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Empty marine container logistics: facts, issues and management strategies

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Abstract With the global container population exceeding 25 million TEU (Twenty-foot Equivalent Unit) and the annual production of new boxes exceeding 3 million TEU it is estimated that around 1.5 million TEU of empty containers are sitting in yards and depots around the world waiting for use. Although utilization rates have improved since 2004, container utilization depends on the very dynamic nature of container transportation, and the container building and leasing industries. Owing primarily to the chronic trend of increasing trade imbalances across the oceans, and despite recent trends along some trade routes, the empty container management problem has become a major issue for the container shipping industry during the last decade. This paper examines and analyzes empty container logistics at a global, interregional, regional and local level. Special consideration is given to key factors affecting the empty container logistics management and strategies implemented by ocean carriers and other stakeholders to better manage empty containers.

Keywords Empty container logistics · Trade imbalances · Repositioning · Container lessors · Ocean carriers

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Introduction

Empty intermodal container management is one of the most complex problems facing the global logistics industry. Since the beginning of containerization, the industry has seen a general increase in productivity, efficiency, safety, and reduction in cost and service time. Despite these achieved efficiencies, intermodal container transport has suffered from the chronic trade imbalance which creates a need for empty container logistics management, including repositioning at various geographical levels and handling their storage and accumulation in major importing regions.

The fundamental global imbalance of trade between the East and the West as well as the North and the South is considered as the main cause of the empty container handling issues. Additional causes include: tariff imbalance and the related costs of repositioning empty containers from surplus to deficit areas; cost of inland transportation; marginal and volatile profitability of the leasing industry; cost of manufacturing and purchasing new containers in relation to the cost of leasing containers; leasing contract terms; the cost of inspection and maintenance of aged containers; and the cost of disposal (Boile 2006).

The last few months at the end of 2007–beginning of 2008 have seen a decrease of imbalances in major trade lanes with a decrease in import volumes and in some cases increase of exports from main consumption regions, compared to the same months last year.

According to figures published by CI Online in the May 16th 2008 issue, for example, April 2008 TEU imports at the port of Los Angeles were down by 11% while exports increased by 19.5% compared to April 2007. At the port of Long Beach, exports increased by 35% percent during the same time period. Changes in the import/export patterns between regions due to recession and currency exchange rates appear to be the primary reason for decreasing imbalance, as indicated below. However, tight capacity availability due to shifting some minor bulks to containers may be another contributing factor. Projections, however, indicate a continued increase in the overall trade growth and sustained imbalance of trade.

With the global container population exceeding 25 million TEU (Twenty-foot Equivalent Unit) and the annual production of new boxes exceeding 3 million TEU it is estimated that around 1.5 million TEU of empty containers are sitting in yards and depots around the world waiting for use. Although utilization rates have improved since 2004, container utilization depends on the very dynamic nature of container transportation, and the container building and leasing industries. According to the May 7th, 2008 CI-Online issue, containership fleet capacity is 13,335,155 TEU, while according to the same source, the total container fleet is 25,365,000 TEU. Projections indicate that the container fleet size as well as the vessel size will continue to increase as newbuilds are being added to the current fleets to accommodate the increase in trade demand. This is an indication that the volume of empty containers that will need to be handled in the future will continue to increase.

This paper examines global empty container logistics and analyzes the empty container management problem. A discussion about trade imbalances is presented in the following section, including some indication of the cost of empty container management inefficiencies. Section "Players involved in empty container logistics" presents the major players involved in empty container logistics and their interests and interrelationships. Empty container logistics patterns are discussed in Section "Structure of the container market", along with the challenges facing the container transportation players in addressing the empty container management problem. Section "Empty container logistics patterns" presents the structure of the container market, the evolution of the global container fleet and their impacts on empty container management. Section "Optimization strategies and technology solutions" presents optimization and technology based strategies that are being considered as promising in improving the efficiency of empty container management and mitigating the adverse effects of unproductive empty container movements.

Containerization and trade imbalances

The surge of production in East Asia and mainly in China led to the explosion of containerized trade, with double digit annual growth rates experienced for the first time in year 2001. Total throughput handled by container ports worldwide grew at an average annual rate of 11% between 2002 and 2006 (ITMMA 2007). In the U.S. waterborne foreign container trade and the imbalance between import and export volumes have been growing steadily over the period from 1997 to 2006 as shown in Fig. 1. In 1997 about 7.8 million TEU were imported, while about 7 million TEU were exported. In 2006, imports reached the 18.5 million TEU, while the exports increased at a smaller rate, to be about 9 million TEU. Taking 2001 as a reference, it is estimated that by the year 2011 the volume of containerized trade will double (UNCTAD 2006), despite the lower annual growth rate anticipated for the coming years.

The structural changes of the Global Production Networks (Notteboom and Merckx 2006) have led to a substantial endemic increase in trade imbalances. These imbalances have escalated, for instance, from

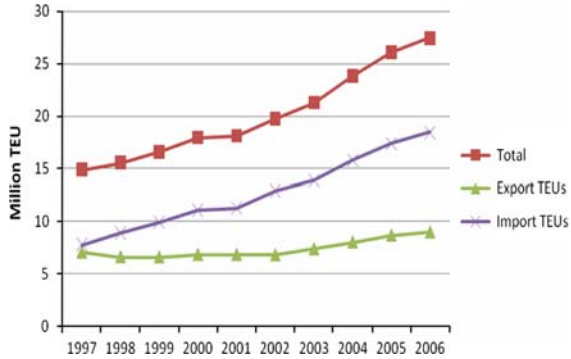

Fig. 1 U.S. Waterborne Foreign Container Trade (all trading partners). *Source*: Authors' analysis of the U.S. Waterborne Foreign Container Trade by Trading Partners, MARAD

figures of 18% for the Transpacific trade and 27% for the Europe – Far East trade in the year 1995 (GlobalInsight 2005) to figures of 67% and 65% respectively in the year 2005 (Fig. 2). In the U.S., about 70% of the slots of the container vessels leaving the country were empty in the year 2005 (Boile et al. 2006).

As a result of this tremendous increase in sea container transportation volumes, the volume of empty containers to be repositioned from consumption to production regions has seriously escalated. Despite the fact that the recent economic recession in the US and the currency exchange rates have led during the last year in a decrease of imbalances percentage wise (Fig. 2), with most notable the decrease in the Transatlantic trade from an overall 35.3% in the year 2006 to 18.2% in the year 2007, the problem of trade imbalances and the need for empty container repositioning is still and will continue to present a serious transportation logistics problem. For instance, although the trade imbalance for the US trades dropped from 53% in the year 2006 to 42% in 2007, nearly nineteen vessels with a carrying capacity of 8,000 TEU are required weekly for empty repositioning from US to overseas destinations (Dynamar 2008). Beyond the trade imbalances between the main trading regions (North America, Europe, Far East), trade imbalances are rapidly growing in the intra Asia trades, which have shown a solid growth during the late 1990s and early 2000s. Forecasts indicate a compound average growth rate of 8.3% per annum over the period 2002–2015, while other intraregional trades are expected to grow at a rate of only 3.5% per annum.[1]

The structural changes in global trade lanes have led also to rate imbalances between the head haul and the back haul routes, making the freight transportation logistics management a very complex task (Notteboom and Rodrigue 2007). Back haul freight rates can be as low as 40–50% of the head haul freight rates. For instance, for the last quarter of the year 2007 the average eastbound Asia-US (head haul) freight rate per TEU was US $ 1,707,[2] while the average westbound US-Asia (back haul) rate was only US $ 794, a low 46.5% of the head haul rate.

