MODELING THE EMPTY CONTAINER FLOW: IDENTIFYING PRIMARY INFLUENCING FACTORS THROUGH SCENARIO ANALYSIS

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ABSTRACT

Empty container management is a critical managerial area that affects the profitability of the container industry. Multiple factors that include the trade imbalance, storage costs, tariffs, taxes, handling costs and cost of manufacturing new containers affect the flow of empty containers. Trade imbalance is generally known as the primary influencing factor that leads to empty container accumulation. This study presents a view that trade imbalance is just an enabling factor and that the underlying reasons for accumulation of empty containers are the dynamics associated with the container leasing industry. The present study capitalizes and extends a previous study developed by Tulpule, Diaz, Longo, & Cimino (2010) that concerns with identifying the critical factors that intervene in empty containers management and creating a system dynamics framework for modeling this system. This extension further characterizes containers 'owned' by the shipping company and those 'leased' by the same company. Moreover, this new model includes new container manufacturing capacities and is used to perform a theoretical scenario analysis. This model forms a basis for reasoning about the possible trends in empty container movements such that the decision-making processes can be aided and improved.

Keywords: empty containers, system dynamics, decision support system

1. INTRODUCTION

The basic framework for the present study was introduced in Tulpule et al. (2010). This study extends the basic framework to include factors associated with the container leasing industry and the container manufacturing industry. The extended framework is used to test two theoretical scenarios in the container industry. The results of the scenario analysis are envisioned to provide insights into the primary causes leading to empty container accumulation in container surplus areas. The literature in this are traditionally focuses on trade imbalance as the major cause of empty container accumulations (Boile, 2006). Empirical data generated from the present study suggest that trade imbalance is an enabling factor while the dynamics associated with the container leasing industry are the primary reasons for empty container accumulation. These effects are further escalated by the changing preferences of the shipping companies to increasingly own containers instead of leasing them.

The problem of empty container accumulation according to Boile (2006) include trade imbalances, rate imbalances, new container prices vs. cost of inspecting and moving empties, un-timely shipment and delivery of containers, high storage fee in areas of high demand. While these factors certainly play a significant role in repositioning decisions, the third cause in the listing above has a significant impact on these decisions. This can be justified from the fact that although trade imbalance may encourage repositioning to demand areas and high storage fees may deter the same, large scale repositioning of empty container is inconceivable performed under normal circumstances if the cost of such an effort is higher than the cost of a new container in the demand area. This simple fact becomes complicated by the changing patterns of container ownership over the past few years.

The proportion of container owned directly by the shipping lines has steadily increased over the past few years (Theofanis & Boile, 2009). Shipping lines now own about 60 % of all the shipping containers while the rest is mostly owned by container leasing firms. Depending on the type of the lease that the containers are on, the shipping companies may be able to off-lease the containers in container surplus areas so as to avoid repositioning costs. Under such a scenario the leasing company becomes liable towards repositioning the container to the high demand areas. However such repositioning could become infeasible if the total cost of repositioning the empty container is more that the cost of purchasing new container in the deficit area. The shipping company has a distinct advantage of being able to reposition its own empties on its own ships without any freight costs (at least in a practical sense). This is because the ships travel largely empty on the backhaul and the trade imbalance ensures that practically no opportunity costs are involved. The leasing companies on the other hand have to pay the shipping company some freight charge to be able to reposition its container overseas. An approximate cost analysis in the later part of the paper shows that generally the shipping companies find (at least over the last decade) the repositioning option to be feasible over purchasing new container. The leasing companies, however, may or may not find repositioning feasible depending on the relative cost of repositioning versus purchasing new containers.

Since the shipping companies are liable for the containers they own, it is expected that they actively reposition them as required to ensure optimum utilization and avoid storage costs. This is not true regarding leased containers that can be possibly off-leased. With the tendency of the shipping companies to increase their ownership of the containers, such off-leased container may be replaced by purchasing new containers in the deficit area. This systematically leads to an accumulation of empty containers in the surplus areas. It can also be seen that a majority of these accumulated containers will be owned by leasing companies. This dynamic only changes in situations where the demand for empty containers is highly elevated and the container manufacturing facilities in the deficit region are unable to keep up with the demand. Under such a scenario the shipping companies in their need for empty containers and intense supply pressure of new containers opt to lease/purchase accumulated containers in the surplus region and transport then to the deficit region so as to satisfy customer demand. This situation results in a considerable drop in the container accumulation scenario.

