mitigation strategies that may accompany internalisation are further challenged when the causal relation between the negative externality and its community impact is unclear.

Recognising the limits of internalisation strategies means recognising that ports are integral parts of the urban economies, communities and polities they inhabit; this is especially the case with container ports in major metropolitan areas. Wicked problems can be tackled partially and incrementally; while there may be no permanent solutions, temporary improvements are achievable. This implies the need for constant policy attention, discussion, exchange and learning; having the right governance frameworks; and never assuming that a given project will be the last. Ultimately, port and city need governance frameworks that can promote mutually beneficial traffic management planning, which includes but is not limited to internalisation strategies (see section *Emerging practices and strategies*).

Actors and interests: Elements of the port's hinterland system

Who are the actors and stakeholders we need to include when trying improve the connectivity of a port to its immediate and remote hinterland, and what are their mutual and conflicting interests in this regard? Table 1 below lists the relevant actors, highlighting the range of variation within each group, and outlining in highly stylised terms some of their interests which may influence their approach to the traffic planning task in port cities. The list is long and the interests are many because, in a word, traffic planning is *political*.

I have deliberately cast a wide net here to include ocean carriers, governments, communities and economic interests, as well as those directly involved in providing terminal-hinterland transportation services. For instance, shippers' role in transport decision making is often ignored, even though they play an important role in setting or shaping the contractual terms of carriage. Likewise, new research is highlighting the role of dockworkers in identifying and shaping the adoption of greening practices in ports and port cities (Vasconcelos et al., 2016).

There are, of course, variations in how the interests and relationships of these port actors and stakeholders are configured in different parts of the world, especially with regards to port authorities and governments. For example, port authorities the USA and north-west Europe tend to be part of local and state governments, and so may be more responsive to concerns of actors close to the port and in the immediate port hinterland. Port authorities in most former European colonies tend to be part of the national government despite decades of governance reform in port administration (Brooks et al., 2017); and in other places, notably China (Wang, 2014), governance arrangements are fluid and overlapping.

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Institutional arrangements make a difference in how port traffic issues are (or are not) addressed, but port governance is only one of many factors affecting hinterland connectivity. In all port systems, once we move landwards of the marine terminal, the range of actors involved in hinterland connectivity, and hence the range of (competing) interests, multiplies exponentially. For instance, moving from oceanic foreland to landside hinterland, we immediately shift from one (ocean shipping) to three (road, rail, waterway) competing and, with respect to trucking, internally fragmented transport modes.

The number of actors and their range of interests are important because this influences how easy or difficult it is to find collective action solutions to hinterland traffic planning. Acciaro and McKinnon (2013) argue that "hinterland chain coordination has become an even more significant attribute of the effectiveness of container terminals as social and environmental sustainability considerations are taken into account. It is only through terminal and hinterland coordination that some of the negative externalities associated with large container ports can be managed, as the success of the dry port concept seems to attest"(8).

At the same time, it would be a mistake to assume that more actors or divergent interests is necessarily worse for a port-city economy; urban economies thrive on their diversity and unconcentrated nature (Glaeser et al., 1992). If traffic planning meets the interests of only a small number of actors, then it is likely to exclude actors and stakeholders who in turn, may act in ways that are counter-productive to transport and cargo interests. At the extreme, they may choose to disinvest from the port city. Or they will challenge what they regard as illegitimate decisions. For example, in order to achieve more efficient truck staging and so improve terminal operations, the Port of Vancouver closed one road access point to the Burrard Inlet container terminals (Hall, 2015). The result was the displacement of port trucks onto neighbourhood streets, upsetting residents. Because of the powers of the City of Vancouver and the successful organising of the neighbourhood residents, a deal was eventually struck to route port-destined container trucks around the neighbourhood. The eventual solution enjoys sufficient support, but the bad publicity for the port could have been avoided if the range of interests considered initially had been cast more widely.

In the next section, we will turn to the question of how the actors described in Table 1 relate to each other with regards to the hinterland movement of containers. The metaphors which we use to describe these relationships are not just important in an analytical sense; they also shape how we think and communicate about addressing the challenges of securing efficient and socially and environmentally acceptable traffic planning solutions.

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Table 1. Actors and interests with regards to terminal-hinterland connectivity for container ports

