SMART PORT CONCEPT APPLICATIONS FOR PORT HINTERLAND INTERMODAL NETWORK OPTIMIZATION

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ABSTRACT

The growth in container volumes and the concentration of container flows on a limited number of hubs, along with the increasing vessel size, requires the development of new terminal infrastructure at ports enabling them to handle the latest generation of vessels. Moreover, this fact highlights the pressure created by such vessels on the terminal cargo handling capabilities, where those larger vessels will definitely require higher capacity in terms of hinterland transportation. In other words it will require rationalization and better use of existing transport alternatives to reduce both congestion and environmental impacts. Port authorities should take into their consideration, when developing terminal infrastructure, the effects those increasing traffic volumes will have on the existing infrastructure.

Since ports mostly cannot expand its area forever, better organized port processes and transport flows could significantly enhance port competitive position. This highlights the issue of how could the raising importance of hinterland characteristics affect the port position under the Smart Port Concept holistic perspective in regard to enhancing port operational effectiveness and developing hinterland connections that eventually viewed as driving force for the economic development which by its turn could bring eventually a net positive contribution to the Arab Region.

This paper focus on how Smart Port Concept implies for smarter infrastructure for container ports and thus raises the question of how to handle increasing container volumes in the shortest conceivable time in an area of relatively constant size? This is only achievable through deploying and utilizing the latest hinterland infrastructure design. The paper introduces modern hinterland intermodal transport management under the Smart Port Concept regarding port operational efficiency and sustainable development, focusing on the challenges that the development of container terminal infrastructure through Smart Port Planning is likely to bring to the local communities. Recommendations and a set of good practices are provided.

Keywords: SMART port concept, hinterland connections.

INTRODUCTION

Sea port-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 the light of SMART holistic concept and proposes some steps towards a further integration between seaports and the hinterland. The key point 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 competitiveness of a seaport depends on the extent the cargo handled in the port can reach its hinterland destination The importance of hinterland connections has been recognized as one of the most critical issues in port competitiveness and development in most ports around the world. Upgrading of facilities and equipment, privatization of port operations and increased sophistication of berth planning has resulted in drastic reduction of ship turnaround times over the last decade. The smoothness of port-hinterland connections has not followed at the same pace. Increasing ship vessel size – and the related emergence of maritime hubs and spokes – will only exacerbate the bottlenecks related to port hinterland connectivity. One of the main issues related to the development of adequate hinterland connections in ports is the need to coordinate multiple actors often with conflicting mandates that constitute the mêlée of private and public institutions governing port hinterland infrastructure development.

The critical role that container infrastructure plays in favoring the economic development of a country or region is well established. Infrastructure is the necessary condition for efficient cargo handling operations and adequate infrastructure is needed to avoid congestion, foster trade development as well as securing deep-sea container connectivity for economies heavily dependent on international trade. Container infrastructure, however, needs to be complemented by efficient hinterland transport connections if the port is to fully exploit its potential as growth catalyst and supply chain node.

The expected increase in transshipment associated with larger vessel size, is likely to impact on the terminals not only forcing them to handle higher volumes in the same period of time, but also to reduce the variability of their operations (i.e. increase reliability) in order to guarantee seamless flows of cargo among transshipment ports and/or transshipment port and feeder ports. The increases in productivity and reliability at terminals will require more tracking, greater container visibility and more emphasis on environmental and regulatory compliance particularly as terminals now occupy critical positions the supply chain.

The development and expansion of container ports therefore needs to be supported by good hinterland transportation and adequate provisions must be made for rail or road capacity if the container terminal has to function and add value. Typically the port hinterland logistics chain processes can be segmented in terminal gate processes, the hinterland transport processes and dry ports. Hinterland transport should be divided into road, rail and inland waterways. Considering that with some noticeable exceptions, inland waterways play a limited role in most ports, less attention has been devoted to this mode.

Each of these hinterland logistics chain components plays a critical role in ensuring that the terminal delivers its supply chain value. 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. Terminal managers, public authorities and logistics service providers need therefore to embed the sustainability of the container hinterland process in the terminal expansion and development plans. These processes start at the terminal gate, and include inland transport to a dry port and beyond.

SMART Port Gate Management

Container terminals are Transmodal facilities whose efficiency is dependent on the execution of distinct but interconnected processes. Typically container terminal processes are subdivided into three groups: waterside, yard and landside. While it is not unusual for container terminals to perform deep-sea or feeder transshipment operations, most terminals have at least a small percentage of gateway traffic, i.e. containers that are trans loaded from container ships through the yard and eventually to some mode of land transport and vice versa.