Having introduced the background, the further paper is organized as follows; the next section includes a brief review of the relevant literature. This is followed by a brief introduction to the previously introduced model for the benefit of readers not acquainted with it. The fourth section discusses key extensions to the model developed by Tulpule, Diaz, Longo, & Cimino (2010). This is followed by developing two scenarios of interest and discussing the key results obtained by implementing the scenarios in the extended model. The paper concludes by discussing important findings and identifying the scope of future work.

2. LITERATURE REVIEW

Relevant literature pertaining to the empty container repositioning problem in general was covered in Tulpule, Diaz, Longo, & Cimino (2010). A brief summary of this literature is presented in this paragraph.

In general, empty container problems can be classified as inventory control problems (Cimino, Diaz, Longo, & Mirabelli, 2010). According to Lam, Lee, & Tang (2007) the literature dedicated to empty flows in terms of their application can be classified as operational, tactical, and strategic with a major portion of the literature inclined towards operational factors like depot location, and sizing. A comprehensive discussion the container industry in general with special emphasis on the reasons behind the accumulation of empty containers in all major ports in the US during that period has been provided in (Boile, 2006) and Theofanis & Boile (2009). The model presented in Tulpule, Diaz, Longo, & Cimino (Tulpule, Diaz, Longo, & Cimino, 2010) concerns with utilizing some of the factors identified in these studies as the basis for creating a system dynamics framework for modeling and simulating container movements. The critical point to be considered is the feasibility of the repositioning activity versus the option of purchasing new containers. In this sense, it is important to understand the costing structure behind shipping rates. An excellent analysis of the shipping fee costing and particularly the associated terminal handling charges is provided in European Commission (2009). Following is a brief account of the relevant aspects found in this paper. The shipping fee consists of three primary components namely two terminal handling charges at both the ports and a freight charge for movement over the ocean in terms of port-to-port container movement. The terminal handling charge recovers the fees that the shipping line has to pay to the terminal authorities for handling the container until it is loaded on the ship. The terminal handling charge has several cost components most of which (about 80%) are charged to the shipper in the form of the terminal handling fee. The balance, around 20%, is paid by the shipping company. Different rates may be charged for handling full versus empty containers. While the terminal handling charges are relatively stable the freight charges are the function of the supply/demand dynamics, operational costs, and fuel costs.

There is a clear difference between the shipping companies and the container leasing companies in terms of their repositioning cost structure. Assignment of freight cost to shipping company in terms of backhauling empty containers is a more or less theoretical issue and this cost is practically assumed to be zero in many cases (Konings, 2005). Another aspect that affects this relation is the relative demand for empty containers and the availability of new containers. Boile (2006) reports that excessive demand for empty containers in China around 2005 and a shortage of new containers due to limited manufacturing capacity forced the shipping liners to reposition containers form the US to China, thus, reactivating container that were off-lease for a considerable duration of time.

In summary, the literature points to the fact that container accumulation is affected by a combination of demand/supply dynamics as well as manufacturing capacity for new containers. Repositioning of empty containers is more feasible for the shipping lines as compared to the leasing companies. Also, the shipping companies may be increasingly adopting mass repositioning of empty containers in face of acute empty container shortages in demand areas. Lastly, the increasing tendency of the shipping lines to own container as reported by Theofanis & Boile (2009) adds further complexity to this system.

3. MODEL DESCRIPTION

This section briefly introduces the model that was previously introduced in Tulpule, Diaz, Longo, & Cimino (2010) which introduces a simple two port system with a trade imbalance setting. The port with a positive trade balance has the option of either importing containers from the other port or purchasing new containers. However, the preference for this decision depends on the relative cost of repositioning versus the cost of purchasing new containers. It is assumed that repositioning empty containers or purchasing of new ones is the only options for acquiring containers at the point of interest.

The model assumed an equal and fixed storage cost at both the ports and the same assumptions holds for the present analysis. Also the considerations of capacity made in the original model are no longer included. Sufficient capacity is assumed to be available at both ports to handle the container traffic. If the trade imbalance between the ports starts to change over time, an attempt is made to adjust the repositioning policy such that excessive accumulation will not occur in any of the ports. A delay of sixty days is introduced before decision makers can appreciate a significant change in trend of trade imbalance and make corrective actions to their policy.