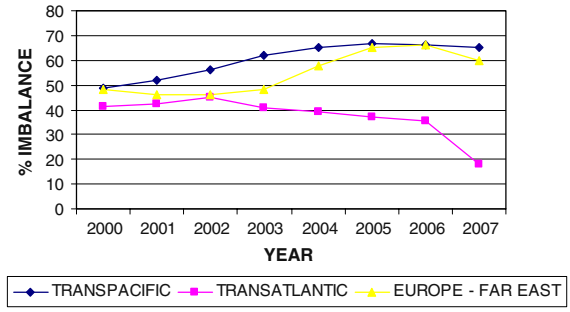

Fig. 2 Trade imbalances in major east-west trade lanes. *Source*: Authors' compilation of data from Containerization International and DynaLiners (various issues)

Demand levels for container transportation constitute another factor influencing the repositioning decisions of ocean carriers. In low demand periods, the ocean carriers tend to exploit all backhauling cargo opportunities, while on high demand they concentrate their efforts on the immediate repositioning of empty containers to the demand areas (ITMMA 2007). However, backhauling cargo is not always attractive and depends on the cost of empty container transportation to the loading location, the return freight rate, and whether the destination is a direct source of cargo (MariNova 2006). These dynamics have resulted in the following conditions recently observed in the U.S. During the early 2000s, accumulation of empty containers near-by major ports was identified as a serious problem. Low export demand and the low cost of manufacturing new containers overseas are two of the main reasons that have resulted in ocean carriers storing empty containers in depots near-by the ports over extended periods of time. Increase in steel prices and the resulting cost of building new containers is one of the factors that resulted in the massive overseas repositioning of empty containers, which begun in late 2005. Increase in the intra-Asia trade is possibly another factor. Today, there is a growing demand for exports from the U.S., while recent economy downturns have slowed the growth of imports. U.S. exporters are now facing a major problem, due to the lack of empty containers available to ship their goods to customers overseas. The fact that the origins of goods to be exported are often far from places where imported goods are being unloaded, along with the increasing energy costs, further aggravate this problem (Aeppel 2008). This mainly applies to

[1] http://www.unescap.org/ttdw/Publications/TFS_pubs/pub_2398/pub_2398_ch4.pdf, last accessed: 03/30/2008.

[2] www.ci-online.co.uk, last accessed: 02/26/2008.

containerized bulk shipments. According to the Westbound Transpacific Stabilization Agreement (a forum of the major ocean carriers serving the transpacific trade), it is difficult and costly to provide empty containers to rural Mid-West and Plains grain exporters, since inland rail and truck transportation rates have increased on the order of 30%.[3]

Considering the dynamics of container transportation and the interdependencies of various factors affecting them, makes the task of accurately calculating the overall cost of container management inefficiencies and the cost of empty container repositioning a rather challenging one. Various sources provide some rough indications of this cost. The cost of container management inefficiencies in year 2001 was estimated to reach almost US$17 billion (Boile 2006). Another source based on Drewry Consultants 2002 information estimates that repositioning costs reach US $ 20 billion yearly (Veestra 2005). According to a third source (ROI 2002) a 10% reduction in repositioning and container equipment management costs can potentially increase industry's profitability by 30–50%. Ocean carriers try to keep tighter control over their container equipment by reducing the free time they allow to consignees and their representatives before returning the empty container back to them and by increasing the daily retention fee (also known as "per diem") charged if retention by the consignee exceeds the free time. This fee quadrupled between 1998 and 2002 in the ports of Los Angeles and Long Beach (The Tioga Group 2002). Furthermore, shipping lines try to keep tighter control over the container logistics through stripping and stuffing operations in warehouses and distribution centers in the immediate hinterland of the ports, a practice that results in shorter empty container rotation time.

Players involved in empty container logistics

Understanding the dynamics of empty container management and empty container logistics patterns involves defining the major players, the levels of empty container balancing and repositioning decision making, as well as the ownership and use patterns of the container fleet.

Essentially, there are two main groups of owners of marine (ISO) containers, the ocean carriers, including global, niche and feeder carriers, and the container leasing companies. A small share of containers, usually old ones close to the end of their useful life, is owned by depot operators, who also handle, store, and repair empty containers. Some major shippers may also own or lease a relatively small amount of containers for their dedicated use, although this is not very common. Shippers in general avoid owning containers, since transportation is not their core activity and due to the liability issues associated with container ownership. A small amount of containers is also owned or leased by all kinds of transport operators and transportation intermediaries. Excluding the very small share of containers owned by third parties, currently, ocean carriers and other transport operators own about 59% of the total global container equipment fleet, while leasing companies own about 41% of the total fleet.

The container leasing industry was developed in the 1970s as a result of the economic benefit and flexibility lessors offer to carriers, especially during periods of high demand for containers. Large container leasing companies capitalize on the convenience of their worldwide network and container availability. Smaller container leasing companies capitalize in areas where they can provide close dedicated service to selected customers. The major growth of the container leasing business in the 1970s, reaching annual growth rates as high as 20%, was followed by a lower growth rate period in the 1980s and a subsequent increase during the 1990s. Currently, the situation is rather volatile but there is a steadily decreasing share of the leasing companies' ownership after year 2000. Concentration in the leasing industry occurred as early as mid 1990's and follows patterns presenting similarities with those of the liner shipping industry. Currently, almost 60% of the total leasing equipment is owned by five leasing companies, while five leasing companies have made 50% of the total purchases of new leasing equipment for the year 2006.

It is worth noting that ocean carriers and leasing companies have essentially different and conflicting goals. In principle, carriers are handling containers as transportation equipment and equipment management

[3] Containerisation International, July 2008, p. 21.

decision making is focused towards facilitating cargo move and minimizing transportation and handling costs. Leasing companies consider containers as their core assets, seeking to cover depreciation and make sustainable profit out of their leasing. The interactions between these two main players are extremely complex and cannot be easily conceptually described. Traditionally, ocean carriers have extensively used leased equipment, exploiting the flexibility of leasing arrangements, off hiring containers in surplus areas and on hiring them in areas of high demand. During the last five years, ocean carriers have increased their ownership of container equipment, following the increasing integration tendencies and the use of tight management approaches, like revenue management, in their operations. Furthermore, some of the major carriers have entered the container manufacturing industry with the view to integrate their shipping business with box ownership and direct availability (Boile 2006).

Leasing arrangements fall into the following three types: Master Leases, Long Term Leases and Short Term Leases. Master leases, also called full service leases or container pool management plans, are massive, medium term container leasing arrangements, with complex conditions regarding off hire and on hire of equipment and debits and credits between contracting parties depending on the condition of equipment at the time of interchange. The leasing company is responsible for the full management of the fleet (repositioning, maintenance and repair) and for repositioning following off hire and contract termination. Long term leases, also called dry leases, are associated with extended use by the ocean carrier. Long term leases normally follow the purchase of new container by the leasing company and they do not involve any management service by the lessor. The leasing company seeks to amortize the investment during the long term lease period. The short term leases, also called spot market leases, are normally associated with acute demand for equipment by the operators. Lease prices are very volatile and leasing companies, in general, try to avoid having a substantial percentage of their equipment on spot market leases, since risk exposure to unused equipment during low demand periods is high. Table 1 summarizes the characteristics of the different container leasing arrangements.

