Policy Analysis of Supply Chains for Asia – USA Containerized Imports

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Abstract

We critically consider policies of large importers and policies of domestic port agencies and governments with respect to managing the large flows of containerized imports from Asia to the United States. We describe the results of an optimization analysis of the Asia – USA supply chain of a large importer distributing retail goods nation-wide, leading to our first policy recommendation: For the top 10 and perhaps as many as the top 40 importers of Asian goods, it is more profitable to adopt a portfolio of supply chain strategies corresponding to the importer's portfolio of imported goods in lieu of a single homogeneous strategy applied to the entire portfolio. Second, we consider risk management in the design of the supply chain. We observe that large importers design supply chains with infrastructure and transportation rates to utilize more ports of entry than is optimal in a deterministic sense. We analyze the benefit of such redundancy in terms of coping with a temporary disruption to imports at the Ports of Los Angeles and Long Beach. When the deterministic optimal supply chain calls for LA-LB to be the only port of entry, redundancy at one more port is cost-effective. Otherwise, operating savings from such redundancy are relatively modest, probably not enough to justify the added investment. We are left with a conclusion that the primary justification of redundancy as practiced by large importers is bargaining power for annual negotiations with transportation carriers, third-party logistics operators and landlords.

Next, we consider governmental policies. Our first governmental policy recommendation is that continued investment focus and environmental mitigation focus on channels accommodating direct inland shipping of marine containers must be tempered by the fact that market share for such channels is declining, and the decline is likely to accelerate in coming years. Instead, there needs to be greater focus on the channels involving import warehousing and cross-docking, whereby imports are trans-loaded into domestic containers and trailers. This leads to our second governmental policy recommendation: Land-use policies should promote the development of cross-docks and import warehouses in industrial properties in the vicinity of the ports. Reducing the scope of dray transportation by means of cross-dock and warehouse development can be much cheaper than building truck lanes on the freeways or special rail systems to haul boxes to/from more distant inland warehouse parks.

At present, the environmental impact review process for logistics infrastructure projects considers the environmental impacts in the surrounding local area of the project. In the case of infrastructure used for handling Asia – USA imports, the impacts are nation-wide, and the nation-wide impacts can be quite different from the local impacts. Our third governmental policy recommendation is that the national-level environmental impact ought to be assessed in EIR processes in lieu of solely a local assessment.

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1. Introduction

In 2006, about 7 million containers of imports from Asia entered continental USA ports. The supply chains which these imports followed are in a state of flux driven by changing economics both within the USA and abroad. Analyses based on retailers' supply chains suggest that many steps can be taken to improve supply chain cost and efficiency. The purpose of this article is to make policymakers and supply chain participants aware of these trends, and to suggest changes to transportation and distribution infrastructure and utilization that could significantly increase supply chain efficiency.

A typical large US importer/retailer operates a fleet of Regional Distribution Centers (RDCs) spread across the Continental USA that restock retail outlets. Differences in inventory costs resulting from use of alternative supply channels typically extend only as far as the RDCs, which are typically located within an overnight drive to the outlets they supply. In this article, we consider the origins for import shipments to be factories in China and elsewhere in Asia, and the destinations are RDCs spread across the Continental USA. While the portfolio of products for an importer may encompass multiple origins, typically any particular product to be distributed across the Continental USA is sourced from a single Asian origin.

Marine containers from Asian origins are shipped on vessels to ports of entry (POE) to the USA, called "ports" in this article. The containers may be directly shipped inland to the RDCs, called "direct shipment," or they may be unloaded at trans-load or import warehouse facilities and the contents sorted and re-shipped in domestic vehicles to multiple RDCs, under a strategy termed "consolidation-deconsolidation" shipment. Under the consolidation-deconsolidation scheme, marine containers containing goods destined to multiple RDCs are channeled through a common port and routed to a deconsolidation center (trans-load warehouse or cross-dock) located in the hinterland of the port of entry. The goods are unloaded from the marine boxes, sorted and re-loaded into domestic containers or trailers for final landside movement to the RDCs, possibly after some valued-added processing. Both direct and consolidation-deconsolidation shipments may use various landside transportation modes (channels) to reach RDCs; i.e., train, truck, and local drayage (dray).

Depending on the selected port of entry and the landside mode of transportation, the importer will face different transportation costs. Another source of cost is the opportunity cost of working capital tied up in the inventory throughout the supply chain. This cost is usually expressed as an interest rate times the amount of capital invested per unit of inventory times the average inventory level.

There are three types of inventories in the chain: cycle inventory, pipeline inventory, and safety stock. Cycle inventory is a function of the replenishment frequency (e.g., weekly) and is otherwise independent of the selection of the supply chain strategy and channel. Pipeline inventory is the amount of inventory in the pipeline, and it is a function of the transportation time. Safety stock is the extra inventory kept by retailers to satisfy customer demands on time. Safety stock is maintained as a hedge against potential delays to shipments and potential errors in sales forecasts. It is a function of the customer service level, the uncertainties in the shipment lead time, and the demand forecast error. Requiring a higher customer satisfaction level, or making use of supply channels that entail longer or more unreliable lead times, results in the need for larger safety stocks at RDCs.

The consolidation-deconsolidation strategy exemplifies the concepts of “postponement” and “risk pooling” to reduce the requirement for safety stocks at destination RDCs. By postponing the commitment to specific channels and RDCs, the importer can exploit an updated match-up of supply versus demands to reduce safety stocks. The risky exposure to demand surges or supply shortages over the long lead times from Asian factories to the RDCs can be reduced to a relatively low-risk exposure over the short lead times from the trans-load warehouse to the RDCs. Furthermore, by pooling the forecast errors of demands at different RDCs together, served by a single port, importers face less demand uncertainty, and can reduce the level of safety stocks.

In typical practice, the contents of five forty-foot marine containers fit into three domestic containers or trailers that have much larger cubic capacities. The savings from fewer inland vehicle movements partially off-sets the extra costs for the transportation circuitry and for trans-load handling of goods associated with the consolidation-deconsolidation strategy.

Some retail importers are large enough such that they not only have the opportunity to employ trans-loading strategies, but are also able to profitably employ multiple strategies for importing their portfolio of goods, e.g., some goods imported via direct shipping and others via trans-loading. We will make some reasonable assumptions and show that their overall supply-chain problem can be optimized by performing a single-strategy optimization multiple times, and then applying a simple shortest path algorithm to group portions of their portfolio into particular strategies.

Most importers make little or no investment in facilities upstream from the RDCs, choosing to subcontract trans-loading and import warehousing services. They review their supply-chain strategies annually. Their transportation, trans-loading and import warehousing services are put out for bid, leading to annual contracts for such services provided by steamship lines, intermodal marketing companies, and third-party logistics providers. Thus import supply-chain strategies are static over a 12-month time frame but can be changed in minor ways or major ways from year to year in response to changing transportation or inventory economics.

When the volume of any given shipment from the port to the RDC does not exactly match the size of a container (marine or domestic), importers will have to deal with less-than-container shipments. For a shipment that only takes up a fraction of the container's volume, the importer may be required to pay the full transportation costs, or a cost greater than that given fraction of the container's volume. Using this analysis, we examine the cost reductions for a case-study retailer. We will also analyze which retailers appearing in US Customs data operate at a large enough volume to realize a cost reduction by deploying multiple import strategies for their portfolio of goods.

We will also examine the value of port redundancy in a retailer's supply chain strategy. Interviews with a number of large retail importers reveal that in actuality these large retailers manage import warehouses and trans-loading operations at more ports than would be considered optimal by our analysis. We compare the costs of utilizing these additional, and potentially unnecessary, ports to the costs of disruptions at the ports of entry we find to be optimal in a deterministic sense. Port redundancy may be worthwhile as a preventative measure in those cases where a disruption at the reduced number of ports would cause a large increase supply chain cost.

2. Data Sources

For this research, we procured data from a large big-box national retail chain, on their transportation and handling costs via all channels and strategies, landside and across-the-water transit times, and import volumes during different times of the year.

We secured US Customs data for year 2006 as summarized in the PIERS (http://www.piers.com/) commercial data subscription. These data specify for each US port, each importer, and each of 99 commodity codes the total volumes of imports from Asian origins (measured in twenty-foot equivalent units, or TEUs). We also secured the customs data for year 2006 as summarized in the World Trade Atlas commercial data subscription, which summarizes total volumes of imports to the Continental USA from Asian origins by total declared value for each of the 99 commodity codes. These data enabled the authors to make estimates for volumes and declared values per cubic foot by commodity type for general retailers. We then assumed a comparable value distribution for the big-box retailer, as this particular chain sells goods encompassing the entire value spectrum.

The major North American ports of entry are as follows:

1) Vancouver, BC (VAN), assumed no trans-loading through this port, only direct shipment of marine boxes (to USA destinations).

2) Seattle-Tacoma, WA (SEA), assumed trans-loading is allowed.

3) Oakland, CA (OAK), assumed trans-loading is allowed.

4) Los Angeles – Long Beach, CA (LA), assumed trans-loading is allowed.

5) Lazaro Cardenas, Mexico (LAZ), assumed no trans-loading.

6) Houston, TX, (HOU), assumed trans-loading is allowed.

7) Savannah, GA (SAV), assumed trans-loading is allowed.

8) Charleston, SC (CHA), assumed no trans-loading.

9) Norfolk, VA (NOR), assumed trans-loading is allowed.

10) Port of New York – New Jersey (NY), assumed trans-loading is allowed.

11) Prince Rupert, BC (PRU), assumed no trans-loading.

There are other ports handling Asian imports to USA, but in much smaller volumes than handled by the above ports. Other important data concern mean and standard deviation statistics on container dwell times in port terminals, and on container flow times in landside channels, as reported in private communications from major importers, terminal operators and railroads.

In our study, the continental United States is divided into 24 regions corresponding to the RDCs employed by the retailer, with the entire import demand for each region concentrated at a single location. In actuality, the case-study retailer employs 26 RDCs in the continental United States. However, two pairs of these RDCs are in such close proximity to each other geographically that we chose to combine them. We believe these pairs of facilities simply handle distribution of different portions of the product portfolio within the same regions.

Costs to ship imports from the ports of Qingdao, Shanghai, Ningbo, Xiamen, and Yantian in mainland China to the ports of entry in the United States were provided by the retailer as of 2010. For each port of entry and each destination, 2010 rates were provided for two alternative supply-chain channels: (1) shipping marine containers direct from Asia to RDC destinations, and (2) shipping marine containers to trans-loading warehouses in the hinterlands of the ports of entry, thence re-loading the imports in domestic rail containers or truck trailers for re-shipping from trans-loading warehouses to regional destinations.

In many cases, the retailer did not have transportations costs for certain channels, as they are not currently in use. For these channels, costs to importers for routing imports were developed. Year 2007 rate quotations to various importers from steamship lines, non-vessel-operating common carriers, intermodal marketing companies, trans-loading warehouse operators, railroad carriers and trucking companies were obtained. Considerable variation in rates from carrier to carrier and customer to customer was encountered. Average rates were developed from a basket of rates for each channel. Year 2010 fuel recovery surcharges were applied.

We have observed in practice that typically each RDC is supplied using only one channel. Volume is concentrated on a channel in order to negotiate a favorable rate as well as to simplify information management. We have therefore assumed in the model below that for a particular set of goods each RDC must be replenished using a single port and a single landside channel. We assume independent and identically distributed normal variables for demands and lead-times, with no correlation among these variables.

3. Heuristic Algorithm

The simplest setting of the problem under study can be translated to a p-median problem, in which *p* facilities are to be selected to minimize the total (weighted) distances or costs for supplying customer demands. In addition, we consider more complexities such as the inventory costs, which are nonlinear in the assignment variables, and the selection of transportation modes in a multi-echelon setting. Thus, the problem we are studying is more difficult than the standard p-median problem, which is already a well known NP-hard problem (e.g. see Revelle et al., 2008).