The functionalities of this model are demonstrated using data from the Port of Los Angeles. For the sake of simplification it was assumed that the Port of Los Angeles has a single trading partner in China. The TEU statistics for the port of Los Angeles were obtained from (Port of Los Angeles, 2010). Figure 1 and 2 display the simulated and the average actual TEU of containers repositioned (out empty) from the Port of Los Angeles from 2000 to 2009 per day. As can be observed the simulated and the actual values follow similar trend and take comparable values. This provides an empirical validation for the proposed model.

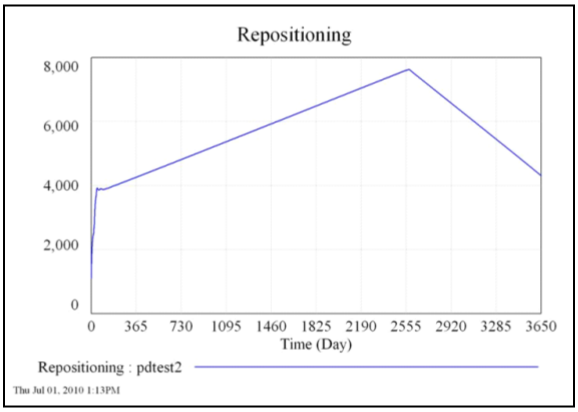

Figure 1 –Volume of repositioned TEU for port of Los Angeles

The said model is expanded to separately include representation for the 'leased' containers and is shown in Figure 3. It is known that about 60 % of the containers are owned by the shipping companies with the majority of the reminder are owned by container leasing firms (Theofanis & Boile, 2009). In the present model, the incoming containers are separately categorized as owned or leased. This is done by assuming a fixed ratio of split between owned and leased containers for containers coming into the US port. The present study assumes that 60% of the containers are owned by the shipping companies. Notice that the 'owned' portion of the containers also include leased containers that are on long term leases with the shipping company. Thus, the owned containers include all containers whose management is the liability of the shipping company. The 'leased' portion of the containers include containers that are on short term leases and which can be relinquished back to the leasing entity at the end of the trip. The empty containers (owned or leased) are used to satisfy the demand of empty containers by exporters and are consequently shipped back to the parent port (since this model has only two ports, the option of transshipment to a third port is not available).

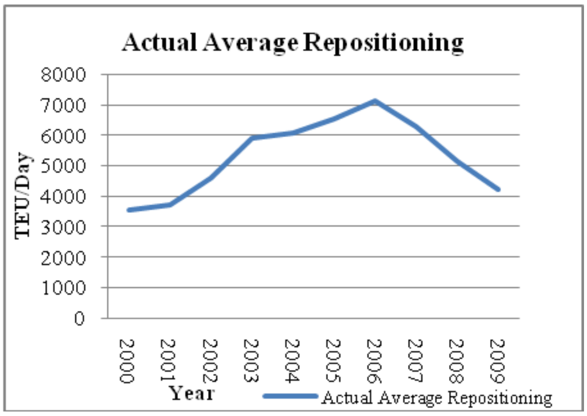

Figure 2 –Average volume of repositioned TEU for port of Los (Simulated) Angeles (Actual)

While segregation between 'owed' and 'leased' containers is included on one port, container manufacturing dynamics are included on the other port. The difference between required and the available empty containers indicates the number of containers that need to be newly manufactured. A fixed manufacturing capacity is assumed to be available. Excessive demand for newly manufactured empty containers uplifts the utilization levels of the manufacturing facility, thus, putting pressure on the container supply. This pressure is taken into account by introducing the factor 'Supply pressure.'

The utility of this factor is discussed as follows. The trade imbalance is a primary cause of empty container accumulation in ports with negative trade imbalance. Empty containers accumulate if the cost of repositioning empty containers to the deficit region is more than buying new containers in the deficit region. In this paper, the authors have asserted that trade imbalance is just an enabling cause of empties accumulation and that the factors associated with container leasing are the primary cause of accumulation.