The intensity and complexity of landside activities vary considerably depending on the size of the terminal, the type of transportation infrastructure available in the region and the operations technologies used on the terminal.

Larger terminals tend to rely on a mix of rail, road, and, when available, barge transportation to the hinterland. Road transport, however, remains one of the main hinterland transportation modes in view of its flexibility and the possibly of trucks going virtually wherever there is a road.

The port gates are one of the most critical pieces of terminal infrastructure where a large part of technical and administrative procedures take place. In addition to separating and protecting the terminal from the outside, terminal gates also act as administrative border for custom and other legal procedures and function as the interface between the terminal and the hinterland. Furthermore, since the overall efficiency of a terminal is dependent on the efficiency of its subsystems, terminals are particularly wary of delays at a gate. Gate operations are often the result of a coordination effort between the terminal and shippers, drayage and rail operators, freight forwarders and port authorities.

For this reason the efficiency of gate operations has been investigated extensively, especially in relation to trucking operations, in the attempt to improve their performance, eliminate congestion and bottlenecks or reduce negative environmental externalities. Gate systems can be grouped in three major types: ‘first come first serve’, appointment systems and time window systems. Most terminals use a ‘first come first serve’ policy, where container trucks are loaded or unloaded depending on their arrival time at the terminals. One of the major disadvantages of such method is that it often generates peaks in operations and queuing ensues.

In order to resolve the complexities associated with terminal gate management and to reduce congestion in the proximity of the port, the extended gate concept has been proposed as an alternative to direct trucking operations at the port. The extended gateway would allow truck operators to move containers to a hinterland location, ideally making use of barge or rail connection. In this way the terminal would reduce congestion at its gates as well as reducing pressure on its yard capacity. The concept has been associated with that of dry port, which will be discussed more in detail later.

At the basis of the dry-port concept is the ability to relocate some loading and unloading operations inland in order to exploit economies of scale from route density and reducing external costs. As synchronization of container terminal activities across the supply chain allows terminals to increase their competitive advantage. The extended gate concept then is based on the possibility for the terminal to perform its gate activities at the inland terminal. The transportation to the inland terminal is then internalized by the terminal operator, which then is in a position to move larger volumes by rail or barge inland.

Some of the issues associated with the extended gate concept are related to the terminal location decision the coordination of container movements (e.g.

different containers arrive and are requested by their customers at different times), the connectivity of rail or barge transport, information exchanges, network design and administrative (e.g. customs) procedures. The growth of vessel sizes, as outlined in the introduction, requiring container terminals to find alternative and more innovative ways to handle container flows at the terminal gate and the extended gateway could provide a valuable option.

SMART Gate Management Practical Considerations

The efficiency and effectiveness of a gate operation system depends on the availability and characteristics of IT systems employed at the terminal, the degree of coordination and information exchange among operators, labour regulation, safety and security policy at a terminal level as well as truck labour regulation. It is expedient to focus on three main practical considerations that might affect the efficacy of specific gate management systems:

- ***IT infrastructure:***
  There is the need to provide accurate and on time information. Data exchange is instrumental not only for allowing coordination among hinterland transport actors, but also to ensure visibility in the chain for efficiency, security and planning purposes. As the role of ICT in terminal management is critical to ensure efficient operations. Gate systems typically operate as part of a multipoint system, where information on the container manifest, the cargo or the truck driver can be collected and linked to the terminal EDI system. Increasingly container terminals make use of advanced identification technologies for security and efficiency reasons, and these are an essential component for integration along the supply chains. Challenges on the implementation of ICT at terminals and ports are well documented also in developed markets, and cooperation or joint ventures might be a possible solution to reduce them.

- ***Labour regulation and trucking industry practices:***
  The implementation of a gate appointments system that might appear as a feasible way to improve container terminal gate efficiency faces challenges often related to labour regulation, working practices in the industry and inherent difficulties in managing the process. The applications of a gate appointments scheme appear to have been more successful when there has been a stronger action from the side of the regulator, but in general, with a few

exceptions, have not delivered the expected benefits. Labour regulation and industry practices, such as opening hours of distribution facilities and customer warehousing, remain a critical factor for the efficiency of gate systems.