Actors		Number of actors and range of variation in their interests	Key interests with regards to hinterland connectivity
Ocean carrier		Few actors, often related in conferences/alliances/slot-sharing agreements; low variation in interests.	Seek rapid terminal turn-around times; sufficient space for staging and surge. May seek to balance in- and out-bound cargo.
Terminal operator		Few actors, typically from 2 to 5 per port; competing but with low variation in interests.	Seek efficient use of terminal investment, including land. Try to reduce cargo dwell time.
Port authority		Typically a single actor per port, trying to meet/satisfy multiple competing interests. Important differences in port governance structures persist around the world.	Seek overall efficiency of port operation. May favour some supply chains, depending on governance and mission. Will seek to secure social license to operate, especially regarding environmental and other impacts.
Landside and non-oceanic transportation service providers	Trucking	Many actors (owner-operators); some variation in interests, including local vs long-haul.	Seek rapid terminal gate turnaround times, expanded roadway capacity. Driver interests may vary by contract or employment relationship.
	Rail	Few actors; some variation in interests, including on- vs off-dock, and local vs main-line.	Seek high volume corridors and reduced grade crossing conflicts. May have specific interests depending on routes, terminal locations and hinterland destinations.
	Inland/ coastal waterway	Many actors (owner-operators); low variation in interests.	Seek high volume corridors and terminal access. Interested in channels, berths, safety, etc.
Handling, storage, distribution and logistics service providers		Many actors; some variation in interests by function (storage, transloading, warehousing, etc).	Seek cheap, large sites for space-extensive activity, with good land transport access.
Governments, which range from…	Municipal/ Regional/ Metropolitan	Many actors; widely divergent interests.	Some local governments seek to attract cargo-related activity, others actively discourage.
	Transport agencies	Few, with interests matched to mode (transit, bridge, road, etc.)	Seek overall efficiency of transport system.
	Province/ State/ Nation	Typically, a single actor per port, trying to meet/satisfy multiple competing interests.	Seek port efficiency in service of overall economy and specific (usually export) supply chains.
Communities, which range from…	…close to marine/other terminal	Few; often poorer communities, but increasingly include wealthy waterfront residents.	Address air quality, noise, light, congestion due to transport, handling and related impacts.
	…across the metropolitan region	Many; diverse interests, but generally share desire of quality of life, minimum freight impacts.	Congestion on metropolitan highways. Truck routing and rail grade crossing conflicts.
Economic interests, which range from…	…transport workers	Many actors; similar interests, may compete between modes.	Seek to grow/maintain jobs, earnings, health and safety.
	…direct shippers	Many actors; similar interests, with import/export variation.	Seek efficiency of hinterland access and port operations.
	…others	Many actors; divergent interests.	May have competing land development goals.
Environmental organisations		Many actors; similar interests, may have focus on particular environments (aquatic, land, air) or biota (plant, animal, human).	Seek to reduce impact of port activity from local (habitat, land conversion) to global (greenhouse gasses) scales.

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Why the metaphor matters: Pipeline, chain, gateway or network?

To say that communities, the public, or non-shipper economic interests, are stakeholders in the port system does not mean that they will attend a port traffic planning meeting (unless they are unhappy about something). Indeed, one of the challenges that port cities face all over the world is that the public has relatively little understanding and appreciation about the work performed in the port system, or role of ports in the economy. Patterns vary from place to place, but the core elements of the problem are the same; the public generally has little opportunity to learn about the port as terminals have gotten larger, more security-conscious, and more likely to be relocated away from core urban areas. Diversified urban economies provide desirable locations for container ports (Hall and Jacobs, 2012; OECD, 2014); but this means that ports only account for a small share of direct employment in the cities they inhabit, except in places such as Le Havre or Felixstowe that are dominated by port activity. Out of (work-)sight, ports are out of mind. For most urban consumers, the port is only noticed when the goods do not arrive as usual, or when port activity affects quality of life. For these reasons, port authorities around the world have started to invest more in public awareness and education (OECD, 2014), though we don't yet know whether this can reverse the tides of ignorance or hostility.

Metaphors - identifiable, digestible, credible - are essential in such public awareness campaigns, but this is much more than a question of public communication; the metaphor of "what is the port" is also important for shaping the ideas and expectations of port managers, urban planners, elected officials, transport engineers, and other experts. When port managers conceive of the port as a pipeline they are more likely to be thinking about a closed, engineered system; when they think of the port as a link in the chain, they are more likely to be thinking about transactional relationships. So, metaphors influence how we understand and communicate about the dimensions of an issue, and the potential solutions; they also influence which stakeholders are invited to participate in the decision making.

Four main metaphors have dominated thinking about terminal-hinterland connectivity in relation to container port systems: pipelines, chains (and competing chains), gateways and networks. The core elements of each metaphor, as well as the advantages and disadvantages of each, are summarised in Table 2.

The pipeline metaphor derives from engineering, and hence tends to focus more on the physical dimensions of the system. This metaphor is especially apt in a sector requiring large, lumpy investments of fixed capital and has proven remarkably powerful in the face of the challenges for ports resulting from larger container ships and more efficient but land-constrained terminals. The changes in ship and terminal technology mean that more boxes need to be distributed to the close and distant hinterland as quickly as possible.

The pipeline metaphor, and the associated idea of "bottle-necks" - which neatly depicts a pipe that is constrained – implies that expanded capacity and faster turn-around times are the solution to the throughput problem. The pipeline metaphor also promotes the idea that the port and its hinterland connectivity are closed or isolated systems that are not intimately connected to other urban activity systems. This is precisely where the pipeline metaphor begins to break down; ports are not isolated from their urban context: most port container trucks also drive on roads used by commuters, container storage facilities compete with industrial and non-industrial uses for urban land. The pipeline metaphor also subtly communicates the idea that cargo flows like water in a continuous stream; but the container

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enjoys widespread use precisely because it has been unitised, hence allowing custom delivery by truck. At the human urban scale, port trucking is resisted because it is not neatly contained; it goes all over the map, including into residential neighbourhoods.

At a system-wide level, the "pipeline" capacity-expansion approach has contributed to the well-recognised problem of overcapacity in the marine and terminal markets (see ITF, 2016a). At the same time, a lack of hinterland connectivity investment has been noted in many parts of the world. While this may be related to a general lack of investment in urban infrastructure, it may also be argued that the bottleneck removal approach tends to exacerbate fragmented planning approaches. These take the form of piecemeal investments in overpasses, highway ramps and lane expansions that may create overcapacity in some elements of the system, but hold-up problems and intense conflicts over capacity expansion in others, and an overall uneven distribution of the impacts of port-related activity on urban communities.