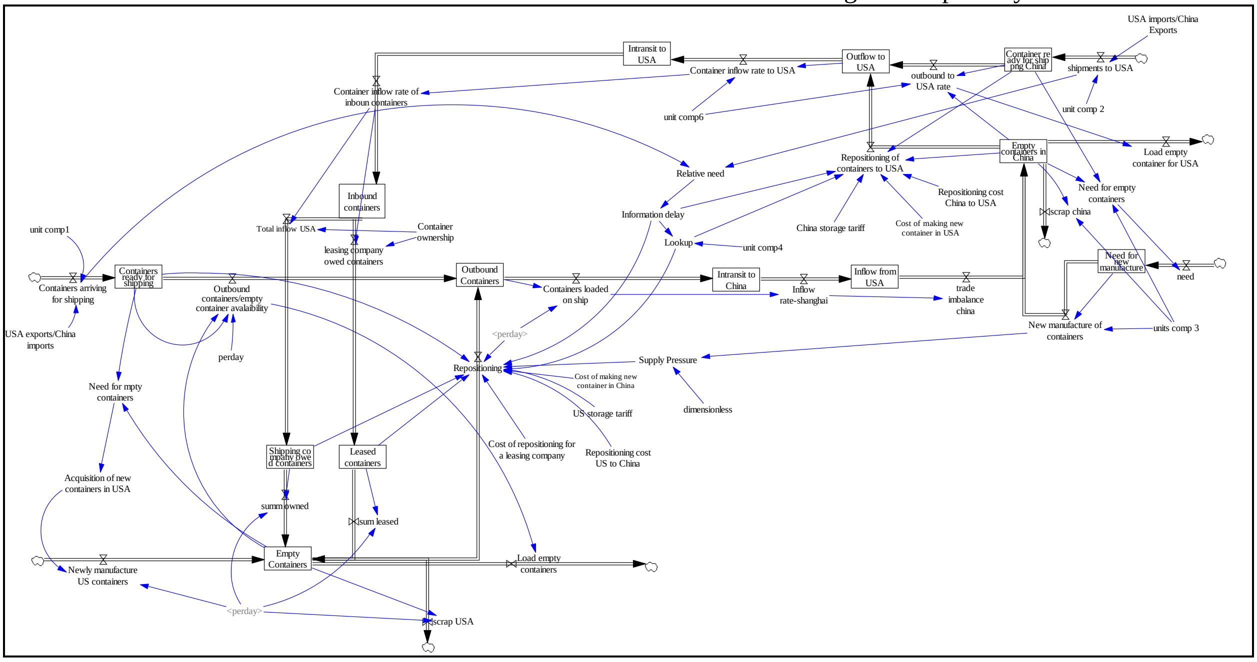

Figure 3 – Extended model for container movements

The fee charged by shipping companies to shippers for port-to-port transportation is primarily divided into three components namely a 'terminal handling charges' at both the ports and a 'freight charge' for transport over the ocean. Generally the terminal handling charge is split between the shipper and the shipping company in 80/20 ratio. To reposition an empty container, the shipping company becomes liable to pay the terminal handling charge at both the ports since it itself is the shipper.

There is no direct freight charge involved since the vessels travel largely empty in the reverse direction due to the trade imbalance and hence no significant opportunity costs is involved. However, this only is true if the container is 'owed' or on a long term lease with the shipping company.

The average terminal handling charge in 2009 at the port of Shanghai for a 20' dry container (generally any port in China) was 475 RMB with amounts to approximately 75 dollars. During the same period the terminal handling charge at the Ports in the US was 390 USD. Thus, at least in theory the total terminal handling charge that a line charges to its customers for a trans pacific movement is approximately (75+390)= 465 USD. Adding 20 % to this cost to over the liabilities of the shipping companies in terms of the terminal handling charge gives the total amount of 558 USD. (Veenstra, 2005) reports a cost of about 400 USD per empty repositioning.