A Mixed Integer Non-Linear Programming approach is discussed in Jula and Leachman (2011), which allows for mixed strategies of trans-loading and direct shipments for the same set of goods. That is, some port-RDC combinations will be serviced by direct shipping, while others will employ trans-loading. In Davidson and Leachman (2012), a heuristic is described that more accurately matches what retailers do in practice. In the heuristic, for a set of goods we only allow one homogeneous strategy selected from among a set of fixed strategies. For the case-study retailer, we generated 15 potential strategies, some actually practiced by the retailer as well as others that they could conceivably explore given their current infrastructure. A sample of the potential strategies include the following:

1) TL-LA: Consolidate-deconsolidate and trans-load using a warehouse in the hinterland of the Ports of Los Angeles and Long Beach (LA-LB) only. Importers of expensive goods, difficult-to-forecast goods and goods experiencing rapid obsolescence have been observed to practice TL-LA supply chains. Such supply chains permit inventory to be managed as tightly as possible, albeit with transportation costs higher than for other alternatives. LA-LB is chosen as the single port of entry because Southern California is the largest local market, and so transportation costs are minimized compared to using a different single port of entry.

2) TL-2-Sav: Consolidate-deconsolidate and trans-load using warehouses at both LA-LB and Savannah. Compared to TL-LA, this strategy can reduce transportation costs by making use of all-water transit to a de-consolidation center located on the East Coast. However, safety stocks and pipeline inventories are increased.

3) TL-2-WC: Consolidate-deconsolidate and trans-load using warehouses at both LA-LB and Seattle (WC short for West Coast). As in TL-2-Sav, safety stocks and pipeline inventories are increased while transportation costs are decreased. Additionally there may be favorable rates through Seattle that would partially make up for the increased distance from East Coast RDCs.

4) TL-3-Sav: Consolidate-deconsolidate and trans-load using warehouses at LA-LB, Seattle, and Savannah. Compared to TL-2-Sav or TL-2-WC, transportation costs are reduced further, but safety stock requirements are increased. This strategy is employed by the case-study retailer for much of its import portfolio.

5) Direct-WC: Direct-ship marine boxes to RDCs considering use of only West Coast ports. Small and regional importers of relatively expensive goods have been observed to practice such an import supply chain strategy.

6) Direct-All: Direct-ship marine boxes to RDCs considering use of all ports. This strategy is commonly adopted by importers of low-value goods and by small importers with insufficient volume to effectively practice consolidation – de-consolidation. It offers the potential for lowest transportation and handling costs, in exchange for inventory requirements greater than that of the alternatives.

The other nine strategies included for the heuristic utilize trans-loading in various combinations of ports.

4. Shortest Path Model to Optimize a Portfolio of Goods

As the inventory holding cost increases, the cost of safety stock will grow, eventually growing large enough to dominate the costs of transportation. As shown in Jula and Leachman (2011), direct shipping is likely to be the optimal strategy for cheaper goods, a multiple port trans-loading strategy is likely to be optimal for goods with medium value, and a single port trans-loading strategy is likely to be optimal for the most expensive goods. In Davidson and Leachman (2012), we show how to split a retailer's goods into a portfolio of goods and use the single strategy heuristic to find the optimal supply chain cost and strategy for a set of goods within that portfolio. We can then use a shortest path model to select an importing strategy for each type of good within that retailer's portfolio of goods. Under this shortest path model, we only need to consider one optimal strategy for a consecutive set of good values. That is, we will only consider cases where if two sets of goods with declared values *a* and *b* use the same optimal importing strategy, all goods that have a declared value between *a* and *b* will also use that same optimal strategy. We are able to prove that this consecutive bins shortest path model provides an optimal solution to the total supply chain cost for that total portfolio of goods.

There may be some retail importers that have other operational considerations, such as having a fixed cost to employ each separate strategy, or being limited to a certain number of strategies. We can deal with both of these operational considerations as extensions of the shortest path problem.

5. Simulation Results

Each retail importer is assumed to have a value distribution defined as a set of value bins, each bin having a pre-specified declared value holding rate and demand volume. By treating sets of consecutive bins as if each set was a separate retail importer in the original problem, and utilizing a Shortest Path algorithm to cover all bins, we can find the optimal set of strategies and lowest total cost for that retail importer.

Based on the data from the case-study retailer as well as on Customs data collected on all Asia – USA importers, an approximate value distribution with nine bins was generated as below. The weighted mean declared value of the goods in this distribution is $25 per cubic foot.

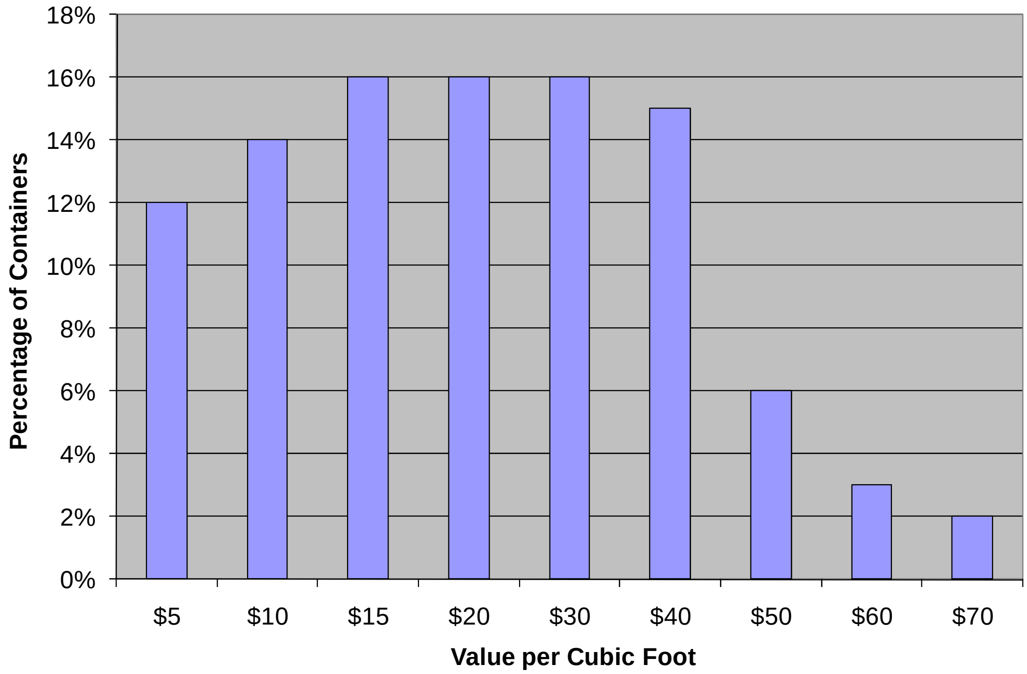

Figure 1.Approximated Good Value Distribution for Case Study Retailer.

Although not all imported containers destined for a specific RDC will always use the same port of entry, it will be a reasonable approximation to assume this. Thus, we can approximate the overall supply chain strategy and its associated costs for a given retailer. We can now examine the cost differences between its (approximated) current strategy and the calculated optimal set of strategies:

Table 1. Cost Reduction Using the Heuristic & Shortest Path Multi-Strategy Model for the case-study retailer.

Number of Strategies Allowed	Cost Reduction Using Multi-Strategy & Heuristic	Selected Strategies Using Multi-Strategy Heuristic (Volume Employing Each Strategy)
1	2.16%	TL-2-WC (100%)
2	2.83%	Direct (26%), TL-2-WC (74%)
3	2.95%	Direct (26%), TL-3-Sav (48%), TL-LA (26%)
4	3.0396%	Direct (26%), TL-3-Sav (48%), TL-2-WC (31%), TL-LA (11%)
5	3.0404%	Direct (26%), TL-3-Sav (48%), TL-2-WC (31%), TL-LA (11%)
6	3.0406%	Direct (26%), TL-3-Sav (48%), TL-2-WC (31%), TL-LA (11%)

Allowing more than six strategies does not change the minimal cost solution and optimal set of strategies in this case. Note that the optimal solutions for the cases of up to four strategies allowed, up to five strategies allowed, and up to six strategies allowed actually send the same volumes via the same strategies. However, underlying the strategy selection is the allocation of the particular RDC volumes to particular ports. When these underlying allocations differ for different bins of goods, the strategies are considered to be different. Thus, using these given cost and transit time data, there is a benefit to allowing some merchandise to use the same strategy but with slightly altered port-RDC allocations.

To be assured that this is a robust result, we introduced a second potential value distribution for the retailer's imported goods. This distribution introduces more low- and high-value goods, while reducing the amount of medium-value goods, while keeping the weighted mean of the goods value the same.

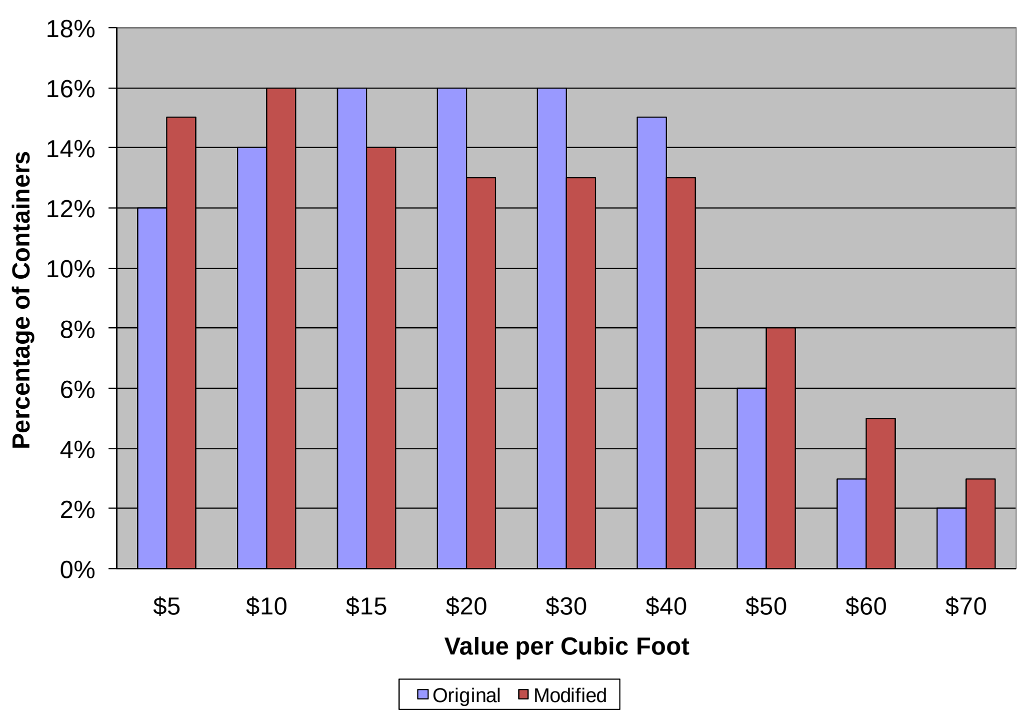

Figure 2.Modified Good Value Distribution for Case Study Retailer.

Using this modified value distribution, we find there is an even greater reduction in cost afforded this retailer by employing multiple import strategies:

Table 2. Cost Reduction Using the Heuristic & Shortest Path Multi-Strategy Model for the Case-study Retailer.

Number of Strategies Allowed	Cost Reduction Using Multi-Strategy & Heuristic	Selected Strategies Using Multi-Strategy & Heuristic (Volume Employing Each Strategy)
1	2.21%	TL-2-WC (100%)
2	3.00%	Direct (31%), TL-2-WC (69%)
3	3.19%	Direct (31%), TL-3-Sav (40%), TL-LA (29%)
4	3.2630%	Direct (31%) TL-3-Sav (27%), TL-2-WC (26%), TL-LA (16%)
5	3.2639%	Direct (31%) TL-3-Sav (27%), TL-2-WC (26%), TL-LA (16%)
6	3.2641%	Direct (31%) TL-3-Sav (27%), TL-2-WC (26%), TL-LA (16%)

Our case-study retailer has a total yearly supply chain cost of approximately $1.4 billion per year. Here we see that by using these optimal strategies, they can save between $30 million and $47 million per year, depending on what their true goods value distribution is, and depending upon how many supply chain strategies they can operationally handle. There may be additional operational costs associated with increasing the number of strategies that the retailer does handle. This analysis does not take any of these costs into account.

