Market Potential and Marketing Strategy for Short-Haul Intermodal Service in Southern California

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1 December 2023

Executive Summary

Commissioned by Pacific Harbor Line, this report quantifies the import and export markets for a short-haul rail intermodal service between marine terminals at the San Pedro Bay ports and one or more terminals located in the Inland Empire. The report provides an overview of the nature and structure of supply chains deployed by various types of importers. Analysis is provided of the impact on total import volumes through the San Pedro Bay ports as a function of the difference in cost to beneficial cargo owners between use of the intermodal service and current drayage services. Strategies and stakeholder agreements facilitating the formation of a successful short-haul intermodal service are discussed.

Potential Import Market

On an average weekday in 2019, 5,120 marine containers were drayed 60-90 miles from marine terminals at the San Pedro Bay ports to distribution facilities located in the greater Inland Empire of Southern California. This amounts to more than 3 million TEUs per year. Another 640 53-foot trailers per day of trans-loaded imports were drayed from cross-docks located in the communities surrounding the Ports to Inland Empire distribution facilities, while 1,020 53s moved from such cross-docks to downtown Los Angeles rail intermodal terminals or through downtown en route to Northern California distribution centers. There were reverse movements of like numbers of empty containers and trailers. Dray rates for such movements have climbed rapidly in recent years, approaching $1,000 in peak season for a single dray from marine terminals at the San Pedro Bay ports to Inland Empire warehouses.

Realistically, a short-haul intermodal service would have capacity and investment limitations and thus should be expected to capture only a portion of the total market. Were the short-haul intermodal service able to secure, say, a 50% share of this traffic, it would fill more than seventeen round-trip trains per operating day, each hauling 250 forty-foot containers. A 50% share of the direct ports-to-Inland-Empire movement of marine containers alone would fill more than ten round-trip trains per operating day.

To be successful, the service (including destination dray) needs to be priced competitively with direct dray, terminate at one or more terminals located in the heart of the Inland Empire, and be operated every day marine terminals collectively have a significant number of boxes to be moved to the Inland Empire. If priced at enough of a discount to direct dray, it not only would capture the existing import volume moving to Inland Empire distribution facilities, it would encourage large, nationwide retailers to concentrate more of their Far East – Continental USA imports via the San Pedro Bay ports. At a discount of $400 compared to direct dray, calculations made using 2019 import data predict the share of total annual import volume for the San Pedro Bay ports would grow by about 1 million TEUs. Moreover, it is likely that cross-docking activity presently occurring in communities near the ports would migrate to the Inland Empire.

Potential Export Market

In contrast to imports, which are almost entirely containers of retail goods whose de-vanning is strongly concentrated in the Inland Empire, export shipments originating in Southern California

are predominantly containers of agricultural goods packed in various growing regions outside the Los Angeles Basin. The entire waterborne, containerized export volume via the San Pedro Bay ports in 2019 of agricultural goods originating in California, Nevada, Arizona and New Mexico was on the order of 500,000 – 600,000 TEUs, about 11-13% of the import volume suitable for short-haul intermodal service. Backhauls of agricultural exports drayed to its Inland Empire rail terminals could be a suitable feature of the service.

Potential Inland Terminals for the Service

Existing Inland Empire rail intermodal terminals do not have the capacity to accommodate the short-haul intermodal service; one or more new terminals would be required. Property in the Inland Empire that could be secured to develop terminals for the service is scarce. However, property that could be suitable is located in zip code 91761 and straddling zip codes 92316 and 92324. Some of this property is in the public domain, and some is under railroad ownership. While offering plenty of space for developing the service and growing it over the years, the political, legal and environmental feasibility of using either site is unknown to the author.

Track Capacity

Track capacity between the San Pedro Bay ports and Inland Empire terminals for the service is another concern. Both the BNSF and Union Pacific main lines host Metrolink commuter services, and the BNSF line also hosts frequent Amtrak service to and from San Diego. This issue deserves further study.

Public Benefits

The public could benefit substantially from a successful short haul intermodal service. It seems well within reach that the entire import supply chain from departure from marine terminals through Inland Empire distribution facilities and on to Inland Empire domestic rail terminals for furtherance could be accomplished with zero emissions. Taking thousands of truck round trips per day off of Los Angeles Basin freeways between the San Pedro Bay ports and Inland Empire distribution facilities would entail a substantial reduction in truck traffic. Public investment to help realize the service seems justified.

Public-Private Partnership

A public-private partnership may be the best way to enable a successful service. Under such a partnership, the various stakeholders could make the following commitments to enable a successful launch of the service:

- The dock-to-door service would be priced competitively with direct dray
- Major importers would commit to use the service
- Public agencies would assist in securing the site(s) for Inland Empire terminal(s) for the service. Terminals would be operated with electric cranes
- The San Pedro Bay ports would sponsor low, tax-free interest bonds to develop the terminal(s), as was done for the ICTF and the Alameda Corridor
- The service would be provisioned with battery-powered locomotives

- Dray and chassis providers would agree to operate in the Inland Empire in connection with the service. Battery-powered dray tractors should be provided to dray operators
- Arrangements for allocation of operations to lines and appropriate investments in track capacity would be made so as to efficiently accommodate the short-haul intermodal service while maintaining passenger service and other freight services in the area
- Ocean carriers would agree to source empty marine containers from the Inland Empire terminal(s) to agricultural exporters requesting container supply

The short-haul intermodal service as envisioned here is an extraordinary undertaking. But it would provide extraordinary benefits to the public, to importers and exporters, and to supply-chain participants.

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Import Market

As a precursor to analysis of the import market for short-haul intermodal service in Southern California, it is helpful to gain a general understanding of the supply chain strategies pursued by various types of Far East – Continental USA importers.

A Brief Primer on Supply Chain Strategies and Terminology

Any supply chain for retail goods has factory origins and retailing destinations. In a *Push* supply chain, shipping of goods is closely tied to factory production schedules. In typical Push supply chains, production and shipping are performed at a contracted steady rate throughout the year, thereby minimizing investment and operating costs for manufacturing and transportation.

In a *Pull* supply chain, shipping of goods is more closely tied to retail sales. Typically, retail sales fluctuate over the course of the year (e.g., large sales volumes towards the end of the year associated with Christmas gift-giving, large sales volumes during promotions), and so shipping quantities in Pull supply chains fluctuate more than in Push supply chains.

Pull supply chains focus on controlling inventory costs and enabling increased sales, at the expense of higher costs for manufacturing and transportation. In contrast, Push supply chains focus on minimizing production and transportation costs, at the risk of higher inventory-related costs or diminished sales.

To decide shipping rates in Push supply chains requires long-range forecasts of sales. If such forecasts are prone to error, there can result panic adjustments to the Push shipping plan, e.g., cancellation of long-term shipping contracts (in the case of a forecast turning out much too high) or emergency shipments paying high spot prices for shipping (in the case of a forecast turning out much too low).

A compromise strategy is a *Push-Pull* supply chain, in which an inventory stocking point situated in between production source and sales outlets is deployed. The location of the inventory point is termed the *Push-Pull boundary.* Goods are pushed from factory to stocking point, then pulled from stocking point to sales outlets.

When there are geographically-dispersed sales outlets in the supply chain, a common supply chain strategy is to ship from factory to an inventory stocking point or a de-consolidation point without pre-allocation to sales outlets, then prepare an allocation plan and re-ship from the stocking point or de-consolidation point to sales outlets. If the shipping time from this point to the sales outlets is much shorter than the shipping time from factory to this point, the forecasts of sales at outlets made just in time for shipping from this point to sales outlets will be much more accurate than forecasts made just in time for shipping direct from the factory. Moreover, shipping from factory to this point need only rely on a forecast of total sales across all outlets, which percentage-wise, will be much more accurate than forecasts of sales at individual outlets.

If the de-consolidation point is simply a cross-dock or trans-load facility with no capability to stock inventory, then any excess in overall supply from the factory must be pushed onto the sales outlets. Any excess can be proportionately spread across the retail outlets, thereby minimizing

the inventory consequences. Similarly, a shortage in overall supply from the factory can be proportionately spread across retail outlets, reducing the need for safety stocks at the outlets. If the de-consolidation point includes a warehouse able to stock inventory, then excess supply from the factory can be held for deployment to mitigate future shortages rather that proportionately pushed on the retail outlets, and the resident inventory can be tapped to make up for a shortage in supply arriving from the factory. In that case, lower inventory-related costs and higher sales can be achieved, in exchange for the expense of maintaining the warehouse and its inventories.

Typically, a well-designed Push-Pull supply chain can garner much of the shipping economies of a Push supply chain, as well as much of the inventory economies of a Pull supply chain. Thus, it embodies a strategy superior to either extreme. Of course, there are many alternative specific configurations of a Push-Pull supply chain, e.g., where should the Push-Pull boundary be located, which shipping modes should be used, should there be just a trans-load facility or also a warehouse. The most effective specific configuration depends on the relative magnitudes of shipping-related and inventory-related costs.

A glossary of supply-chain acronyms and terminology used in this report is provided in Appendix 1 of the report.

Overview of Contemporary Far East – USA Import Supply Chains

Containerization and intermodal transportation dramatically lowered the costs of international shipping, enabling American retailers to tap low-cost Asian manufacturing. The improvement in international supply chain efficiency and reliability facilitated the outsourcing of American manufacturing which began in the early 1980s and accelerated through the 1990s. From 1980 to 2006, the total waterborne, containerized imports from Asia to North America via West Coast ports grew rapidly. Figure 1 displays the total containerized imports through major US and Canadian West Coast ports during the period 1999 – 2015.[1] Volume doubled from about six million twenty-foot equivalent units (TEUs) in 1999 to almost 12 million TEUs in 2006, before a deep recession arrested import growth. While imported container volumes declined for several years following 2006, by 2015, imports via West Coast ports surpassed the 2006 peak. Thereafter, volume grew steadily through 2018, faltered in 2019, then shot up during the pandemic, slightly exceeding 15 million TEUs in 2022. In 2019, port shares of containerized imports from the Far East to Continental USA were about 45% passing through the San Pedro Bay ports, 38% passing through East Coast or Gulf Coast ports, and 17% passing through other West Coast ports.

Ocean carriers providing containerized transport in the Far East – North America market offer three basic service products. Under CY (container yard) service, the ocean carrier supplies an empty container to the Far East origin factory or warehouse, drays the loaded container to the origin port, and provides vessel transport to a North American port. It is the responsibility of the importer to bring tractor and chassis to the North American port to pick up the box. SD (store door) service is the same as CY except the ocean carrier also pays for a dray from the North American

[1] Includes only inbound loaded international containers. Ports included: Long Beach, Los Angeles, San Francisco, Oakland, Portland, Tacoma, Seattle, greater Vancouver metro area, and Prince Rupert. *Source*: Port websites.

port to a destination warehouse in the hinterland of the port. Originally, under SD service the ocean carrier hired a local drayman and provided a chassis for the destination dray. However, the ocean carriers no longer provide chasses, and most importers prefer to control the dray themselves using draymen they employ or contract. When an importer purchases SD service but performs the dray itself, the ocean carrier rebates the destination dray cost. The third service product is IPI (inland point intermodal). Under IPI service, shipments move intact in marine containers from Far East origins to inland USA destinations using a combination of modes: initial dray by truck from Far East origin to Far East port, vessel from Far East port to North American port, double-stack train from North American port to inland rail terminal, and then final dray by truck from rail terminal to destination. In the case of IPI service, the ocean carrier sells a door-to-door transportation product, subcontracting a drayman in the Far East to dray an empty box from the Far East port to the factory origin and dray the loaded box to the origin port, subcontracting a North American railroad to haul the box from the destination port to a distant inland rail intermodal terminal, and subcontracting a North American drayman to haul the box from the destination rail terminal to the receiver's dock.

If the importer wishes to de-van the imports from the marine container, sort them at a cross-dock or inventory them at a warehouse, and subsequently re-ship them, he can procure CY or SD service from the ocean carrier to move the imports to the cross-dock or warehouse in the hinterland of the port of entry, but then he must hire a domestic landside transportation company for re-shipment from cross-dock or warehouse to the desired inland destinations. He can hire a trucking firm for movement of goods in a 53-foot trailer. He can hire an LTL (less than truckload) carrier for movement of pallet-sized shipments. He can hire UPS or Fed Ex Ground for even smaller shipments.

Securing rail intermodal service for full truckloads is a different story. Except Wal-Mart and Amazon, importers cannot procure rail intermodal service directly from the railroads.[2] They must procure this service from a third party known as an Intermodal Marketing Company (IMC). Examples of IMCs include J B Hunt, Hub Group, and Schneider. The IMC sells the door-to-door service of shipping a 53-foot domestic container or trailer from importer's cross-dock or warehouse to destination warehouse, sub-contracting with a railroad for line haul. Some IMCs have their own drivers, dray tractors, containers, and chassis; others sub-contract with dray companies to perform origin and destination drays. Some secure chasses and containers from the railroad; others have their own.

Figure 2 summarizes these terms of trade. For intact movement in marine containers, the importer need only do business with the ocean carrier. For a supply chain in which goods will be de-vanned from marine containers before continued movement from the hinterland of the port of entry, the importer is hiring a port area dray company to bring the box from the port to the cross-dock or warehouse and hiring a chassis provider for that move. It may hire a third-party logistics company

[2] And in the case of Walmart and Amazon, most of their domestic rail shipments are procured through IMCs rather than directly from the railroads.

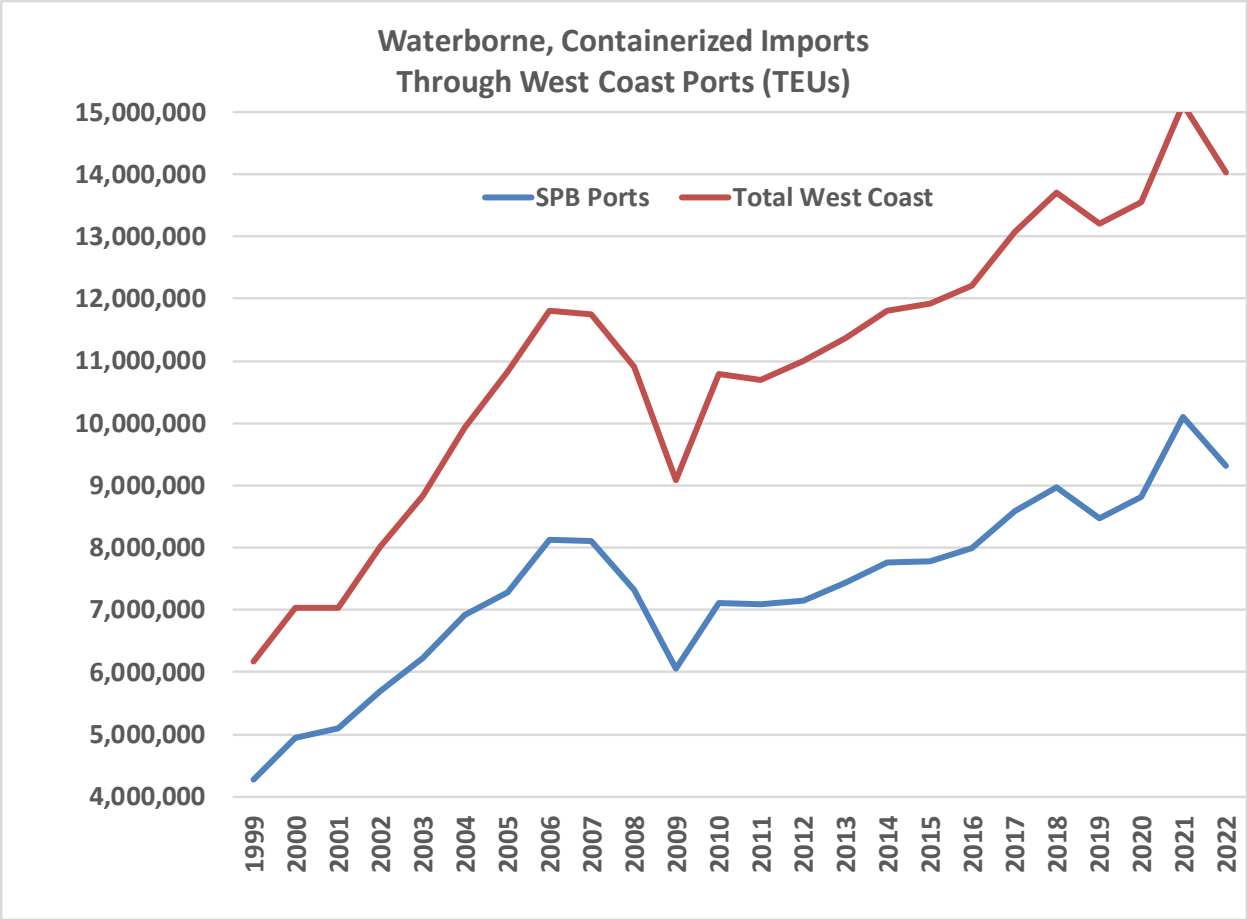


Figure 1: Containerized Imports through US and Canadian West Coast Ports 1999-2022 (TEUs)

Sources: Port web sites.

(3PL) to operate the cross-dock. For outbound movements from the cross-dock, it hires an IMC for the re-shipment in domestic containers from cross-dock or warehouse to distant inland destinations and trucking companies for re-shipment in trailers to points for which rail intermodal service is unavailable or not competitive.