Developments during the last few years have shifted the balance, favouring long term leases over Master leases. The initial tendency was driven by high repositioning volumes and repositioning costs paid by the leasing companies, although ocean carriers would pay a fee for off hiring containers in certain areas of high empty container surplus. Currently, ocean carriers prefer long term "dry" leases and integration of the leased with their own equipment. This tendency affects depot operators, particularly in the high container surplus areas. Long-term leases have a significant negative impact on the throughput volume in depots, as they lead to lower gate volumes from leasing companies and therefore, to lower storage and repair revenues (Boile 2006). Given the fact that the depot operation is highly marginal, this tendency leads gradually to shrinking of this independent business activity in many metropolitan areas, and integration of depot operations in the ocean carriers' vertical integration chain.

Table 1 Characteristics of the container leasing arrangements

Lease type	Duration	Repositioning	Maintenance and repair	Other arrangements
Master lease	Short to medium term	Leasing company	Leasing company	Variable number of containers (min/max)
				Variable lease duration
				On hire and off hire credits/debits (depending on location and equipment condition)
Long term lease	5–8 years	Lessee	Lessee	Fixed number of containers
				Predetermined delivery schedule
Short term lease	Short period/trip/round trip	Lessee	Lessee	_

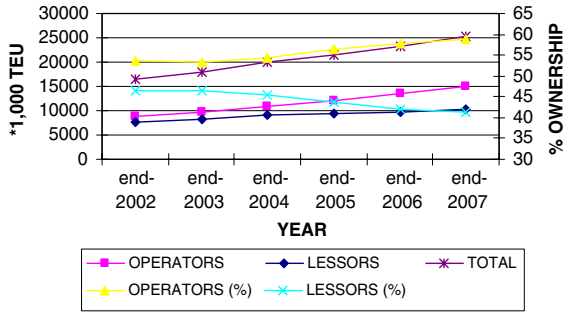

Fig. 3 Evolution of ownership of World Container Fleet. *Source*: Containerization International (various issues), 2007 figures are estimates based on third quarter 2007 data

Structure of the container market

Container market dynamics are greatly influenced by container shipping dynamics and at the same time they influence empty container management. Understanding the container market structure and evolution helps in shaping robust decisions regarding empty container logistics management.

The world container fleet has increased substantially during the last five years, mainly as a result of the unprecedented growth of global container transportation (Fig. 3). The fleet size of 16 million TEU in 2001 has been reaching a figure of more than 25 million TEU at the end of 2007.[4] At the same time the share of ocean carriers and other transport operators has substantially increased from 53.6% in the year 2002 to almost 59% at the end of year 2007, while the share of the leasing companies reached a low of 41% at the end of the same year. Leasing industry's share of equipment ownership was as high as 53% in the 1980s. It is interesting to note that currently almost all the containers owned by the leasing companies (95.6%) are on operating lease, therefore they are in the transportation business cycle and not dormant in depots, a situation totally different from that of the early 2000's. In the early 2000, because of the lower new container prices and the lower demand, ocean carriers preferred to off lease empty containers at surplus areas through their master lease arrangements, so they could avoid the high repositioning cost. This cost was taken by lessors and given the very competitive cost of new "ex works" boxes in demand areas, empty containers were sitting idle in depots of surplus areas for long time periods. Therefore, a substantial part of the containers owned by the leasing companies was out of the transportation cycle for a long period of time, and the percentage of those not on an operating lease was high.

At the same time, annual new container manufacturing production reached an all time high of 3.25 million TEU and the operators purchased two out of every three new containers (Fig. 4). This tendency leads to a further shrinkage of the share of leasing companies and the industry anticipates that this share will reach a value as low as 35–37% in the coming years.

This tendency of increasing ownership share of operators can be attributed to certain reasons, relating to the facts that: ocean carriers want to further integrate their activities and therefore take, if possible, full control of their container equipment; they have established better equipment management systems and therefore they streamline their inventories; they have gained further experience and know-how on this issue, which along with the sharp increase of the container transportation demand during the last years enabled them to devote a part of their investment to container equipment acquisition. On the other hand, based on their bargaining power, ocean carriers are constantly squeezing the profits of the anyway marginal leasing industry, therefore, leasing activity increasingly less attractive business, although recently and before the subprime banking crisis, some institutional investors have invested in container leasing activities, in search of constant cash

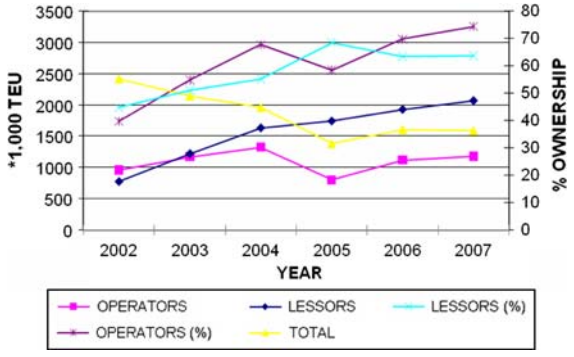

Fig. 4 Evolution of new container purchases. *Source*: Containerization International (various issues) 2007 figures are estimates based on third quarter 2007 data

[4] MARAD, http://www.marad.dot.gov/MARAD_statistics/index.html, last accessed: 02/26/2008.

flow stream investments. In certain cases ocean carriers developed their own leasing subsidiaries (e.g. Florens of Cosco Group) that lease containers to both their ocean carrier affiliates and to third parties. In that sense the container industry complexity develops in the same line with the container shipping industry. The concentration patterns mentioned earlier for the leasing industry are much more prominent for the container manufacturing industry, where last year the two major manufacturers reached nearly 75% of the total production.

Figure 5 presents the prices of new containers "ex-factory", i.e. delivered in the factory without the cost of transportation, for three classes of containers. Prices reached a high of $US 2,100, for a 20 ft unit, in the year 2005. The low prices in the years 2002 and 2003 ($US 1,350 for a 20 ft unit), along with the cost of repositioning, is a root cause for the severe container accumulation problem that took place during this period in highly consuming metropolitan areas.