Note also that the large majority of the cost benefit is realized when optimizing to a two-strategy solution. Adding additional strategies reduces the total supply chain cost only marginally. The cost reduction in using the two-strategy solution primarily comes from splitting off the cheap goods that can be handled with a Direct strategy from the more expensive goods that should be handled with a Trans-loading strategy. By finding that single breakpoint for the retailer, we can capture over 90% of the total possible cost reduction based on our optimization heuristic.

Note that due to a lack of communication between the transportation and inventory departments at the case-study retailer, we were not able to obtain accurate data for this value distribution. If we had the true version of this data, we would be better able to find this breakpoint to capture as much of the cost reduction as possible without major operational changes. A major finding of this study suggests that just by having more communication within the company itself, it can take advantage of some large global cost savings to the company that may not be possible if those departments focus myopically on their assigned costs.

6. Less-Than-Container Shipments

The total shipped volume of a set of goods from a particular port to a particular destination RDC will usually not fit exactly into an integer number of containers. As much as a retailer will attempt to balance the number of shipments to minimize this problem, they will often have to make some less-than-container shipments. This can be considered inefficient, as the retailer would be paying the full transportation cost, or a higher than expected portion of that transportation cost to ship a non-full container.

Considering the shipments fulfilling the weekly volume for a given port-RDC combination, this will likely affect only one container, as all but one can be fully packed. To accurately calculate transportation costs for a given port-RDC combination, we can then round up the volume to an integer number of containers. We can take the ratio of the rounded-up integer number of containers to the fractional number, and multiply that by the applicable transportation costs. As the original volume becomes large, the amount added when rounding up will become a smaller proportion of the original amount, so this ratio will clearly become closer to 1. Using this rounding factor, we would be more likely to aggregate more volume into the same strategy, in order to economize on transportation costs.

This factor only applies to the transportation costs. We detail how to include this partial container factor in the single strategy heuristic in Davidson and Leachman (2012). It is important to note that by introducing this round-up factor, we can no longer say that a consecutive bins shortest path solution is optimal. When some bins have very low volumes, those bins might be most efficiently pooled with some other bin that is not a neighbor. However, given reasonably large volumes in every bin, the consecutive bins shortest path solution will likely provide near-optimal results. As such, we will continue to use the shortest path solution for our study of the multi-strategy optimal solution even when including the less-than-container round-up factor in the transportation costs.

We subsequently analyzed the data from the case-study retailer using this rounding factor to account for less-than-container shipments. We again examined the cost differences between their approximated current strategy and the optimal set of strategies:

Table 3. Cost Reduction Using the Heuristic Modified for Less-than-Container Shipments with the Shortest Path Multi-Strategy Model for the Case-study Retailer

Number of Strategies	Cost Reduction Using Multi-Strategy & Heuristic	Selected Strategies Using Multi-Strategy & Heuristic (Volume Employing Each Strategy)
1	2.15%	TL-2-WC (100%)
2	2.61%	Direct (26%), TL-2-WC (74%)

The two-strategy solution given is optimal under this modified heuristic, even when more than two strategies are allowed. This is an expected change, as the modified transportation cost formula suggests that aggregating more volume into the same strategy would generate cost savings. We note that the cost reduction is not as great as in the modified heuristic. This is also an expected result, as there is now an additional penalty for breaking the goods up into separate strategies. Nonetheless, the cost savings for the two-strategy solution are still impressive for a high-volume importer; the case-study retail importer would save an additional $6.5 million over the best single-strategy solution. (This compares to a savings of $9.4 million calculated in Table 1 for the case of all full-container shipments.)

7. Breakpoint Analysis

Using the partial container analysis as outlined above, we can examine the sensitivity of the specific optimal strategy to variation in a number of parameters. By running an exhaustive set of simulations, we can approximate the volume at which splitting goods into multiple importing strategies generates cost savings for the retailer. It is useful to note that if we do not use the partial container version of the analysis, then a different importing TEU volume per year would not affect the optimal strategy. If we do allow fractional container loads with no cost penalties, the importing demand can always be split as necessary without affecting the cost per TEU. As the cost per TEU for a given strategy would remain the same for all retailers at a given declared goods value, the optimal strategy will remain the same for all importing volumes.

We will focus on a particular set of parameters for this test. We will use the transportation costs and transit times as provided by our case study retailer, but applied to RDC distributions as per the average United States retailer according to US Customs data. We will also use the original declared goods value distribution. (See Figure 1.) This set of parameters cannot perfectly approximate a "generic top-5" retailer, as the regional presence of the case study retailer is also reflected in the provided transportation rates and transit times, but we expect that this set of parameters will most accurately reflect the average large US retailer that could potentially take advantage of this strategy splitting.

For many major retailers, however, trans-Pacific supply chains for their most expensive goods (electronics, etc.) are managed by the Original Equipment Manufacturers. That is, the OEMs control the importing strategy of these expensive goods until they arrive at the retailer's RDCs. As such, we will also test a distribution that is basically equivalent to that used in the case study, but removing all goods with a valuation of $40 or greater. In this truncated distribution, the mean goods valuation is just under $15. Clearly, the goods valuation distribution will have a major effect on the optimal strategy or strategies, but this analysis will show that we can use the analysis to find the importing volume at which it is reasonable to switch strategies or split into multiple strategies. We will not show the exact set of goods that would be recommended to each given strategy, as that would overly complicate these graphs. However, it should be clear that the cheapest goods will be utilizing Direct shipping strategies, slightly more expensive goods will use a multi-port Trans-loading strategy, and as we continue increasing goods valuation we reduce the number of ports until the most expensive goods use the Trans-load only at LA strategy.

We will examine a chart that shows the optimal strategy for the retailer at different volumes. This chart will also show the average cost per TEU imported, thus showing how the economies of scale provide an advantage to the larger retailers, specifically in terms of the partial container round-up effect. We will now show hypothetical retailers with import volumes ranging up to a volume that would be approximately equivalent to five times the recent import volume of Wal-mart, for illustrative purposes.

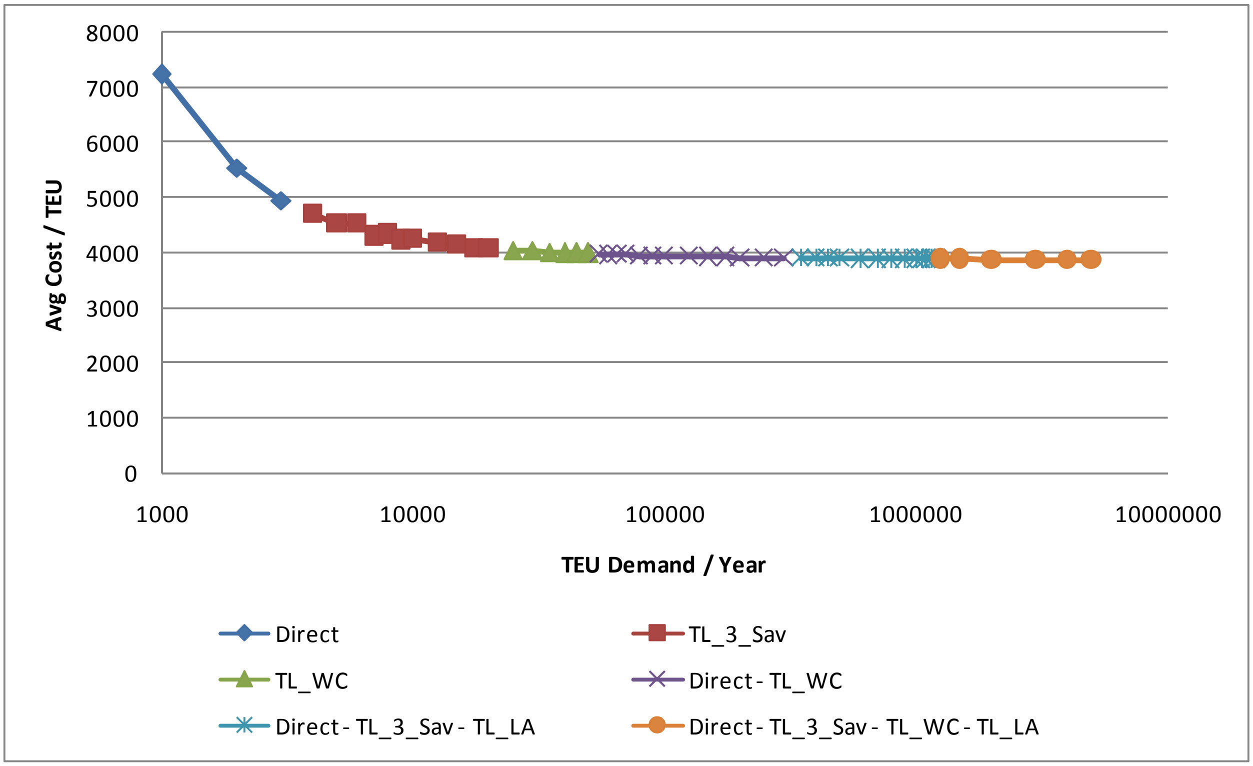

Figure 3. Average Cost Per TEU and Optimal Strategy for the Case Study Top-5 US Retailer with the Capability to Handle Multiple Strategies Using Average Retailer RDC Demand, All Goods Included

Up to an import volume of approximately 50,000 TEUs per year, our analysis suggests that a single strategy is optimal. Between 55,000 and 300,000 TEUs per year, the analysis suggests that the retailer should split their goods such that the cheapest goods are shipped using a Direct IPI strategy, while the most expensive goods are Trans-loaded through LA and Seattle. For a retailer importing between 350,000 and 1,200,000 TEUs per year, the analysis recommends a third category, where the medium valued goods are Trans-loaded through an additional port, Savannah. For retailers at “super-Walmart” levels of volume, over 1,200,000 TEUs per year, this analysis recommends splitting goods such that four separate strategies are applied, with the most expensive goods being shipped through LA only.

We note that as the importing volume increases from the lowest volumes, the average cost per TEU drops very drastically and very quickly converges to some stable average cost.

This high cost per TEU at the low volumes is due to the partial container round-up. At low volumes, this increase to the cost will be large relative to the other costs. As the volume increases, the partial container factor will reduce substantially. It is also interesting to note that the cost per TEU does not change drastically when the optimal set of strategies changes.

We will now show the same chart for the truncated goods valuation distribution. That is, the chart shows how to split strategies given that we are ignoring all goods valued at $40 or greater.