- ***Security and custom procedures at the terminal:***
  Security and custom regulation can impose substantial delays in the operation of the terminal and it is therefore vital that coordination with the agencies responsible for these activities is negotiated and security practices are embedded in terminal gate management. Literature now exists in the area of security for container logistics, but major issues remain with reference to the impact of scanning procedures, ISPS code or terminal operation resilience. From the analysis of previous studies on container terminals it appears that security has a negative impact on the operational efficiency of terminals, especially through inspection regimes, although the nature and scale of this impact depends substantially on the type of regulation and security strategy of the terminal.

SMART Hinterland Logistics and Infrastructure Development:

Of the various factors influencing the competitiveness of a port, the quality of transport infrastructure across its hinterland is one of the most critical. There have been numerous examples of new port developments under-performing because of a lack of investment in supporting transport infrastructure. This is hardly surprising as good hinterland connectivity is one of the key criteria than shipping lines, shippers and logistics service providers take into accounting in deciding on their choice of port. This connectivity can be measured in several ways, by the:

1. Density of inland transport networks,
2. Accessibility to key industrial and logistical centers – measured by transit time and transport costs,
3. Range of modal options available to carriers,
4. Capacity of the main corridors,
5. Reliability of deliveries across the hinterland.
6. These aspects of connectivity are clearly inter-related. Inadequate capacity, for example, causes congestion which in turn impairs reliability. This inter-relationship between capacity, congestion and reliability is fundamental to the planning of hinterland transport networks. It has become increasingly important as a result of six major trends:

- The tightening of logistical schedules as companies have cut inventory levels and compressed order cycle times. This has made their production and distribution systems more vulnerable to delays at a time when globalization has extended their supply lines and made them more dependent on deep-sea container services.
- The rapid growth in container traffic that has occurred mainly as result of trade liberalization and the globalization of manufacturing and procurement strategies.
- The sharp increase in the size of container vessels which is causing inland flows to spike and create bottlenecks at weak links on hinterland networks.
- The concentration of production capacity and inventory in fewer locations as companies seek economies of scale. This is consolidating container flows on key corridors, which often lack the capacity to cope.
- The adoption of ‘slow steaming’ by container shipping lines, primarily to cut bunker fuel costs. To compensate for the lengthening of transit-times on the maritime leg, shippers are keen to accelerate hinterland transport and improve its reliability to minimize adverse effects on production and distribution schedules.
- The shift in the balance of costs between deep-sea and hinterland transport. As increasing vessel size reduces cost per TEU-km on the maritime leg, the share of total door-to-door costs attributable to hinterland transport increases. The share is further inflated by rising energy prices (as the energy- intensity of hinterland transport is significantly higher than of deep-sea shipping) and deteriorating reliability on congested hinterland networks.

These trends emphasize the importance of logistics to the planning of hinterland transport, a subject that has attracted significant academic attention over the past decade. Much has been written about the transformation of ports from basic transport terminals to supply chain hubs in an effort to extend their range of value-adding services. In pursuit of added value shipping lines have also diversified into land-based logistics. Another aspect of this ‘logistification’ of maritime transport, which has so far generated less interest, is the alignment of hinterland infrastructure planning with the changing geography of companies’ logistics systems. In many countries the interface between the container shipping network and shippers’ supply chains has been changing, altering the pattern of container movement within national markets. As keeping ports competitive in this new regime requires ‘coordinated action, both within existing supply chains and between competing supply chains that share the same port–hinterland spaces and infrastructure’.

The pattern of container movement is largely shaped by the locations at which containers are loaded and unloaded (so-called ‘transloading’ locations) and the repositioning of empty containers within the hinterland either to collect an export consignment or to be returned to a port for global redistribution.

SMART port repositioning of empty containers

Marshalling the stock of empty containers is one of the greatest challenges of containerization. In almost every country it is considered very inefficient, though the degree of sub-optimality is very difficult to assess given the lack of data on empty container movements. It is common, for example, for containers emptied at an import location to be returned to the port prior to dispatch to an export location to collect its next load. Where ‘triangulation’ occurs within the hinterland, the routing is often needlessly circuitous. Even where container loads are received and generated by the same factory or warehouse, the chances of an inbound container being reloaded with an export consignment are often quite limited. As a result of these practices:

- Container turnaround times are lengthened.
- Shippers are often unable to get an adequate supply of the specific types and sizes of container they require when they need them.
- Much unnecessary transport is generated across the hinterland, increasing traffic levels, costs and emissions.