Ocean carriers, as already mentioned, are pushing leasing companies to shift from short term oriented master leases to long term "dry" leases with lower per diem leasing rates. The reason is that ocean carriers are considering the prices of new containers high, though not as high as in the year 2005, and at the same time they manage the containers under "dry" lease contracts like having ownership in terms of repositioning and maintenance. It is worth mentioning that during the 2002–2003 period, leasing companies were pushing for long term "dry" lease contracts to avoid the high repositioning costs, as

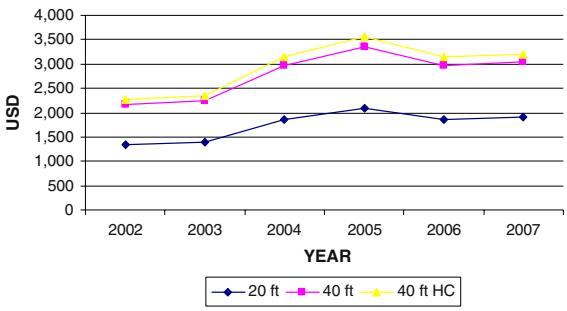

Fig. 5 Evolution of price of new containers. *Source*: Containerization International (various issues) 2007 figures are estimates based on third quarter 2007 data, HC reads for high cube

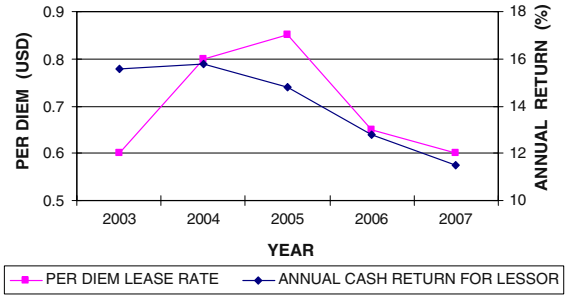

Fig. 6 Evolution of Per Diem lease rate and returns for lessors (20 ft standard container). *Source*: Containerization International (various issues) 2007 figures are estimates based on third quarter 2007 data

compared to the low price of new containers, since off lease penalties of the existing master leases at that time could not cover the repositioning expenses. Long term leases were considered also as hedge tool against obsolesce, in view of the low demand at that period of time. This is a further indication of the highly volatile and dynamic container equipment market.

Figure 6 presents the evolution of the average per diem rate (daily lease rate) and the annual cash return rate for a 20 ft standard container between the years 2002 and 2007. As it can be seen, per diem rates in 2007 were the same as in the year 2003, when prices of new containers were particularly low. The level of the annual cash return for the leasing companies has dropped from 15.8% in the year 2004 to 11.2 in the year 2007. This means that the amortization period for a newly purchased container has escalated to almost nine years, while the container useful life is considered to be about 12 years, though there are cases that containers can have a longer useful life, depending on their previous use.. This is a further indication that the leasing business is becoming an increasingly less attractive activity from an investment point of view, therefore leading to the increase of container ownership by the ocean carriers.

Empty container logistics patterns

Imbalances in empty container supply and demand are a consequence of trade imbalances along the main trade lanes, a structural and endemic problem of the global trade. Empty container repositioning is an

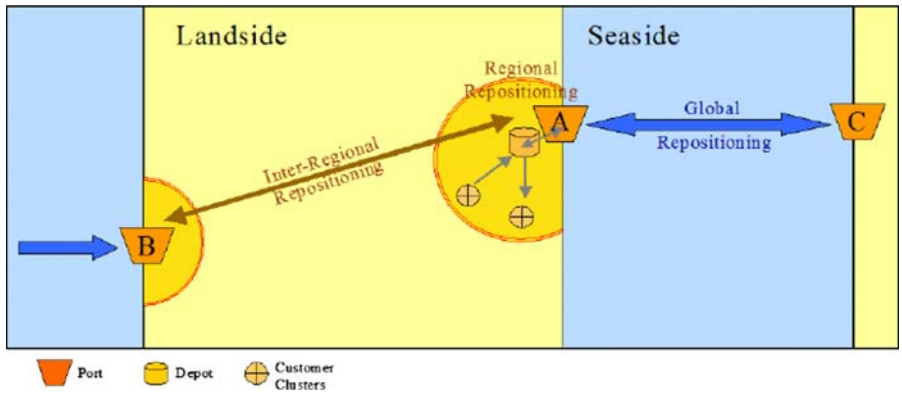

Fig. 7 Levels of empty container repositioning (Boile et al. 2008)

integral part of an overall efficient global transportation system. Although it is a non-revenue generating, expensive and undesirable exercise, empty container repositioning is required to balance demand and supply between major exporting and importing regions.

Empty container management involves four geographical levels, namely global, interregional, regional and local (Fig. 7). The global level involves massive empty container all sea repositioning from surplus to deficit areas. The interregional level involves either balancing repositioning inside a wide geographical area (N. America, Europe, or Asia) or on a leg leading finally to global repositioning. Interregional repositioning is accomplished either intermodally or through short sea transportation (feeder or part of a pendulum service). Regional and local level can be considered together and they mainly involve drayage operations.

Regional empty container strategies mainly involve empty balancing between importers, exporters and the marine terminals, while local strategies involve balancing between marine terminals and empty depots. At both levels operational strategies are considered to minimize unproductive empty container movements in a region. Issues that are being examined and which cut across both levels, include the optimal location of storage depots near the marine or intermodal terminals and near customer clusters, and the issue of maintaining sufficient inventory in relation to the repositioning lead times should peak demand arises. Interregional repositioning is mainly associated with balancing in a cost effective way interregional surpluses and deficits, as well as feeding the most suitable port gateways for overseas repositioning, based on empty slot availability on board containerships. Global repositioning is a complex process, since it is tightly associated with parameters as the availability of backhauling commodities, structure of ocean carriers' global service network, availability of empty slots in certain liner service strings, price of new containers, collaborative agreements between ocean carriers, the percentage mix of own and leased containers of the ocean carriers, and the degree of the vertical integration of the carriers' own activities, to mention a few. The relationship between repositioning strategies and the cost of repositioning at different levels is shown in Fig. 8.

To better understand the dynamics of global empty container repositioning, consider Fig. 9. The figure illustrates the options in ocean carriers' decision making for the global movement of containers between surplus and deficit regions, with reference to the inflow in a major coastal economic activity region. If the inflow of containers exceeds the outflow (i.e., the region is a consumption center) then the region exhibits a surplus of empty containers. In this case ocean carriers have several options, including the following: to reposition empty containers to areas of high demand at their own expenses (either all sea globally to a major production center, or interregionally to balance demand); to off-hire the surplus containers and let lessors take the appropriate decision about their availability; to temporarily store them in a depot at the surplus area before making any decision; to sell them out to the secondary market-particularly if their age is greater than or near the end of the useful life and their condition substantiates such a decision; to match their needs with other carriers' needs, although this decision is rather rare, since all ocean carriers are expected to face surplus or

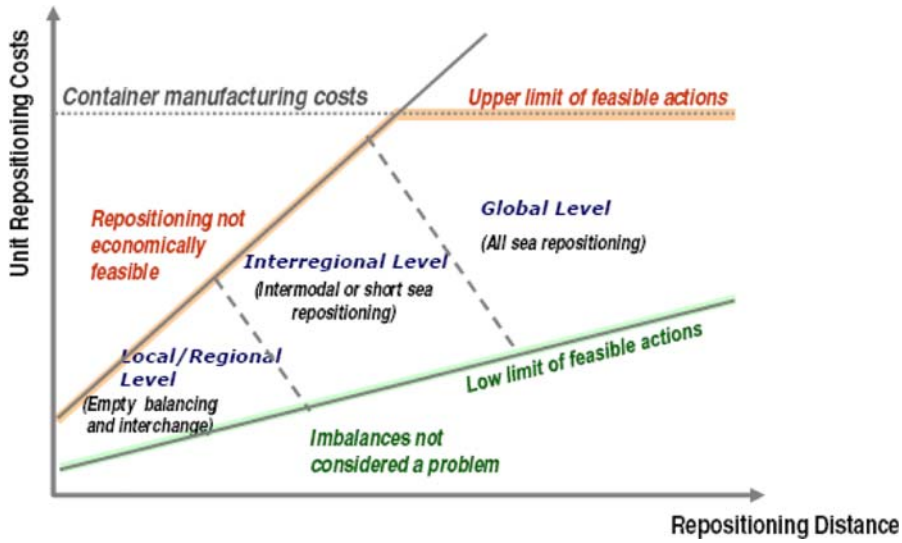

Fig. 8 Imbalances and empty container management strategies (adapted from Theofanis, Rodrigue and Boile 2007) (http://people.hofstra.edu/geotrans/eng/ch5en/conc5en/ch5c4en.html, last accessed: 02/26/2008)