The investments made by West Coast ports, the railroads and marine terminal operators, facilitated rapid growth in the movement of IPI shipments for over two decades. However, changes in the nature of retailing in the US, along with increases in the size of domestic containers and the commercial incentives to use the large domestic containers provided by railroads, shifted the growth vector in international containerized transportation from intact to trans-loaded shipments.

The cubic capacity of domestic intermodal containers paced the increase in size of highway trailers, growing from 45 feet to 48 feet to 53 feet in length. Combined with aggressive pricing spurred by modal competition, low-cost domestic container service drove a major shift away from intact international container shipments. By the mid-2000s, virtually the entire domestic container

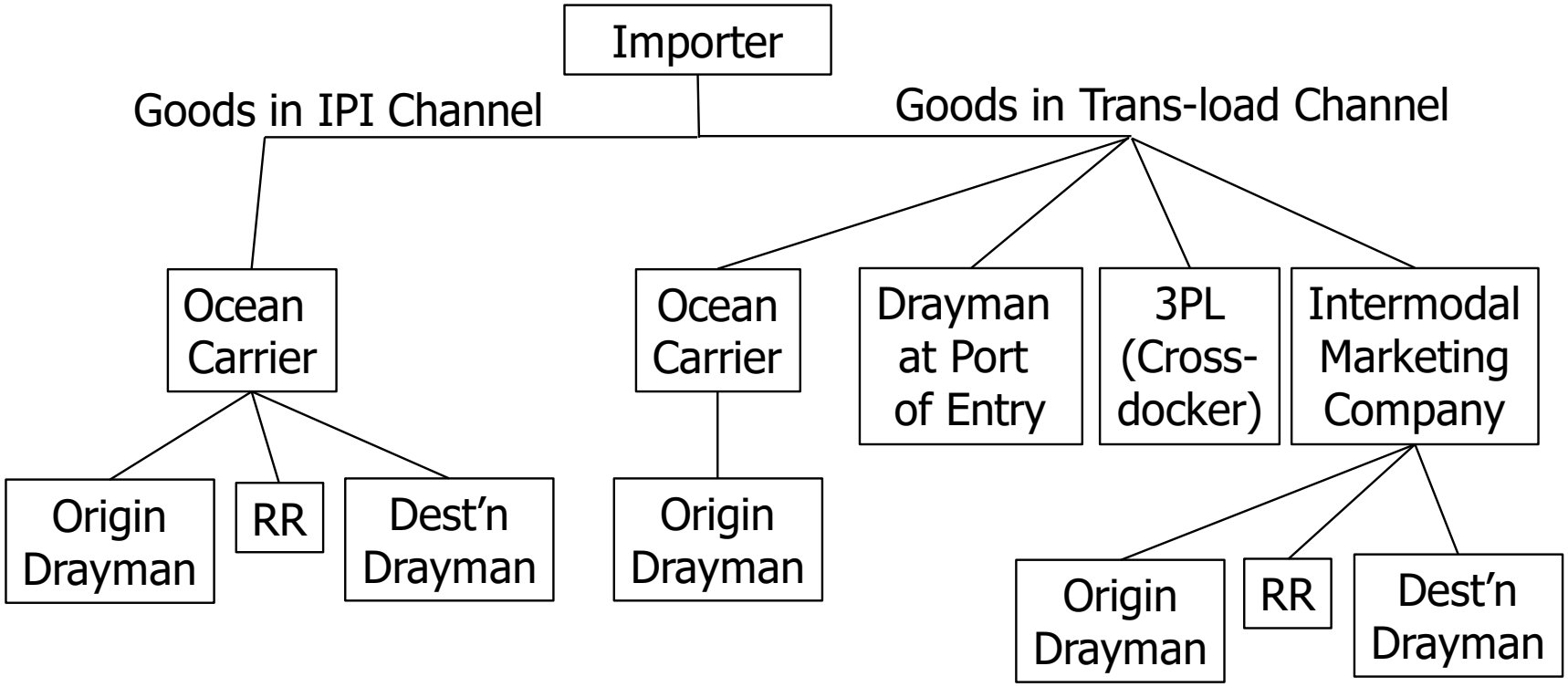


Figure 2. Contractors and Sub-contractors in Far East – USA Waterborne, Containerized Supply Chains

fleet in the Continental USA consisted of 53-foot containers. Their cubic capacity is about 4,000 cubic feet, compared to about 2,700 cubic feet for a "high-cube" 40-foot marine container that is nine feet, six inches tall, and compared to about 2,400 cubic feet for an ISO 40-foot marine container that is eight feet, six inches tall. For "cube" freight, i.e., freight that reaches space limits before reaching highway weight limits, the contents of three marine containers fit in two domestic containers or trailers.

Demand for larger domestic containers was driven by an evolution in the mix of importers and an associated increase in the sophistication of supply chain management. The 1980s and 1990s saw the rise of nation-wide "big-box" retailers such as K Mart, Wal-Mart, Target and Home Depot. The big-box firms steadily took more and more market share from small and regional retailers. These large, nation-wide retailers enjoy economies of scale and scope that enable a new and more efficient kind of supply chain to be embraced, a supply chain in which goods do not move intact in marine containers from Far Eastern factories to stores or regional distribution centers (RDCs), but instead are de-vanned and sorted in the hinterlands of the ports of entry, then allocated to RDCs and re-shipped in domestic trailers or containers. This re-allocation happens subsequent to the long lead time to book vessel passage and move goods from an interior point in the Far East to a USA port of entry, with only the much shorter lead times remaining to move the goods from port of entry to the RDCs across the USA. Much more accurate projections of sales in various regions are available over these shorter horizons than for the long horizon facing the importer before vessel passage was booked. Re-allocation of goods by RDC destination after arriving at port of entry enables a much better match-up of supply and demand to be made.[3]

The average time until sale of goods is thereby reduced, and, consequently, the average pipeline inventory is reduced, and the required safety stocks at RDCs are sharply reduced. Thus, this sort of supply chain is especially attractive for goods with high inventory costs or rapid price erosion.[4] Better yet, if the imported goods at the time of arrival at port of entry are not yet in demand at any RDC, they can be stored in an import warehouse in the hinterland of the port of entry and shipped later once demand materializes, in lieu of immediate, speculative shipment to what could turn out to be the wrong RDC (wrong in the sense that, if the items had been shipped to a different RDC, they could have been sold much earlier, perhaps at higher prices.)

Considering the cubic capacity advantage of domestic trailers and containers over international containers, the transportation cost savings associated with the reduced number of inland container shipments afforded by domestic containers partially offsets the extra handling costs

[3] Wal-Mart was the first champion of widespread application of *cross-docking* in its supply chains, whereby a fleet of inbound containers or trailers from multiple origins is brought to a dock where their contents are unloaded, sorted and re-allocated to a fleet of outbound containers or trailers heading to multiple destinations. This technique enables better management of pipeline inventories by fine-tuning the alignment of supplies with demands. The technique is now intensely practiced by all of the nation-wide "big-box" retailers. A similar strategy is practiced by original equipment manufacturers (OEMs) bringing imported goods into the USA and re-selling them to US retailers, whereby the imports may be inventoried for some time pending sale and domestic re-shipment.

[4] Inventory costs are high when the declared value of the goods is high, when the retail price erodes very quickly (such as for fashion goods or electronics), and/or when sales are difficult to forecast (such as new toys).

associated with de-vanning marine containers, sorting and re-allocating the goods, and reloading them in domestic containers. This savings extends the portfolio of goods for which supply chains that re-allocate goods after arrival at port of entry and re-ship them in domestic containers and trailers are superior to supply chains involving intact shipment in marine containers to inland distribution centers. The economies large nationwide retailers derive from such supply chains are not available to a retailer operating retail outlets in only one region (because there are not multiple RDCs in multiple regions with offsetting sales fluctuations whose inventories can be re-balanced by re-allocation of imports), nor are they available for small retailers (because the need to re-load from marine containers into domestic containers of a different size requires sufficient, sustained import volumes so that the result is not half-empty containers or trailers shipped domestically).

The recent rise of nation-wide e-commerce retailing, both by the Big-Box retailers such as Wal-Mart, Target and Home Depot, as well as by pure e-commerce enterprises, such as Amazon, has accelerated the shift of import volumes into such trans-loading supply chains. The economic gains in terms of quicker liquidation of inventory at higher average selling prices afforded by not making geographical commitments on pipeline inventory outweigh the extra handling costs associated with cross-docking and warehousing in the hinterlands of ports of entry. Moreover, direct shipping to customers using parcel and express services, without need to stock retail stores, enables on-line retailers to make much less geographical dispersion of imports, and maintain much less total inventory than otherwise. Thus parcel and express carriers also have seen in increase in business stemming from e-commerce re-shipments of imported goods.

Distribution of Far East – USA Waterborne, Containerized Imports by Commodity, Value and Importer Type

The factors driving the distribution of importers of Far East-manufactured goods are the same ones driving the shift from IPI/intact container shipments to trans-loaded shipments:

1. High value goods, such as electronics, imported by large scale OEMs continue to grow in volume and in share of imports.
2. Large-scale e-commerce firms, such as Amazon, also are rapidly growing their shares of imports.
3. Large-scale retailers continue to take market share from small and regional retailers who were the primary users of IPI/intact shipments.
4. The supply chain characteristics of the large-scale OEM, e-commerce and retailing importers drive toward trans-loading at ports of entry rather than inland IPI/intact shipments.

To comprehend the relative volumes in trans-loading supply chains vs. direct-shipment supply chains, we will review the distribution of Far East – USA imported goods by commodity and inventory value, the volumes of such imports by importer type. After that, we will elaborate on the characteristics of the supply chains practiced by the various types of importers.

Port Import-Export Reporting Services – Trade Intelligencer (PIERS-TI) and Global Trade Atlas (GTA)[5] summaries of US Customs transactions on waterborne, containerized imports from Asia to the United States for Calendar Year 2019 were secured by the author. Table 1 classifies these imports by commodity. Customs utilizes 99 commodity types in order to assess duties. Shown in the table are the top twelve commodity types (top twelve in terms of volume). These twelve account for almost three fourths of total imports. As may be seen, by a wide margin, the largest import commodity (in terms of cube or TEUs) is furniture and bedding; the next largest, with less than half that volume, is electronics.

Table 1: Distribution of Far East – USA Containerized Imports

Commodity (Two-digit US Customs HS code)	Percent of Total Volume	Average Declared Value ($ per TEU)
Furniture, bedding, lamps	16.8%	$15,346
Machinery and computers	8.8	$61,799
Electronics, electrical equipment and electrical appliances	8.2	$59,135
Toys, games, sporting goods	6.7	$26,579
Plastic goods	6.7	$40,062
Apparel	5.2	$66,214
Auto parts, motorcycles	5.2	$39,969
Rubber goods	4.3	$23,795
Steel goods	3.8	$26,955
Footwear	3.2	$40,933
Linen, blankets, curtains	2.1	$33,125
Leather goods (e.g., handbags)	2.0	$30,820
Paper products	1.9	$16,961
Wood products	1.9	$15,090
All others (85 types)	23.2	$41,152
All commodities	100.0	$37,825

Source: PIERS-TI data for March, July and October, 2019 for imports to USA from 17 Far East nations. PIERS-TI reports volumes in terms of twenty-foot equivalent units (TEUs).

There are three important takeaways from Table 1. First, the lion's share of containerized imports from the Far East to the USA is accounted for by retail-ready goods or goods that are very close to retail-ready goods. Even the auto parts category in Table 1 consists predominantly of spare parts flowing to the dealer network and to auto parts retailers rather than components for use in vehicle assembly. The other 85 commodity types not shown in the table are largely retail-ready goods as well. Second, while there are a few weight-freight commodities such as steel goods, imports from the Far East are largely cube freight, not weight freight. Inland transportation economies are afforded by trans-loading to domestic vehicles. And third, there is a wide variation in the average declared value of these commodities. As will be discussed, the least costly supply chain for furniture and bedding, at about $15,000 declared value per TEU of container space, is very

[5] PIERS-TI and GTA are commercial data service products of S&P Global.

different from the least costly supply chain for electronics, with declared values averaging about $59,000 per TEU.

Table 2 lists the top twelve importers of waterborne, containerized imports from Asia to the USA in 2019 (by volume). As may be seen, the top importers include familiar "big-box" nation-wide retailers. General broad-category stores such as Wal-Mart, Target and Family Dollar are represented, as are home improvement and furnishing chains such as Home Depot, Lowe's, Ashley Furniture and Ikea. Large original equipment manufacturers selling to these and other retailers also appear in the top ten, such as Samsung, LG and Nike. Amazon was number 19 in this list in 2019; in more recent years it has probably moved up in the rankings.

Table 2: Far East – USA Waterborne Containerized Import Volumes by Importer

Importer	2019 Volume (TEUs)	Share (%)	Type of Company
Wal-Mart	893,000	7.63	Big-box retailer
Target	600,000	5.12	Big-box retailer
Home Depot	400,000	3.42	Big-box home improvement
Lowe's	292,000	2.49	Big-box home improvement
Ashley Furniture	270,000	2.30	Furniture retailer
Samsung	181,000	1.55	OEM of electronics and appliances
Family Dollar/Dollar Tree	172,000	1.47	Big-box retailer
LG	156,000	1.33	OEM of electronics and appliances
Ikea	132,000	1.12	Big-box home improvement
Nike	118,000	1.01	OEM of Footwear
Williams Sonoma	88,800	0.76	Retailer of appliances and home hardware
Rooms to Go	69,680	0.60	Furniture retailer
Subtotal, Top Twelve	3,214,000	28.82	
Subtotal, Top 90 Firms	5,150,000	~ 44	

Source: Journal of Commerce. Figures rounded to nearest thousand.

Figure 3 aggregates all 99 commodity types of Far East – USA waterborne, containerized imports in 2019 as a cumulative distribution over declared value. Note the curve rises steeply at low declared values and much more slowly at high declared values, i.e., there are considerable low-value imports and much less high-value imports. Imports are classified as inexpensive, moderate-value and expensive, for reasons that will become clear below. Up to about $15,000 in declared

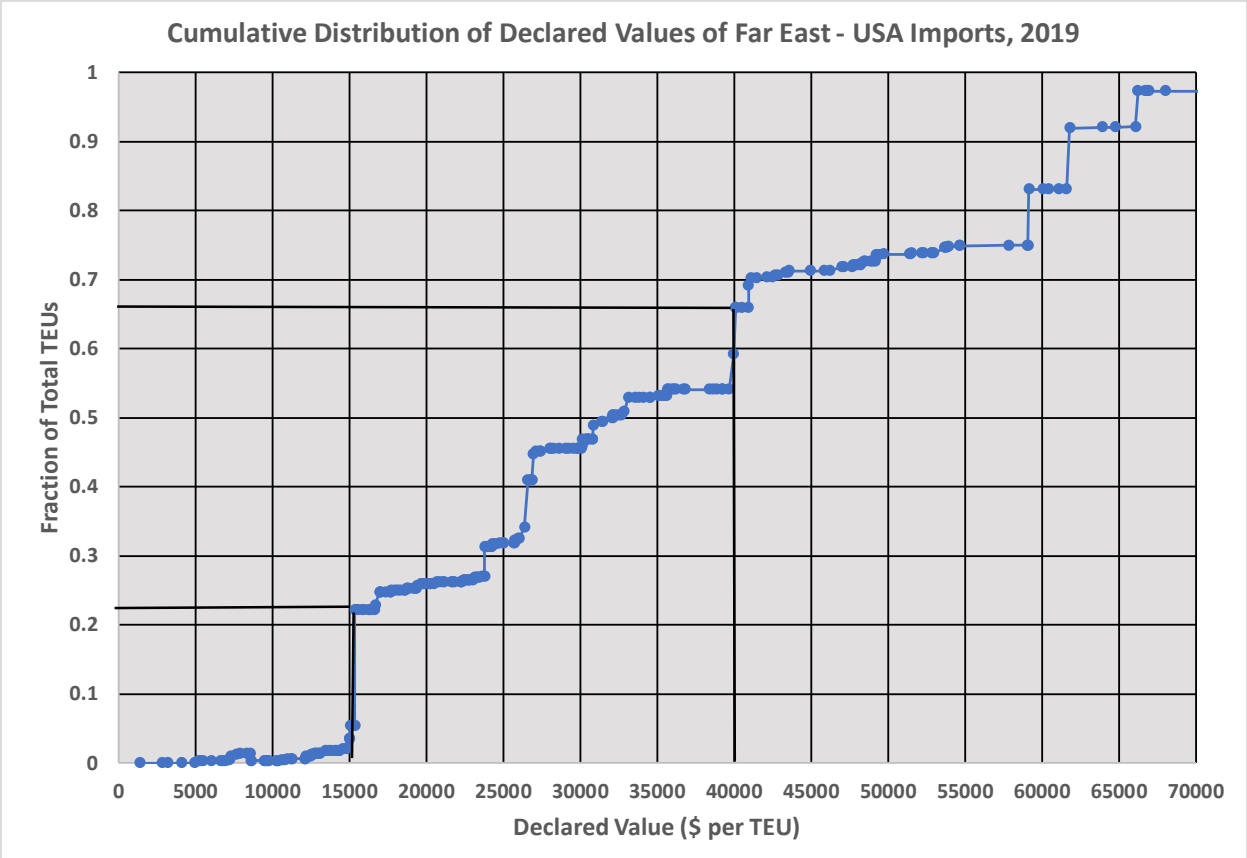


Figure 3: Value Distribution of 2019 Far East-USA Waterborne Containerized Imports

Source: PIERS-TI data for March, July and October, 2019.

value per TEU accounts for about 22% of imports ("inexpensive imports"); from $15,000 per TEU to about $40,000 per TEU accounts for about 45% of total imports ("moderate-value imports"); and above $40,000 in declared value per TEU accounts for about 33% of total imports ("expensive imports"). Generally, expensive imports are not sourced directly from Asian factories by USA retailers, as they refuse to buy such expensive items in Asia. Instead, the retailers insist that the original equipment manufacturers (OEMs) bring such goods to the USA, whereby retailers procure such items domestically from the OEMs much closer to the time the retailers can sell them and thereby avoid substantial, risky inventory investments.