The chain metaphor builds on ideas from industrial organisation and economic geography to understand how different actors come together to organise and govern throughput. The chain idea is powerful because it focuses attention on the interactions between the actors in the supply chain. This is useful for thinking both operationally (e.g. how to make transfers more efficient) and strategically (e.g. when is it beneficial to contract for a service, and when is it beneficial to keep an activity in-house).

The metaphor works well in understanding many features of the global economy. Today, many of the key actors in supply chains from ocean shipping, to terminal operations and cargo owners are large, technology-intensive, powerful multinational organisations. Others are relatively weak, including truckers, independent warehouse operators and even some governments. The chain metaphor recognises that the terminal-hinterland connectivity system is only as "strong as its weakest link". This catchy but rather vague expression highlights that some parts of the supply chain are more vulnerable to disruption, because they are inefficient, poorly integrated with adjacent supply chain activities, and/or are poor social and environmental performers.

Port container trucking is one such weak link; it is recognised as a highly competitive and fragmented, yet vital link between marine and inland terminals. It is thus not surprising that port trucking is often a source of contention between ports and cities. Disruptions may occur when truck drivers are squeezed to work longer hours, take short cuts, often using older, polluting vehicles. And, as has been experienced on the West Coast of North America in the past decade, disruptions to port container trucking – whether due to strikes or chassis availability – lead to disruptions of the entire port system.

Attempts to find collaborative solutions to problems in the port trucking sector are undermined by ease of entry, which means that any benefits to drivers and the wider society from improved port trucking practices are quickly competed away. In contrast, regulatory solutions are widely resisted by shippers, terminal operators, and even by some truck owner-operators themselves. There is an urban dimension to this dynamic; urban economies provide rich market alternatives and back-haul opportunities for the readily transferable skills and equipment of truck drivers and owners. This creates a context within which marginal (private) cost pricing is almost always irresistible.

For these reasons policy attention, especially in the European Union, has focused on trying to increase the mode-share of container movements in the hinterland away from road to rail and inland waterways (EU, 2015). However, such policy attention and incentives for more environmentally friendly modes is often undermined by subsidies for the road-based competition. For example, in a policy review of the Chilean port system, the ITF (2016b) recommended an end to subsidies to the trucking industry. These subsidies come in the form of an implicit cross-subsidy to trucking which does not pay a proportionate share for its impact on road wear and tear, as well as a diesel fuel subsidy.

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An elaboration of the chain metaphor is the idea of competing chain systems (Robinson, 2002). This metaphor focuses attention on the idea while each supply chain has its own internal dynamics and relationships, they are also in competition with other supply chains to serve the same origin-destination pairs. Competing supply chains may intersect in the same locations, for example, at key channels, ports and inland terminals. These points of supply chains intersection are important; they influence the overall capacity and flexibility of supply chains. Supply chain actors work hard to secure access to such "critical supply chain assets" (Robinson, 2002; 241). Hence, we have carriers investing in marine terminals, but we typically don't have them investing substantially in port trucking for which there is market availability for variable needs.

Supply chain actors are also always looking for ways to not be dependent on a single critical supply chain asset; they seek to maintain flexibility because requirements to move goods are seasonally variable and cyclically uncertain. Metropolitan urban areas are desirable to supply chain actors precisely because they provide many of the diverse resources and options required for such flexibility. In this regard, a "network" is a better metaphor than a "chain" for describing why this activity occurs in urban space, and indeed why the relationship between port and city is often so contentious.

Before discussing the network metaphor, I want to mention the "gateway" metaphor, which has deep roots in the transport geography literature and which has gained considerable prominence in Canada over recent decades. The gateway metaphor identifies port cities as portals to multi-modal hinterland corridors for imports and exports. In turn, these corridors may be conceptualised as pipelines and/or chains, depending on whether physical infrastructure and/or organisational relationships are to be emphasised. Since at least the early 1990s, and most especially since the mid-2000s the gateway metaphor in Canada has provided a strong organising principle for co-ordination between the federal government, several provincial governments, port authorities and key transportation service providers. It has successfully secured substantial public and private infrastructure investments: "The Asia-Pacific Gateway and Corridor Initiative is an integrated set of investment and policy measures focused on trade with the Asia-Pacific Region. Its mission is to establish Canada's Asia-Pacific Gateway and Corridor as the best transportation network facilitating global supply chains between North America and Asia" (Canada, 2017).

Although the gateway has proven to be a compelling metaphor, it is subject to challenge when it is perceived to focus too much on remote hinterland interests to the exclusion of those who make the (urban) gateway their home. In the greater Vancouver case, local non-transport and non-cargo interests, especially municipal, community and environmental interests have felt excluded. They have complained that the "gateway" makes them a "doormat". I will return to some of the steps that gateway proponents have taken to address these concerns in the conclusions (see section *Emerging practices and strategies*).

The network metaphor for the port-logistics sector depicts an interconnected and intricate system of actors, activities, and relationships that support the movement of goods between remote locations. A network, like a chain, is only as strong as its weakest link. Networks are composed of nodes (ports, terminals, warehouses) and links (road, rail, water) each with different throughput capacities; however, the capacity of each node and link is dependent on others in the network. The most efficient port terminals will not be efficient if they are not well connected with adequate warehousing, distribution centres, transloading facilities and storage capacity in the hinterland.