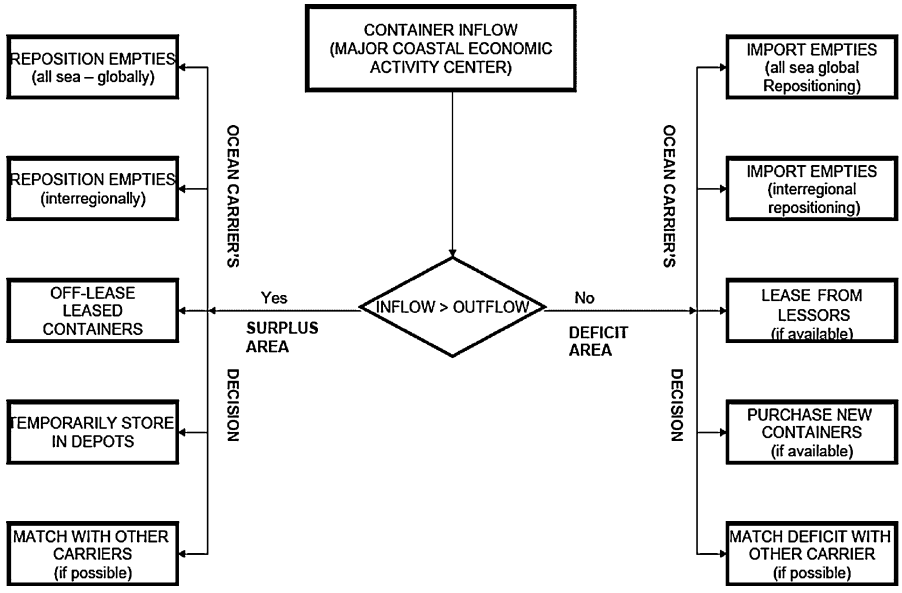

Fig. 9 Empty container management options (adapted from Boile et al. 2006)

deficit in the same regions, and at the same time ocean carriers prefer to use their own containers as market branding tool (Notteboom and Rodrigue 2007). When the outflow is greater than the inflow (i.e. the region is a production center) the ocean carrier has the following options: to import empty containers from surplus areas (repositioned either overseas or interregionally); to lease containers from lessors (either locally available or to be repositioned from other areas); to purchase containers (particularly when available at the local market—a case for Far East, since China is currently the exclusive container manufacturing country and a high demand area at the same time) or to match the needs with other carriers.

At the interregional level, ocean carriers often apply mixed strategies regarding the control of their equipment. In general, they prefer to vertically extend their service network and provide rail services to control their logistics costs, ensure better equipment visibility and efficiently manage empty container repositioning at this level (Debrie and Gouvernal 2006). In Europe, there are two contractual arrangements for container delivery to the consignee, the "carrier haulage" and the "merchant haulage".

Under the carrier haulage, the ocean carrier is responsible for final delivery to the consignee. Under the merchant haulage, the consignee or the third party representatives are responsible for the delivery. Carrier haulage allows shipping lines to have a tight control over boxes moving inland. Under the merchant haulage carriers might loose visibility of the box fleet leading to misallocations of boxes.Nevertheless, under certain circumstances, they may limit their door-to-door service network, to avoid the cost of returning empty containers to marine terminals (Mongelluzo 2007), particularly when profit margins of the sea transportation leg are considered low and the revenue of the headhauling cargo at the land leg is too small (insufficient) to cover the round-trip door-to-door costs. In this case, equipment visibility is reduced and the ocean carriers' customers at destinations not covered by their service network have to take the responsibility of returning empty containers to marine terminals or rail hubs. This is particularly the case in North America, where the "asynchronous" rail transportation system, i.e. railroads own their separate track and yard infrastructure, prohibits ocean carriers from taking control of the intermodal transportation leg and the total door-to-door service cost relies heavily on the intermodal rates charged by the railroads. Container-on-barge transportation can be a viable alternative for empty container transportation, as it is the case in Europe (ITMMA 2007).

A very important issue in streamlining repositioning costs at the interregional level is that of the "container cabotage", i.e. repositioning for domestic traffic (Notteboom and Merckx 2006). Ocean carriers can develop partnerships with inland transport operators, who will move the empty container to the location needed with no cost and in return will exploit free one way use of the container.

In Fig. 10 the dynamics and interactions among stakeholders at the local and regional level, with influence from the interregional level are depicted. Consignees, consignors, ocean carriers, marine terminal operators, depot operators, drayage operators and, possibly, transport intermediaries are involved. A full container can reach a consignee's premises by truck either directly through a marine container terminal or intermodally. Once stripped, the empty container can be either returned to the marine terminal or a storage depot, or directly "street turned" to a consignor's premises to be filled with an export or backhauling load. Occasionally, empty containers can be interregionally repositioned

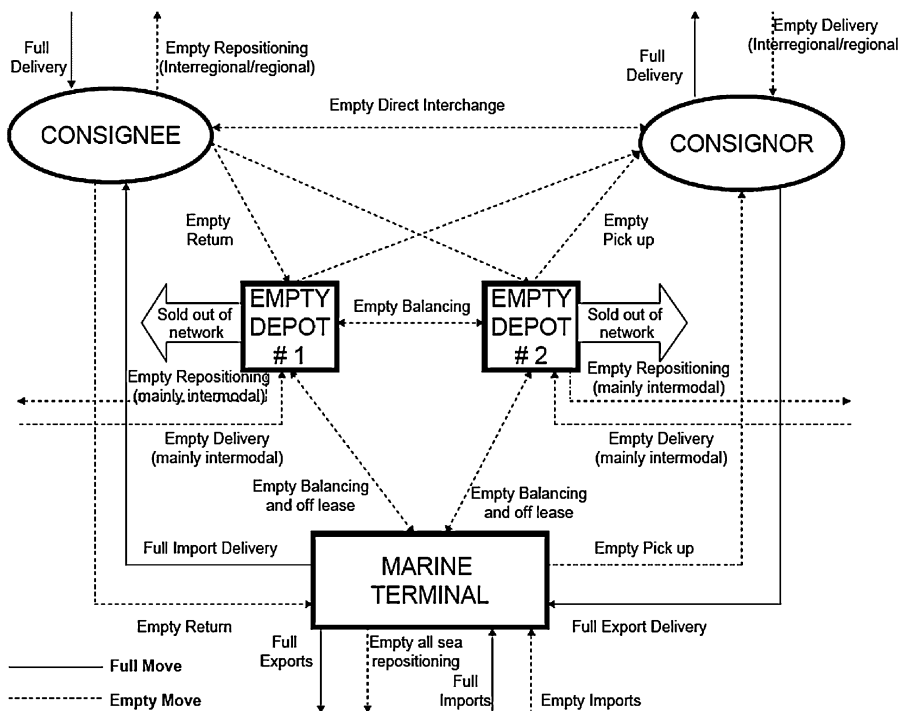

Fig. 10 Empty container flows—regional and local level (adapted from Boile et al. 2006)