Inefficiency in the landward repositioning of empty containers has persisted for a several reasons, including poor IT, the refusal of shipping lines to share boxes, tight demurrage restrictions and a general lack of co-ordination between stakeholders. The concept of the ‘grey box’ has long been advocated as a means of pooling empty container capacity and thus rationalizing the movement of empty containers across hinterlands. There are few examples, however, of it being successfully or sustainably applied. The adoption of PCL would also help to ease the empty repositioning problem, though, as discussed earlier, this may prove to be attractive to limited numbers of companies with specific logistics requirements.

An alternative, or supplementary, option would be to use some of the empty container capacity in the domestic distribution of industrial and retail supplies. This would entail greater integration of maritime and domestic logistics within the port hinterland and some relaxation of current restrictions on the use and return of containers. It could lead to containers being increasingly used to carry domestic loads on routes back to the port or to an export location. In those countries where much of the hinterland movement of containers is handled by merchant haulage, shippers have a strong interest in maximizing revenue from container repositioning trips, incentivizing them and their carriers to find backloads. Online load matching sites can facilitate the search for suitable backloads, though the deployment of empty container capacity in domestic logistics also requires the adaptation of handling systems and reception bays at industrial and commercial premises. Overall, as in so many aspects of hinterland transport, there would be a need for much greater co-ordination between all the relevant actors to take full advantage of this proposal.

Rationalization of the movement of empty containers across the hinterland would ease infrastructural pressures on key routes to and from the port, particularly where repositioning regularly entails the routing of boxes via the port terminal.

SMART hinterland transport:

Intermodal freight transport means the transportation of freight inside the intermodal container or trailer by using different types of transport modes (rail, ship and truck). Intermodal transport has numerous advantages in logistics, for instance: it simplifies the logistics chains, reduces cargo handling, and improves safety damage or loss of the cargo inside the container or trailer. Intermodal transport, compared to the other different transport, reduces transport costs and greenhouse gas emissions. It has a high ratio in the world transport trade and is still rising up.

Because of the importance of intermodal freight transport, the ports along the world spread up the intermodal port services. For handling high volume of containers (trailers...) in the ports a high capacity infrastructure is needed. The containers could be loaded/unloaded directly from the train/truck to the ship (or reverse/and vice versa). High capacity container ships could be loaded with 10,000 to 15,000 TEUs. For that type of ships a storage area near the container terminal is needed with a numerous railway sidings for container trains.

The containers could leave the port by train, truck or by ship. A lot of ports include also transshipment – a container is handled from one ship to another ship. For the transshipment additional storage area should be available. For the movement of containers from the port to the hinterland terminals (final customers) railway or road transport is used. Containers could be also transported by the barges at the river transport (inland waterways).

To protect the environment the containers should be transport to the hinterland terminals by rail. One train composition (rail wagons) could replace around 50 road trucks. It is necessary that the ports should increase the share of containers transported by rail. To reach that goal, the existed port and hinterland railway infrastructure should have enough capacities to carry a huge amount of containers (TEUs).

In order to reduce congestion on road transportation and to exploit the economies of traffic density one of the solutions that is most often advocated is to increase the share of rail and inland waterways to that of trucks. These two alternative modes of transport offer substantial cost and environmental advantage, but are generally less flexible and require increased coordination as multiple private operators and public agencies need to cooperate harmoniously. This coordination does not come about spontaneously, but requires specific policy action.

Given the complexity of rail coordination, the potential for a switch to rail for transportation to/from container terminals is dependent on the institutional model that is used for rail in a particular country. Railway infrastructure and operational configurations typically are subdivided on the basis of the degree of geographical and functional integration. While there are arguments in favor and against various institutional configuration models, in the specific case of railway access to container terminals the development of dedicated freight corridors often requires the agreement of multiple actors, network operators and the infrastructure developer. Furthermore, in case a mixed network, i.e. networks that cater simultaneously for passenger and freight transport, the relations with the passenger rail operator can become a critical factor. KPI relative to the operational issue under the SMART port concept:

- Magnitude of the rail infrastructure (Total sidings in port area (Km)/Total terminal area).
- Use of the intermodality-railway option (Total TEUS transported by rail/Total TEUS).
- Use of the intermodality- road option (Total TEUS transported by road/Total TEUS).