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Table 2. Four metaphors of the container port system, focusing on terminal-hinterland connectivity

The port is a…	Core elements of the metaphor	Advantages of the metaphor	Disadvantages of the metaphor
Pipeline	The volume of liquid that can flow through a pipeline is a function of the size of the pipeline and the viscosity/friction of the liquid.	Focuses attention on specific capacity constraints "bottlenecks" which impede throughput productivity.	May focus too much on engineering solutions and physical infrastructure. Ignores the actors and their interests.
	The volume of cargo which can be handled is determined by the capacity of the narrowest segment of the pipeline, and the speed of handling throughput.	May focus attention on speed of handling within given physical capacity constraints.	Promotes the idea that connectivity is an enclosed system, and may ignore alternatives to the main "pipeline".
	"Bottlenecks" in the pipeline need to be removed.		Viewed from close-up, container cargo is more granular than fluid.
Chain and competing chains	A chain is a set of linked elements of potentially different sizes and types; the chain is as strong as its weakest link.	Focuses attention on the nature and strength of the relationships between actors in the chain.	May focus too much attention on actors within existing chain.
	Cargo is moved within competing chains that can be both parallel and intersect at key points (e.g. port is a link in competing supply chains).	May recognise that actors can forge new links or break existing links.	May not focus enough on alternatives to existing chains. May also ignore stakeholders outside existing chains.
	Weak links in the chain need to be strengthened.	May focus attention on the capacity or strength of a given link/relationship.	May not focus enough on physical capacity, especially of shared/public infrastructure.
Gateway (and corridor)	Gateways are portals to hinterland corridors consisting of many, multi-modal chains.	Combines attention to physical dimensions of each element of the system, and the relationships between the elements.	May focus too much on remote hinterland interests.
	Hinterland connectivity may emphasise pipeline and/or chain metaphors, and related interventions.	Provides metaphor for co-ordination between and among state/national governments, and transport service providers.	Local non-transport and non-cargo interests feel excluded; complain about being a "doormat".
Network	A network structure consists of nodes and pathways, each with their own operational, volume and speed characteristics.	Combines attention to physical dimensions of each element of the system, and the relationships between the elements.	This more complicated metaphor may make decision making more difficult.
	Cargo can move through any existing combination of nodes (ports, terminals) and pathways (road, rail, water).	Recognises that actors can keep options open by changing, or having multiple, nodes and links.	May create the impression that container port systems are too unstable for coherent planning.
		Recognises that there may be abrupt changes in network configuration.	

This point introduces one of the key strengths of the network metaphor over the pipeline, chain and gateway metaphors *at the urban scale*, namely, the recognition that actors outside the cargo handling transaction can and do have a profound influence on hinterland connectivity. For example, most road

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connections between marine and inland terminals are public roads, built for and used by non-port users. Wan et al. (2013) concluded that investment in port highway access infrastructure may not lead to congestion relief if realistic assumptions are made about use of these highways by commuters. Similarly, the conditions influencing the availability and operating terms of inland terminals are subject to general land market conditions, zoning, and a variety of permitting, nuisance and other municipal bylaws.

The network metaphor helps us understand some of these challenges confronting traffic planning in port cities. While networks may be stable over time, the possibility of change is almost always present – even if changes have costs and may not be possible to implement in the short run. Unlike in the case of the pipeline metaphor, the network metaphor highlights that users may have options off the main pathway. And unlike in the case of the chain metaphor, a weak link in a network can be bypassed. In short, if a route becomes congested, unreliable or too expensive, a quicker, cheaper or more reliable route will be found. At the same time, the metaphor highlights that other urban actors may seek to withdraw a node or link from the network. Often with municipal government support, real estate interests may eye an old industrial site for residential or commercial redevelopment, or residents may press for the removal of rail lines that are associated with noise or delays at grade crossings.

This helps emphasise that actual cargo movement systems are composed of linkages and nodes that may be more or less contested, efficient and reliable. Shippers interested in moving a container between a given origin and destination may confront a combination of network choices. The network metaphor helps us recognise that some inter-regional flows are organised between large, relatively stable dyads; for example, inter-city container barging between Rotterdam and Duisberg on the Rhine, or intermodal rail services between Los Angeles and Chicago. At the same time, the network metaphor highlights that, especially within metropolitan space, there may be uneven, surprising and unwelcome shifts in cargo movement patterns. For example, the opening of a new transloading facility or empty container storage yards may introduce trucks on local roads. Under these conditions, cargo volumes at one node or link in the network may rise or fall disproportionately to overall cargo volume growth or decline.

From the perspective of communities, commuters, businesses and public officials, it is precisely such changes in port-related activity that disrupt the vital patterns of urban life – home-making, daily travel, and private and public investments in the urban economy. Urban governance with all its complexities is unavoidably part of the hinterland traffic planning of the container port; from work and delivery time schedules, wage expectations, the public willingness to invest in roads and other infrastructure, to the planning and pricing of land resources, all will affect the port's ability to interact with its hinterland.

Spatial unevenness, scales and jurisdictions

We can further nuance this analysis by considering the questions of spatial unevenness, scale and jurisdiction. The port hinterland connectivity system is bedeviled by the well-appreciated fact that it always crosses jurisdictional boundaries. Much has been written about the need for better co-ordination in the governance, planning, investment and operation of inland corridors and the terminals they connect (Wilmsmeier et al., 2011; Van den Berg et al., 2012; Monios, 2014; Witte et al., 2016).

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We can illustrate this point with reference to the system of port trucking regulation in Vancouver: in response to disruption of the port trucking industry… we had a federally-created port authority, trying to ensure continued services provided by a fragmented trucking industry… that is provincially licensed and regulated, and which makes use of a road network that is constructed and maintained by three levels of sub-national government… and that is financed by… well, you can see the problem. Perhaps we may also appreciate the significant achievement represented by the enacted regulatory system (see below and section *The potential and limitations of "internalisation"*).