As mentioned earlier, the above argument is valid only for container owned by the shipping companies. As against this the leasing companies would have to pay considerably more to have their container repositioned to deficit areas since they would also be liable to pay some ocean freight charges in addition to the charges mentioned above (Konings, 2005). Repositioning cost of the leasing companies could easily exceed 1,000 USD (Prozzi, Spurgeon, & Harrison, 2003) and are highly susceptible to demand/supply dynamics and fuel costs. Noting that the cost of a 20' dry container has never been below 1,500 USD in the last decade (Barnard, 2010), the following summary can be drawn. Firstly, repositioning is always preferable to purchasing new containers, in case where the containers are owned by shipping lines. However, this may not be true for containers that are off lease and possessed by the leasing company and depends on the relative costs of repositioning and cost of manufacturing new containers. Thus, accumulation results only if a container is off leased by the shipping company in a surplus region and the cost of repositioning the off lease container to the deficit region for the leasing company is higher than purchasing a new container in the deficit region. The only means of disposal for such containers if through the secondary market or during the periods of extreme demand for empty containers wherein the shipping companies may agree to lease or purchase those containers in the surplus region and take the cost of repositioning them to the deficit region upon themselves. The accumulation is abated by the tendency of the shipping companies to increasingly own their container fleet. Thus, containers off leased in the surplus region have likely been replaced by 'owed' containers purchased new in the deficit region.

The above discussion can be summarized as follows.

1. Shipping companies proactively reposition empty containers that they own to the deficit region since the cost of repositioning is always less than purchasing a new container (although new containers may still be purchased to satisfy increasing demand).

2. Cost of repositioning is higher for the leasing company, and thus, containers off leased in the surplus area may not be economically repositioned to the deficit areas as compared to purchasing new containers in the deficit areas.
3. The rising tendency of the shipping companies to own the containers leads to the tendency of off-leasing the container in surplus area and buying new containers in the deficit area, thus avoiding the cost of repositioning. From the first three points one could assert that empty containers owned by the shipping lines have a lesser chance of accumulation as compared to those owned by the leasing companies.
4. Extreme demand for empties and a shortage of new containers force the shipping containers to purchase or lease the containers in the surplus area and bear the repositioning cost to the deficit area, so as to be able to meet the demand for empties in the deficit area. In such a situation the surplus region should see a significant drop in accumulated containers as they are repositioned to the deficit regions.

The observations noted above are incorporated into the system dynamics model. The model is simulated and the results are used to validate if the model behavior replicates the hypothesized system behavior noted in the enumeration above.

4. SCENARIOS ANALYSIS AND RESULTS

This section would briefly introduce the model that was previously introduced

4.1. Scenario 1 - Constant export trade volume at both the ports with variable proportion of containers owed by shipping companies

Under this scenario, it is assumed that both the ports have a constant trade volume implying a constant trade imbalance. The cost of repositioning for a leasing company is same as that of a new container in the deficit area. Also, the cost of repositioning for a shipping liner is half that of the cost for a leasing company, since it is assumed that the shipping company does not incur any ocean freight charge. The following two scenarios are tested to see the effect of container ownership percentage on container accumulation and repositioning trends.

- Case 1 – Shipping companies own 60% containers
- Case 2 – Shipping companies own 100 % containers

It can be seen in the Figure 4 below a higher proportion of leased containers under the assumed circumstances leads to a higher accumulation of containers in the surplus area. These results from the fact that the shipping companies off lease the containers in the surplus areas and it is economically infeasible for the leasing companies to reposition the containers back to the deficit areas. On the other hand, containers owned by the shipping companies can be repositioned economically as the shipping companies incur lower repositioning costs. Secondly an adequate supply of new containers in the deficit area makes sure that the shipping companies can purchase or lease new containers in the deficit areas thus leading to an accumulation of empty containers owned by leasing companies in the surplus area. This observation of primarily leased containers being accumulated is reinforced in Boile (2006).

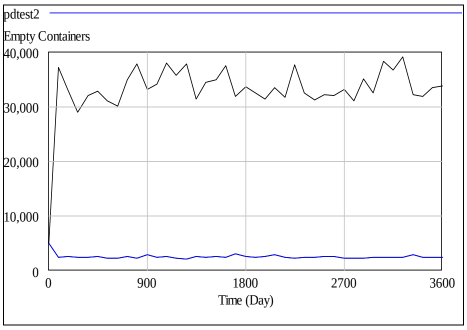

Figure 4- Container accumulation at US port, Case one – black line, Case two – blue line

It can also be seen from the Figure 5 below that in general the number of containers repositioned increases when the proportion of the containers owned by the shipping companies increases. This further reinforces our first observation of a lower accumulation rate in the same context.