Main challenges and added values in rail hinterland transport

Coordination in hinterland railways does not come about spontaneously, but requires specific policy action. Difficulties in coordination emerge as a result of the multiple actors being involved in developing and planning of container rail transport infrastructure.

This paper; based on previous studies, lists some of the coordination problems arising in container rail transport, specifically: unused capacity and congestion often combined in the peak-load problem, delays due to limited planning on rail terminals, and limited exchange of traction and of rail cargo. Yet, the paper also summarized the key suggestions that former studies and researches concluded. There are four major ways in which such coordination can be improved:

- **Introduction of incentives:** through the development of a reward or penalty systems, differentiated tariffs or capacity auctioning;
- **Creation of inter-firm alliances:** through joint ventures, project specific contracts or other forms of vertical cooperation along the chain;
- **Organization scope change:** introduction of mechanisms for risk sharing or integration along the chain;
- **Collective action:** through governmental intervention or private intervention.

In order to understand the challenges associated with the use of container terminal transportation by rail to and from the hinterland of a port, it is important to distinguish between three interlinked but distinct issues:

1. ***Value for the users***
   Container rail transportation will be valuable as long as shippers can gain some form of benefit from using rail transport. In recent years the question of the competitiveness of intermodal chains has emerged. In addition to clear environmental benefits that can be obtained from using rail transportation, the question remains about whether reliability and cost savings can compensate for the greater flexibility offered by road transportation.
2. ***Rail service quality and price.***
   The attractiveness of the rail link depends on the pricing policies, the quality of the service and the conditions under which the rail connection is provided. Pricing policies for rail connections are difficult to formulate and typically do not allow for full infrastructural cost recovery. The efficiency of the network, access to terminals and shunting yards, and the interaction with other parts of the network are also likely to influence the reliability and effectiveness of rail transport. In particular marshalling and switching infrastructure, signaling and the degree and availability of electrified tracks and terminals are some of the aspects to be considered to assess the attractiveness of the rail and rail terminal facilities.
3. ***Rail network development and financing.***
   Given the costs associated with the development of railroad infrastructure, the model employed to build and finance the network is also likely to have an impact on operation. While the use of public private partnerships appears quite successful in the development and management of road infrastructure, its implementation in the case of rail or other intermodal infrastructure has been less encouraging. This implies that the development of new freight rail infrastructure typically require a certain degree of public funding. This is

particularly true in the case of vertically separated railroad networks. Dedicated rail corridors in areas with predictable and stable volumes might prove more attractive, but typically infrastructure recovery times are longer than what the private sector is willing to accept and, given the economies of scale associated with rail infrastructure development, private financing may result in under-provision or under-maintenance.

INTERNATIONAL EXPERIENCES

In Europe, policy has aimed at separating infrastructure management from passenger and freight operation, in the attempt to overcome the natural monopoly held by nation-wide integrated rail networks. The transition from national railway monopolies to an integrated network of nationally-managed infrastructure and European-wide rail operators is far from completed. The reform has favored the development of dedicated railway companies especially in the vicinity of larger ports. The number of container shuttle services has been rising and is expected to increase in response to environmental and economic pressures. In particular the development of dedicated freight corridors, such as the “Betuwe Route” in the Netherlands, with more than 350 trains per week, or the “Iron Rhine” in Belgium, that contributes to the 200 container trains departing from Antwerp weekly, aim at improving the conditions for rail transportation.

A particularly successful case relates to the development of hinterland cargo movement by rail from the port of Hamburg and Bremen to their hinterland. In Hamburg the port railways network is managed by the Port Authority and is responsible for the movement of 2 million TEU along the 300 km network (Hamburg Port Authority 2012). 92 operators are licensed to use the port rail infrastructure and this account for over 30 per cent of Hamburg container flows handled by rail (against the 10% handled by Rotterdam and Antwerp). The port is handling today approximately 200 train per day that is expected to double in the next decade. The port of Bremerhaven has the highest percentage share of container rail transport, with over 45 per cent of container throughput being moved inland by rail.

In the case of Russia, railway reform is currently underway, with the intention of establishing some form of vertical restructuring and some cross-subsidization between freight rail transport, currently responsible for the very high utilization of railways in Russia and passenger transport. The intention behind rail reforms in Russia, and elsewhere, are lowering national government contributions to the sector, increasing the sector efficiency and providing competitive options for shippers (Pittman 2013). It is particularly interesting to notice the development of the container infrastructure between the recently built port of Ust Luga and the

Predportovy Distriport and Interterminal Predportovy, as well as other logistics facilities in the area.