There are two additional dimensions to the spatial "problem" of hinterland connectivity. First, the positive and negative impacts of port activity and hinterland connectivity, as well as the potential remediating interventions, tend to be misaligned in space. It is now well understood that there is a spatial mismatch between the costs of port activity (pollution, congestion, etc.) which are most intense in the port-adjacent communities and metropolitan hinterland of the port, and the benefits of port activity (trade, economic specialisation, etc.) which are widely dispersed across the globe (Hall, 2007; OECD, 2014).

Secondly, the spatial scales in which actors attempt to shape the port-hinterland connectivity system are not fixed or static. As the size of ships has grown, they have been matched by more productive but also larger terminals to deal with surge and storage. Such pressures on terminal space and the hinterland are relentless. Yet, the desire of one group of actors to have the rest of the system match the speed-up in their part of the system unleashes political processes with uncertain outcomes. Terminal operators and port authorities should not expect the metropolitan area to simply accept their wishes. Table 1 highlights that vibrant urban economies necessarily involve multiple actors, interests and politics, while the network metaphor in Table 2 highlights the influence of these actors.

Still, the institutional arrangement of sub-national government does influence the ways in which port-related activities relate to the metropolitan hinterland. For example, in his book on Chinese port cities, Wang (2014) makes the compelling argument that port development is pursued by the local state (whether it is municipal, provincial, or special status jurisdiction) to support manufacturing-based land development. In this context, ports and the surrounding infrastructures and land uses are often well integrated. But, because the distances are short, the mode share of trucking in most Chinese port cities is disturbingly high, which is especially troubling from a local environmental perspective when the age and condition of the truck fleet is considered (i.e. this is a wicked problem!). In Dalian, the Chinese port with the best rail infrastructure, only 9 000 of 349 000 containers handled by rail are international (Yang, 2016), which implies that just about every import-export container is trucked within the city.

In so-called post-industrial contexts, local governments may not see value in logistics land development; this is manifestly the case in Vancouver, where a relatively weak regional authority (Metro Vancouver Regional District) has fought an uphill battle for several decades to slow the conversion of industrial land to other urban uses. Still, the recent Regional Growth Strategy (Metro Vancouver, 2011) is an impressive attempt to secure collaboration amongst 24 municipalities to protect industrial lands when every one of them could add more value to their property and revenue base, while receiving fewer neighbourhood complaints, by rezoning from industrial to residential development. The Vancouver port authority added their voice in support of this strategy, as did port industry actors.

In many metropolitan regions, a patchwork of land-use approaches to logistics is common. As the case studies of Chicago, Los Angeles, Paris, and southern Ontario in Hall and Hesse (2013) reveal, competition between local governments to attract/resist wanted/unwanted logistics land uses contributes to their fragmented (and fragmenting) insertion into metropolitan space. Too little competition for logistics land uses results in the concentration of negative externalities in the poorest areas; too much competition for

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logistics land uses undermines the goal of high volume, environmentally efficient, rail and waterway corridors. Monios (2014) makes a similar point in his comparative study of inland terminals (and their port connections) in Spain, the Netherlands, the United Kingdom and the United States, presenting a strong case for modest state intervention, inter-governmental collaboration and strengthened planning frameworks.

When looking to craft market-correcting solutions, the spatial unevenness, scale and jurisdiction problems quickly translate into problems of attribution and intervention. We should expect to struggle to find existing governing institutions whose jurisdictions are well-matched to those of either the polluter or the polluted. Likewise, society-wide optimal outcomes are not necessarily locally-optimal outcomes (cf. Rittel and Webber, 1973), hence creating a requirement for targeted mitigation and compensation schemes. In practice, these interventions are difficult to calibrate.

The Port of Long Beach has been wrestling with precisely this problem. As they have tried to determine which of the local negative impacts (especially particulate matter and other criteria air pollutants, congestion, noise and water quality) of the port require compensation, they have struggled to define which impacts would not have happened without the port being there. In part, this is a technical question since many impacts are difficult to quantify, diffuse and variable (ICF International, 2016). But there is also an institutional and political dimension to what is counted as a (positive or negative) impact of port activity. To illustrate the dilemma, here is an extended quote from the *draft* July 2016 Port of Long Beach Community Impact Study which was designed to identify the geography of impacts and mitigation:

> *Direct impacts are impacts from land over which the Port and the Long Beach Board of Harbor Commissioners exert control, as well as impacts from Port-related sources originating from or destined for the Port. In accordance with CSLC guidance, the Port cannot use public trust revenue to mitigate impacts associated with third-party operations on non-Port property, such as container storage yards or warehouses. These uses may indeed cause negative impacts on the community, but these impacts cannot be directly attributed to the Port. According to the CSLC, "[a]ctivities by third parties on property not under control of the Port are the responsibilities of local, state and federal government bodies with jurisdictions over those activities" (CSLC 2008). For this reason, the CIS does not analyze impacts from such ancillary port uses. (ICF International, 2016: 1-4)*

The lesson I take from this quote is not that the approach of the Port of Long Beach or the CLSC is right or wrong, but rather to appreciate that feasible interventions to address the negative externalities of port activity and improve traffic planning require institutional authority. Hence, we could propose that the reason why we have seen more action to address gate queuing and terminal turn-around times in container ports around the world, but rather less attention to off-dock container storage yards and trucking parking issues – both of which generate community opposition to port activity – is that the terminal operators and port authorities are more willing and able to intervene in the former instance.