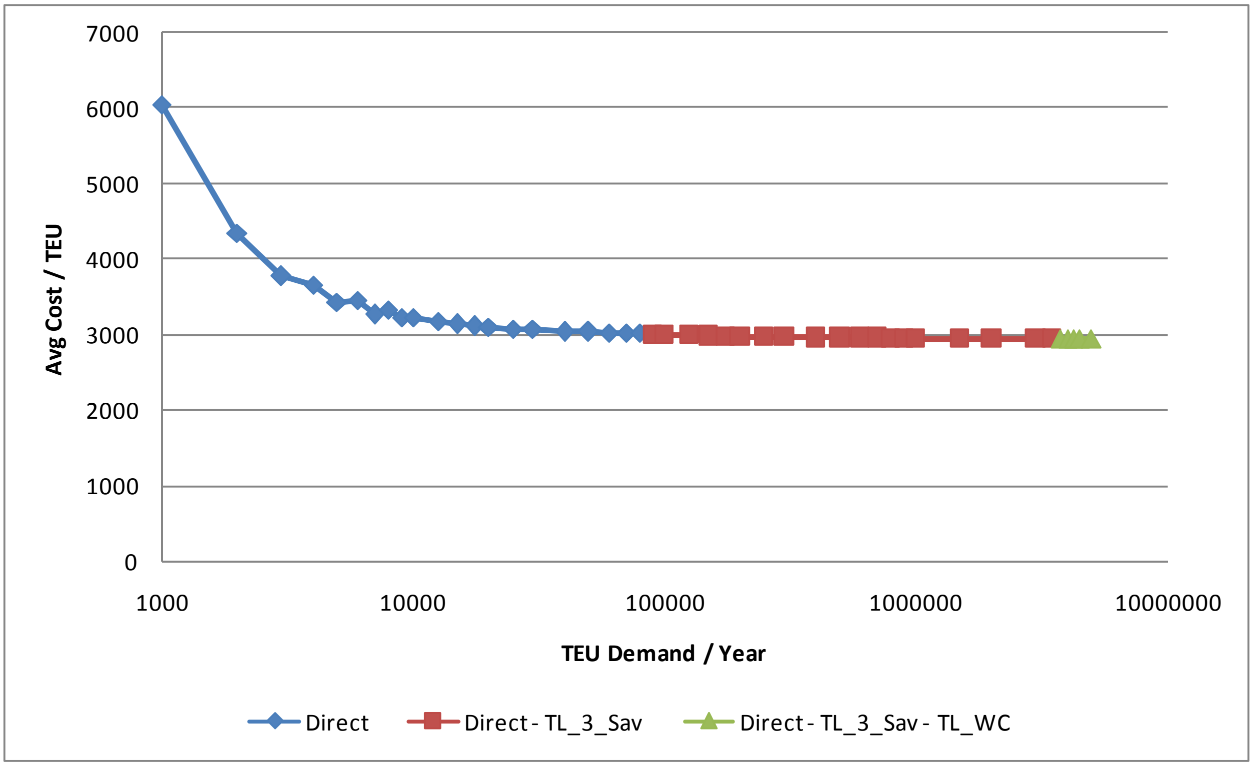

Figure 4. Average Cost Per TEU and Optimal Strategy for the Case Study Top-5 US Retailer with the Capability to Handle Multiple Strategies Using Average Retailer RDC Demand, Goods Limited to Valuations At or Below$30

We no longer see single strategy recommendations for Trans-loading. This is not surprising, as the single optimal strategy for goods at the new average goods valuation of $15 is Direct shipping, The split to two strategies happens at 90,000 TEUs per year. The split to three strategies occurs at a volume of 3,750,000 TEUs.

Using this model, for a given set of transportation rates, RDC demands, and a goods valuation distribution, we can pinpoint the annual volumes that would benefit from a multiple-strategy solution, what sets of goods should be shipped via which strategies, and which RDCs should be allocated to each port within each strategy.

While the conclusion is clearly dependant on the goods value distribution for these retailers, we believe that there are at least 10, and possibly up to 40 US retailers that operate at a large enough importing volume to potentially take advantage of splitting their goods into multiple importing supply chain strategies. The more varied the goods imported by the retailer, the more likely that they can take advantage of this splitting.

8. Port Redundancy Analysis

Interviews with a number of large retail importers reveal that in actuality these large retailers manage import warehouses and trans-loading operations at more ports than would be considered optimal by the analysis of the preceding sections. For example, for their normal operations, the case-study retailer employs a modified 4-corner trans-loading strategy, with import warehousing and trans-loading infrastructure at Los Angeles-Long Beach, Seattle, Savannah, and Norfolk. For any given product in its portfolio, they will generally import into three of the four ports listed above, always using LA and Seattle, and for goods destined for the east coast entering through either Savannah or Norfolk. For a total import volume of approximately 350,000 TEUs per year and an average goods value of $25 per cubic foot, the single optimal strategy would use no more than two ports: LA-LB and Seattle. If we were to allow the case-study retailer to use a multiple strategy solution, our analysis would suggest adding only Direct shipping operations, with no need for more trans-loading infrastructure than at the two aforementioned ports. At a slightly lower average goods value, the model does recommend to use Savannah as a third port for trans-loading operations. We do not find any cases for the case-study retailer where an optimal strategy would be to use all four ports.

Similar patterns are found for other retailers. Our model recommends either using fewer ports for trans-loading import operations, or using as many ports as are actually used only for a very small subset of goods. We must now consider why these retailers build and utilize this infrastructure for their importing operations, as the costs for warehousing rent and trans-loading operations at any given port are substantial.

There are two related factors that we will touch on briefly, but will not analyze in depth. The first factor is capacity. A retailer may for some reason have only a certain amount of capacity for importing at a given port, perhaps in warehouse space or in trans-loading labor or operating shifts available at facilities in the hinterland of that port. For a long-term steady state analysis of a retailer's operations, neither of these should be an issue. We assume that warehouse space can be freely expanded as necessary with either sunk costs for building or additional rent payment. Similarly, trans-loading capacity is provided by third-party logistics companies, and can generally be expanded as necessary with new contracts.

The second factor that we will not analyze is that of negotiating power. By utilizing more ports for warehousing and trans-loading infrastructure, the retailer may be able to negotiate reduced costs for both that infrastructure as well as transportation costs. We have already noted in the above section that the case-study retailer has been able to secure comparatively lower costs for their IPI transportation than the averages of rate quotations to many importers. It is conceivable that by having infrastructure at additional ports, they can get better rates for adding trans-loading volume at any given port by playing off the landlords, third-party logistics companies, and transportation carriers at these different ports against each other. We cannot quantify how much of a cost reduction this will be for any given retailer, as these negotiations will certainly be kept private.

Robustness or redundancy is another reason to build infrastructure at more ports than may be optimal according to a steady-state model. There may be cases where a port becomes more costly to use for a short amount of time, due to some sort of shock. In 2004, the ports of Los Angeles and Long Beach were in a situation such that there were many more incoming container ships than they could handle during their peak season. They were over their capacity and as such their container dwell times sky-rocketed. We consider events such as a labor strike or the 2004 over-capacity meltdown in Los Angeles and Long Beach as examples of such a shock. If a shock were to occur at any given port, the cost of using that port would increase substantially. By having infrastructure and rates at other ports in place before such a shock, a retailer may attempt to avoid some of that additional cost.

We can attempt to model the additional cost to a retailer due to such a shock. We will examine the cost increases to the total supply chain as dwell time at the ports of Los Angeles and Long Beach increases until they become basically unusable. We have chosen LA-LB as our port to “shock” as it is clearly the most common port recommended for use in our model, and will thus show the largest cost changes. As the transportation time through LA-LB increases, the inventory cost of imports allocated to that port will increase. Given different baseline strategies, we will examine how the total supply chain cost increases as we increase the dwell time through LA-LB, up to an additional 50 days. At 50 additional days through LA-LB, no retailer tested will allocate any imports to LA-LB unless forced to.

8.1. Locked Strategies

We will run this analysis for all combinations of importing volume and declared goods values. We will use the single strategy with average US retailer costs as a baseline. We will first examine the case where each retailer must use the same set of ports available to them in that baseline. For example, for a retailer with an importing volume of 10,000 TEUs per year and a declared goods value of $50, the optimal single strategy is TL_WC, or trans-loading at LA-LB and Seattle. For this section of the analysis, we will allow the use of both LA-LB and Seattle. We will also allow imports destined for an RDC that had previously been allocated to LA-LB to shift to Seattle as the cost through LA-LB increases. We selected six representative retail importing volumes to focus this analysis: 1,000 TEUs per year; 3,000; 7,000; 10,000; 70,000; and 400,000. These six representative volumes provide enough variation to examine all possible strategies for the baseline LA-LB transit time.

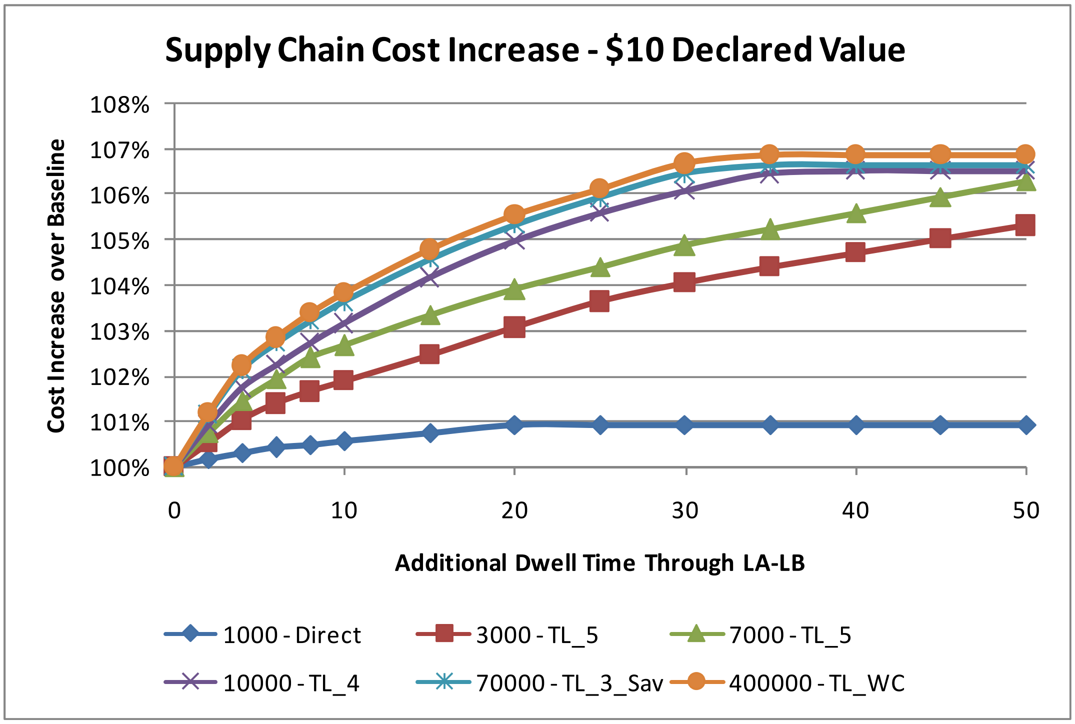

Figure 5. Steady State Cost Increase Due to a Shock at the LA-LB Port for $10 Declared Value Retailers

At a declared goods value of $10, we see five different strategies represented: Direct Shipping for the lowest volumes, and trans-loading through various combinations of ports for the higher volumes. The increase in dwell time affects the inventory cost, which grows with the declared value. The retailer using the Direct strategy as baseline sees an increase of approximately 1%. The TL_5 retailers see an increase of between 2% and 3% at an additional dwell time of 10 days, with a maximum increase of between 5% and 6%. The other retailers all have different optimal baseline strategies, utilizing fewer and fewer ports as the volume increases. The additional cost increases faster and has a larger maximum with fewer available ports. At 10 days, the retailers whose baseline strategies utilize between two and four ports see a cost increase of between 3% and 4% at 10 days of additional dwell time, and about 7% at maximum. Clearly, as we reduce the number of ports available to a retailer, the more cost will be incurred by a shock to any one of those ports.