The penetration of rail transportation in Asia has not followed the same pattern around the continent with marked differences between the systems used in China, India and South-East Asia. While rail transportation does not show the same degree of efficiency as in other parts of the world, intermodality is becoming increasingly important. The development of Chinese dry-ports is still hindered by congested infrastructure and administrative inefficiencies. The Indian case is characterized by congestion and a very fragmented logistics infrastructure with virtually no rail transportation in South-East Asia.

In North America, rail transportation has for long constituted the backbone of freight movement and the development of an integrated network of dry ports. In particular, the development of freight hubs, such as Chicago, has been made possible by the affordable and reliable rail freight transport connecting large ports to inland satellite terminals and load centers. Issues related to capacity constraints and the difficulties in coordinating expansion among the seven main independent rail operators and the transmodal challenges in Chicago, have started to affect the efficiency of the system.

In the South American railway sector reform has been carried out extensively and completed by the nineties, with Mexico and Argentina leading the way, with Brazil following in more recent times. The system has been characterized by the preference for vertically integrated railroad concessions. The main challenges in those countries for the attractiveness of railway in terms of freight corridors seems to be related to the very high intermodal competition as well as the management of access rights to the main ports, e.g. Santos in Brazil.

ASSESSING THE ENVIRONMENTAL IMPACT OF PORTS

It is the ships visiting the ports, rather than port activities themselves that are the main sources of pollution and the main concern is over pollution by noxious gases rather than CO2 emissions. As road transport has traditionally used lighter, cleaner fuels and been subject to much stricter emission controls than shipping, a wide gap exists in the tolerated levels of pollution from these two modes. Global efforts to reduce levels of maritime pollution, mostly administered by the IMO under its MARPOL program, have made limited progress over the past few decades, leaving it to ports to take the environmental lead and try to improve air quality for their local populations. They can do this, for example, by requiring vessels to switch to cleaner, lower-sulphur diesel fuels as they approach the port and by providing shore-side electricity to ships when moored by a practice known as ‘cold-ironing. By installing ‘scrubbers’ to capture Sulphur emissions some vessels have been able to meet air quality restrictions while continuing to burn bunker fuel. Several Sulphur Emission Control Areas (SECAs) have also been established around world (e.g. on the Californian coast, the Baltic and North Sea) to reduce the permitted level of Sulphur emissions in ship exhaust fumes. Modernization of the fleet with larger, cleaner, more fuel-efficient vessels is also cutting emission levels per TEU or tonne transported, but the longevity and slow replacement rate of ships makes this a relatively slow process.

On the landward side, some ports have introduced ‘clean trucking’ schemes. Some ports with the necessary infrastructure are promoting a modal shift to rail and waterborne transport. The Port of Rotterdam, for example, is planning to shift much of its hinterland container traffic from road to rail and barge by 2030, changing the proportion of containers moved by these modes from, respectively, 49%, 37% and 14% in 2007 to 35%. 45% and 20% in 2030. This is one respect in which the environmental leverage of a port can extend well beyond the direct emissions from port handling activities. By offering a competitive range of rail and waterborne services, which emit much less noxious pollutants and CO2 per TEU- or tonne-km than road, a port can significantly reduce the environmental impact of the wider container supply chain.

Although ports are directly responsible for a very small percentage of the CO2 emitted by the typical deep-sea container supply chain, many are refining their measurement of these emissions, setting ambitious targets for reducing them and implementing a range of decarburization measures (European Sea Ports Organization 2012). For example, by electrifying its rubber-tire gantry cranes, the Port of Hong Kong (2012) has been able to reduce average CO2 emissions per container moved by roughly 60%. While such savings in carbon emissions are welcome they can be far exceeded by improvements in the environmental performance of hinterland transport.

SMART Reduction of Emissions from Hinterland Transport

These emissions can (smartly) be reduced in five ways:

1. ***Rationalizing the pattern of container movement***
   The amount of vehicle movement per container load within the hinterland can be reduced in various ways. This can be done by reducing the number of links in the container supply chain by, for example, adopting a port-centric logistics strategy and repositioning empty containers directly from import to export locations rather than via the port. Even where the number of links remains constant, containers can be more efficiently routed between the various handling and storage nodes in the chain. The resulting reduction in the transport intensity of container distribution translates directly into lower emission levels.