Comparing the value distribution for Far East imports to the USA in 2005 (not shown), the inexpensive category has declined from 25% to 22%, the moderate-value category has declined from 50% to 45%, and the expensive category has increased from 25 to 33% of total imports.

Categorization of Far East – USA Waterborne, Containerized Supply Chains

There are three types of supply chains that dominate Far East-USA logistics. We shall label them as follows: Push, Push-Pull-All-at-San-Pedro-Bay, and Push-Pull-3, 4 or 5-Corners. The Push-Pull

supply chains featuring trans-loading are growing in application while the Push supply chains making use of IPI service are diminishing in use.

A typical large US retailer operates Regional Distribution Centers (RDCs) that restock its retail outlets or its retail customers. A large, nation-wide retailer operates on the order of 20-40 RDCs across the Continental United States. Typically, such RDCs are located within an overnight drive of the stores they serve with in-house or dedicated-contract-service trucking used to replenish stores from the RDCs. Most of the retail goods inventory is held at the RDCs or further upstream in the supply chain where the impacts of store-level fluctuations in sales can be pooled.

Whether sourced directly from Asian factories or from the domestic national distribution center of an OEM, imports flow from factories in Asia to the RDCs. Broadly speaking, a fundamental decision in designing the supply chain for flows of containerized imports from Asia to RDCs in the Continental United States, concerns whether to make intact container shipments directly from Asian supplier factories to RDCs (a Push supply chain), or, alternatively, to re-allocate and re-bundle factory shipments in the hinterland of the port of entry before re-shipment to RDCs (a Push-Pull supply chain).

Push Supply Chains: The label "Push" reflects the fact that imports may be forwarded to RDCs well before replenishment of RDC inventories is required. Importers purchase transportation of marine containers from Asian factories to their regional distribution centers (RDCs) under long-term (e.g., annual) contract with the ocean carriers requiring steady shipping rates. Allocation to RDCs of container-sized quantities of output from each Far East factory source is decided by the importer before booking vessel passage. Landside movement to RDCs distant from ports of entry is typically made using IPI service. Landside movement is made via dray of the marine container direct from port terminal to the RDC serving the port's local region or by over-the-road trucking to RDCs located in regions lacking IPI service, typically regions not as distant as the regions for which IPI service is available.[6]

Push-Pull Supply Chains: The label "Push-Pull" reflects the fact that imports are "pushed" as far as the ports of entry to North America, but "pulled" from facilities near the ports to the RDCs, only if and when, required to replenish RDC inventories. A set of one up to five ports for handling all imports to the Continental USA is selected by the importer. In the hinterland of each selected port, the importer maintains an import warehouse for storing goods that are imported much in advance of demands at its RDCs, and for which it desires to delay, making the decision to allocate goods to regions until regional demand forecasts become more reliable. The importer also operates or contracts with a third-party logistics firm to operate a cross-dock or trans-load facility located near but not within the port of entry. Staff at the cross-dock unload the contents of marine boxes, sort the imported goods by destinations specified by the importer, and re-load the goods into

[6] Strictly speaking, what we term a "Push" supply chain strategy herein is actually a Push-Pull supply chain with the Push-Pull boundaries established at the RDCs. Because all supply chain alternatives examined in this report are identical from RDCs to retail outlets, we focus on the portion of the supply chain up to the RDCs, and for this portion of the chain this strategy is Push.

domestic rail containers and highway trailers. Under Push-Pull, the decision is made before booking vessel passage as to how to allocate marine containers to the selected ports of entry (if here is more than one), but the decision as to how to allocate port volumes to RDCs is deferred. Just before vessel arrival, the retailers make an allocation of the marine boxes to the trans-loader/de-consolidator in the hinterland of the port, the import warehouse in the hinterland of the port and the local RDC. Most containers are routed via the trans-loader/de-consolidator; a smaller fraction is routed directly to the import warehouse. In the case of high-volume importers, a small fraction of import containers may be routed directly to the local RDC. Drays of the marine boxes from the port terminal to these three destinations are made accordingly. For boxes routed to the trans-loader/de-consolidator, the retailer makes decisions just before the time of vessel arrival about how to allocate the contents of each marine box into domestic rail containers and highway trailers destined to various inland RDCs, the local RDC and the import warehouse. The trans-loader/de-consolidator processes the contents of the marine boxes and dispatches domestic rail containers and highway trailers accordingly. The domestic rail containers loaded by the trans-loader/de-consolidator are drayed to a nearby rail terminal, moved by train to a ramp in the general area of the destination RDC, and then re-loaded onto chassis for final dray movement to the RDC. The highway trailers loaded by the trans-loader/de-consolidator are drayed to the local RDC, drayed to the import warehouse, or trucked to RDCs in regions not as distant as the regions for which domestic rail service is utilized. For boxes routed to the import warehouse, the goods in those boxes are unloaded and placed in storage. At some future time decisions will be made to allocate those goods to RDCs. For goods allocated to the local RDC, there is local dray movement. For goods allocated to distant regions, domestic rail containers are brought to the import warehouse, loaded and drayed to a nearby rail intermodal ramp. The domestic containers are moved by domestic double stack train to a rail terminal in the same area as the destination RDC, then re-loaded onto chasses for final dray movement to the RDC. For goods allocated to other regions for which rail intermodal service is not available or is not economical, the goods are loaded into highway trailers for truck movement to the RDCs in those regions.

For "cube freight" (i.e., imports that reach space capacities of containers before reaching weight limits), the contents of three marine containers fit in two domestic containers or trailers.[7] As noted above, the lion's share of imports from Asia is cube freight. For trans-loading to be cost-effective, the import volumes need to be at a scale of at least ten TEUs per week per RDC (i.e., five marine containers per RDC per week) or perhaps more. Importers operating at a scale smaller than this are generally restricted to Push supply chains.

A special case of Push-Pull supply chains concerns the case in which goods from Asia are imported by the original equipment manufacturer (OEM) and brought to the OEM's national distribution center (NDC), typically located in the hinterland of a single port of entry. The imported goods are sold by the OEM to nationwide retailers and re-shipped from the NDC to the retailers' RDCs in domestic containers and trailers, typically at the retailers' expense. Figures 4 and 5 depict these strategies in terms of the stages of transit and inventory and the types of transportation vehicles

[7] Some importers shipping a variety of carton sizes within each marine box report that they find the contents of five marine containers fit into three domestic containers. Most say the ratio is three to two.

employed (marine container, line-haul domestic container or trailer, and in-house or dedicated-service domestic trailer). Figures 6, 7 and 8 interpret the alternative supply chain strategies geographically. Figure 6 depicts a Push supply chain for a nation-wide retailer operating RDCs spread across the Continental USA. Typically, all or nearly all ports of entry are used, thereby minimizing land transportation costs. A line roughly passing through Pittsburgh and Atlanta divides RDCs served by West Coast ports from those served by East Coast ports. Texas RDCs might be served by the Port of Houston, a Mexican port of entry or the San Pedro Bay Ports (Southern California). This supply chain strategy minimizes transportation and handling costs, but experiences relatively high inventory costs because goods must be "pushed" on RDCs from Asian factories before it is known at which RDC they would sell the earliest. Figure 7 depicts the other extreme, a Push-Pull supply chain in which all imports are passed through a cross dock or national distribution center located in the hinterland of the Ports of Los Angeles – Long Beach. This supply chain permits inventory to be managed as tightly as possible, in exchange for increased transportation and handling expenses. Figure 8 depicts a "Four Corners" Push-Pull supply chain, in which RDCs are allocated to cross-docks and import warehouses in the hinterlands of the Ports of Seattle-Tacoma, Los Angeles – Long Beach, Savannah and New York – New Jersey. This is a compromise strategy in the sense that both transportation and inventory expenses are intermediate to the Push strategy and the Push-Pull-All-at-San-Pedro-Bay strategy. Variants of the Four-Corners Strategy include Three-Corners Strategy (in which only one West Coast or only one East Coast port is utilized) and the Five-Corners Strategy (in which Houston is added as a port of entry to the Four-Corners Strategy.

The number of RDCs and regions served by each varies according to the importers' level of retail sales. An Amazon or a Wal-Mart may operate on the order of 40 RDCs; a Target or a Home Depot 20-30; and smaller nation-wide retailers may have 8-20.[8] Table 3 displays the case of 22 RDCs and regions; this configuration approximately characterizes several of the large nation-wide retailers. Typically, each RDC is situated within its region so that most or all the region's retail outlets may be re-stocked with overnight deliveries. In the depicted scheme, the Intermountain region comprises only 3.3% of the purchasing power of the Continental United States, and thus can be expected to ultimately receive and consume 3.3% of Far East – Continental USA imports.

In typical Push-Pull 4 Corners supply chains, regions assigned to the San Pedro Bay corner for inventory replenishment include Southern California, Northern California, Intermountain, Houston, Dallas, Kansas City, and Memphis. The Chicago, Columbus, Cleveland and Pittsburgh regions comprise the "Neutral East," i.e., regions which might be assigned to either the Puget Sound corner or to the San Pedro Bay corner, because rail rates from the two ports to Neutral East regions are competitive. Considering the purchasing power of the regions involved, we expect that, at a minimum, the San Pedro Bay corner handles 38.3% of USA imports moving in such supply chains, and up to 55.9% if the entire Neutral East is assigned to San Pedro Bay. For Push-Pull 3

[8] Terminology varies from company to company. E-commerce firms such as Amazon tend to refer to RDCs as "fulfillment centers."