through a depot or an intermodal terminal. Empty containers can also reach consignors' premises through intermodal transportation and last mile drayage. Once filled at the consignor's premises, a container is normally drayed to an intermodal terminal or a marine terminal for export. Empty containers can also reach storage depots and be temporarily stored before overseas repositioning takes place, once off hired by an ocean carrier. From storage depots, aged containers, particularly those stored over a long period, may be sold out of the transportation network to the secondary market. Empty containers may move between marine terminals and storage depots or between different storage depots for balancing purposes. Several terminals operate satellite empty container depots to gain additional storage capacity, avoid congestion at the gates and provide dedicated service to ocean carriers. In the US, where chassis are owned by ocean carriers, marine terminal satellite empty depots are often combined with chassis pools.

Again in the US, the content of an ISO marine container may be transloaded to a 53 ft domestic container at a transloading facility and subsequently moved by truck to the consignee's premises. The empty container may be returned to the marine terminal or to an empty storage depot. Transloading facilities tend to be located in close proximity to marine terminals to avoid the long distance repositioning of the empty containers. Transloading presents the advantage of using two 53 ft domestic containers for every three 40 ft ISO marine containers, a fact that combined with avoiding costly per diem penalties for late empty container return justifies the cost of the transloading operation. This strategy of empty container management and distribution logistics is one of the several factors affecting the decisions of major retailers in the US (WalMart, Home Depot, Target) on how to optimally locate regional distribution facilities. Traditionally, the West Coast traffic has been predominant, even serving East Coast destinations. Rail transportation has been dominating the long haul empty repositioning and all sea repositioning of empty containers arriving full at West Coast ports may be accomplished from East Coast ports. This landbridge multiplies the complexity of empty repositioning. It should be noted, however, that there is an increasing tendency for Far East–US East Coast (FE-USEC) services either through Suez, or through Panama canal. These ocean carrier decisions influence the empty container management in North America.

Under certain circumstances, the empty container accumulation in storage facilities at major importing regions with substantial import–export imbalances may become a serious problem. The process of empty container accumulation is highly dynamic and follows the dynamics of container shipping. Apart from the fundamental global trade imbalance, other root causes include container rates imbalances and the related cost of repositioning empty containers from surplus to deficit areas, imbalances in type of containers available and demanded, cost of inland transportation, marginal and volatile profitability of the leasing industry, cost of manufacturing and purchasing new boxes in relation to the cost of leasing containers, terms of leasing contracts between leasing companies and ocean carriers, the cost of inspection and maintenance for aged containers and the cost of disposal (Boile et al. 2006).

Empty containers accumulated in a region fall within the categories of those temporarily stored, waiting to be filled and exported or to be repositioned back to demand areas; and those aged containers that are long term stored waiting to be sold to the secondary market. While for the first category the decision making falls with the transport operators, for the second category positive fiscal measures (e.g. tax incentives for the owners) taken at a local and regional level may increase the possibility of selling them to the secondary market or for scrap. Since empty container management is driven by a global and complex industry, measures taken at the local level to reduce accumulation of empties, such as restrictions of storage height at depots or imposition of storage fees by local authorities, not only may prove to be ineffective in tackling the problem in most cases, but they may also present a threat for the competitiveness of the transportation industry in the region.

Dwell time restrictions and associated pricing mechanisms exercised by container terminal operators (e.g. reduced free storage, scaled increase in storage fees, moving containers outside of the marine terminal to a satellite facility after a high storage time threshold is exceeded at the expense of the receiver) substantially improve port productivity and throughput and may influence the effectiveness of empty container management. Terminal operators, following the concept of

"port teminalization" (Rodrigue and Notteboom 2008) are gradually introducing tighter time requirements for better resource management. Given the fact that container terminals are used as overflow nodes by shippers (Merckx 2005) and marine terminal operators are interacting with ocean carriers and not shippers, introduction of pricing mechanisms may have side impacts (e.g. competitiveness effects). Combined operation of marine with inland terminals as buffer capacity may optimize container handling.

Optimization strategies and technology solutions

Since empty container imbalances is a chronic and structural problem of container transportation, the container shipping and equipment industries have dealt with it quite extensively over the years. In addition, substantial scientific research has been devoted to empty container repositioning optimization during the last fifteen years. Ocean carriers and other transport operators are typically facing the challenges of finding effective and robust solutions to problems such as the service network design with empty container repositioning considerations, the matching of container availability and demand and the issue of backhauling cargo, the design of a storage inventory network to balance demand and supply of empty containers, and the availability of empty container vessel slot capacity for least-cost repositioning.

The problems can be considered at a certain level (e.g. global) or at a combination of two levels. For instance, interregional balancing decision making and allocation of empty containers for global repositioning to US West and East Coast ports interacts with service network considerations and empty slots availability during multiport calls of a certain service (e.g. pendulum). At the same time the problems to be tackled can be considered to be of strategic, tactical or operational type (Lam et al. 2007). Figure 11 summarizes a number of typical issues that stakeholders face in empty container management at the macro (global), meso (interregional) and micro (regional/local) levels.

Substantial research has been published so far related to the empty equipment management problem, focusing primarily on the equipment transportation optimization problem. Issues considered include the empty equipment allocation and distribution problem and the balancing of demand and supply between terminals to meet future demands (Crainic 1993; Gendron and Crainic 1995; Shen and Khoong 1995; Coslovich et al. 2006; Choong et al.

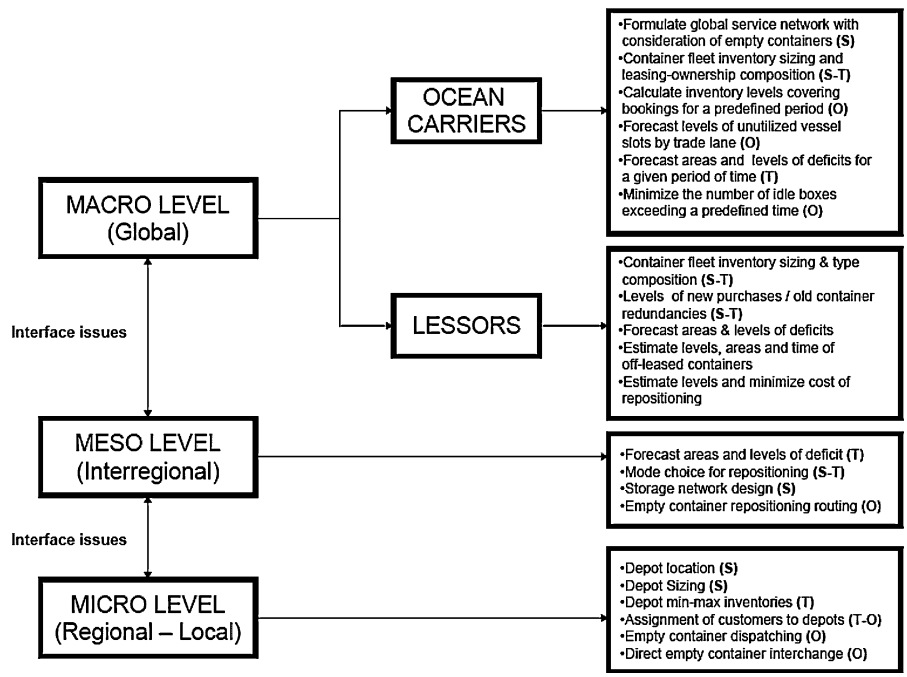

Fig. 11 Typical issues to be tackled through optimization approaches. *Note*: S reads for strategic problem and T and O for tactical and operational problems, respectively