This proposition is both pessimistic and optimistic. On the pessimistic side, it implies that we still struggle to find planning solutions that reduce the conflicts which arise out of the negative externalities of the port hinterland connectivity system, and so improve their overall efficiency. Solutions are partial and temporary, and they often run the risk of displacing negative impacts elsewhere within metropolitan space. On the optimistic side, we are given a strong reason to seek solutions where the interests of public and private actors within the hinterland transportation system coincide. Recent research emphasising that some seaport and inland terminals exist in mutually reinforcing dyads is important. Hinterland distribution networks are structured through the interests of many actors; governments,

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landside transport providers, terminal operators, port authorities, inland facility developers, communities, and more (see Table 1). But some nodes and links are dominated by relatively few powerful actors, with the potential to sustain high-volume, efficient corridors.

Wilmsmeier et al. (2011) make a useful distinction between two types of such port-inland terminal corridor systems, based on how they are initiated: "Inside-Out, whereby inland intermodal terminals seek greater integration with their sea ports, often driven by public body intervention. By contrast, Outside-In development is displayed by the conscious use of an inland node as a tool for sea port actors (whether port authorities or terminal operators) to expand their hinterland and capture discretionary cargo" (1379). When such corridor systems achieve market dominance in particular origin-destination pairings, they may come to resemble the pipeline metaphor after all, in the sense that they may be characterised as relatively bounded systems. When such systems achieve economies of scale at the inland terminal, they can concentrate flows and out-compete the default competition (i.e. trucking).

In other words, the creation of new institutional arrangements and organisational structures which transgress existing spatial scales and jurisdictions may be a necessary (though likely not sufficient) condition for improved traffic planning in the port hinterland.

The potential and limitations of "internalisation"

One way of thinking about why some port and inland terminal dyads have succeeded in supporting high-volume rail and inland waterway corridors is that they have internalised the latent economies of scale in those less polluting modes. This is in contrast to what happens when container terminals achieve higher throughput by imposing costs on the surrounding city; whether it is by causing trucks to queue/idle at the gates, or by demanding roadway investments that come at some opportunity cost, or by externalising their surge and storage functions onto the local road network and urban lands. How far can internalisation take us in improving traffic planning in port cities?

Many of the urban problems associated with ports can be conceptualised as negative externalities – air polluting emissions, noise, dust, light and other impacts from ships, terminal activity, trucks, trains and barges which exert a negative effect on others who are not parties to the cargo handling transaction. A negative externality exists when those creating the unwanted effects do not experience the full costs of them in the price they pay, and so they consume more than might be regarded as socially optimal. Economic theory indicates three approaches to dealing with this situation.

The first approach, associated with economist Ronald Coase is to ensure that property rights are fully specified. In practice, this is almost impossible to achieve. If the only people affected (positively or negatively) by a port's activities are the citizens of a port city, then vesting ownership of the port with the municipality might create an appropriate institutional mechanism for internalisation. To some extent this is what happens under the joint municipal-state shareholding arrangement for the Port of Rotterdam, and there surely would be reduced port-city traffic conflicts if municipalities had a stake in the financial success of their ports. But, it is equally important to recognise that Rotterdam is in a competitive port range, and there is active involvement by the national state to curb local rent-seeking behaviour. As the Long Beach example above illustrated, in practice, assigning property rights in a complex urban system is

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difficult, since air and water pollution show little respect for jurisdictional boundaries. Coasian contracts are difficult and costly to negotiate and enforce; one affected community could hold out for a better deal, and the incentives for one polluter to free ride while their competitors bear higher costs is great. It is worth emphasising that these co-ordination challenges are multiplied in complex urban systems.

Coasian solutions may work when there are relatively few actors and localised externalities. One example in which a Coasian-type solution has proven highly effective is the establishment of a property right to queuing time for port truck drivers. In Vancouver, under the recent dispute settlement, truckers with a reservation are compensated if they have to wait longer than a specified time (90 minutes) at the terminal gates. Hence, regulation essentially enforces a property right to their time. The establishment of this right has important quality of life and earnings effects for truck-drivers, and it may also reduce other negative environmental externalities resulting from idling trucks. To the extent that it results in more efficient terminal operations, we could also speculate that it may have positive effects on drivers' behaviour who are less pressed to drive faster in order to make up for lost (uncompensated) time spent waiting at the terminal. However, the potential for regarding driver time as a property right might cause terminals to vertically integrate port trucking into their operations. While this might be good for the (now salaried) drivers, it comes with a cautionary note from De Borger and De Bruyne (2011) who concluded that vertical integration between terminals and port trucking might result in more congestion on the roads around ports if more efficient on-terminal operations displace truck queuing and staging onto the surrounding roadways.

The second approach to internalisation is quantity regulation, without or with tradeable permits. With quantity regulation without tradeable permits, governments regulate the amount of an activity, and through this try to reduce the negative externalities. In a very general sense, the 2006 Clean Air Action Plan of the Ports of Los Angeles and Long Beach can be regarded as a response to quantity regulation without tradeable permits. In order to ensure compliance with federal, state, regional and local air quality standards, and to address the political pressure behind them, the twin ports implemented a variety of strategies to reduce terminal emissions, including cold-ironing, on-dock rail, automation and use of hybrid terminal equipment (Knatz, 2016). Truck appointment (reservation) systems also have a role to play in reducing emissions by reducing idling, and generally smoothing the flow of container trucks in urban traffic (Giuliano and O'Brien, 2007; Huynh et al., 2016).