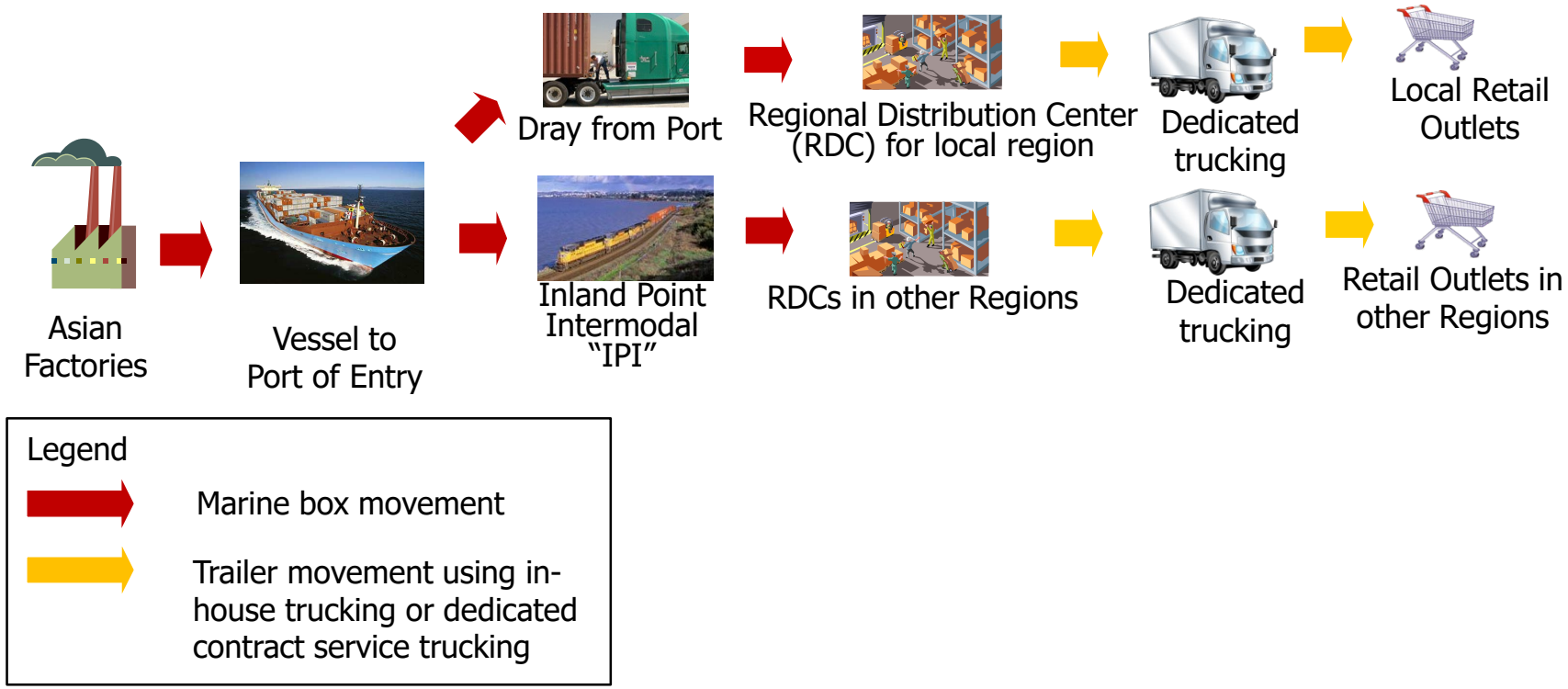


Figure 4: Push Supply Chain

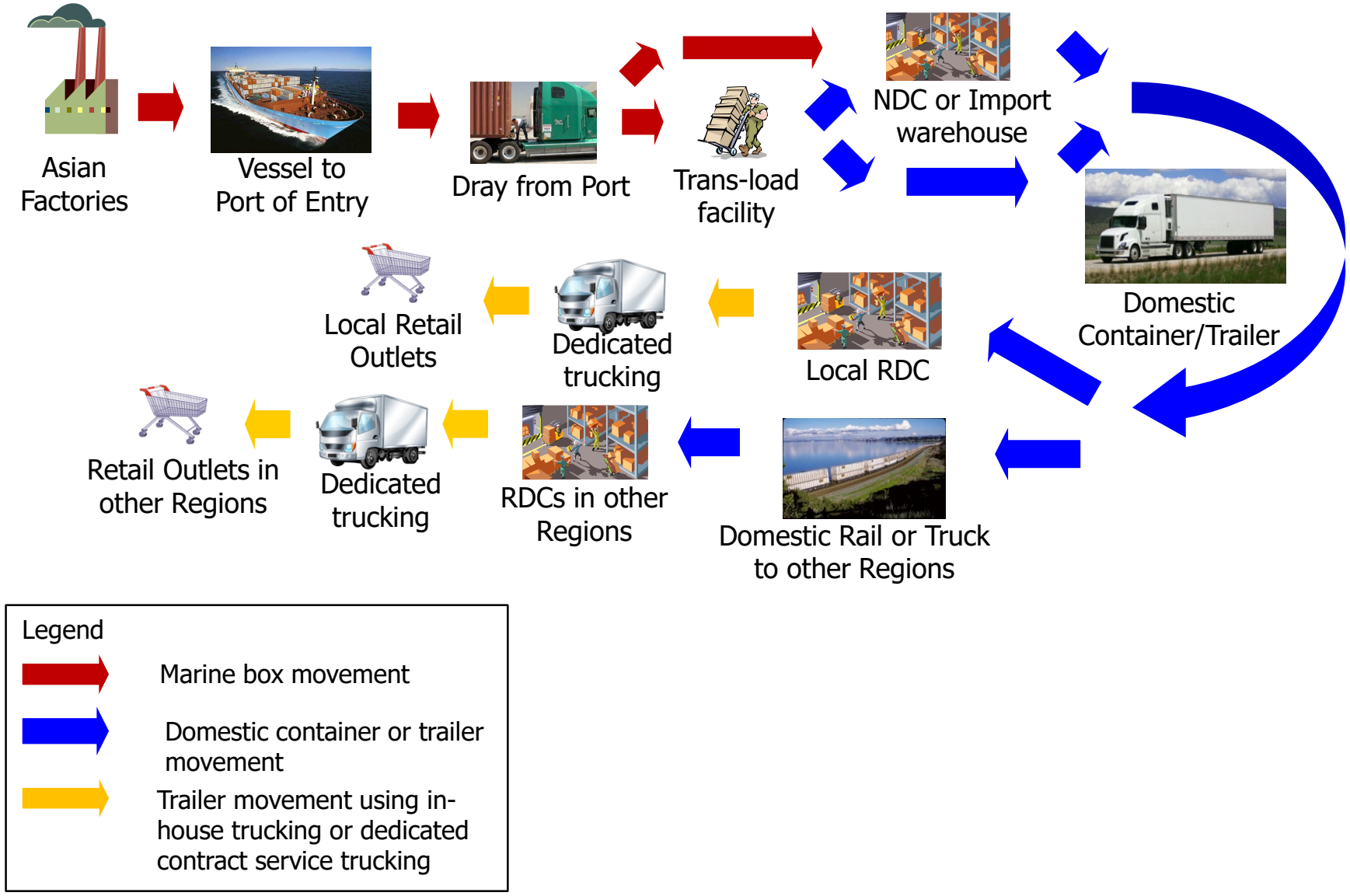


Figure 5: Push-Pull Supply Chain

Figure 6: Push Supply-Chain Strategy

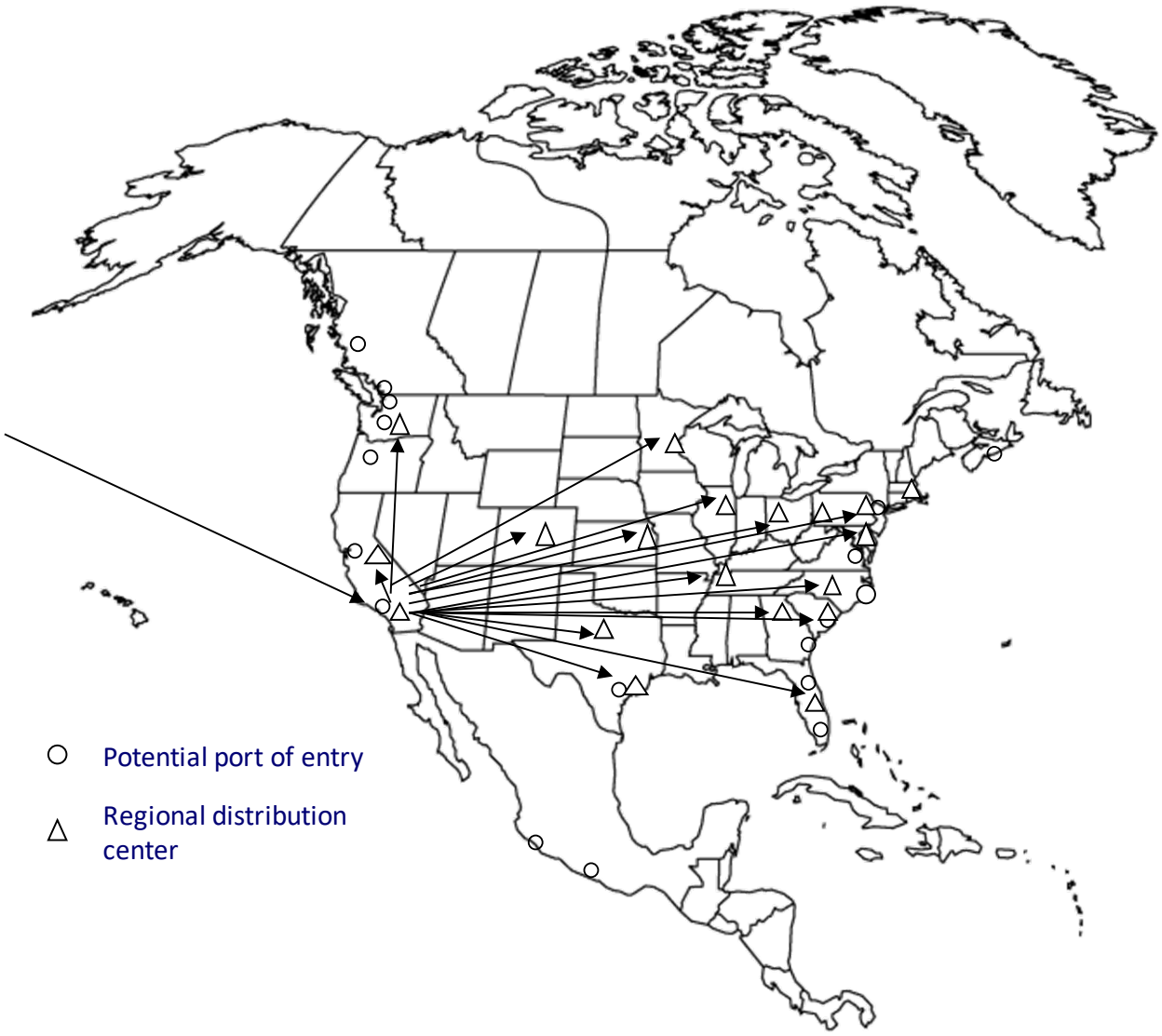


Figure 7: Push-Pull-All-at-San-Pedro-Bay Supply Chain Strategy

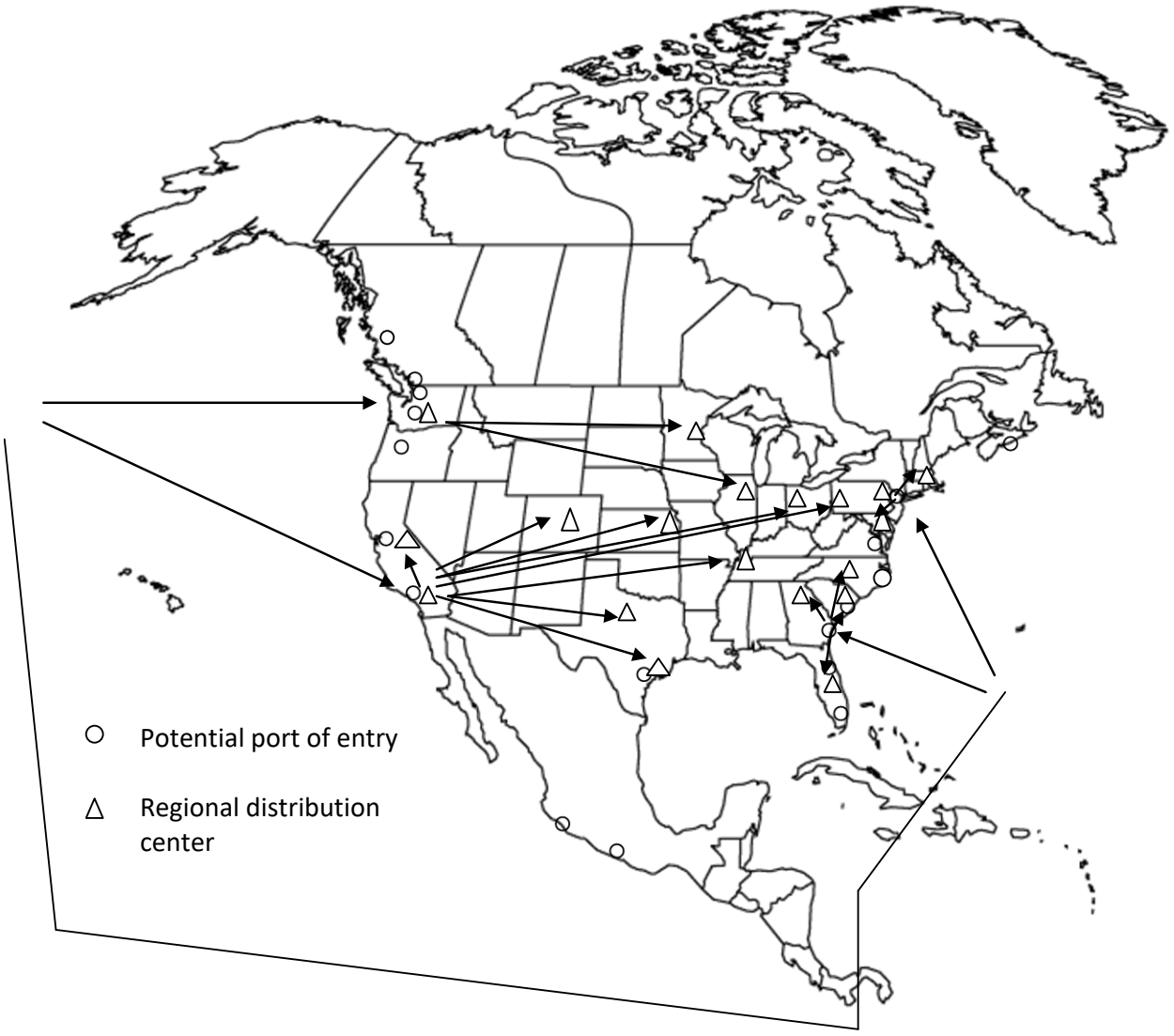


Figure 8: Four-Corner Push-Pull Supply Chain Strategy

Table 3: Purchasing Power in Retailing Regions of the Continental USA

Region	Assumed Location of RDC	Assumed Geographical Extent (expressed percentages of states apply to total purchasing power in those states)	Fraction of Cont. USA Purchasing Power
Southern California	Ontario, CA	60.1% of CA, all of AZ and NM, 67% of NV	0.108
Northern California	Lathrop, CA	39.9% of CA, 33% of NV	0.054
PNW	Kent, WA	WA, OR, 50% of ID, 50% of MT	0.041
Intermountain	Salt Lake City, UT or Denver, CO	UT, WY, CO, 50% of ID, 50% of MT	0.033
Houston	Baytown, TX	50% of TX, all of LA and MS	0.059
Dallas	Midlothian, TX	50% of TX, all of OK	0.051
Kansas City	Lenexa, KS	KS, NE, MO, IA	0.041
Minneapolis	Rosemount, MN	MN, SD, ND, 50% of WI	0.033
Memphis	Millington, TN	KY, TN, AR	0.037
Chicago	Joliet, IL	50% of WI, all of IL, IN and MI	0.099
Atlanta	Duluth, GA	50% of GA, 50% of FL, all of AL	0.056
Columbus	Springfield, OH	50% of OH	0.017
Cleveland	Chagrin Falls, OH	50% of OH, 25% of NY	0.035
Pittsburgh	Beaver Falls, PA	50% of PA, all of WV	0.025
Savannah	Garden City, GA	50% of GA, 50% of FL	0.044
Charleston	Summerfield, SC	50% of SC	0.007
Charlotte	Salisbury, SC	50% of SC and all of NC	0.035
Norfolk	Suffolk, VA	VA	0.030
Baltimore	Frederick, MD	MD, DE, DC	0.030
Harrisburg	Allentown, PA	50% of PA	0.020
New Jersey	East Brunswick, NJ	NJ, CT, 75% of NY	0.103
Boston	Milford, MA	MA, VT, NH, ME	0.042

Source: Purchasing power figures from the US Census web site.

Corners supply chains, the range would move up; for Push-Pull 5 Corners supply chains, the range would move down.

Supply Chain Strategies for Various Types of Importers

Supply-chain strategies for various types of importers are summarized as follows:

- **Large Original Equipment Manufacturers (OEMs) of expensive goods** (e.g., LCD screens, appliances, machinery) – these firms typically operate a single National Distribution Center (NDC) near a single port of entry. Retailing customers pay for domestic transportation from the NDC. All imports move to retailing RDCs and Fulfillment Centers in domestic vehicles.
- **Large Nationwide Retailers** (e.g., Wal-mart, Target, Home Depot, Lowe's, Amazon) – operate 20-40 regional distribution centers (RDCs) feeding retail outlets or fulfillment centers within each region. They utilize 3-5 ports of entry. They utilize a mix of IPI/direct dray and trans-loading to domestic vehicles. They don't import expensive goods, instead buying them domestically from OEMs.
- **Large OEMs of moderately expensive goods** (e.g., auto parts, tires, luggage, toys) – These firms operate 1-5 distribution centers (DCs) using 1-5 ports of entry. Retailing customers pay for domestic transportation from the DCs.
- **Small OEMs, small and regional retailers, contractors** – These entities operate a single DC or staging point receiving all imports. They utilize IPI or direct dray.

Nationwide, the fraction of Far East – Continental USA waterborne, containerized import volumes accounted for by each of these importer types is estimated by the author as follows:[9]

- Large OEMs of expensive goods **13.7%** (all de-van and re-ship)
- Large nation-wide retailers and large OEMs of moderate-value goods **31.9%** (3.5% IPI or direct dray, 28.4% trans-load or de-van and re-ship)
- All other **54.4%** (almost all IPI or direct dray)

About 85% of the large OEMs of expensive goods have located their NDC in Southern California's Inland Empire. As discussed above, the large nation-wide retailers serve a substantial portion of the Continental USA via the San Pedro Bay (SPB) ports "corner". Consequently, imports via the SPB ports experience a much higher fraction trans-loaded or de-vanned and re-shipped than do imports moving via other ports.[10] Aa a result, there is a tremendous amount of truck traffic in the Los Angeles Basin associated with imports. As will be discussed, on a typical working day there are about 5,000 truck trips hauling imports from the greater SPB ports area to distribution facilities

[9] These estimates are based on 2019 PIERS-TI and Journal of Commerce data.

[10] Hereafter, the "trans-load" category of imports will include all imports placed in inventory for some time and later re-shipped in domestic vehicles as well as imports experiencing so-called "live" trans-loading performed at cross-docks.

in the greater Inland Empire and a like number of empty returns, not counting trips from warehouses to domestic rail terminals nor trips from IW or NDC facilities to RDCs.

The most effective supply chain for a given importer depends on (1) whether the importer possesses the scale and geographical scope to effectively practice trans-loading from marine containers to domestic containers and trailers, and (2) the opportunities, if any, afforded by trans-loading for reducing inventory expenses and risks associated with the goods being imported. Small-scale and regional importers typically cannot benefit from trans-loading; only large-scale importers distributing goods nation-wide can. (More on this point below.) For goods imported in sufficiently high volumes and distributed nation-wide, the Push-Pull supply chains achieve lower inventory costs and higher average retail prices than Push supply chains, but in exchange for increased handling and transportation expenses.

The Push supply chain strategy is used to some extent by large nation-wide retailers for inexpensive goods (e.g., furniture and bedding) and for goods marketed in one-time sales events, such as patio furniture at Memorial Day or back-to-college refrigerators in late August. It also is used by contractors to supply one-time large projects, e.g., construction of new hotels or apartment complexes. In addition, the Push supply chain strategy must be practiced by all small and regional importers, as they do not possess the scale or scope to practice Push-Pull strategies.

In typical application, the large nation-wide retailers operating Push-Pull 3[4][5] Corner supply chains equip each Corner with a cross dock or trans-load facility (most commonly operated by a third-party logistics company also serving other importers, but sometimes owned and operated in-house) as well as an import warehouse (typically an in-house facility for the largest nation-wide retailers, but operated by a 3PL in the cases of some other smaller, nation-wide importers).

Sophisticated computer algorithms plan the disposition of containers arriving on each vessel. Databases are queried to ascertain inventory and sales levels in each region served by the port to deduce for each imported product which regions served by the port have near-term need for the product. Containers containing at least some products with near-term need in at least one region are routed to the cross-dock. If the entire contents of the container are not needed in any region in the near term, the container is routed to the import warehouse. If the entire contents of the container can be consumed in the region local to the port in the near term, the container can be routed to the local RDC. The algorithms also plan the dispatch to RDCs of domestic container or trailer loads from the import warehouse and from the cross-dock. Some loads exiting the cross-dock will be in domestic containers drayed to domestic rail intermodal terminals; some will be in trailers destined to RDCs served by trucking; and some will be in trailers destined to the import warehouse. The algorithms prepare lists for the cross-dock operating staff showing for each carton in an inbound marine container, into which outbound domestic vehicle it should be loaded.

For the nation-wide Big-Box retailing importers utilizing Push-Pull 3[4][5] Corners supply chains, the split of their imports routed to cross-docks vs. import warehouses varies by time of year. During years before the pandemic, the split favored the import warehouses in the spring and early summer

(because imports exceeded sales during that time frame), but shifted to favor the cross-docks in late summer and the fall (preparing for the Christmas peak when sales would consume the inventory accumulated in the import warehouse). A small portion of their import volumes would be drayed directly from the ports to their RDCs serving the Southern California region. A portion of the imports routed via the cross-dock is drayed from the cross-dock to the import warehouse before allocation and re-shipment to an RDC; again, this fraction diminishes towards the end of the year.

Increased Application of Push-Pull Supply Chains

During the period 2005-2015, the use of Push-Pull supply chains with the Push-Pull boundary located in the hinterlands of the ports of entry grew while the use of Push supply chains declined. Nation-wide, it is estimated that, in 2005, total Push imports to Continental USA from Asia were 64% and total Push-Pull imports were 36%, whereas in 2019 the split was 58% Push and 42% Push-Pull. That is, the share of Push-Pull climbed six points over 14 years.

There are several reasons for this change in supply-chain mix. First, large nation-wide importers have been learning to manage their supply chains better and re-engineering them accordingly. They are realizing the "Power of Postponement" afforded by waiting to commit regional destinations for imports until after arrival at port of entry, when a much better estimate of near-term regional demands is available. By routing goods to where they can be sold first, cash flow is accelerated and high selling prices are maintained.

Second, the product portfolios of certain importers include both "weight freight" imports and "cube freight" imports sourced from different factories in the Far East, perhaps located in different countries. For example, a home improvement retailer imports marine containers loaded with hardware (heavy) and other marine containers loaded with furniture or bedding (light). The marine boxes of these imports may be routed to the same cross-dock, where the contents can be blended into domestic container loads that weight-out approximately when the cubic capacity is reached, thereby significantly reducing inland transportation requirements. The low-value loads of furniture and bedding, which otherwise might have been shipped directly to inland RDCs in IPI service, are trans-loaded to domestic containers drayed from cross-docks to domestic rail terminals.