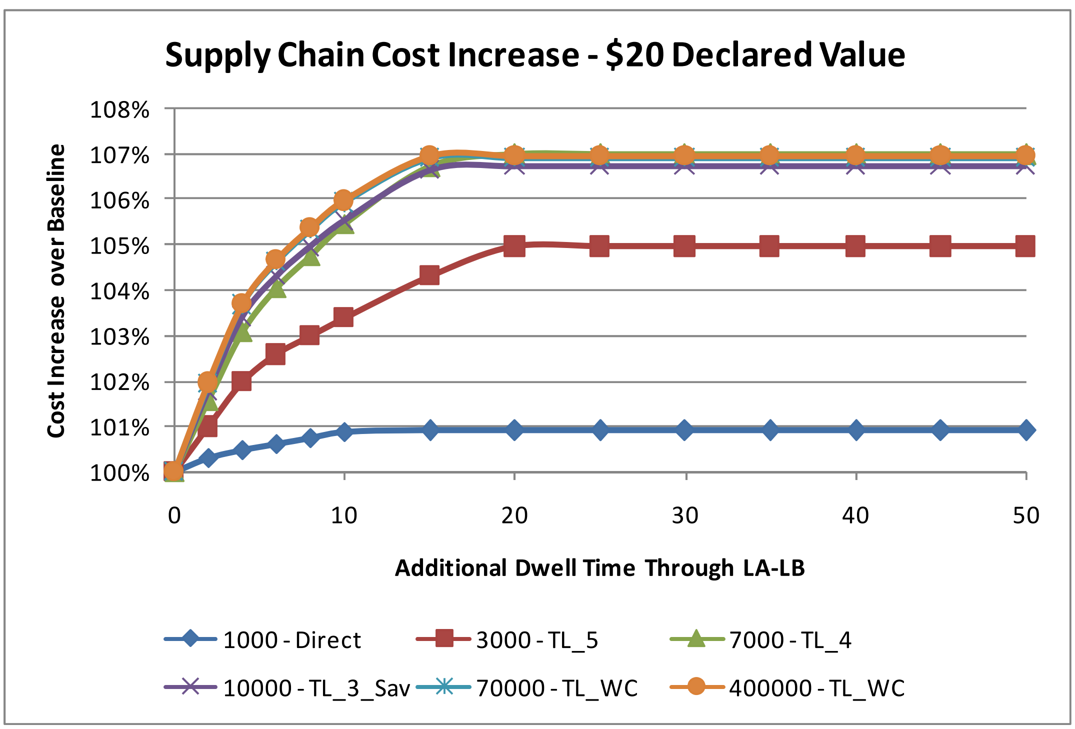

Figure 6. Steady State Cost Increase Due to a Shock at the LA-LB Port for $20 Declared Value Retailers

As the declared goods value increases, the cost increase reaches it maximum at fewer and fewer days of additional dwell time. Due to higher inventory cost through LA-LB, more of the RDCs allocated to LA-LB in the baseline strategy will shift to a different available port. While the maximum cost increase stays approximately the same for a given baseline strategy, we see the increase at the additional 10-day dwell time grows to between 5% and 6% for the retailers using two to four port baseline strategies for a goods value of $20.

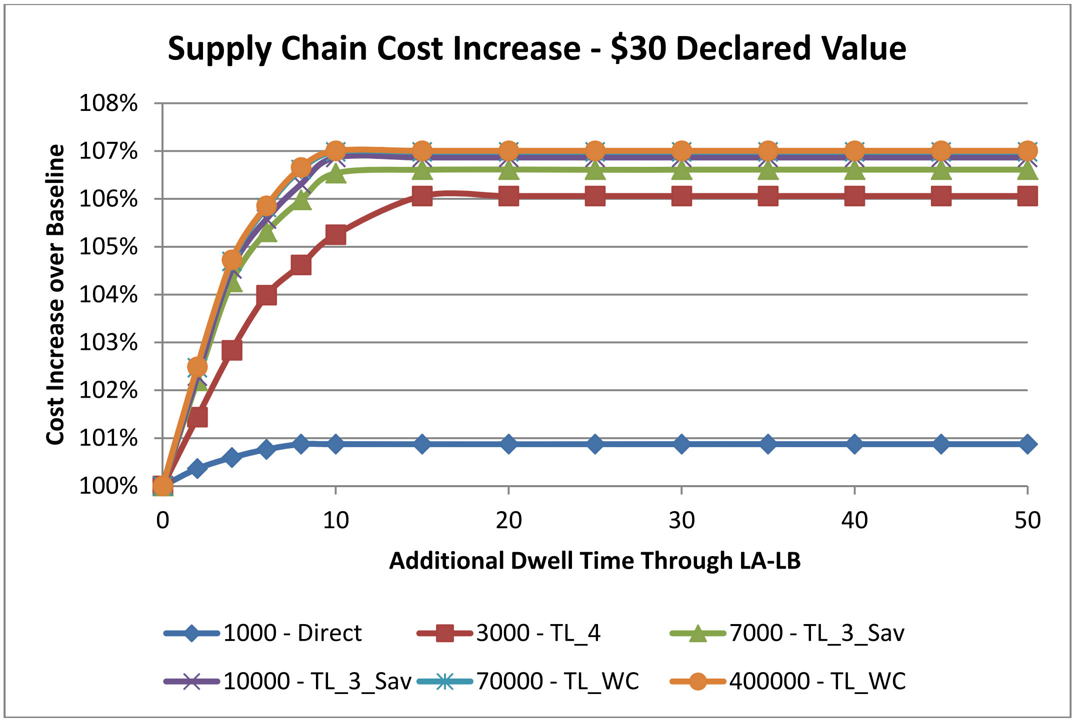

Figure 7. Steady State Cost Increase Due to a Shock at the LA-LB Port for $30 Declared Value Retailers

At $30 per cubic foot declared goods value, we see most RDCs shifting away from LA-LB at 10 days of additional dwell time. The maximum additional cost remains between 6% and 7% for these retailers, all using between two and four ports in their baseline optimal strategies.

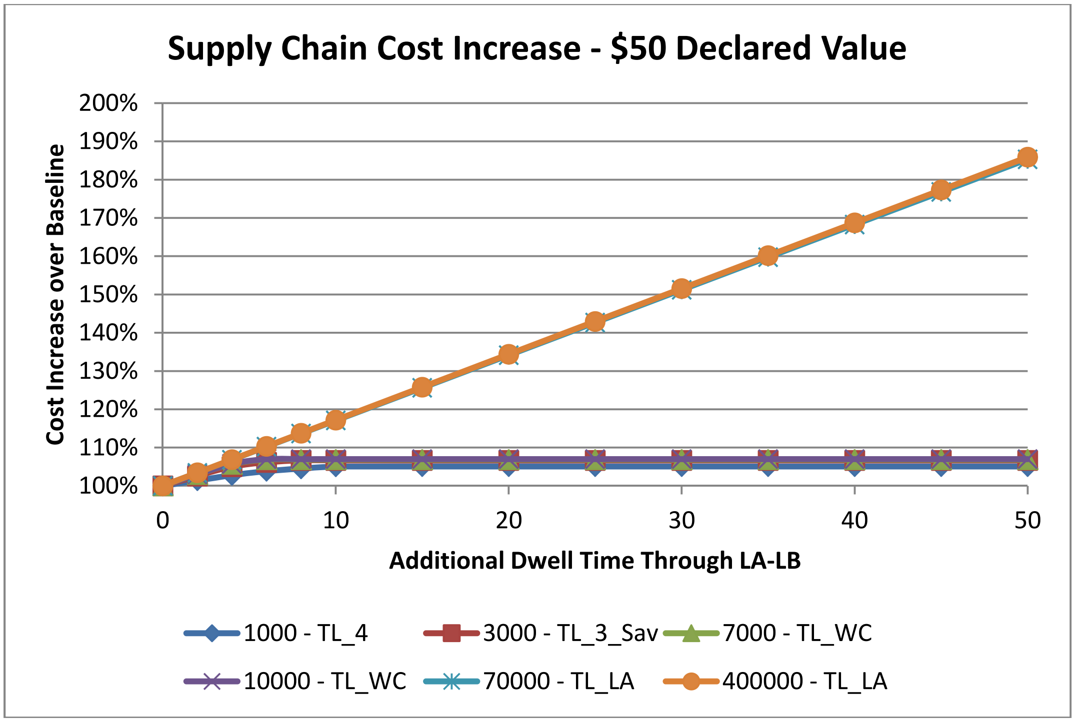

Figure 8. Steady State Cost Increase Due to a Shock at the LA-LB Port for $50 Declared Value Retailers

At a declared goods value of $50 per cubic foot, we now introduce retailers whose optimal baseline strategy is to trans-load at LA-LB only. If these retailers are locked into only using LA-LB, their costs will increase linearly with the additional dwell time. For those retailers with a TL_LA baseline, at 10 days of additional dwell time, we see an increase of approximately 17%. Obviously, a shock to a retailer's only available port could cause disastrous cost increases. Even if that shock does not last a long, it could affect the retailer's total yearly supply chain cost. We can formulate a simple example of a TL_LA retailer encountering a single event that causes LA to be unavailable for exactly 10 days, but regaining full capacity and clearing all backed up goods once that 10 days is over. In this example, goods coming in on the first day of "shut down" would be delayed exactly 10 days, goods coming in on the third day would be delayed by exactly 8 days, etc. Goods coming in as the port re-opens would clear immediately. In this example, this single event would increase the total yearly supply chain costs by 0.24%. In fact, this simple example is likely an underestimation of the effect a true shut down would have at a port. It is unlikely that all goods would be able to be cleared immediately when the port re-opens, and thus we would expect that capacity issues would cause lingering after-effects as the labor at the port catches up to the imports that have been waiting. If we were instead to spread that 10-day shut down such that the delay reduces back to zero over the course of a month after the port re-opens, this event would increase the total yearly supply chain costs by 0.94%.

This total supply chain increase in cost increases linearly in the time it takes for the port operations to return to normal. However, as the length of the shock increases, the cost increases grow super-linearly. If the shock were to last 20 days instead of 10 days, even if all goods clear immediately, the cost increase to the supply chain would be 0.94%. If it would take an additional month to clear the goods from the shock, the cost increase to the supply chain would be 2.35%.

8.2. Allowing a Single Additional Port

We now would like to examine the cost increases when we allow a retailer to open a single additional port for use in their trans-loading strategy. We will also allow retailers to revert to a Direct shipping strategy, if that generates the optimal cost as the delay through LA-LB increases.

We would expect the cost increases to not change for the retailers that use the Direct shipping strategy for their baseline, as all ports are already available for use through IPI channels. For more expensive goods, we now have the opportunity to see the cost reductions as a retailer opens additional ports for use in their trans-loading strategies. We will start with goods with a $10 declared value, and show how their optimal strategies change as the delay at LA-LB increases.

Table 4. Optimal Single Strategy for $10 Declared Good Value Retailers for a Delay at the LA-LB Port

Import Volume		1000	3000	7000	10000	70000	400000
Baseline Strategy		Direct	TL_5	TL_5	TL_4	TL_3_Sav	TL_WC
Delay	**2**	Direct	TL_5	TL_5	TL_5	TL_4	TL_3_Sav
	4	Direct	TL_5	TL_5	TL_5	TL_4	TL_3_Sav
	6	Direct	TL_5	TL_5	TL_5	TL_4	TL_3_Sav
	8	Direct	TL_5	TL_5	TL_5	TL_4	TL_3_Sav
	10	Direct	TL_5	TL_5	TL_5	TL_4	TL_3_Sav
	15	Direct	TL_5	TL_5	TL_5	TL_4	TL_3_Sav
	20	Direct	TL_5	TL_5	TL_5	TL_4	TL_3_Sav
	25	Direct	Direct	TL_5	Direct	TL_4	TL_3_Sav
	30	Direct	Direct	TL_5	Direct	TL_4	TL_3_Sav
	35	Direct	Direct	Direct	Direct	TL_3_Sav	TL_3_Sav
	40	Direct	Direct	Direct	Direct	TL_3_Sav	TL_3_Sav
	45	Direct	Direct	Direct	Direct	TL_3_Sav	TL_3_Sav
	50	Direct	Direct	Direct	Direct	TL_3_Sav	TL_3_Sav

For the retailers with import volumes between 3,000 and 7,000 TEUs per year, we see a reversion to a Direct strategy at a large enough LA-LB delay. The baseline optimal strategy for the retailer with a 10,000 TEU volume is to trans-load at four ports. We see that opening the fifth port to trans-loading, Houston in this case, has an immediate benefit for this retailer as the LA-LB delay increases. We also see that it too will eventually shift to a Direct shipping strategy to take advantage of the lower partial container factor. The retailer with a 70,000 TEU volume shows an interesting pattern. Its baseline strategy is to trans-load at three ports: LA-LB, Seattle and Savannah. When facing a delay at LA-LB, it sees an immediate benefit by opening a fourth port: NY-NJ. However, when the LA-LB delay grows to a large enough level, this retailer will no longer allocate any RDCs to LA-LB, and its optimal strategy will be to consolidate at only

Seattle and Savannah. That is, at a certain delay, the optimal strategy will only use ports available in the baseline strategy. There will be no additional benefit to opening an additional port to trans-loading volume. However, delays of this magnitude are unlikely to occur.