2002, Olivo et al. 2005; Song and Earl 2008), the effect of the planning horizon length on empty container distribution management (Jansen et al. 2004; Cheung and Chen 1998), the dynamic equipment allocation and reuse problem (Jula et al. 2006; Janakiraman et al. 2007), and the empty balancing strategies within the context of a network design problem (Gendron and Crainic 1997; Bourbeau et al. 2000; Imai and Rivera 2001; Li et al. 2004; Ting and Tzeng 2004; Song et al. 2005; Ang et al. 2007; Shintani et al. 2007; Boile et al. 2008)., while Lai et al. (1995) present models analyzing stakeholder operational activities.

The implementation of more sophisticated management approaches, such as the adoption of revenue management (Ting and Tzeng 2004), along with more efficient Management Information Systems has substantially improved the container equipment asset management of most ocean carriers. Ocean carrier sponsored portals (INNTRA, CargoSmart), though they mainly focus on automatic booking to invoice processes, have also indirectly assisted ocean carriers. Efforts to introduce container pools (such as the grey box concept), container capacity exchange systems or electronic freight markets with customers from ocean carriers, the leasing industry and transportation intermediaries have met the reluctance of the ocean carriers to share information (Notteboom and Rodrigue 2008). Electronic markets and intermediaries are used, in certain cases, by leasing companies to find available free slot space for empty container repositioning. All these pooling efforts are focusing on exchanging large blocks of available equipment or slot carrying capacity.

Efforts were also made during the last 5 years to establish neutral internet based information exchange platforms to assist in direct empty container interchange between consignees and consignors in major metropolitan areas, the so called "street turns" in the US. The purpose of these platforms is to reduce the empty container distance travelled and mitigate congestion and environmental effects of drayage. Three pilots, called "virtual container yards", have been implemented or are at the implementation stage in the US, at the ports of Oakland, Los Angeles/Long Beach and New York/New Jersey (Theofanis and Boile 2007; Theofanis et al. 2007). These efforts are the outcome of collaboration of private vendors providing the exchange platform with the Port Authorities. Similar efforts leading to drayed empty container interchange or empty container interchange at local level by other modes of transport are reported in the Port of Rotterdam, with the Box Sharing initiative developed by Port Infolink BV (Veestra 2005), the Port of Melbourne, Australia, with the Smart Freight container triangulation initiative (Bovis Lend Lease 2004) and the Port of Hong Kong and the cross border "Laden-in/Laden-out" concept and its Cross-Boundary Haulage Matching Platform.[5] These systems are focusing on container unit exchange rather than on container block exchange. Again, these efforts have not been proved successful so far, mainly due to the fact that ocean carriers are reluctant to devote common shared logistics resources at local level and exchange information, and due to a series of institutional issues (liabilities for container interchange, reluctance to re-start the free time allowance, which is also called the "per diem clock", when an empty container interchange takes place, etc.).

Efforts to introduce foldable containers to reduce empty container transportation, handling and storage costs have not been, in practice, successful yet, though they were launched in the early '80s (Konings 2005). The application of the concept has not been proved successful, mainly due to reasons associated with high purchase price, higher tare weight, costs of folding and unfolding and vulnerability to damage and had never passed the small scale demonstration application. Nevertheless, the concept has potential for future large scale application, provided that shortcomings will be overcome.

Conclusions

Current global production patterns have led to the emergence of systemic, chronic and structural trade imbalances between the major trading regions. Therefore, substantial container imbalances and need for extended empty container repositioning operations are inherent characteristics of the container transportation industry. The problem is expected to be intensified in the future, owing to the steady increase in global container traffic, despite some short term changes in trade dynamics.

[5] http://www.modernterminals.com/eng/theCompany/enews040402.htm, last accessed: 02/26/2008.

Understanding the empty container logistics patterns at global, interregional, regional and local levels, analyzing the root causes of empty container imbalances and empty container storage accumulation, and focusing on the market dynamics of container ownership and the role of leasing and manufacturing industries in relation to the container transportation industry, are prerequisites in decision making for the optimal empty container management.

The substantial structural changes in the container transportation industry have been followed by changes in the ownership of the global container fleet and respective changes in the leasing and container manufacturing activities. Ocean carriers, through the vertical integration of their activities, are becoming gradually the dominant player in empty container management issues.

Ocean carriers recently have made remarkable progress in adopting effective management techniques, earlier applied in other sectors of the transportation industry, to streamline their container inventories, reduce repositioning costs and increase asset visibility. The application of these new management techniques in future is expected to intensify, coupled with the adoption of container supply chain visibility technologies. To what extent this combined effect of new management approaches and technologies will effectively improve the empty container management efficiency remains to be seen.

Third party service providers have also provided IT solutions to facilitate container equipment interchange between industry players at various levels. The potential of these technology solutions has not been exploited fully yet, mainly due to the reluctance of the ocean carriers to share commercially sensitive information with other parties.

References

Aeppel, T. (2008). U.S. container shortage puts U.S. export boom in a box. *Wall Street Journal*, April 10.

Ang, J. S. K., Cao, C., & Ye, H.-Q. (2007). Model and algorithms for multi-period sea cargo mix problem. *European Journal of Operational Research, 180*, 1381–1393.

Boile, M. (2006). *Empty intermodal container management*. Report FHWA – NJ – 2006-005 for the NJ DOT. Retrieved February 26, 2008 from Rutgers University, Center for Advanced Infrastructure and Transportation Web site: www.cait.rutgers.edu/finalreports/FHWA-NJ-2006-005.pdf.

Boile, M., Theofanis, S., Baveja, A., & Mittal, N. (2008). Regional repositioning of empty containers: A case for inland depots. *Transportation Research Record: Journal of the Transportation Research Board* (in press).

Boile, M., Theofanis, S., Golias, M., & Mittal, N. (2006, January). Empty marine container management – Addressing locally a global problem. *Proceedings of the 85th Annual Meeting of the Transportation Research Board*, Washington, D.C.

Bourbeau, B., Crainic, T. G., & Gendron, B. (2000). Branch-and-bound parallelization strategies applied to a depot location and container management problem. *Parallel Computing, 26*, 27–46.

Bovis Lend Lease. (2004). *Container triangulation within the Port of Melbourne Supply Chain-Business Case Analysis*. Smart freight Stage 1 Report, Melbourne. Retrieved February 26, 2008 from:http://www.doi.vic.gov.au/doi/doielect.nsf/2a6bd98dee287482ca256915001cff0c/c5082d09dd22c032ca2572110021855f/$FILE/SmartFreight-Report_7-Container_Triangulation_Business_Case.pdf.