Third, the cost advantages of large, nation-wide retailers enable them to undercut small and regional retailers and drive them out of the market. From calculations made using the author's elasticity model, the large nation-wide importers practicing Push-Pull supply chain strategies enjoy a 18-20% cost advantage (in terms of total transportation and inventory costs for imports from Asia) over small and regional importers unable to effectively adopt such strategies. This explains the increasing dominance of retailing by the large nation-wide retailers and the steady decline of small and regional retailers. The 2008-2009 recession was particularly hard on many small and regional retailers. For example, in California, the Mervyn's and Gottschalk's chains closed down. Their market shares were taken by the likes of Wal-Mart, Target and Sears/K-Mart, and thus their import volumes moved from Push supply chains to Push-Pull supply chains.

Finally, at the start of the new millennia, the ocean carriers still enjoyed long-term (e.g., 10-year or 15-year) contracts from the railroads for IPI service to haul marine boxes inland at attractive rates. These legacy contracts started to expire in 2007; the last of them expired in the spring of 2011. They were replaced by contracts with shorter terms (e.g., one year) at much higher (typically 25-35%) rates. Thus rail rates on marine boxes have risen more than have rail rates on domestic boxes. This serves to help offset the extra handling costs associated with cross docking, thereby making Push-Pull more attractive and Push less attractive than otherwise.[11]

As a consequence of this as well as increased competition from other ports, the IPI share of SPB imports has plummeted, as depicted in Figure 9, dropping from about 44% in 2006 to 25% in 2021.

Why Large Nationwide Retailers Trans-load

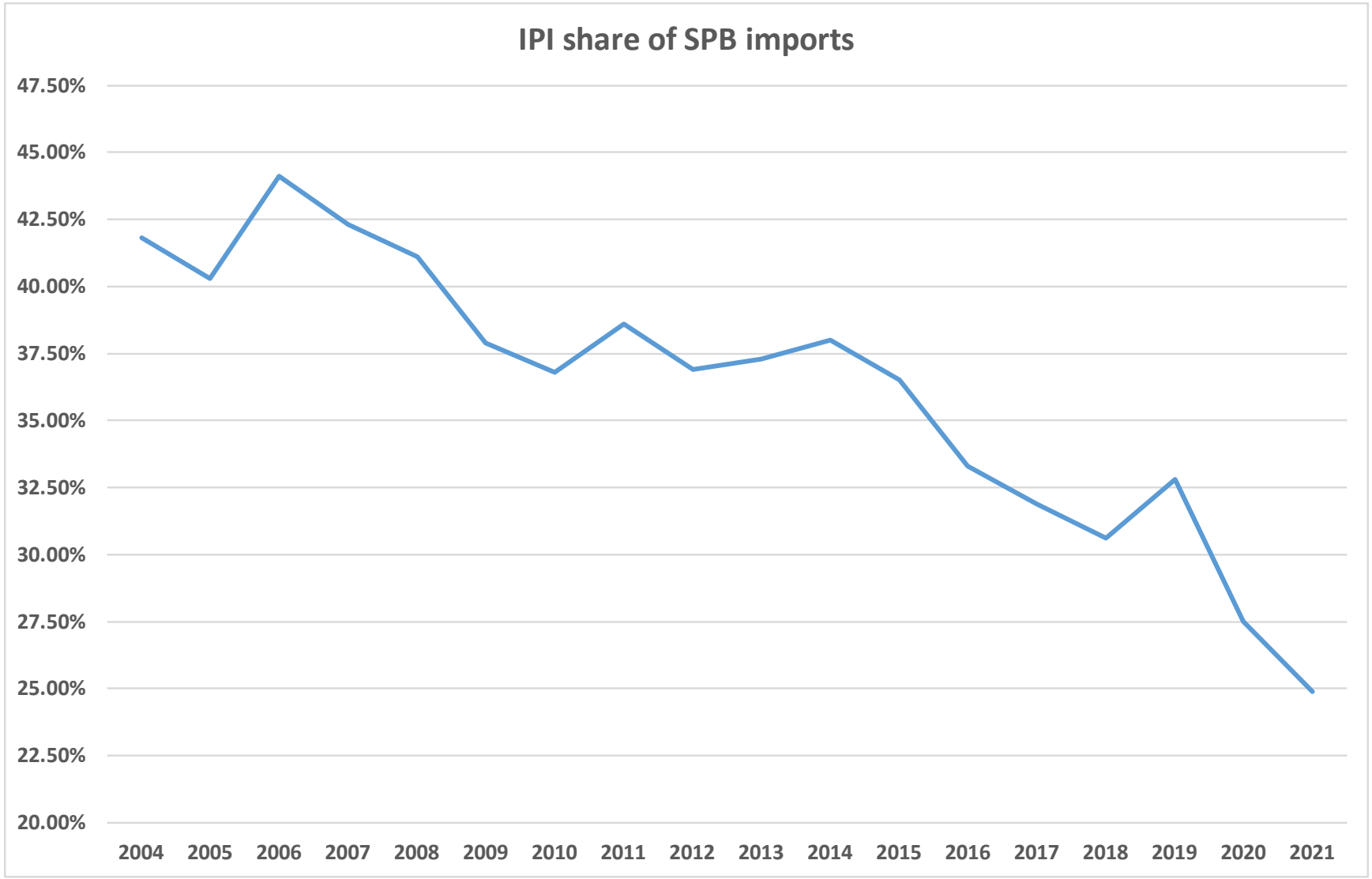
To re-iterate primary reasons for the shift of inland transportation of Far East – Continental USA imports from marine containers to domestic vehicles: This is a consequence of the concentration of retailing into large nation-wide firms, both brick-and-mortar, and e-commerce, and the efficiencies they pursue in supply-chain management. It has little to do with transportation economics (shipping intact in marine containers is generally cheaper than trans-loading, once costs for cross-docking and extra drays are included), and much more to do with inventory management.

Overall inventory for such firms consists of (1) cycle stock (the average stock level between replenishments), (2) safety stock (hedging against variability in when a replenishment shipment will arrive and fluctuations in sales before then), (3) seasonal stock (sales are concentrated at the end of the year, so there is considerable supply coming from the Far East way ahead of time), and (4) pipeline stock (goods purchased from factories in the Far East but still in-transit).

A Push supply chain, utilizing IPI and direct dray, is an impediment to managing all four components of inventory:

- Cycle stock: One import container comes from one factory, containing large quantities of only a few items or "stock-keeping units" (SKUs). Even the aggregate sales of an entire region could take a long time to consume the contents of one container, resulting in risks of markdowns, remaindering and obsolescence. It is better to allocate the contents across multiple regions.
- Safety stock: Suppose a firm imports one container per week from a Far East factory to each of *N* regions. Suppose one container misses the weekly vessel; perhaps the dray in the Far East broke down or got stuck in a traffic jam, or the paperwork was unacceptable. The RDC for that region needs enough safety stock to survive until shipment on the next vessel a week later. On the other hand, if all the other *N*-1 containers are routed to the

[11] The rise in IPI rates also prompted a shift in imports from IPI via West Coast ports to "all-water" service via the Panama Canal to East and Gulf Coast ports of entry.



Source: ACTA web site

Figure 9. Inland Point Intermodal Share of San Pedro Bay Imports, 2004 - 2021

same cross-dock, the firm can re-allocate the contents across the regions and send all regions (N-1)/N of what they need, dramatically reducing the required safety stock.

- Seasonal stock: If IPI and direct dray are used, the firm has to make an allocation and push seasonal stock into all regions way ahead of time. If instead imports a routed to an import warehouse (IW) in the hinterland of the port of entry, it can wait to see how demand develops in each region and later allocate the stock more proportionately to where it can be sold.
- Pipeline stock: IPI service is more infrequent and slower than domestic-box service, and so consumes more pipeline stock.

Shipping in domestic 53-foot containers or trailers partially offsets the costs of trans-loading. Together with inventory economies, it makes sense to trans-load most imports, provided the firm operates in multiple regions and has enough scale to make the 2-TEU into 3-TEU vehicle exchange yet fill up the 3-TEU vehicles.

That said, it does not make sense for large nationwide retailers to trans-load all imports. Things that don't get trans-loaded: high-volume low-value imports (for which inventory costs are not significant and risks are minor), "one-off" goods (e.g., patio furniture, Halloween costumes) sold only once per year and thus there are no inventory replenishments, and some goods involved in large promotions (again there are no inventory replenishments). So virtually every nationwide retailer makes at least modest use of IPI and direct dray services.

Import Supply Chain Geography of Southern California

Figure 10 displays a geographical overview of the import supply-chain geography of Southern California. Historically, San Pedro Bay was not a primary West Coast port; that role was filled by San Francisco Bay. Main-line railroads were located so as to terminate in downtown Los Angeles, not in the SPB ports. As containerization developed, the role of the SPB ports in international trade became elevated. Rail service to and from the ports utilized slow-speed branch lines passing through urban areas of the Los Angeles Basin to reach main line connections near downtown Los Angeles. In 1983 the author published a report commissioned by the Southern California Association of Governments proposing what became known as the Alameda Corridor (reference 1). A subsequent 1991 report by the author (reference 2) demonstrated its operational practicality leading to environmental approval. Nineteen years and 2.4 billion dollars after the 1983 report, the ribbon was cut on the Corridor, and a high-capacity, completely grade-separated rail main line connected the ports to Union Pacific and BNSF main lines near downtown.

In the communities surrounding the SPB ports there are a considerable number of warehouses built after World War II up through the 1960s. By and large, these warehouses were not built for international trade activity. Instead, they were built for inbound logistics for the defense and aerospace system-integrator companies assembling aircraft and other military or aerospace equipment in the vicinity of Torrance, El Segundo and the Los Angeles airport. Many small machine shops located throughout the Basin fabricated components for military-aerospace

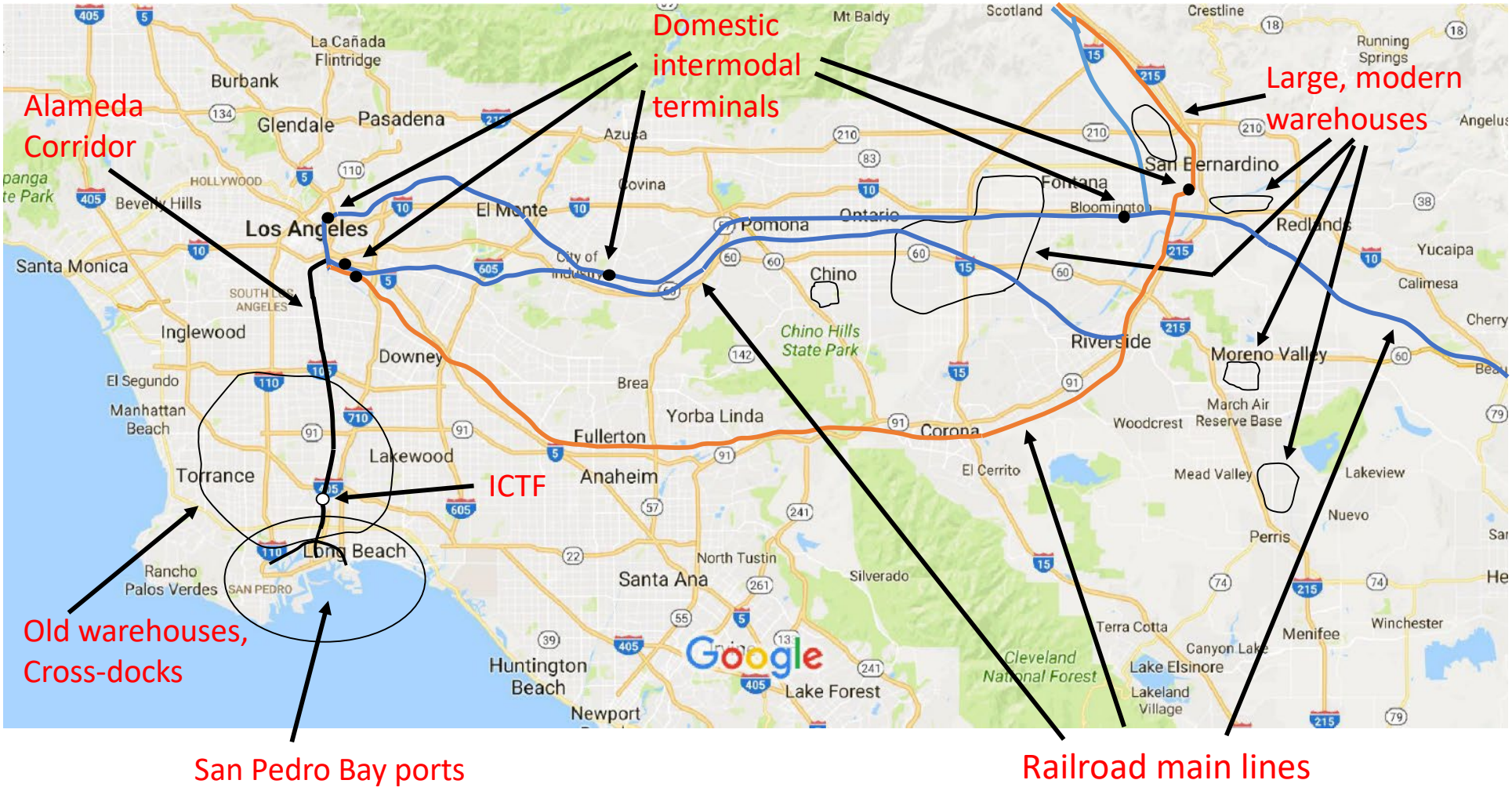


Figure 10. Import Supply-Chain Geography of Southern California

equipment, acting as subcontractors to the large system-integrator companies. As Federal Government expenditures on space exploration and defense wound down, this industry slowed.

System-integrator assembly plants have been closed, and many of their inbound-logistics warehouses became surplus. Typically 50,000 – 100,000 square feet in size, these facilities are too small to function as RDCs, NDCs or IWs for large importers; generally, only smaller OEMs or regional retailers can use them as distribution centers. Most have instead been converted into cross-docks operated by 3PLs, de-vanning marine containers and sorting and re-stuffing imported goods into domestic trailers and containers per the instructions of the importers.

Large nation-wide retailers and OEMs need warehouses on the order if 500,000 – 2,000,000 square feet to function as RDCs, NDCs or IWs. By the time containerized volume at San Pedro Bay was growing strongly in the 1980s, the nearest place such facilities could be developed by commercial real estate companies was in the Inland Empire. As shown in the figure, large, modern warehouses were constructed just east and south of Ontario. A few comparable facilities were constructed near Chino. More recently, large, modern warehouses have been developed north and east of San Bernardino, in Moreno Valley, and near Perris. Vacancy rates in these locales are low, and there is very little opportunity to develop additional facilities. Dray distances from marine terminals at the SPB ports to these warehouses are 60-80 miles. Queues to enter SPB marine terminals are very long. It can take a long time to collect a load in the terminal. It can be a very long trip out to the Inland Empire on congested freeways. Dray prices of late approach $1,000.

In the early 1980s, hardly any marine terminals had the capability to load stack trains. A near-dock terminal, known as the Intermodal Container Transfer Facility (ICTF), was proposed. Santa Fe and Union Pacific railroads declined to serve it, but Southern Pacific agreed to do so. As a requirement of the bonds for ICTF, at least 80% of the lift volume handled at the facility was required to be marine containers. Nowadays, the lion's share of SPB marine terminals have on-dock rail loading capability. The ICTF bonds have been retired, and the percentage of ICTF lifts accounted for by domestic containers loaded at nearby cross-docks and shipped via Union Pacific, which absorbed SP in 1996, has been rising.

Other domestic-box rail intermodal terminals are located near downtown Los Angeles: Hobart/Commerce on BNSF, and Los Angeles Transportation Center (LATC), East Los Angeles and City of Industry on UP. Additional domestic-box rail intermodal terminals are located in the Inland Empire: San Bernardino on BNSF, and the Inland Empire Intermodal Terminal (IEIT) on Union Pacific. Generally speaking, the downtown terminals handle express and parcel shipments (UPS and Federal Express) and loads generated at cross-docks located in the corridor from downtown to the SPB ports, while Inland Empire terminals handle loads generated at NDCs, IWs and cross-docks in the Inland Empire, as well as parcel and express shipments from that region.

What Happened During the Pandemic

The 2020 COVID pandemic seriously disrupted supply chains for Far East – USA waterborne, containerized imports. First, consider what happened to retail sales (excluding the automotive sector), as depicted in Figure 11. The pandemic struck in March 2020. Retail sales in April collapsed. Many large retailers cancelled their annual contracts with ocean carriers for steady shipping of imports from the Far East, fearing a glut of imports they would not be able to sell. But unable to spend money on dining, entertainment and travel, American consumers focused on home remodeling projects and increased their acquisitions of electronics and other durable consumer goods. By July, retail sales had shot up to unprecedented levels and continued to sustain an extraordinary growth rate through March, 2021, leaving retailers scrambling to catch up. Not shown in the figure, there also was a substantial shift in retailing from sales in physical stores to on-line sales. From March, 2021 to July, 2022 retail sales were fairly stationary, still at a high level. During the period July 2019 – July 2022, retail sales grew by 17.5%, a rate clearly unsustainable over the long run.