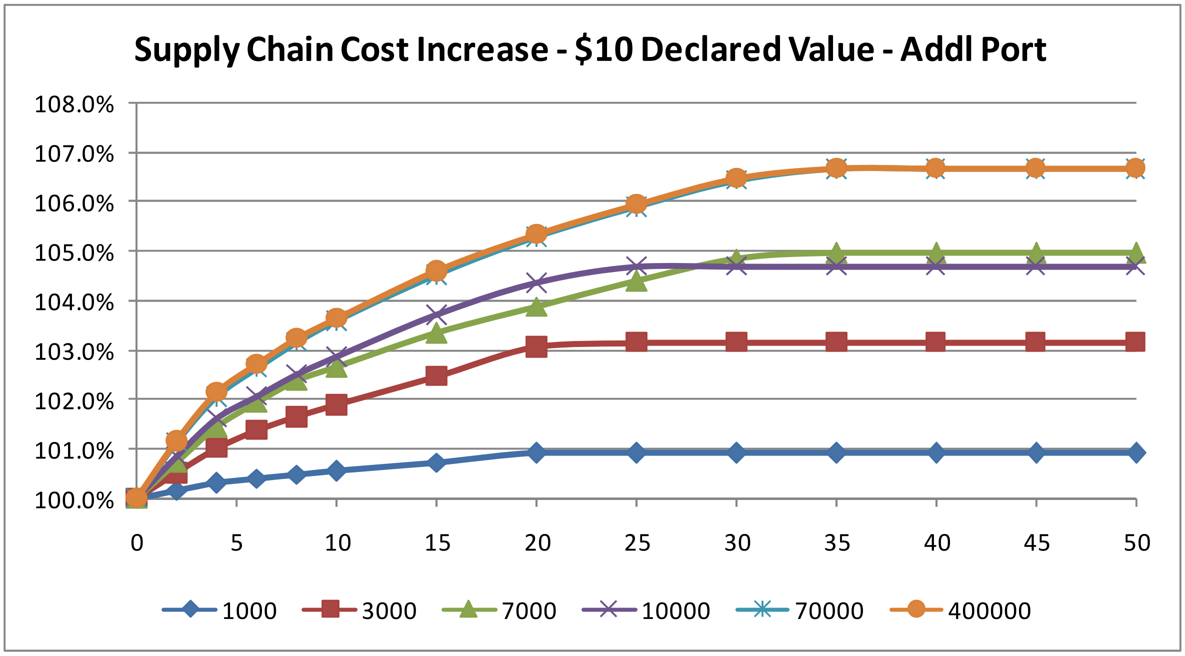

Figure 9. Steady State Cost Increase Due to a Shock at the LA-LB Port for $10 Declared Value Retailers Allowing a Single Additional Port

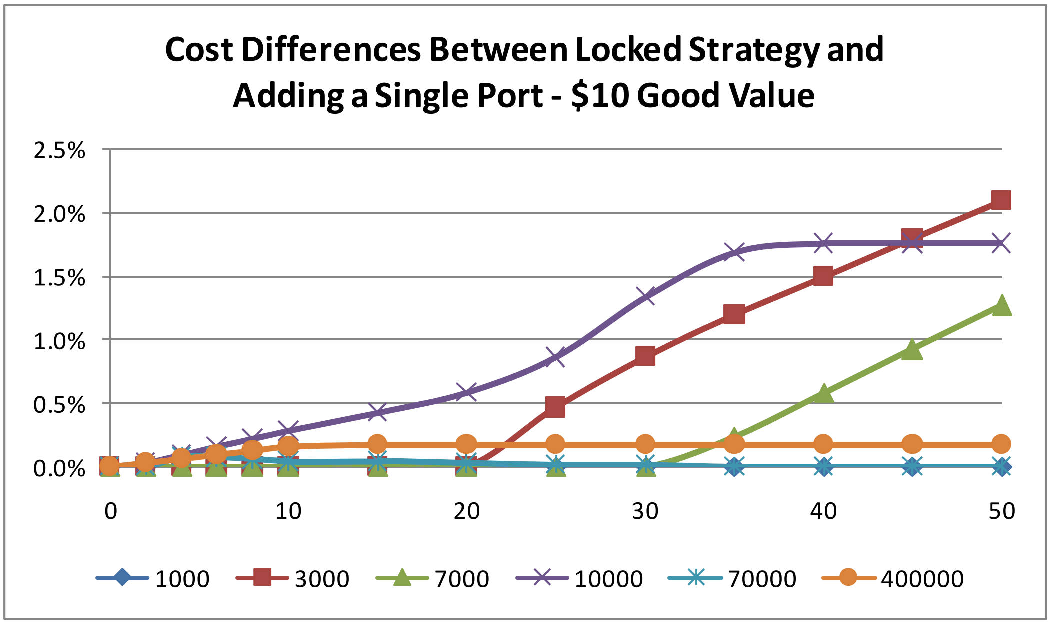

Figure 10. Cost Differences Between a Locked Strategy and Allowing a Single Additional Port for $10 Declared Value Retailers

The reductions in the cost increases are the most notable at the point where a retailer transitions to Direct shipping. The addition of the fifth port for the 10,000 TEU retailer or the fourth port for the 70,000 TEU retailer reduces those cost increases by a negligible amount. The addition of the third port for the 400,000 TEU retailer shows a greater benefit. We would expect that adding ports has marginal benefits. For a baseline strategy with more available ports, adding additional ports does not show benefits as great.

For retailers with greater declared goods values, we see usage of LA-LB drops with greater delays, but generally without the need to add more ports. For the $20 declared goods value retailers, we see the following set of strategies for LA-LB delays.

Table 5. Optimal Single Strategy for $20 Declared Good Value Retailers for a Delay at the LA-LB Port

Import Volume		1000	3000	7000	10000	70000	400000
Baseline Strategy		Direct	TL_5	TL_4	TL_3_Sav	TL_WC	TL_WC
Delay	**2**	Direct	TL_5	TL_4	TL_3_Sav	TL_WC	TL_WC
	4	Direct	TL_5	TL_4	TL_3_Sav	TL_WC	TL_WC
	6	Direct	TL_5	TL_4	TL_3_Sav	TL_WC	TL_WC
	8	Direct	TL_5	TL_5	TL_3_Sav	TL_WC	TL_WC
	10	Direct	TL_5	TL_5	TL_3_Sav	TL_WC	TL_WC
	15	Direct	TL_5	TL_5	TL_3_Sav	TL_Sea	TL_Sea
	20	Direct	TL_5	TL_5	TL_3_Sav	TL_Sea	TL_Sea
	25	Direct	TL_5	TL_5	TL_3_Sav	TL_Sea	TL_Sea
	30	Direct	TL_5	TL_5	TL_3_Sav	TL_Sea	TL_Sea
	35	Direct	TL_5	TL_5	TL_3_Sav	TL_Sea	TL_Sea
	40	Direct	TL_5	TL_5	TL_3_Sav	TL_Sea	TL_Sea
	45	Direct	TL_5	TL_5	TL_3_Sav	TL_Sea	TL_Sea
	50	Direct	TL_5	TL_5	TL_3_Sav	TL_Sea	TL_Sea

Only the 7,000 TEU retailer adds ports to its optimal strategy as the delay through LA-LB increases. All of the other retailers use the same set of ports but shift the allocations away from LA-LB until that port is no longer used. However, it is worthwhile to note that by using these strategies these retailers, especially the 70,000 and 400,000 TEU retailers, are now very vulnerable if a shock were to occur at both LA-LB and Seattle. This is not an unlikely occurrence. If the port of LA-LB were to face a labor strike or other shock, a substantial volume of imports from many retailers may abandon LA-LB for Seattle, and in the process cause an over-capacity shock to Seattle. After the over-capacity melt-down at LA-LB in 2004, many retailers sent more of their goods to Seattle in 2005, thus causing an over-capacity issue in Seattle. Although these events occurred a year apart, a shock at one port directly caused a shock at the other.

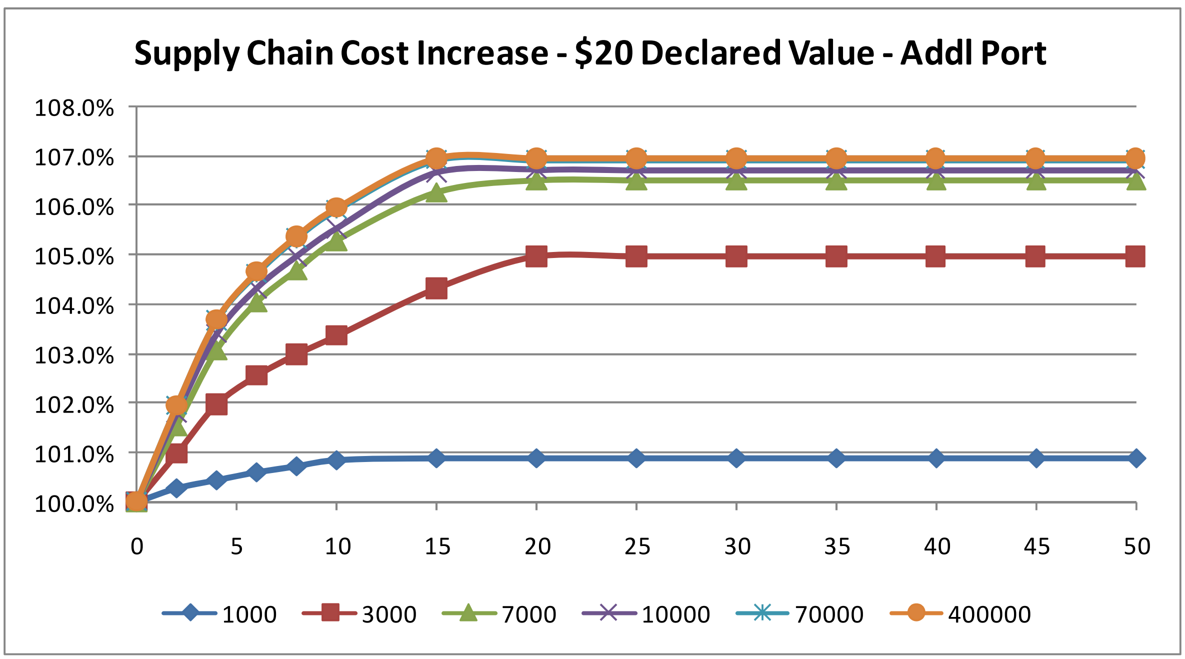

Figure 11. Steady State Cost Increase Due to a Shock at the LA-LB Port for $20 Declared Value Retailers Allowing a Single Additional Port