2. *Shifting container traffic to lower carbon transport modes*

In most cases this entails a switch from road to rail, though in some countries, such as Belgium and the Netherlands, inland waterways and coastal shipping provide an important hinterland feeder service. Typically rail and waterborne transport emit between 25% and 50% of the CO2 emissions per TEU of a trucking operation. The magnitude of their environmental advantage depends on a series of factors which vary internationally, including:

- The degree of rail-freight electrification and carbon intensity of the electricity used.
- Restrictions on the weights and dimensions of the relevant trucks, trains and barges.
- The relative vehicle age and emission profiles of the various modes.
- The relative density of the different modal networks.
- The number and locations of intermodal terminals, including dry ports.
- The last of these factors is particularly important as rail and waterway services very seldom provide a door-to-door service and must rely on road feeder movements. This generally makes the freight movement more circuitous and erodes some of the environmental benefit of using rail or water. Nevertheless, the use of intermodal services can still yield substantial reductions in truck-kms, fuel use and emissions. The channeling of container flows by rail to an inland ‘dry port’, rather than by road, has also been shown to offer large CO2 savings.

3. *Improving the loading of vehicles, wagons and barges carrying containers*

If one takes the internal loading of the container as given and measures capacity utilization on a TEU basis, significant potential exists for raising load factors. A survey of container trains leaving UK deep-sea ports found that, on average, only around 62% of the available slots on existing services were filled. In some European countries, 13.6 meter trailers carrying 20ft (6 meter) containers are quite a common sight. Relaxing restrictions on truck length, for example, from 16.5 to 25 meters allows haulers to combine a 40ft and 20ft container on the same vehicle, significantly cutting emissions relative to moving them in two separate vehicles. This, however, conflicts with the modal shift objective, as it substantially improves the price competitiveness of trucking, and can cause a net increase in emissions where much of the rail-based container traffic migrates to road. Where rail infrastructure permits, as in the US and Canada, double-stacking of container trains not only cuts emissions per ton-mile for existing rail traffic, but also helps rail to expand its share of the hinterland transport market.

4. Increasing the energy efficiency of hinterland transport operations

Extensive research has been done on the opportunities for improving the energy efficiency of freight transport, most of which would apply as much to containerized traffic as to other forms of goods movement. Much of this research has focused on the trucking sector which is understandable as it is by far the dominant freight mode and is more energy-intensive than rail and waterborne modes. A common finding of these studies, particularly those on road freight, is that there is a broad suite of technological, operational and behavioral measures available to cut energy consumption, ranging from driver training through aerodynamic profiling to the redesign of the vehicle engine and transmission systems.

5. Powering these operations with cleaner, lower carbon fuels

Like the previous measure, switching to alternative fuels is a means of decarbonizing all forms of freight transport and has no special relevance to the hinterland transport of containers. The potential reductions in noxious and greenhouse gas emissions from freight operations achievable through ‘repowering’ with alternative fuels.

CONCLUDING REMARKS

The development of container terminal capacity needs to be complemented by the expansion of the hinterland links under the SMART port concept in order to enhance supply chain value creation and reduce external costs associated with increasing container flows. The importance of adequate hinterland infrastructural capabilities and efficient transport services to and from container terminal facilities cannot be over-stressed, especially in view of the global trends towards larger container vessels, mounting inter-terminal competition and increasing requirements for supply chain effectiveness.

This paper has focused on SMART hinterland transportation and services, analyzing the various components of inland container transport where improvements can accompany container port expansions. As in the end it is the efficiency of the entire container supply chain, from shipper to consignees, that matters for the success of a container port inadequate hinterland infrastructure and services can be a major bottleneck. The paper argues that substantial improvements under the SMART port concept are possible in the interfaces between the container terminal and the inland transport modes, and through a better use of road and rail transport involving for gate management and empty container management and port environmental impact management.

The increasing importance of sustainability considerations in container supply chains also requires terminals and infrastructure development authorities to take more account of emissions and other external effects, so that the externalities can be actively managed and the economic benefits of increased connectivity are balanced against societal and environmental costs.

It is only through a concerted effort among container terminals, local and national authorities, private road haulers and railroads operators, as well as dry port managers and freight forwarders that the benefits of SMART port applications for hinterland intermodal network both at the port and inland can be maximized.

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