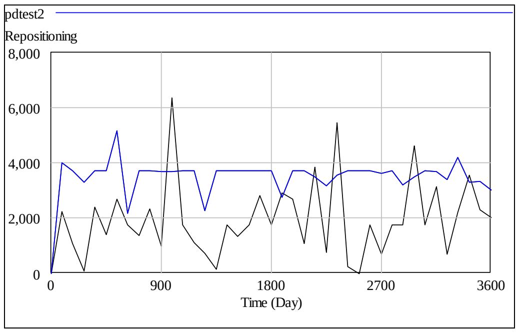

Figure 5- Container repositioning at US port, Case one – black line, Case two – blue line

4.2. Scenario 2 – Sharp increase in export trade volume at China port followed by sharp decrease, with variable proportion of containers owed by shipping companies

In the second scenario a very sharp increase in export volumes of the deficit port is assumed. The sharp rise in exports (TEU) is followed by an equally sharp drop as shown in the Figure 6 below. It is necessary to point out that such a trend is just theoretical in nature and does not reflect a real scenario. Such a trend is useful in observing how the modeled container market reacts to sharp rise and fall in demand.

Case 1 – Shipping companies own 60% containers

Case 2 – Shipping companies own 100 % containers

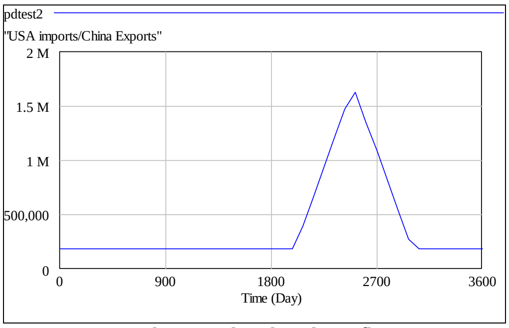

Figure 6- Theoretical trade volume fluctuation

As expected, the sharp rise in demand for empty containers exert an excessive pressure on the supply of empty containers as shown in Figure 7. As the container manufacturing facilities fail to meet the demand, the shipping companies in desperation turn to the accumulated containers owed by the leasing companies in the surplus areas. The shipping companies undertake to reposition these containers from the surplus to the deficit areas after acquiring them on lease or by purchase. This is reflected in the Figure 8 wherein a sharp drop in the accumulated leased containers is observed. Also as seen in Figure 9 the repositioning volumes of owned as well as leased containers match closely during the demand hump as opposed to the observation in the first scenario. It can also be seen from Figure 10 that a sharp fall in demand that is followed by the sharp rise leads to an excessive accumulation of empty containers in the previously deficit regions. This observation is reinforced in (Bloomberg, 2009). This is because a large number of containers repositioned to the deficit areas are no longer required which results into the observed accumulation in the previously deficit areas.

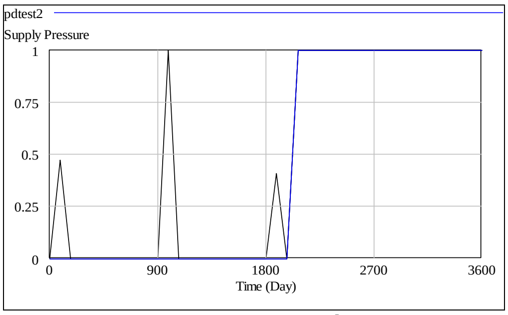

Figure 7- New container supply pressure

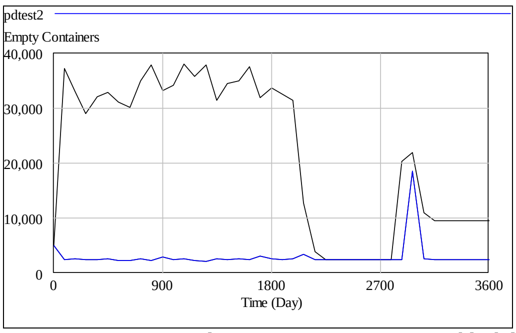

Figure 8- Container accumulation at US port, Case one – black line, Case two – blue line