It is probably the case that most existing environmental and quality of life-oriented interventions aimed at terminal operations and traffic externalities are quantity-based regulations; from the hours of operation of the terminal including gate hours, to the designation of truck routes, to dust, noise and light suppression, to habitat restoration requirements, all are essentially quantity-based regulation mechanisms. We might ask which of have been exposed to rigorous study of their net benefits?

The general problem with the quantity regulation without tradeable permits approach is that polluters have different abilities to reduce pollution, and it may be more efficient to allow pollution per polluter to differ (so that we get more pollution reduction overall per dollar invested). This is likely not a trivial consideration in the port-hinterland context. For example, it is probably less costly to achieve emissions reductions by electrifying marine terminal equipment than it is to electrify or hybridise a port trucking fleet with its widely-dispersed origins and destinations, and the limitations on capturing the benefits of economies of scale in equipment purchase and maintenance, etc. Tradeable permits allow for the establishment of socially acceptable levels of emissions, and an efficient reduction to these levels. Still, because of the spatial unevenness problem, tradeable permits might still leave some of the least powerful citizens living in neighbourhoods disproportionately affected by particulate matter and other pollutants.

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The general point is that choosing and implementing any quantity regulatory approach is not easy, nor free from politics (nor should it be in a democratic society). Again, because of the spatial jurisdiction problem, it is also not a trivial matter to ask which government level should determine the regulatory approach and set the permissible emissions: should it be the local level where the costs of port activity are felt, or national level where the benefits of trade are enjoyed, or some combination of these?

A third internalisation policy option is price regulation through corrective (Pigouvian) taxes. Like tradeable permits, in theory taxation leads to more efficient outcomes than pure regulation: polluters who can more easily reduce their pollution will do so, and policy makers can adjust the tax level to achieve the desired level of pollution. The spatial targeting problem remains: a tax which reduces the amount of overall diesel particulate matter emission may achieve the aggregate desired social level of pollution, but will not necessarily address the spatial distribution of negative effects. However, taxes do have the built-in possibility of generating revenue to compensate for specific spatial effects.

PierPass, implemented by terminal operators in the Ports of Los Angeles and Long Beach is essentially a tax designed to internalise the costs of congestion. While it probably does little to reduce overall traffic levels, it has succeeded in shifting truck trips to off-peak periods (Le-Griffin and O'Brien, 2013). PierPass collects fees per TEU that is picked up or delivered during daytime weekday hours, and uses the revenue to meet the higher costs of keeping gates open at night and on weekends. From the perspective of congestion reduction and terminal operation, the programme may be regarded as a success (Lubulwa et al., 2011). A similar night gate program has been implemented in Vancouver.

Bergqvist and Egels-Zandén (2012) have proposed that green port dues can be used to incentivize the use of high-capacity, hence less environmentally harmful, hinterland transport modes, specifically rail and inland waterways. Their analysis suggests that such policies are most likely to be implemented when the local government is the public owner of the port: "(t)he local government in such a situation has many incentives to act as well as power, moral legitimacy, proximity, and potentially urgency, and other salient stakeholders are unlikely to take an active negative position against it" (90). Even though such policies have scarcely been implemented, Bergqvist and Egels-Zanden's analysis resonates with the arguments of this paper in that they pay attention to understanding which stakeholders will support the initiative under given circumstances, and also because of their attention to the spatial dimensions of who can and should take leadership. Indeed, they supplement their core proposal with the observation that "(t)o increase the feasibility of differentiated port dues, a regulatory framework of a larger area as opposed to a single port authority would minimise distortion of competition and large inter-port shift of volumes" (90).

Internalisation strategies have their place in improving traffic planning in port cities, particularly regarding levelling the playing field between trucking and less environmentally damaging alternative modes. Vigorous road and carbon taxes might not address all port-hinterland connectivity dilemmas, but they surely would help. However, internalisation strategies also have their limits. In practice, internalisation through property rights is difficult to operationalise, and may have perverse unintended effects. Direct regulation is widely used in the port-city context without consideration to efficiency, while tradeable permits and taxation schemes are bedevilled by the problems of spatial scale.

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Emerging practices and strategies

In the previous sections, I argue that improved traffic planning for port-hinterland connectivity is complex and political; it is a wicked problem. There are many actors with a stake in the issue, and in many cases, their interests run counter to the immediate interests of those directly involved in port container transportation. This is not to say that action is impossible, but rather to recognise that traffic planning is never quite finished. Partial, incremental and temporary improvements are achievable when they are part of an on-going governance process that promotes discussion, exchange and learning.

I argue that the metaphor we use to describe how these actors are related to each other makes a difference to how we define and understand the challenge, and it may also inform who we include in decision-making processes. The network metaphor best captures the breadth of actors who may influence the conditions for port hinterland connectivity, as well as the idea that transport actors always seek to maintain some degree of flexibility in the nodes and links they use. Urban areas provide an environment rich in such network opportunities, but for this very reason, the port's relationship with its immediate metropolitan hinterland is complicated and typically conflictual.

The spatial distribution of the costs and benefits of port activity further complicate the tasks of attributing impacts, distributing mitigation and compensation, and identifying institutional actors with the willingness and ability to overcome the inevitable collective action problems. Strategies to internalise the externalities of port activity are vital, yet they are also limited by the spatial dynamics and other complexities that come with an activity that has multiple connections to the urban economy.

In this context, governance frameworks that include all the relevant actors in the search for collaborative solutions to improve traffic management and planning, but that also have the institutional power to enforce them, are probably more important than any one single intervention. In that spirit, I will conclude with an observation about some common elements of the most promising strategies that are emerging in port-city-hinterland connectivity around the world.

