Empty container repositioning and short term leasing option in global container management

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1 Empty container repositioning

One of the major problems liner shipping companies are facing is the global unbalanced freight flow network. The imbalance is especially strong on the Far East-North Europe (1.9 to 1) and Far East-North America (1.6 to 1) direction. As a result, around 20% of all maritime container transportations refer to the repositioning of empty containers from surplus areas to areas where they are needed (Drewry, 2010). Even though empty boxes are normally piggybacked on the regular liner services, fuel and handling cost is still incurred and added to the repositioning cost, which can account for around 27% of the total spending in container management (Song et al., 2005). The high cost of repositioning or other losses in the back hauls to Asia could be covered by surcharges to the freight rate in the head hauls. This, however, increases the price of imported goods and thus affects all parties of the whole supply chain (Ng, 2012). The accumulation of empty containers in the surplus areas also binds storage capacities, which can impact port operations; for a survey see, e.g., Stahlbock and Voß (2010). In order to mitigate effects of imbalanced container flows, liner shipping companies search for solutions on strategic, managerial, logistic, IT and technological levels.

Another approach to managing the flow imbalance can be found in long- and short-term leasing. The long term lease (5-8 years) has typically the highest share due to its lower cost and the full integration of leased containers into the carrier’s fleet, enabling more effective management of the equipment. The short term lease (short period/trip/round trip), on the other hand, offers the flexibility in the situation of fluctuating demand, avoiding at the same time the long term binding of the capital. In order to prevent the excessive on-hire of containers in a shortage area and their return in a surplus area the leasing companies not only use additional on- and off-hire charges but also set the different quota for the lease return allowed on a certain time interval (usually for a month). The price of the short term lease can still present an alternative to the empty container repositioning.

This paper focuses on the problem of container management on a liner shipping network considering the short term leasing option. It also involves the option of demand rejection in
case if vessel capacities are not adequate for the total container transportation or if the freight rate surcharges in the head hauls from Asia are not enough to cover the empty repositioning cost and other losses in the unprofitable back hauls. The purpose of the paper is to develop a tactical model enabling to analyze the short term leasing strategy by altering its conditions and study the relation between own inventory deployment and leasing decisions under the impact of different parameters.

2 The model with assumptions
The problem is formulated as a multi-commodity network flow model that seeks to maximize the total profit obtained from container management.

Network representation and flow formulation: The physical maritime network is converted into a time-space network to account for the dynamic decision process. The set of weekly liner services with respective cost and travel times is given for container transportation. The set of customer demands is defined by a number of containers to be shipped from a port in a specific time to a destination port in a defined time. In order to account for availability of empty containers the inter-balancing constraints are applied to each node. The decision variables refer to the two main flows: the flow of containers owned by a shipping company and leased for a specific time.

The short term lease conditions are reflected by the pick-up and drop-off charges as well as per diem rate. It is assumed that containers are available for leasing at any time but considering that the leasing companies are trying to have only a small amount of equipment available for the short term lease, the restriction of the lease quantity is added. The model also sets the minimal average leasing duration and constrains the lease return in the ports. The total quantity of containers allowed to be returned on a certain time interval is calculated and updated based on a defined return quota, which is applied to the number of all leased containers available under the carrier’s disposal on this time interval. In order to model the leasing cost for the containers that are not allowed to be returned at the end of the planning period due to the restricted return quota, the cost of keeping the leased containers beyond the horizon is included in the model and the worse scenario is assumed: storing without using until the return is possible.

The on-hire of additional equipment not only impacts the utilization of own containers neglecting their inventory carrying cost but also binds the finances required for the leasing. Thus, the total leasing cost in the model includes also the opportunity cost of additional investments in container leasing.

Demand rejection: It is assumed that the service network might contain less or even unprofitable directions due to the high repositioning cost and the low freight rates on the routes with a poor traffic, as for example on the Asia inbound direction. The total vessel capacity might also be inadequate for the total container transportation. In case of transport
demand rejection the penalty cost considers not only the profit/loss referring to unsatisfied demand, but also the cost of an empty slot on a vessel.