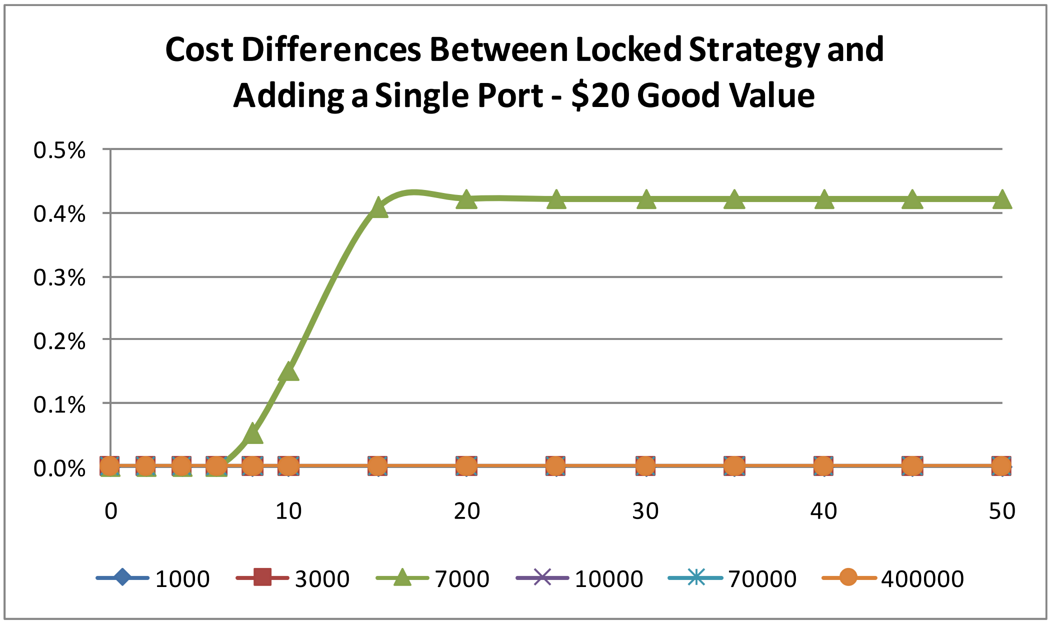

Figure 12. Cost Differences Between a Locked Strategy and Allowing a Single Additional Port for $10 Declared Value Retailers

As we see, only the 7,000 TEU retailer shows any additional benefit by adding ports to its optimal strategy. However, all of the other retailers become more vulnerable to additional shocks.

Lastly, we will examine the cases of retailers whose baseline optimal strategy is to trans-load at LA only. We will examine the retailers with a declared goods value of $50 per cubic foot.

Table 6. Optimal Single Strategy for $50 Declared Good Value Retailers for a Delay at the LA-LB Port

Import Volume		1000	3000	7000	10000	70000	400000
Baseline Strategy		TL_4	TL_3_Sav	TL_WC	TL_WC	TL_LA	TL_LA
Delay	**2**	TL_4	TL_3_Sav	TL_3_Sav	TL_WC	TL_WC	TL_WC
	4	TL_4	TL_3_Sav	TL_WC	TL_WC	TL_WC	TL_WC
	6	TL_5	TL_3_Sav	TL_3_Sav	TL_Sea	TL_Sea	TL_Sea
	8	TL_5	TL_3_Sav	TL_3_Sav	TL_Sea	TL_Sea	TL_Sea
	10	TL_5	TL_3_Sav	TL_3_Sav	TL_Sea	TL_Sea	TL_Sea
	15	TL_5	TL_3_Sav	TL_3_Sav	TL_Sea	TL_Sea	TL_Sea
	20	TL_5	TL_3_Sav	TL_3_Sav	TL_Sea	TL_Sea	TL_Sea

25	TL_5	TL_3_Sav	TL_3_Sav	TL_Sea	TL_Sea	TL_Sea
30	TL_5	TL_3_Sav	TL_3_Sav	TL_Sea	TL_Sea	TL_Sea
35	TL_5	TL_3_Sav	TL_3_Sav	TL_Sea	TL_Sea	TL_Sea
40	TL_5	TL_3_Sav	TL_3_Sav	TL_Sea	TL_Sea	TL_Sea
45	TL_5	TL_3_Sav	TL_3_Sav	TL_Sea	TL_Sea	TL_Sea
50	TL_5	TL_3_Sav	TL_3_Sav	TL_Sea	TL_Sea	TL_Sea

The 1,000 TEU and 7,000 TEU retailers do show a benefit by adding a port available for trans-loading as the delay through LA-LB grows, a fifth port for the 1,000 TEU retailer and a third port for the 7,000 TEU retailer. As is expected, the largest retailers do recommend adding Seattle as a second port as soon as the delay through LA-LB is greater than zero. We would expect to see a major reduction in the cost increases for these two retailers.

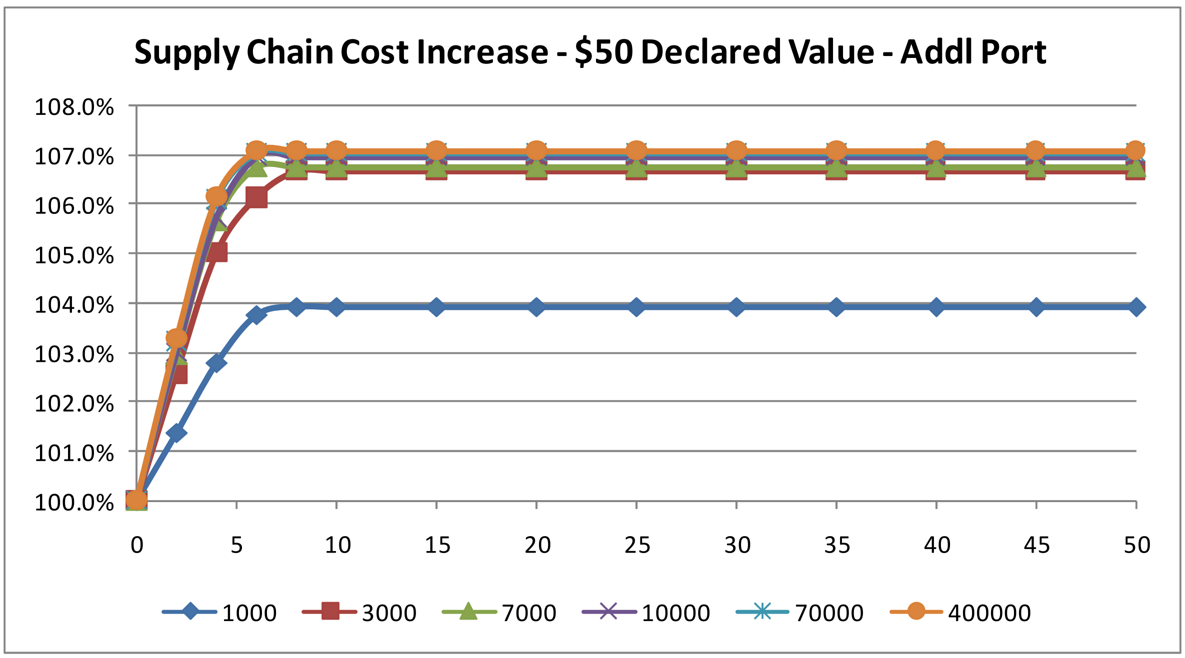

Figure 13. Steady State Cost Increase Due to a Shock at the LA-LB Port for $50 Declared Value Retailers Allowing a Single Additional Port

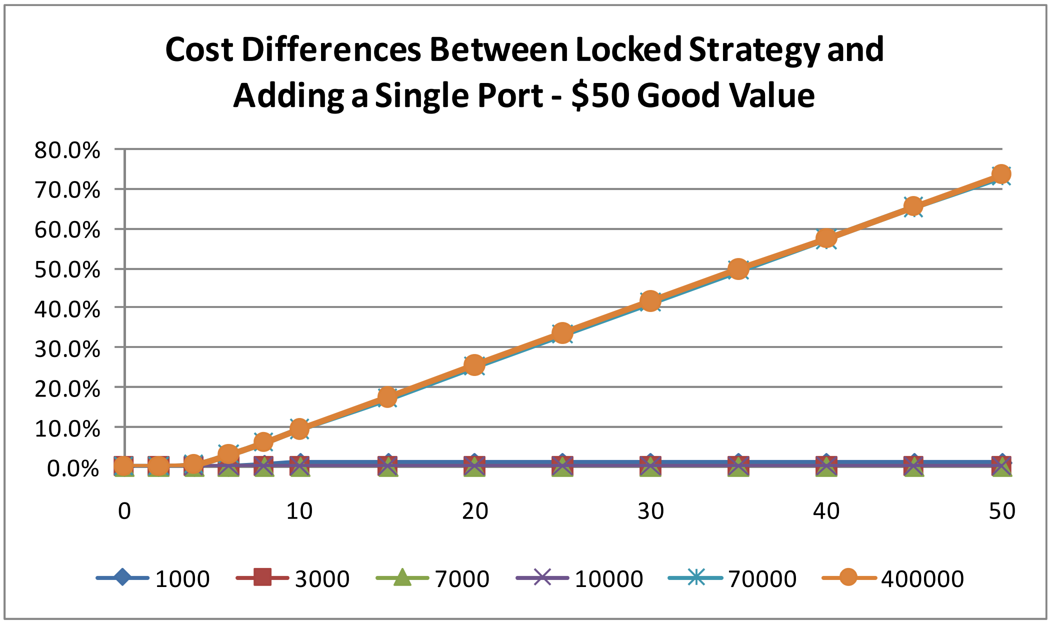

Figure 14. Cost Differences Between a Locked Strategy and Allowing a Single Additional Port for $50 Declared Value Retailers

Now instead of the massive cost increases for the 70,000 and 400,000 TEU retailers, we see cost increases of approximately 7%, more in line with the cost increases seen for all of the other retailers who use two or more ports in their baseline optimal strategy. The addition of one more port for trans-loading substantially reduces the cost increase due to a shock for the retailers who rely solely on that one port.

Under this paradigm of adding additional ports, we can analyze the example from the previous section where the TL_LA retailer encounters the single event that causes LA to be unavailable for exactly 10 days. Now, when the LA port shuts down, goods can start transferring to a new port, instead of being required to face this delay. Under the assumption that goods clear immediately after the shut down ends, this single event would increase the total yearly supply chain costs by 0.15%. If we were instead to spread that 10-day shut down such that the delay through LA reduces back to zero over the course of a month after the port re-opens, this event would increase the total yearly supply chain costs by 0.59%. This is a yearly cost reduction of 0.34% from the single shock case where the retailer is only able to use LA.

If the shock were to increase to 20 days, the immediate clearing cost increase would increase from 0.15% to 0.34%. The cost increase for the case that it takes the additional month to clear the goods would be 0.86%. This is a reduction of 1.5% from the single shock case where the retailer is only able to use LA. As the length of the shock increases, there is more benefit can be derived from having a redundant port available for trans-loading operations.

We can examine situations where we allow retailers to open more than one additional port for trans-loading operations. This seems to have a no effect on the cost reduction in most cases, even with long shocks to LA-LB. There are very few combinations of declared good value and importing volume that do show any benefit by adding infrastructure to two or more ports, and the benefit over simply adding one port is negligible.

We can now examine the costs of adding trans-loading operations to a particular port and compare this to the cost savings in the case of shocks. Most operations specific to cross-docking and swapping cargo are run by third party logistics companies, whose contractual costs will likely be similar at various ports around the country. The main cost associated with opening trans-loading operations will be that of building and leasing land for an import warehouse in the hinterlands of that port. Depending on the yearly importing volume of the retailer, the size of the warehouse necessary for maintaining these operations will vary. For retailers with a yearly importing volume greater than 50,000 TEUs per year, these facilities may be anywhere between half a million and two million square feet. Based on data from a land and property management company specializing in these operations, we found that construction costs at the hinterland of the port would likely be around $25 per square foot and total leasing costs (including utilities and tax) would be between $0.30 and $0.35 per square foot per year, depending on the age and efficiency of the building.

Thus, for the large retailers, building costs would be between $12.5 million and $50 million. Leasing costs would be between $150,000 and $700,000 per year. We can now compare this with the total costs of the supply chain operations for the various retailers to see how this compares to the benefits of opening a new port for trans-loading operations.