In the places where maritime and inland terminal operators, and the transport providers which provide the connective linkages between them, have come together to internalise the costs of some externalities, they have done so because they have been prompted by the political intervention of key stakeholders. For example, the PierPass system in Los Angeles and Long Beach really was a pre-emptive action by terminal operators to avoid even more stringent and potentially unworkable regulation from the state agencies (Giuliano and Linder, 2013). These state agencies in turn were responding to pressures from locally elected representatives, who in turn were responding to the needs of their constituents (Hall, 2007). Likewise, the reservation system, and subsequent actions in Vancouver to compensate truckers for waiting time was the result of strike action by truckers.

We have not yet seen the container terminal operating industry take proactive leadership alone in traffic issues beyond the gates, and perhaps this would be an unwelcome intrusion in an urban democracy. However, there are interesting and important examples of action by public authorities, often in partnership with private actors, of traffic planning that works for multiple interests (Table 3).

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Table 3. Emerging better practices for traffic planning in port cities

Category	Examples
Planning	Permanent forums for information exchange and learning Include wider range of non-cargo, non-transport actors in supply chain planning Include wider range of cargo, transport actors in general land-use planning Collaborative multi-sector regional planning
Pricing	Carbon fuel taxation/pricing Eliminate implicit road transport subsidies Compensation and mitigation, sensitive to spatial distribution of impacts
Mode and system	Support rail and inland waterway modes Eliminate (reduce) empty loads Clean truck and late model programs, hybrid and electric technologies
Land use	Industrial land preservation, especially large sites with rail/waterway access Neighbourhood truck parking management Colocation of functions, such as transloading and empty storage
Hinterland routes	Preserve and enhance freight rail corridors and inland waterways Buffering along truck and rail routes Grade separations and crossing improvements Dedicated and appropriately priced truck routes
Terminal gate	Reservation/appointment systems Wait time compensation Dedicated staging space and roadways Night and weekend gates

In a recent study of inland terminals along the Rhine-Alpine Corridor, Witte et al. (2016) note that inland ports are increasingly recognised as important to enhancing the hinterland accessibility of deep-sea ports using high-volume transportation means. These outside-in developments, to use Wilmsmeier et al.'s (2011) terminology, are being undertaken by competing port authorities and terminal operators. As might be expected, the more successful these terminals are in terms of throughput, the more they find themselves in amenity and land-use conflicts with their host municipalities. After comparing municipal governance strategies in four different countries along the corridor, Witte et al. conclude that the more successful strategies involve high levels of interregional co-operation, and a willingness to engage private sector and civil society stakeholders in collaborative planning processes that reach beyond the formal jurisdiction of the individual inland port authority and hosting municipal government.

Similarly, in their case study of the Port Authority of Barcelona, Van den Bergh et al. (2012) argue that the public authority had to take the lead in order to stimulate new rail connections to develop the port's hinterland connections in a more environmentally friendly way. The Port Authority had a well-developed hinterland strategy that included the development of a network of inland rail nodes, and made investments in rail shuttles which the authors regard as a best practise.

Finally, the Asia-Pacific Canadian Gateway and Corridor Initiative has been most successful – from an urban traffic planning perspective – when its infrastructure investments have been compatible with local quality of life concerns. For example, the Robert's Bank Rail Corridor has replaced several grade crossings with overpasses that improve rail efficiency and commuter safety. In contrast, conflicts with municipal governments and communities have typically been associated with unwanted road expansions and land uses (Hall, 2014). On the land use side, the commitments to industrial land preservation in the Regional Growth Strategy (Metro Vancouver, 2011) are an important but temporary achievement; we do not yet know how vigorously the plan will be enforced, nor how it will deal with the inevitable land use

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pressures. With regards to roadways, in some ways, the Gateway was a victim of its own success when the Provincial government tied its own "Gateway Program" to the federal initiative. The provincial version placed much more emphasis on highway expansions for suburban commuters; in the confusion over which gateway was responsible for which impact, the federal government and port authority found themselves the target of municipal, environmentalist and community opposition.

Importantly, in the Gateway there was belated recognition of these problems, and a demonstrated ability to learn and adapt. In 2011 the "the Asia Pacific Gateway Skills Table (APGST) initiated a study to identify the resources and information required to improve the level of awareness, understanding and integration among those responsible for planning as it affects the Asia Pacific Gateway" (APSGT, 2012: 8). In keeping with the spirit of this paper, the APGST report called for improved "awareness and understanding among regional and municipal governments", and improved "integration of planning for the Canada's Pacific Gateway with regional and municipal planning" (12). The document was an important recognition by Gateway proponents that "traffic planning" for hinterland connectivity in port cities has to involve municipalities, as well as other local non-transport actors.

More generally, we need to recognise that ports are inserted as vital, but not monopolistic elements, within urban economies, polities and communities. Precisely for this reason, terminals and port authorities cannot address their traffic planning challenges alone. The goal of traffic planning for container port systems of the future cannot simply be to speed up the flow of trucks through the terminal gates; rather, it has to be about the hard work of finding synergies between port and city.

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International Transport Forum

Traffic Planning in Port-Cities

Port container trucking is currently one of the most challenging aspects of the love-hate relationship between ports and cities. This paper highlights important examples of emerging good practices at and around the marine port terminal. Hinterland connectivity and landside productivity are increasingly important for port performance. Yet conflicts over congestion, pollution and other negative impacts of container traffic are an increasing source of tensions. Managing these tensions requires a clear understanding of the issues and identification of the stakeholders involved in the transport system of the immediate port hinterland.

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