Next, consider what happened to import volumes, as depicted in Figure 12. Total import volume in 2020 started out similar to but slightly lower than that in 2019. With the reactions of retailers in April to the collapse in their sales, imports plummeted in May. By July, import volumes had fully recovered, and from August, 2020, through July, 2022, they were 15-40% above historical levels.

Meanwhile, supply chain capabilities cratered as workers took ill. The nature of marine terminals exacerbates any shortage of workforce vs. import volume. Import containers are piled on the terminal lot awaiting dray movement off the terminal. At most North American marine terminals, drays of the containers out of the terminal are controlled by the importers, not by the terminal operators. Terminal managers have little or no ability to stage containers in their order of departure, because the order of departure is unknown. When the pile is not too deep, there are not many containers in the way when a drayman shows up to retrieve a particular box. But as the pile gets deeper and deeper, more and more lifts are required to move boxes out of the way to retrieve the desired box. The workload is not proportional to volume; it is *super-linear in volume.* With a reduced staff and a surge in volume, marine terminals filled with containers. Empties coming back to the terminal were diverted to vacant lots, still on chasses. Chasses became scarce, containers became scarce. Ports filled up with container vessels at anchor. Some container vessels were diverted to other ports.

Further down the supply chain, with traffic dropping, the railroads furloughed many workers. Draymen making hauls from inland rail terminals to destination warehouses became scarce as they became ill or stayed home to avoid getting ill. Worse, warehouse workers became ill or were dismissed. With warehouses unable to unload containers, drays could not be dispatched, even if a driver could be found. So inland rail terminals filled up. Trains were parked out on the line.

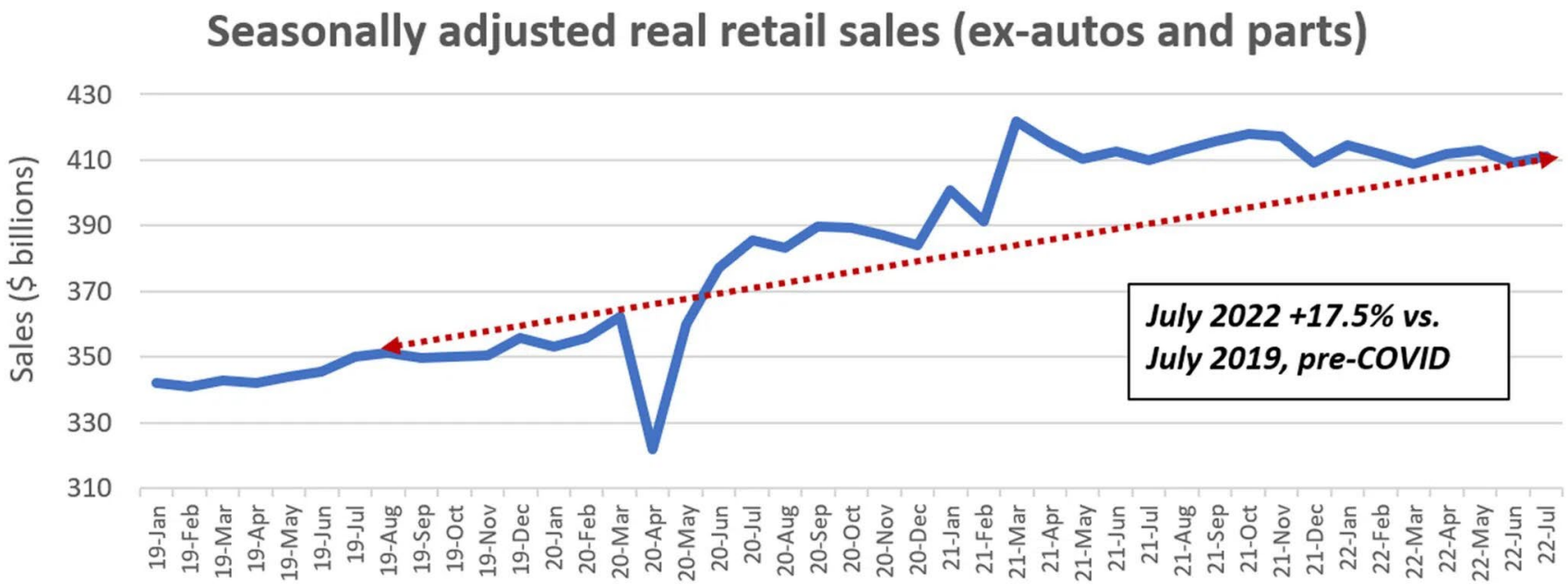


Figure 11. Monthly USA Retail Sales, 2019 - 2022

Sales figures shown are inflation-adjusted to 2019 dollars.

Source: *American Shipper*

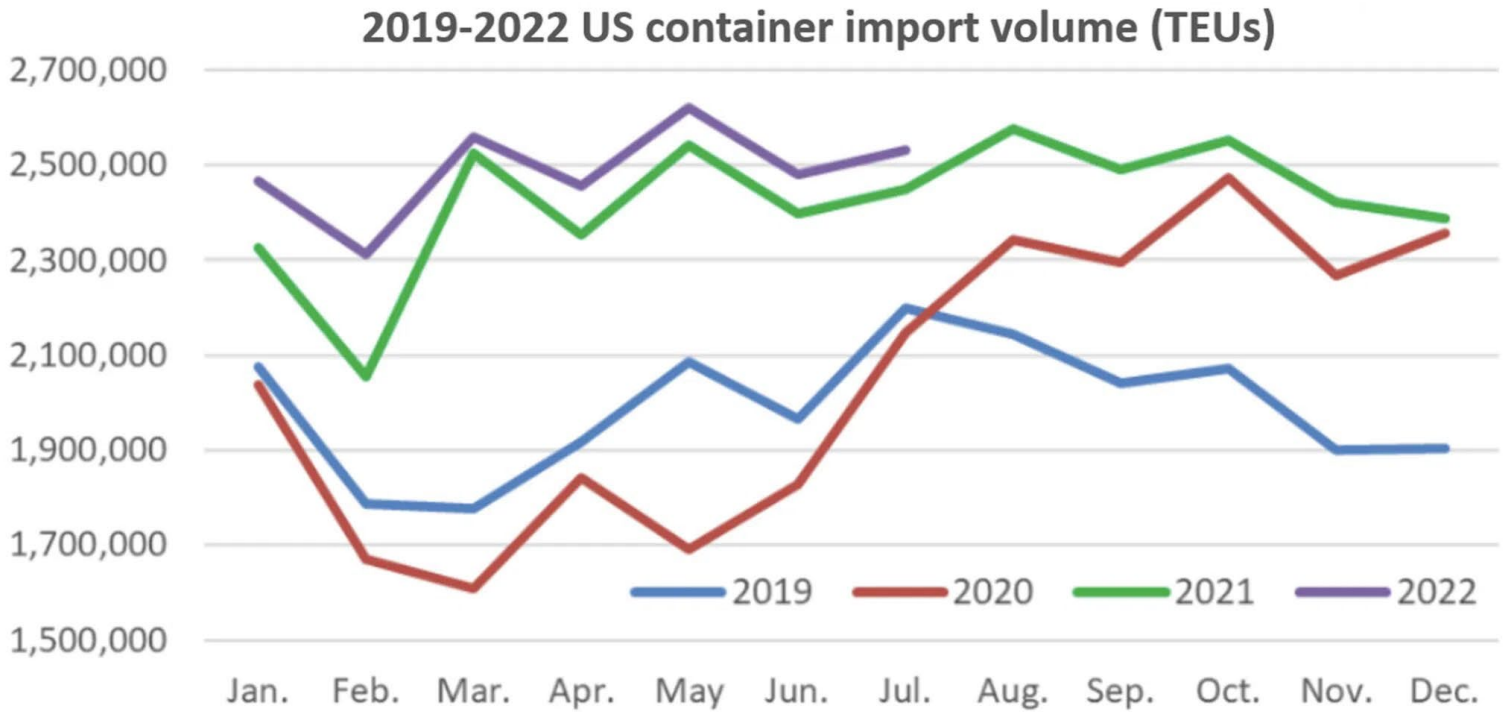


Figure 12. Monthly Waterborne Containerized Imports to the USA, 2019 - 2022

Source: Descartes Datamyne

The Federal government instituted a COVID relief package, providing unemployment benefits equivalent to about a $20 per hour job. For the non-union draymen, rail terminal workers and warehouse workers whose jobs paid on the order of $25 per hour, returning to work provided an increment of about $5 per hour but at the risk of contracting COVID. Many chose not to take the risk, prolonging the back-up. The railroads also have been unable (or perhaps unwilling) to recover their pre-COVID staffing levels.

Conceptually, rail movement of marine containers should have been less impacted by the pandemic than was dray movement, because IPI containers coming off vessels are staged by destination blocks adjacent to loading tracks at the marine terminal. Order within a block does not matter. The IPI containers can be promptly loaded into railroad well cars by a one-man top-picker (in contrast to the three-man rubber-tired gantry cranes used in the dray area of the terminal), as long as empty cars are spotted at the terminal. In sharp contrast to the dray area of the marine terminal, workload at the IPI area is linear in import volume. However, longshoremen assigned to man top-pickers also became scarce when the pandemic took hold. Worse, the railroads adjusted their train operations to reflect "precision scheduled railroading" (which is actually a policy of running longer and less frequent trains in order to reduce train labor costs), thereby straining marine terminals. More recently, the railroads have instituted much stricter attendance policies, and workers have responded by refusing to come back to work from furlough or by resigning. As recently as July, 2022, as many as 20 loaded marine container trains were holding at one time at the San Pedro Bay ports for lack of train crews.

By November, 2022, the queues of vessels awaiting unloading and piles of containers awaiting dispatch were much reduced from pandemic peaks, about the same as pre-pandemic levels at West Coast ports. From the Summer of 2020 until the Summer of 2022 retailers were desperate to get imports in any way they could, be it diverting imports to other ports, utilizing long-distance trucking, or whatever. Annual contract rates for movement across the Pacific at $2,500 or so per container were replaced by spot prices upwards of $12,000 per container, reportedly reaching as much as $20,000 during peak-demand periods. Labor rates and benefits for warehouse workers and draymen are on the rise. In late 2022 rail unions threatened a strike and will be getting higher wages and benefits (and perhaps improved working schedules). Serious inflation, so long dormant in the USA, returned.

At present, most large retailers have excessive inventories of many goods. Amazon has curtailed aggressive expansion plans for its network of fulfillment centers.

There are already indications that the share of consumer spending allocated to dining, entertainment and travel is returning to normal levels. Assuming the pandemic continues to fade and assuming staffing shortages are recovered, the ports, railroads and warehouses should soon catch up on their backlogs.

Because it has taken until the Fall of 2022 for shipping volumes and transportation prices for Far East – USA imports to return to more normal levels, data from the years 2020 through 2022 is

deemed inappropriate as an analytical basis this study. The input data discussed below reflects 2019 overall Far East – Continental USA import volume, 2019 import mix by commodity, declared value and importer, 2018 transportation and handling rate quotations, 2018 purchasing power statistics, and 2015 container flow-time statistics.

Analytical Development of the Import Market Potential

The values of key parameters for estimating the import market for short-haul intermodal are as follows:

- 2019 import volume at the SPB ports: **8.47 million** TEUs (from SPB port web sites)
- 2019 fraction of Far East to Continental USA import volume passing through the SPB ports: **45.7%** (from PIERS-TI)
- 2019 fraction of SPB import volume departing the ports under IPI service: **32.8%** (from ACTA)
- Extent of the local region served by Southern California RDCs: 60.1% of California purchasing power (extending north to about San Luis Obispo and Delano), 67% of Nevada purchasing power, and all of the purchasing power in Arizona and New Mexico. This corresponds to **10.8%** of the total purchasing power in the Continental USA. Retail sale volume of imports (in TEUs) in each region is assumed proportional to the purchasing power in the region. 2018 statistics on purchasing power by state from the U.S. Dept. of Commerce are used for this purpose.
- 2019 fraction of nation-wide imports performed by OEMs operating from a single port of entry: **13.7%** (from Journal of Commerce and PIERS-TI)
- Fraction of imports by OEMs operating from a single port of entry that are passed through the SPB ports: **85%** (author's estimate)
- Fraction of NDCs for OEMs operating in Southern California that are located in the Inland Empire: **85%** (author's estimate; most of the remaining 15% are located closer to the SPB ports)
- Fraction of Far East to Continental USA imports that are made by large, nation-wide retailers or OEMs: **31.9%** (PIERS-TI and Journal of Commerce)
- Fraction of imports made by large, nation-wide retailers or OEMs that pass through Push-Pull supply chains: **89%**, i.e., (0.89)*(0.319) = **28.4%** of the Far East to Continental USA imports pass through Push-Pull supply chains (author's estimate)
- Distribution of push-pull imports at San Pedro Bay by de-vanning facility: **2%** local RDC, **35%** IW, **63%** cross-dock (author's estimates; this distribution varies over the course of the year, and the figures are estimated annual averages)
- Fraction of Southern California IWs operated by large, nation-wide retailers and OEMs that are located in the Inland Empire: **100%**
- Fraction of Southern California RDCs operated by large, nation-wide retailers and OEMs that are located in the Inland Empire: **100%**
- Fraction of SPB Push supply chain imports that are de-vanned in the Inland Empire: **30%**

From these assumed parameters, the following parameters are derived:

- Fraction of SPB imports that become retail sales in the region served by Southern California RDCs: (0.108)*(1 -0.15*0.2)/(0.457) = **22.9%**, i.e., **77.1%** of imports via San Pedro Bay are ultimately shipped to other regions
- Fraction of SPB imports re-shipped to other regions in domestic vehicles: 0.771 – 0.328 = **44.3%**
- Fraction of Far East to Continental USA imports passing through Push supply chains: 1 – 0.137 - 0.284 = **57.9%**
- Fraction of SPB imports moving through Push supply chains: **46.5%** (see Appendix 3 for derivation)
- Fraction of SPB imports moving through Push-Pull supply chains operated by large, nationwide retailers or large, multi-corner OEMs: **28.0%** (see Appendix 3 for derivation)
- Fraction of SPB imports moving through Push-Pull supply chains operated by one-corner OEMs: **25.5%** (see Appendix 3 for derivation

The primary market for short-haul intermodal service consists of imports de-vanned at distribution centers located in the Inland Empire. Components of the primary market developed above are as follows:

- Push supply-chain imports consumed in the local region account for 13.7% of SPB imports. As noted above, the author estimates 30% pass through RDCs located in the Inland Empire, i.e., **4.1%** of SPB imports, and 70% pass through RDCs located elsewhere in the region.
- OEM NDCs are located in the Inland Empire (85%) or in cities close to the SPB ports (15%). OEMs account for 25.5% of SPB imports, so **21.7%** pass through OEM NDCs located in the Inland Empire, and the other 3.8% through OEM NDCs located closer to the SPB ports.
- Large, nation-wide retailers account for 28.0% of SPB imports. They operate RDCs, IWs and e-commerce Fulfillment Centers in the Inland Empire. Cross-docks located close to the ports are operated on their behalf by 3PLs. As above, the estimated annual split of their SPB imports: 2% direct to RDC or Fulfillment Center, 63% to cross-docks, 35% to IW. That is, (28.0)(0.02 + 0.35) = **10.4%** of SPB imports are de-vanned by them in the Inland Empire.

A secondary market for short-haul intermodal service embraces trailers moving from cross-docks located in the general vicinity of the ICTF to warehouses in the Inland Empire. Potentially, these moves could be ramped at the ICTF and moved by train to one or more terminals in the Inland Empire. The author estimates the split of outbound domestic trailer and container shipments from such cross-docks as 19.4% to local RDC, 19.0% to IW, 9.7% truck to Northern California RDCs, and 51.9% to downtown rail ramps or the ICTF. That is, (28.0)(0.63)(0.194 + 0.19) = **6.8%** of SPB imports are de-vanned in the Inland Empire from trailers dispatched from these cross-docks.

A recapitulation of these import flows is as follows.