Cheung, R. K., & Chen, C. Y. (1998). A two stage stochastic network model and solution methods for dynamic empty container allocation problem. *Transportation Science, 32*(2), 142–162.

Choong, S. T., Cole, M. H., & Kutanoglu, E. (2002). Empty container management for intermodal transportation networks. *Transportation Research Part E, 38*, 423–438.

Coslovich, L., Pesenti, R., & Ukovich, W. (2006). Minimizing fleet operating costs for a container transportation company. *European Journal of Operational Research, 17*, 776–786.

Crainic, T. G. (1993). Dynamic and stochastic models for the allocation of empty containers. *Operations Research, 41*(1), 102–126.

Debrie, J., & Gouvernal, E. (2006). Intermodal rail in Western Europe: Actors and services in a new regulated environment. *Growth and Change, 37*(3), 444–459.

Dynamar (2008). DynaLiners Report, 11/2008.

Gendron, B., & Crainic, T. G. (1995). A Branch-and-Bound algorithm for depot location and container fleet management. *Location Science, 3*(1), 39–53.

Gendron, B., & Crainic, T. G. (1997). A parallel Branch-and-Bound algorithm for multicommodity location with balancing requirements. *Computers and Operations Research, 24*(9), 829–847.

GlobalInsight. (2005). *The application of competition rules to liner shipping*. Report to the European Commission. Retrieved February 26, 2008 from: http://ec.europa.eu/comm/competition/antitrust/others/maritime/shipping_report_26102005.pdf.

Imai, A., & Rivera, F. (2001). Strategic fleet size planning for maritime refrigerated containers. *Maritime Policy and Management, 28*(4), 361–374.

ITMMA. (2007). *A market report on the European seaport industry*. Report to the European Seaport Organization. Retrieved February 26, 2008 from:http://www.espo.be/EU_Ports_26_Facts/ESPO-ITMMA_Market_Report.aspx.

Janakiraman, S., Theofanis, S., Boile, M., & Naniopoulos, A. (2007, January). Virtual container yard: Simulation-based feasibility perspective. *Proceedings of the 86th Annual Meeting of the Transportation Research Board*, Washington, D.C.

Jansen, B., Swinkels, P. C. J., Teeuwen, G. J. A., van Antwerpen de Fluiter, B., & Fleuren, H. A. (2004). Operational planning of a large-scale multimodal transportation. *European Journal of Operational Research, 156*, 41–53.

Jula, H., Chassiakos, A., & Ioannou, P. (2006). Port dynamic empty container reuse. *Transportation Research Part E, 42*, 43–60.

Konings, R. (2005). Foldable containers to reduce the costs of empty transport? A cost-benefit analysis from a chain and multi-actor perspective. *Maritime Economics and Logistics, 7*, 223–249.

Lai, K. K., Lam, K., & Chan, W. K. (1995). Shipping container logistics and allocation. *The Journal of the Operational Research Society, 46*(6), 687–697.

Lam, S.-W., Lee, L.-H., & Tang, L.-C. (2007). An approximate dynamic programming approach for the empty container allocation problem. *Transportation Research Part C, 15*, 265–277.

Li, J.-A., Liu, K., Leung, S. C., & Lai, K. K. (2004). Empty container management in a port with long-run average criterion. *Mathematical and Computer Modelling, 40*, 85–100.

MariNova Consulting Ltd. (2006). *The use of containers in Canada*. Report prepared for Transport Canada. Retrieved February 26, 2008 from: http://www.tc.gc.ca/pol/EN/Report/Containers2006/Menu.htm.

Merckx, F. (2005). The issue of dwell time charges to optimize container terminal capacity. *Proceedings of the IAME 2005 Annual Conference*, Limassol, Cyprus.

Mongelluzo, B. (2007). Maersk Line cuts inland service. Direct shipping ends to some U.S. intermodal ramps. *Pacific Shipper*, February 7.

Notteboom, T., & Rodrigue, J.-P. (2007). Re-assessing Port-Hinterland relationships in the context of global supply chains. In J. Wang, D. Olivier, T. Notteboom, & B. Slack (Eds.), *Inserting port-cities in global supply chains* (pp. 51–68). London: Ashgate.

Notteboom, T., & Rodrigue, J.-P. (2008). Containerization, box logistics and global supply chains: The integration of ports and liner shipping networks. *Maritime Economics and Logistics, 10*(1–2), 152–174.

Notteboom, T., & Merckx, F. (2006). Freight integration in liner shipping: A strategy serving Global Production Networks. *Growth and Change, 37*(4), 550–569.

Olivo, A., Zuddas, P., Di Francesco, M., & Manca, A. (2005). An operational model for empty container management. *Maritime Economics and Logistics, 7*, 199–222.

Rodrigue, J.-P., & Notteboom, T. (2008). The terminalization of supply chains: Reassessing Port Hinterland logistical relationships. *Maritime Policy and Management* (submitted).

ROI. (2002). *Profit optimization for container carriers*. The ROI Container Cargo Alliance White Paper. Retrieved February 26, 2008, from: http://www.imsworldgroup.com/Downloads/ROI%20Product@Services%%20v1.8.pdf.

Shen, W. S., & Khoong, C. M. (1995). A DSS for empty container distribution planning." Information Technology Institute. *Decision Support Systems, 15*, 75–82.

Shintani, K., Imai, A., Nishimura, E., & Papadimitriou, S. (2007). The container shipping network design problem with empty container repositioning. *Transportation Research Part E, 43*, 39–59.

Song, D.-P., & Earl, C. F. (2008). Optimal empty vehicle repositioning and fleet-sizing for two-depot service systems. *European Journal of Operational Research, 185*, 760–777.

Song, D.-G., Zhang, J., Carter, J., Field, T., Marshall, J., Polak, J., et al. (2005). On cost efficiency of the global container shipping network. *Maritime Policy and Management, 32*(1), 15–30.

The Tioga Group. (2002). Empty ocean logistics study. Technical Report, Submitted to the Gateway Cities Council of Governments, CA.

Theofanis, S., & Boile, M. (2007). *Investigating the feasibility of establishing a Virtual Container Yard to optimize empty container management in the NY-NJ region*. Retrieved February 26, 2008, from University Transportation Research Center Region II Web site:http://www.utrc2.org/research/assets/105/FinalReport1.pdf.

Theofanis, S., Boile, M., Janakiraman, S., & Naniopoulos, A. (2007, July). Reducing unproductive empty container movements around marine container terminals: The role of a Virtual Container Yard (VCY). In *Proceedings of the 2007 Annual Conference of the International Association of the Maritime Economists*, Athens, Greece.

Ting, S.-C., & Tzeng, G.-H. (2004). An optimal containership fleet allocation for liner shipping revenue management. *Maritime Policy and Management., 31*(3), 199–211.

UNCTAD. (2006). *Transport Newsletter*, 36, Geneva.

Veestra, A. W. (2005). Empty container reposition: The Port of Rotterdam case. In S. D. P. Flapper, J. A. E. E. van Nunen & L. N. Van Wassenhoven (Eds.), *Managing closed – Loop supply chains* (pp. 65–78). Berlin: Springer.