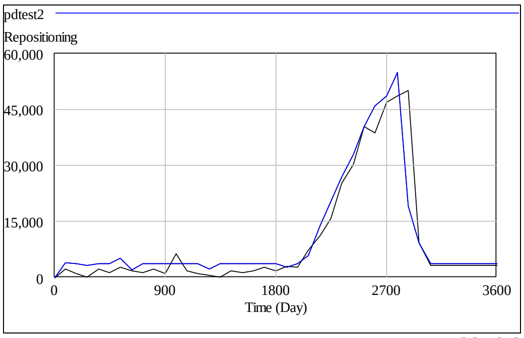

Figure 9- Container repositioning at US port, Case one – black line, Case two – blue line

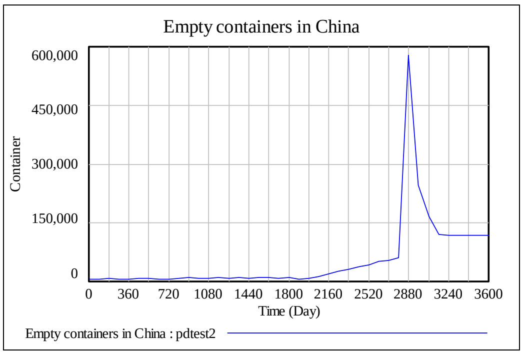

Figure10 - Empty container accumulation in the simulated Chinese port

5. CONCLUSION AND FUTURE WORK

The presents study extends the previously introduced system dynamics model (Tulpule, Diaz, Longo, & Cimino, 2010) for container movements to include container leasing dynamics and new container manufacturing capacity. It is asserted that while trade imbalance is an enabling factor, the actual underlying reason for container accumulation lies in the dynamics associated with the container leasing industry. Theoretically, speaking if all the containers were owned by the shipping lines, then no significant accumulation of the containers should be observed in either of the ports in spite of significant trade imbalance. As discussed, empty container repositioning is consistently more feasible for the shipping lines as compared to the leasing companies since the shipping lines do not have to bear any ocean freight charge, at least in a practical sense. When the demand of the empty containers exert excess pressure on the container manufacturing facilities, the shipping companies may be forced to lease accumulated containers in the surplus region and transport the back to the deficit region taking upon themselves the repositioning costs. However, the need to satisfy customer demand under heavy shortage of empty container makes this choice imperative. The increasing tendency of the shipping lines to own their containers increase pressure on the leasing companies, especially on imbalanced trade routes. A rise in the cost of steel leading to an escalation of new containers can make repositioning a more feasible option for the leasing companies. However, an equivalent rise in freight charges could offset that difference by increasing the backhaul ocean freight charges. In any case, the shipping lines are in a better position to undertake the repositioning activity as compared to the leasing companies.

On the other hand, rising trade imbalance may give the leasing companies some leverage to negotiate better backhaul charges for the empty containers as the shipping lines struggle to find export containers. It seems unlikely though, that it results in any significant gains for the leasing companies unless there is excessive demand pressure for empty containers.

The present study helps to acknowledge and quantify many of these dynamics using a modeling and simulation perspective. The scenarios presented in this paper certainly help in better understanding the factors influencing these dynamics. These results are especially relevant for the leasing companies as they provide a platform to test various scenarios in the context of various leasing options. For example, the leasing companies can and actually do alleviate the problem of repositioning by specifying the 'drop off' location on lease expiry in the container deficit region. However, in case of long term leases specifying such conditions accurately can be difficult as trade patterns keep changing. The leasing companies charge pickup and drop-off fees to the customers to cover the costs of repositioning. However, the cost of repositioning is volatile and subject to demand/supply dynamics and commodity prices which make difficult to ensure that the charged fees can cover the repositioning expenses. Above of all, the fees that can be charged and the lease conditions that can be specified are largely dependent on the leverage that the leasing companies have over the shipping companies. The increasing tendency among shipping companies to own containers act against any leverage the leasing companies have. Appropriate policies can be designed when the dynamics associated with this industry are appreciated and a rigorous scenario analysis is performed to identify and quantify risks and opportunities. The model presented in this paper aspires to support this precise effort.

The present study can be extended to include details on specific lease types such that scenarios can include various lease portfolio options. Also the two port model can be expanded to a multi port system. Primary factors like the cost of steel and oil as well as the supply demand dynamics that affect the freight rates can be explicitly included in the model.

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