Primary market: Push imports (small retailers and OEMs) to RDCs in Inland Empire: **4.1%**

OEM NDCs in Inland Empire: **21.7%**

Large retailer & OEM IWs, RDCs and Fulfillment Centers in Inland Empire: **10.4%**

Subtotal: **36.2%** of 8.47 million TEUs per year, or **3.07 million** TEUs per year

Secondary market: Trailers from cross-docks in the general vicinity of the ICTF to IWs, RDCs and Fulfillment Centers in the Inland Empire: Add **6.8%** or **0.58 million** TEUs per year, generating **0.19 million** 53-foot trailer shipments per year

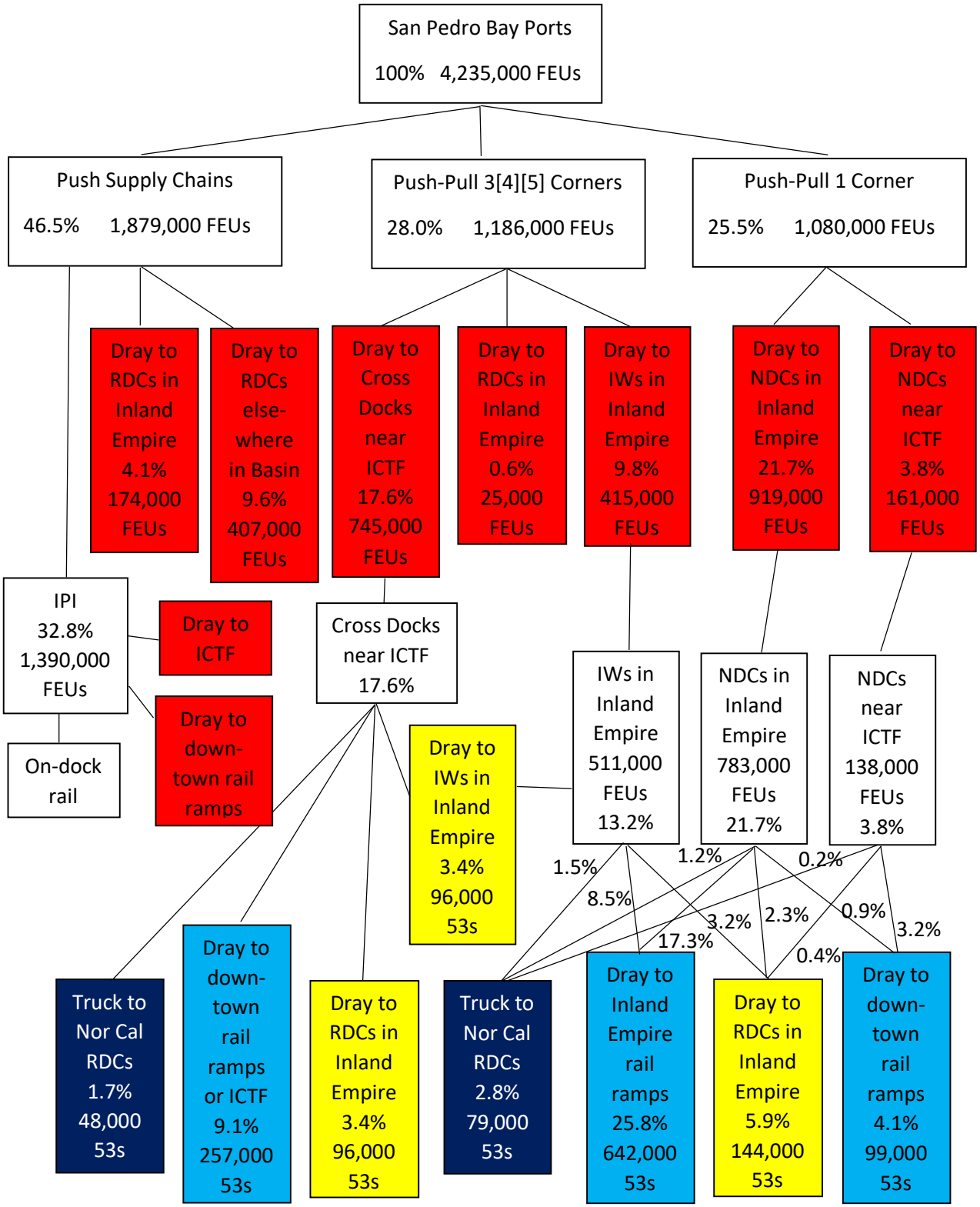
In terms of dray trips per working day, assuming 300 operating days per year and assuming all imports are in 40s, the 2019 import volume amounts to 5,120 dray trips of 40-foot containers from marine terminals to Inland Empire DCs and 640 dray trips of 53-foot trailers from cross-docks near the SPB ports to Inland Empire DCs per operating day.

Figure 13 provides a graphic presentation of the landside freight flows within the Los Angeles Basin stemming from 2019 imports via the SPB ports. Red boxes correspond to drays of marine containers; yellow boxes to drays of 53-foot trailers within the Basin; dark blue boxes to long-haul trucking of 53-foot trailers destined to Northern California RDCs; and light blue boxes to drays of 53-foot containers and trailers to rail intermodal ramps within the Basin. (Because of rounding, the figures shown add to 99.9% of total SPB ports imports.) This diagram by no means presents all freight flows of imports; for example, shipments from RDCs to retail outlets are not included, nor are flows to and from cross-docks in the Inland Empire consolidating purchases by retailers of imported goods from multiple OEMs and de-consolidating into separate shipments to various RDCs. However, all of the flows germane to the analysis of short-intermodal service are shown.

In the author's opinion, the presence of a competitive short-haul intermodal service is likely to induce a migration out to the Inland Empire of the cross-docks currently located in the general corridor of communities between the SPB ports and downtown Los Angeles, mostly near the ICTF. If all were to re-locate, the entire cross-dock volume becomes available for the short-haul intermodal service, i.e., an additional (0.28)(0.63) = **17.6%** of SPB imports, or **1.49 million** TEUs per year, making for a total import market potential of **4.56 million** TEUs per year.

Suppose the short-haul intermodal trains haul an average of 500 TEUs of imports per trip. The 2019 primary market volume (3.07 million TEUs) translates into 20.5 trains per operating day. If all cross-docks were induced to move to the Inland Empire, the potential market volume climbs to 34.2 trains per operating day.

Figure 13. 2019 Import Flows from the San Pedro Bay Ports



Import Market Share

To capture a substantial share of this market, the short-haul intermodal service, including destination dray, must be priced competitively with direct dray. It must operate reliably and frequently. Its inland terminal(s) must be located close enough to warehouse destinations so that the cost and lead time for destination dray do not negate the savings of rail movement. In the author's judgment, that requires the inland terminal(s) to be located in the heart of the Inland Empire.

Costs and queue times at marine terminals are also important factors. The handling of IPI boxes is more streamlined than the handling of dray boxes at marine terminals, explained as follows. Containers off-loaded from a vessel onto a "bomb-cart" making a within-terminal drays proceed from dockside either to the dray yard area or to the on-dock rail area. Containers proceeding to the on-dock rail area are identified to the longshore crew by rail destination code ("block code"), and the bomb-cart dray proceeds to a zone in the on-dock rail area corresponding to the block code. There, a one-man top-picker grounds the box. Later, the one-man top-picker will load the box into a railroad well car. Except for the requirements that 20-foot containers must reside on the bottom level of a well car, and heavy weight-freight containers must be loaded into suitable well cars, there is no need to shuffle boxes in the on-dock rail area; all boxes to the same destination can be loaded into rail well cars indiscriminately.

Containers with no block code are hauled to the dray yard area, where a three-man rubber-tired gantry crane crew places the box in the stacks of containers awaiting outbound dray. Later, when the drayman arrives to pick up the box, the three-man RTG crew will have to shuffle boxes in the stack to retrieve the desired container and place it on the outbound chassis. As the terminal volume rises, so do the stacks, and the number of lifts required to move boxes out of the way to retrieve the desired box grows super-linearly with volume. Before the pandemic, the average number of lifts to retrieve a desired box at SPB terminals was about 2.0. During peak-season periods, it rose to 2.5 or higher. During the worst periods of the pandemic, it exceeded 3.0.

In the author's opinion, it will be essential to the success of short-haul intermodal that boxes destined for this service be identified to longshore crews as such and handled in the on-dock rail areas of marine terminals just like another IPI block. If routed to the dray yard and back, the service cannot be competitive. This means that importers must identify to ocean carriers well before vessel arrival their import boxes they wish to utilize the short-haul intermodal service, and the ocean carriers must convey this information to the longshore crews in the form of a block code. If more than one railroad is participating in the short-haul service and/or if there is more than one inland terminal for the service using the same marine terminal, there will need to be different block codes to distinguish them.

A competitive short-haul intermodal service would gather loaded well cars from every marine terminal with on-dock rail facilities on every operating day, perhaps more than once per day when the volume justifies it. Importers would be advised when their box is released by the

marine terminal as well as when the box departs the on-dock terminal. Again, this requires cooperation from the ocean carriers to establish a communication channel with the importer.

Given efficient marine-terminal handling and frequent, reliable service able to match dray lead time, and given pricing less than or equal to dray, then in principle, the short-haul intermodal service would be in a position to capture the entire import market described above, assuming it has the capacity in crews, terminals, equipment, and motive power to do so, and assuming there are sufficient dray and chassis providers in the Inland Empire working in concert with it. However, for a variety of reasons, it may be unrealistic to expect the short-haul intermodal service to capture the entire potential Inland Empire import market. (For example, suppose some importer fails to advise the ocean carrier in time for the carrier to convey the information to the marine terminal that the importer wishes to use the service for certain boxes on an arriving vessel.)

On the flip side, if the short-haul intermodal service is priced at enough of a discount to direct dray, it could make San Pedro Bay a more attractive corner for importers practicing multi-corner Push-Pull supply chains and induce them to re-allocate their import flows to favor San Pedro Bay. To analyze this prospect, the author applied his so-called Elasticity Model to forecast San Pedro Bay import volumes as a function of short-haul intermodal pricing.

Since 2003 the author has researched Far East – USA waterborne, containerized supply chains, acting as a consultant to governments, ports, ocean carriers, marine terminal operators, 3PLs, railroads, and large importers. An outgrowth of that effort is the author's Elasticity Model. This model predicts changes in port shares and North American landside transportation channel shares of Far East – USA waterborne, containerized imports as a function of transportation and cross-docking charges, government fees, declared values, assumed inventory holding cost rates, and import volumes. The model considers import flows from the points of view of individual importers striving to optimize their supply chains. The model includes all major Continental USA ports of entry handling container vessels plus the British Columbia ports. Details about the analytical methodology are provided in references 4, 5, 6, 7 and 8.

The inputs to the Model are summarized as follows:

- 2019 US Customs data (PIERS-TI): Total volumes and declared values for imports of 99 commodities from the Far East to Continental USA, specific import volumes and commodities for top 90 importers (judged to be capable of practicing both push-pull and push supply chains), volumes for 17 "generic" importers representing small and regional retailers (required to use push supply chains), stratified by declared values so as to match the overall distribution appearing in the Customs data
- Inventory holding cost rates
- Harbor Maintenance Fee at USA ports of entry
- IPI, domestic intermodal, long-distance trucking, and local dray rates
- Trans-loading fees at cross-docks near the various ports of entry

- Mean and standard deviation of transit times in the various landside and across-water channels included in the Model

Given prices and transit times for transportation and cross-docking services (these are confidential data secured by the author from various importers), given inventory holding cost assumptions, the model optimizes supply chains individually for the 107 importers and then tallies volumes by port and landside channels.

The Model was exercised with varying prices for the short-haul intermodal service (including destination dray), assuming the mean and standard deviation of the transit time matched that of direct dray. Results are depicted in Figure 14. As may be seen, for short-haul intermodal pricing offering a discount compared to direct day of $100 or more compared to direct dray, the service induces large importers to shift their import volumes to favor San Pedro Bay. At a discount of $100 per FEU, about 300,000 TEUs of imports per year shifts to San Pedro Bay; at a discount of $250 per FEU, about 800,000 TEUs shits to San Pedro Bay; and at a discount of $500 per FEU, about 1.3 million TEUs shifts to San Pedro Bay. All of this gain is in imports ultimately sold in other regions and handled in Push-Pull supply chains; the Model does not predict any diminution of IPI volumes via San Pedro Bay nor any increase in imports locally retailed.

At first it may seem surprising that decreasing the cost of Push-Pull supply chains does not diminish IPI volume via San Pedro Bay. This is because, within the Model, all importers that could convert from Push to Push-Pull have done so in the base case, when short-haul intermodal cost is the same as direct dray cost. If in reality there is a diminution of Push supply chain volume because of the reduction in Push-Pull supply chain costs, it would come about indirectly, as a result of small and regional retailers being put out of business by larger nation-wide retailers able to practice Push-Pull supply chains. Market shares by importer are fixed in the Model, so this is beyond its scope.

Barstow International Gateway

BNSF has announced plans to develop a "Barstow International Gateway" (BIG). The development would include the following features:

For the IPI business:

- Block-swapping yard enabling mixed-destination trains from marine terminals to be re-classified into pure-destination trains
- Container transfer equipment so that well cars so that well cars loaded with containers to multiple destinations can be re-loaded with containers to a single destination

For the trans-load business:

- Intermodal ramp handling marine boxes and domestic containers or trailers
- Cross-dock and warehousing facilities to de-van marine containers, sort and inventory goods, and re-load domestic containers or trailers

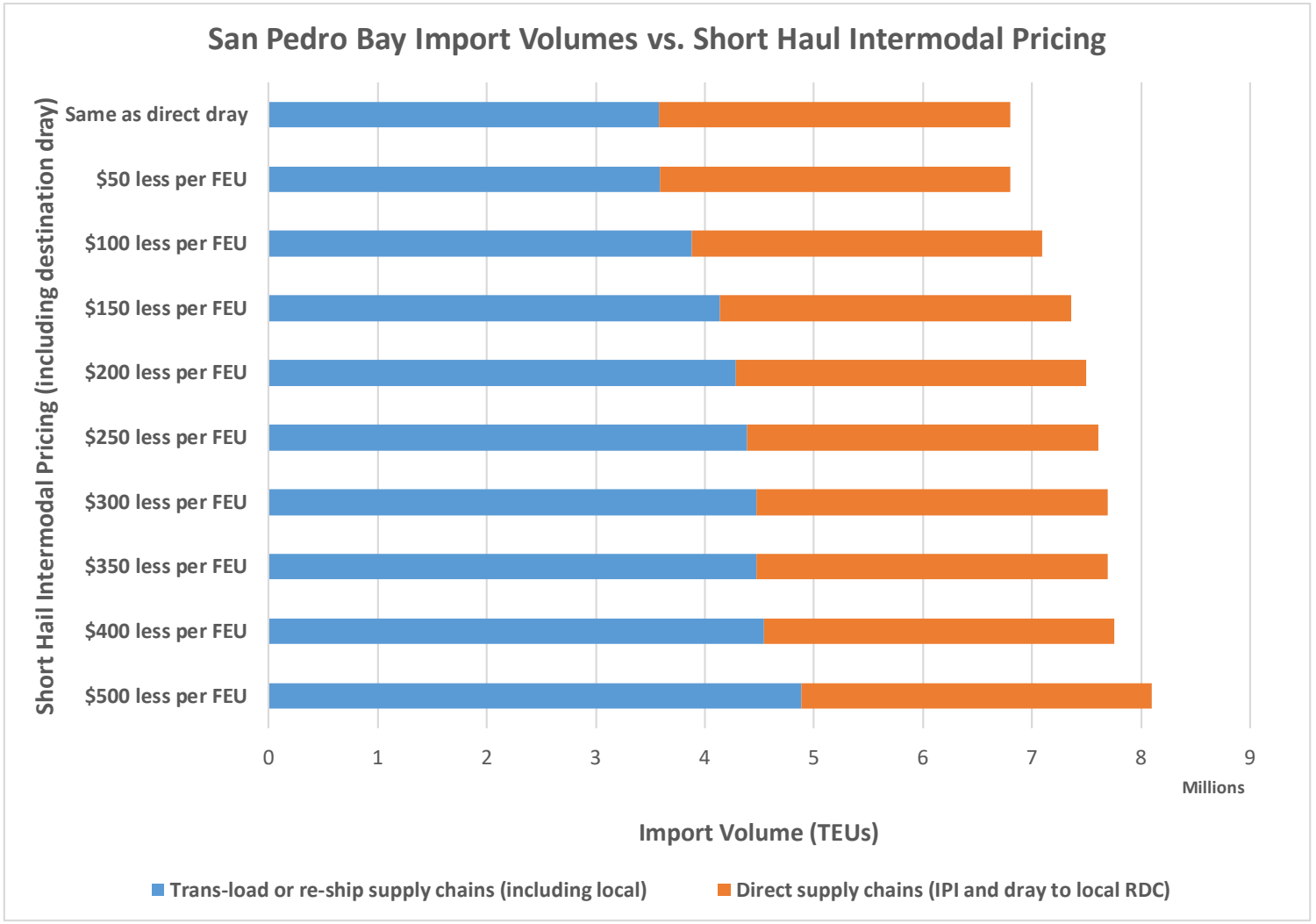


Figure 14. Estimated San Pedro Bay Import Volumes vs. Short Haul Intermodal Pricing

For the IPI business, BIG could offer some significant benefits:

- If BNSF runs frequent departures of mixed-block trains from SPB marine terminals to BIG, then builds trains by destination at BIG, the avg. transit time and the variability in transit time for IPI imports via BNSF could be reduced.
- This could make BNSF and its ocean carrier partners more attractive to IPI importers and hence make IPI via the SPB ports more attractive.
- Whether or not BIG would impact the IPI volume at San Pedro Bay depends on the actually realized changes in transit times as well as the relative changes, if any, in IPI pricing compared to IPI pricing via other ports of entry.

The impact of BIG on the trans-load business is more of interest for the subject study. BIG is not intended to handle imports ultimately consumed in Southern California. BNSF has asserted that it does not want to generate truck traffic hauling SPB imports from BIG back to DCs in the Inland Empire. For the purposes of this study, the condition that BIG will not be a channel to Southern California RDCs is assumed. For one-corner OEMs, this means BIG is not a feasible alternative for them, unless they relocate their NDC to the greater Barstow area. However, in that case, their retailing customers would have to backhaul imports to their Southern California RDCs located in the Inland Empire, which would violate the assumption. For the purposes of this analysis, it is assumed that one-corner OEMs will not be customers of BIG, at least not in the short run.