3 The case study
Numerical results are provided for a case study focusing on the three main trade routes: Transpacific, Transatlantic and North Europe – Far East. The size of the physical network is limited to the major ports in the specific trade regions, e.g.: Hamburg, Singapore, Shanghai, Hong Kong, Tokyo, New York, Savannah, Los Angeles and Vancouver. Considering that the duration of one time period in the time-space network is based on the travel time between ports, the transit time of 3-4 days between ports in the East and West Coast of North America and between Asian ports will lead to the very large scale problem instances. Thus, the East Coast and the West Coast ports are aggregated in two nodes. The Asian ports are included in the network without aggregation. However, the travel time between Shanghai and Hong Kong is assumed to be negligible but the transportation cost of these links is still applied.

The planning period is set to one year, divided into 52 time periods (weeks). 1456 transport demands are generated with a uniform distribution taking into account the imbalance of the trade flow between regions. The demand for the aggregated ports is aggregated, respectively. The total initial own container inventory is distributed among ports according to their export volume. The container traffic/own container fleet ratio is set to 5.

Scenarios: In order to investigate the repositioning and leasing decisions different scenarios are created. They refer to: transport demand pattern (flat, with seasonal fluctuations, with growth tendency), financial aspects (equal transportation cost for loaded and empty containers, consideration of only handling and inventory carrying cost for empty container repositioning, opportunity cost consideration for leasing, slot purchase from other carriers), managerial aspects (unconditioned and minimally required lease duration, limited and unlimited leasing capacity in ports) and technical/other aspects (limited and unlimited storage capacity in the ports, inadequate total vessel capacity).

4 Results in brief and conclusions
The model was implemented using AMPL modeling language and all scenarios were solved using CPLEX 12.2 running under Intel(R) Core(TM) 2 Duo CPU 2.16 GHz processor with 3.5 GB RAM. The model enables to investigate the attractiveness of the short term leasing option under different conditions.

The results demonstrate that the leasing option can be considered as an alternative to the empty container repositioning only if the full sea transportation cost is applied to the empty boxes. This case might take place when purchasing slots from other carriers in the situation of inadequate vessel capacity or chartering the whole vessel only for the empty container shipping. Thus, for the study purpose such scenario is also investigated. Comparison of the total transportation cost in the back hauls to Asia and even the worse case of the short term lease for one-way trip from Asian to North American ports still demonstrates the
attractiveness of the leasing option. As a result, in the scenario with the equal transportation cost for empty and full containers the short term lease reaches 15% in the total container inventory. Containers are being on-hired in Asian ports mainly for the round trips to the U.S. West Coast and back for the reuse. However, more than 50% of those containers are being repositioned empty and only 19% is shipped back full. Moreover, since the return rate is restricted to 15% and the average lease duration is set to three months, more containers than needed are being on-hired, stored without usage and off-hired in Asian ports with the purpose to increase the total allowed container quantity for the return. The restriction of the short term leasing capacity to 1% of the total container inventory results in the deployment of almost 80% of all leased containers between the U.S. West Coast and Singapore/Shanghai. In this case empty container repositioning makes up 18% in the total transportation.

Sensitivity analysis shows the highest dependence of the leasing decisions on the return quota, which is being negotiated with a leasing company. However, the short term lease cannot compete with the repositioning option any longer in the scenario when the sea transportation cost for empty containers considers only their inventory carrying cost. The leasing decisions can be viewed as reasonable only in case of inadequate vessel capacity for the required empty container movements. The restriction of the short term lease capacity results in 1-2% of unsatisfied transport demand in the total container traffic. The customers’ demand is being rejected mainly on the U.S. West Coast – Tokyo/Hong Kong connection due to the lower losses compared with the Europe – Asia connections. However, the consideration of the slot purchase option for empty containers eliminates the need for the demand rejection. The amount of empty boxes shipped on the purchased slots accounts for 11% of the total empty container repositioning. It must also be noted that seasonal fluctuations of demand, if it is predicted and not uncertain, does not impact much the total short term lease number. The performed sensitivity analysis investigates also the influence of other financial, managerial and technical parameters on the leasing decisions for different scenarios.

References