The $50 declared good value retailers with a yearly importing volume of 70,000 TEUs per year and greater were examples of retailers who used trans-loading only at LA as their optimal strategy when there were no shocks causing additional delay at LA. The yearly supply chain cost to the 70,000 TEU per year retailer is approximately $320 million per year, and the cost to the 400,000 TEU retailer is approximately $1.82 billion per year. If we assume normal operations over a year except for a single a 10 day shock with an additional month to clear goods as a baseline to compare against, we see that the 70,000 TEU retailer would save $1.1 million by expanding operations to a second port. The 400,000 TEU retailer would save $6.3 million by expanding to a second port. If we assume a 20 day shock with an additional month to clear goods, we see a cost savings of $4.8 million for the 70,000 TEU retailer and a cost savings of $27.3 million for the 400,000 TEU retailer. Given an appropriately sized warehouse for the retailer, the additional port acts as protection against cost increases caused by these shocks. As there is a comparatively low rental cost, the major downside of opening the second port is the initial building cost. The retailer can consider this as insurance against these kinds of shocks.

For the retailers who already have at least two ports available for trans-loading, the cost protections against these shocks are negligible. We will use the retailers with a $10 declared good value as examples here. The 70,000 TEU retailer with $10 declared good value uses three ports as their normal optimal strategy. The 400,000 TEU retailer uses two ports as their normal optimal. For the larger retailers, opening a third or fourth port saves no more than 0.02% of yearly cost even for the 20 day shock with an additional month to clear. This equates to a savings no greater than $200,000. Smaller retailers may see a slightly larger relative savings, but a similarly low absolute savings. As this may not even cover the cost of the rent on the import warehouse property, the additional insurance of the third or fourth port does not look to be worthwhile investment for retailers whose base optimal strategy already includes at least two ports. It is again worthwhile to note this analysis only considers a shock to a single port without considering the possibility of shocks to two ports at the same time, and does not take into account any negotiation benefits that the retailer can derive from third party logistics providers at multiple ports.

9. Governmental Policies

Generally, port authorities and local governments at port cities in North America are focused on the environmental impacts and capacity requirements for the direct-shipping supply chain channels. For example, in Southern California, investments are currently directed towards near-dock and on-dock rail terminals for marine containers. EIRs are currently in process for the Southern California International Gateway (SCIG, a near-dock rail terminal proposed to exclusively handle rail-borne marine containers), and for an expansion of the Intermodal Container Transfer Facility (ICTF, an existing near-dock rail terminal). In addition, there are several projects in various stages of progress (planning, EIR, or construction) providing increased on-dock rail capacity at the Ports of Los Angeles and Long Beach. As another example, the Vancouver Port Authority, local governments in the Vancouver, B.C. area and the

Canadian government are pursuing a program of grade separations on the rail route to the Roberts Bank marine terminal.

As described in Leachman (2011), direct-shipping supply chains accounted for about 60% of containerized Asian imports to the Continental USA in 2009. Of this amount, about 46% of this amount is comprised of imports by small and regional importers unable to economically implement push-pull supply chains while 54% were imported by large nation-wide importers. The share of Asian imports accounted for by small and regional importers is in decline as they lose market share to large nation-wide chains able to economically deploy push-pull supply chains and achieve a cost advantage. In 2009, the large nation-wide importers only allocated about 25% of their total Asian goods to direct-shipping supply chains; the other 75% were handled in push-pull supply chains. Moreover, as the value of imported Asian goods rises (because of rising Asian wages and because of the dollar falling against Asian currencies), the use of direct-shipping by the large importers will decline. Leachman (2011) estimates that an across-the-board 15% increase in the cost of Asian goods would result in the shifting of 24% of the goods currently imported by large nation-wide importers via direct-shipping channels into push-pull channels. A drop of the direct-shipping share of total Asian imports from 60% to 50% in the near term seems very likely, and further declines in future years seem probable.

As described above, push-pull supply chains involve dray movement of marine containers from marine terminals to cross-docks where imported goods are trans-loaded into domestic containers and trailers. The domestic containers are in turn drayed to off-dock rail intermodal terminals. Some marine containers are drayed directly to import warehouses, and some of the trailers leaving the cross-docks also are drayed to import warehouses. For goods conveyed to import warehouses, at some later times, the import warehouses generate drays of domestic containers to rail intermodal terminals or truck trailer trips to regional distribution centers.

Coupling the dray movements of loaded containers with empty return or repositioning movements, the push-pull supply chains generate a tremendous number of dray trips in the urban area surrounding the port of entry. Leachman (2011) estimates 500 import containers for a large nation-wide importer generate about 1,350 dray trips. This truck traffic represents a serious hardship on the municipalities surrounding the ports.

Typically, governmental policies for transportation infrastructure start by taking transportation demand as a given and then develop mitigation measures or infrastructure expansion projects to cope with growth. Infrastructure in the urban areas surrounding major USA ports of entry can be very costly. For example, as a means of coping with the high levels of dray traffic related to the Southern California ports, serious consideration is being given to double-decking freeways with dedicated truck lanes and to magnetically-levitated trains hauling marine containers between port terminals and inland warehouse parks or rail intermodal terminals.

An alternative to such costly transportation infrastructure investment is to change land-use policies so as to encourage cross-docks, import warehouses and domestic-container rail intermodal terminals to be developed close to the ports. In Southern California there is considerable industrial property in zones relatively close to the ports that once supported the military-aerospace industry. Existing warehouses in these zones are relatively small in size, not well-suited for service as import warehouses.

Generally, cross-docks and import warehouses are operated by third-party logistics (3PL) firms. Typically, the facilities are built and owned by commercial real estate developers. In rare instances some very large importers own their own import warehouses, but their cross-docking needs are always put out for bid to 3PLs.

The financial incentive for commercial real estate developers is to quickly recover their investment in property development by finding a tenant as soon as possible. Generally, tearing down old facilities, with the potential for environmental clean-up requirements and associated permits, takes much longer than greenfield development. So developers are loath to redevelop commercial property near the ports if undeveloped property further inland is available.

Municipalities in the vicinity of ports typically are hostile to new logistics development. Truck traffic and associated pollution are causes for concern.

These forces combine to push development of import warehouses and domestic-box rail intermodal terminals at relatively distant locations from ports. At the same time, securing environmental approval for on-dock rail intermodal terminals is generally easier than securing approval of near-dock or off-dock terminals in urban areas.

These forces conspire to lead public agencies, ports and railroads to favor development of on-dock rail terminals for marine boxes and distant off-dock rail terminals for domestic containers over near-dock terminals, and distant warehouse parks in lieu of near-port development.

At present, there is considerable environmental opposition to the proposed ICTF expansion and the new SCIG near-dock rail terminals in Southern California. The railroads and the ports argue that the terminals are needed to reduce the drays of marine boxes to and from downtown rail intermodal terminals (so-called off-dock terminals) as well as to accommodate continued port cargo growth. Environmentalists argue that there should be expansion of on-dock rail terminal capacity in lieu of near-dock terminals, thereby mitigating the pollution and traffic associated with dray trips between the ports and the near-dock terminals.

From a more nuanced point of view, one can characterize both sides of this debate as partially right and partially wrong. First, the environmentalists are correct that on-dock rail terminals are more efficient and more environmentally kind than near-dock terminals devoted to handling marine containers. Considering the declining market share of push supply chains, the San Pedro Bay Ports' plans for on-dock rail terminal development with generate enough capacity to handle all of the push supply chain import traffic (and rail export return of the marine boxes). But the environmentalists miss a tremendous opportunity afforded by the near-dock terminal capacity. Were the near-dock terminals devoted to handling domestic containers, there could be a substantial reduction in dray-miles for domestic containers moving from cross-docks located near the ports to off-dock rail terminals. That is, not only should push supply chain traffic be pulled into the ports for rail loading and unloading within the ports, but rail loading and unloading of push-pull supply chain traffic should be pulled closer to the ports to utilize near-dock terminals in lieu of off-dock terminals.

Second, the ports are correct that the near-dock terminals are needed to accommodate port growth. But the stated purposes for the terminals, i.e., reducing dray trips to/from the terminals and handling growth in rail movement of marine containers, does not reflect the longer-term traffic mix. Instead, as push-pull supply chains volumes increase, those terminals will be needed to handle domestic containers.

An appropriate compromise would be as follows: Expanded near-dock terminal capacity could be approved with the proviso that on-dock rail capacity expansion within the ports should be pursued to create enough capacity to handle nearly all of the push supply chain traffic. As on-dock capacity becomes sufficient to enable excess capacity at the near-dock terminals, those terminals should be back-filled with domestic containers moving to/from the ports area that otherwise would be handled at off-dock terminals. Ultimately, the near-dock terminals should become predominantly terminals for domestic containers.

At the same time, land use policies should be altered to provide incentive for cross-dock and import warehouse development on existing industrial lands close to the ports. This could be done in a number of ways. For example, there could be public assistance in the environmental clean-up and permitting of logistics redevelopment of old industrial sites.

An overall program of (1) on-dock rail capacity sufficient to handle the push supply chain traffic, (2) near-dock rail capacity sufficient to handle the push-pull supply chain traffic, and (3) redevelopment of industrial parks close to the ports to provide modern import warehousing and cross-docking capabilities would lead to a dramatic reduction in dray traffic within the Los Angeles Basin, reduced costs for importers and reduced environmental impacts.

In Vancouver, there has been considerable development of import warehouses and cross-docks along the south bank of the Fraser River. Dray trips between Roberts Bank and these logistics facilities need not enter the urban area. Subsequently, there are dray trips handling domestic containers between these facilities and off-dock rail intermodal terminals on the east side of Vancouver (in the municipalities of Coquitlam and Surrey). The VPA, local governments and the Canadian government should be preparing to accommodate substantial growth in truck traffic along this corridor. This growth will far exceed growth in double-stack train traffic to/from Roberts Bank. Alternatively, the agencies could explore the development of a new rail domestic-container rail terminal closer to the cross-docks and import warehouses, perhaps back towards Roberts Bank.

10. Conclusions

We first provide conclusions with respect to importer supply-chain policies. Our analysis suggests that the top 10 and possibly as many as the top 40 importers of Asian goods could profitably consider adopting a portfolio of supply-chain strategies for their Asian imports in lieu of a single, homogeneous strategy. Most of the benefits to be obtained are afforded by deploying a simple two-strategy policy, allocating low-value goods into direct shipping channels and higher-value goods into trans-loading consolidation – de-consolidation channels. Allocating the more expensive goods into multiple trans-loading strategies offers only relatively modest additional gains.

Most large importers design supply chains with more ports of entry than is deterministically optimal. We analyzed the value of such redundancy in terms of cost avoidance should there be a temporary disruption to imports at the Ports of Los Angeles and Long Beach. Our analysis suggests that only modest gains are available from such redundancy, probably not enough to justify the redundant investment. We are left with the conclusion that an increased position of power in negotiations with transportation carriers, third-party logistics operators and landlords must be a more prominent justification for redundancy as it is actually practiced. It is also conceivable that the use of these additional ports is due to the regional history of a retailer, before its operations became truly national.

Next, we provide policy recommendations for governments in port areas. Our first governmental policy recommendation is that the current focus for investment and environmental mitigation focus on channels accommodating direct inland shipping of marine containers must be tempered by the fact that market share for such channels is declining, and the decline is likely to accelerate in coming years. Instead, there needs to be greater focus on the channels involving cross-docking and trans-loading to domestic containers and trailers. There is risk that capacity in such channels will be overbuilt.

This leads to our second governmental policy recommendation: Land-use policies should promote the development of cross-docks and import warehouses in industrial properties in the vicinity of the ports. Reducing the scope of dray transportation by means of cross-dock and warehouse development can be much cheaper than building truck lanes on the freeways or special rail systems to haul boxes to/from more distant inland warehouse parks.

Finally, national-level environmental impact ought to be assessed in EIR processes in lieu of an assessment of solely the local impacts. In the case of infrastructure used for handling Asia – USA imports, the impacts are nation-wide, and the nation-wide impacts may weigh differently from the local impacts.

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