At present, at least a portion of nearly every marine box that is de-vanned in the Basin is allocated to a Southern California RDC or Fulfillment Center. To use BIG without backhaul to the Los Angeles Basin, large, nation-wide retailers and multiple-corner OEMs would have to segregate Southern California volume from inland volume before booking vessel passage. This of course would entail increased reliance on long-range sales forecasts, some loss of supply-chain flexibility, and hence engender some unfavorable inventory consequences for them. However, assuming BIG enables enough savings in transit time and in transportation and handling costs compared to trans-loading within the Basin, those savings could offset their increased inventory costs and BIG could be a value proposition for them.

Under the stipulation that there will be no backhaul of imports from BIG to the LA Basin, and assuming large, nation-wide retailers and multi-corner OEMs fully segregate their Southern California import volumes from inland import volumes before booking vessel passage from the Far East, trans-loading activity at BIG can capture at most 20.8% of the import volume at the San Pedro Bay ports. (See Figure 13.) To capture more would involve trucking imports from BIG back to RDCs in the LA Basin or relocation of those RDCs to the High Desert.

The important take-away about BIG with respect for this study: Even under optimistic assumptions about import market share captured by BIG, a very large market would remain for

short-haul intermodal movement of imports from the SPB ports to the Inland Empire, at least 2.87 million TEUs per year (enough to fill more than 19 trains per operating day).

Export market

In sharp contrast to imports almost totally comprised of retail goods, waterborne, containerized exports originating in Southern California are predominantly agricultural products. And in contrast to the concentration of destinations for imports at warehouse parks in the greater Inland Empire, origins for exports are diverse and mostly outside the Los Angeles Basin, notably, the southern portion of the Central Valley to the north of the Basin, and the Coachella, Imperial and Colorado River valleys to the east of the Basin.

Because securing a supply of marine containers at such outlying points can be difficult, time-consuming and expensive, California agricultural exporters seek the establishment of "inland ports." Providing a supply of marine containers closer to the export origins could reduce costs of California exports and perhaps make them more competitive in overseas markets, albeit it is not clear how much, if at all, export volumes would be enhanced.

The Federal Government's Freight Analysis Framework 5 (FAF5) database was researched by the consultant to obtain figures on exports via the San Pedro Bay ports. FAF5 data on calendar 2019 exports secured by the consultant show two-digit standard transportation commodity group (STCG) codes, tons exported, origin state, domestic transportation mode (barge, rail, truck or mixed modes), export transportation mode (rail, air, or water), and region of port. In the consultant's experience in other studies, the FAF5 data was found to have varying accuracy. In particular, origin data for domestic movements via rail unit train or barge were found to be extremely inaccurate. Accuracy of other FAF5 data seems better but nonetheless may have some inaccuracies.

Table 4 displays data on 2019 San Pedro Bay waterborne exports for selected STCG codes. Volumes originating in Arizona, New Mexico and Nevada have been included, albeit the contributions from those origin states are minuscule. Also appearing in the table are consultant's estimates of average weights per FEU and corresponding FEU export quantities for FAF5 export tonnages using truck or rail domestic transportation. As shown in the table, the entire potential agricultural export market is in the range 500,000 – 600,000 TEUs per year. This volume is dwarfed by the 4.6 million TEU import volume de-vanned in Southern California.

It should also be noted that a portion of the export volume (STCG 05 and a portion of STCG 03) requires refrigeration not required by the lion's share or imports de-vanned in Southern California. In sharp contrast to dry freight cargo, the head-haul for refrigerated containerized

Table 4. 2019 Waterborne, Containerized Exports via San Pedro Bay of Regional Agricultural Products

FAF5 Data on 2019 Waterborne Exports from San Pedro Bay Originating in CA, AZ, NM, NV							
		Inbound transportation (1000s of tons)			Est. tons	Truck	Total
STCG Code	Commodity Group	Truck	Rail	Multiple modes	per FEU	FEUs	FEUs
02	Cereal grains (wheat, corn, rice, oats)	13.1	1.1	1.9	20	655	805
03	Fruits, vegetables, nuts	2,479.8	11.4	367.7	14	177,129	204,207
04	Animal feed (hay)	274.6	51.1	52.5	10	27,460	37,820
05	Meat and seafood	63.7	101.5	77.4	18	3,539	13,478
06	Milled grains (flour, pasta)	67.4	0.4	6.3	15	4,493	4,940
07	Food oils, canned foods, dairy, sauces	603.1	161.8	5.8	20	30,155	38,535
08	Alcoholic beverages	55.8	5.2	3.9	20	2,790	3,245
	Subtotal	3,557.5	332.5	515.5		246,221	303,030
	All other except bulk	5,151.7	149.3	615.2			

cargo transported across the Pacific is westbound. There is not a surplus of import refrigerated containers available in the Inland Empire to tap for export traffic; empty box supply would have to be sourced from marine terminals. Moreover, refrigerated shipments require extra infrastructure, in particular, chasses equipped with generators and the staff and equipment to maintain same.

A short-haul intermodal terminal or terminals located in the greater Inland Empire could be a useful supply point of empty marine containers for agricultural exports if dray distances are comparable or shorter than if containers are sourced by dray from marine terminals at the SBP ports. A comparison of dray distances to selected inland agricultural centers is as follows:

Central Valley: Bakersfield to San Pedro Bay ports 130 miles vs. Bakersfield to Ontario Airport 150 miles (171 miles if via Mojave)

Coachella Valley: Indio to San Pedro Bay ports 146 miles vs. Indio to Ontario Airport 91 miles

Imperial Valley: El Centro to San Pedro Bay ports 222 miles vs. El Centro to Ontario Airport 175 miles

Temecula wineries: Temecula to San Pedro Bay ports 92 miles vs. Temecula to Ontario Airport 52 miles

Driving times and distances from the Imperial and Coachella Valleys to an Inland Empire terminal are quite favorable compared to SPB marine terminals, and they not all that different from Central Valley origins. (Although a routing from Bakersfield via Mojave is 21 miles longer, the time savings from avoiding transit through Central Los Angeles at certain times of the day could be attractive.)

While tapping a supply of marine containers at Inland Empire terminal(s) would be preferred by many exporters to sourcing containers from SPB marine terminals, exporters would of course prefer sourcing from a terminal located closer to their origin. This prompts the question: Could a short-haul intermodal terminal located in one or more of the agricultural regions attract import volumes, thereby enabling a two-way haul?

Amazon operates several fulfillment centers located in the Central Valley. Walmart also operates some distribution facilities in the Central Valley. However, given their narrow geographical scope, nearly all of the imports distributed by such facilities are more economically routed via cross-docks and/or import warehouse facilities located in the LA Basin rather than directly to such facilities.

Ikea's import warehouse and RDC serving California and Nevada is located on the Tejon Ranch, 30 miles south of Bakersfield along I-5 (at the foot of the Grapevine Grade). It accounts for about 33,000 TEUs per year of imports via San Pedro Bay. To the best of the consultant's knowledge, RDCs, NDCs, and IWs operated by all other major importers are located within the LA Basin, not in the southern Central Valley.

Further north in the Central Valley, RDCs serving the Northern California region are concentrated in warehouse parks near Tracy, Lathrop and Woodland. While one might consider short-haul intermodal transport of imports en route to these facilities, the dray distances involved are formidable. To date, inland ports that would serve agricultural interests have been proposed to be sited at Shafter (189 miles to the Ontario airport, 209 miles to Lathrop), Mojave (110 miles to Ontario airport, 289 miles to Lathrop), and Indio (91 miles to the Ontario airport, 453 miles to Lathrop). These sites are not useful for routing imports to distribution facilities located in the greater Inland Empire. Given the dray distances, they are at best marginally useful for routing imports to Northern California RDCs. In the author's opinion, inbound trains to terminals at these proposed sites would carry hardly any loads. However, they could bring empty containers to the inland ports from the Inland Empire terminal(s) in lieu of draying them over the road. Considering the extra lifts involved to utilize short-haul intermodal, the cost savings would be modest, if any.

Track capacity

As discussed above, the potential short-haul intermodal market is very large, equivalent to many stack trains. If a large portion of the potential market is to be captured, track capacity from the SPB ports to Inland Empire terminals for the service would seem to be an issue.

It should be recognized that the presence of high-volume short-haul intermodal service likely would prompt changes to BNSF and UP intermodal traffic flows. As discussed above, the author predicts that many or most cross-docking operations currently situated between the ports and downtown rail intermodal terminals would migrate out to the Inland Empire. This in turn would shift substantial domestic intermodal volume from using downtown terminals (Hobart/Commerce on BNSF, East Los Angeles, LATC and City of Industry on Union Pacific) to using Inland Empire terminals (San Bernardino on BNSF, IEIT at West Colton on UP). It is estimated that 257,000 53s of trans-loaded imports (860 per operating day), would shift from downtown terminals to Inland Empire terminals, assuming full service to all destinations is provided from the Inland Empire terminals. Thus the short-haul intermodal traffic would to some extent displace long-haul domestic intermodal traffic between downtown and the Inland Empire, rather than comprise totally additive traffic.

With three main tracks and no passenger operation, the Alameda Corridor extending from the ports to downtown main-line rail connections offers excellent track capacity. Thus the focus for track capacity issues is between downtown connections to the Corridor and Inland Empire terminals. Both BNSF and UP host Metrolink commuter operations. BNSF has a three-main-track line over most of its line from Corridor connections to Colton Crossing. Metrolink operates its Orange County, 91/Perris, and Inland Empire – Orange County commuter services over the line. There also are Amtrak San Diego trains using the line as far as Fullerton. All told, there are 25-26 passenger trains each way between Hobart and Fullerton on weekdays, and 12-14 each way between Fullerton and a point north of Riverside where the line to Perris diverges, and 4 each way operating between that point and San Bernardino.

There are several BNSF stretches with only two main tracks between Fullerton and Colton Crossing. Right of way would seem to exist for a third main track, albeit some significant bridgework would be required and possibly some reconfiguration of certain commuter stations. In previous studies the consultant has performed for SCAG, three main tracks were recommended over the entire line in order to accommodate projected levels of commuter and freight traffic. The consultant believes Metrolink and BNSF are planning such improvements.

The Union Pacific has two routes from downtown Los Angeles to the Inland Empire. The Alhambra Subdivision (the former Southern Pacific route) runs alongside the LATC intermodal terminal and through Alhambra, El Monte, City of Industry and Pomona, running alongside the Ontario airport, and continuing to West Colton carload and intermodal terminals. Metrolink does not operate commuter service on this line, but access to this route from the Corridor requires use of Metrolink's two-main-track West Bank Line hosting 5-6 weekday commuter trains to and from Riverside, as well as crossing Metrolink's busy San Bernardino line (18 trains each way on weekdays) at grade. The Los Angeles Subdivision (original Union Pacific route) runs along the East Los Angeles intermodal terminal, passing through Pico Rivera, City of Industry and Pomona, merging into the BNSF line at Riverside and using BNSF trackage rights north of Riverside. Between East Los Angeles and Riverside, freight trains share tracks with 5-6 Metrolink commuter trains each way on weekdays. The two UP routes come alongside near the western city limit of Pomona where connections between the routes are made. Figure 15 (no scale) displays the various rail main lines between connections with the Alameda Corridor and the Inland Empire.

As may be seen in the figure, Union Pacific has alternate routes between connections to the Alameda Corridor and potential Inland Empire terminal sites, but both host Metrolink service over portions of the lines and both are partially single track. There is the possibility of rationalizing usage of these lines so as to largely separate Metrolink operations from frequent freight intermodal operation. The line selected for freight intermodal should be upgraded to have two main tracks throughout in order to efficiently accommodate the short-haul intermodal service. Detailed train dispatching simulations of potential rationalizations in this regard have been conducted by the author for the Southern California Association of Governments (references 3 and 9).

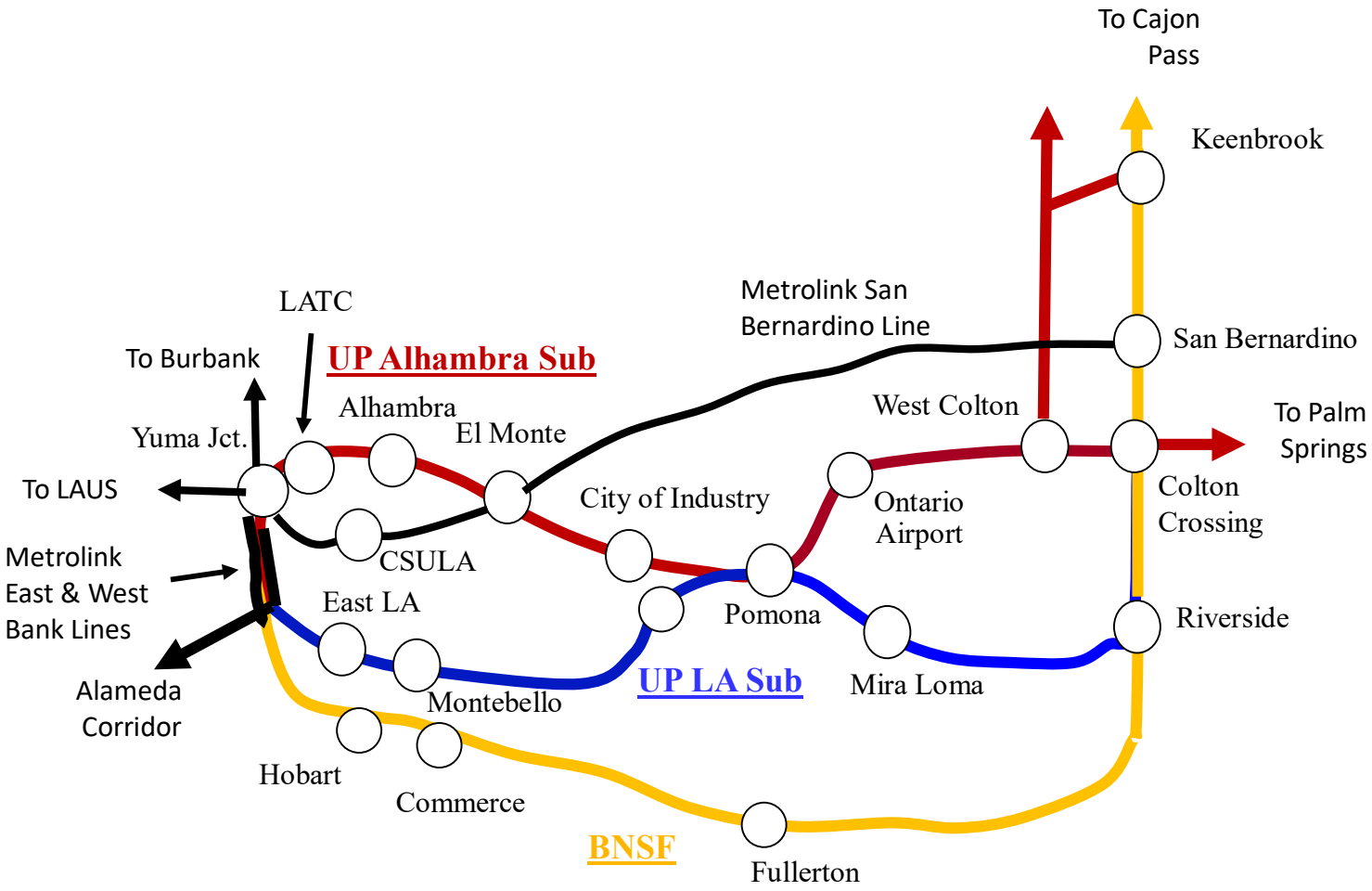


Figure 15. Rail Main Lines in the Los Angeles Basin

Potential Inland Terminal Sites

Another challenge for operating a high-volume short-haul intermodal service is securing sufficient terminal capacity within the Inland Empire. Existing Inland Empire rail intermodal terminals do not have the capacity to accommodate the short-haul intermodal service; one or more new terminals would be required. Property in the Inland Empire that could be secured to develop terminals for the service is scarce. However, property that could be suitable is located in zip code 91761 and straddling zip codes 92316 and 92324. Some of this property is in the public domain, and some is under railroad ownership. While offering plenty of space for developing the service and growing it over the years, the political, legal and environmental feasibility of using either site is unknown to the author.

To gauge how much property is necessary for one or more Inland Empire terminals, it is useful to consider an existing high-volume rail intermodal terminal handling exclusively marine containers. The BNSF Logistics Park facility near Joliet, IL, occupies about 150 acres (about 6.5 million square feet). This facility is a terminal for long-distance inland point intermodal service; as such, train arrivals and dray pick-up are not always coordinated. About 40% of arriving boxes are grounded and stacked awaiting dray pick-up. For boxes that are grounded and stacked, on average about 2 additional lifts after lift off the train are required to dispatch the dray. At this efficient facility, a 500-TEU train can be completely unloaded and reloaded for departure in 2-3 hours. At present the facility performs about 50,000 lifts per month on and off trains, but has performed up to 80,000 in the past. This suggests the facility is capable of processing about half a million FEUs of imports (and a corresponding number of returning boxes) per year.[12]

This benchmark suggests one or more terminal properties aggregating to 650 acres would be required to capture the entire 2019 market share. Making an allowance for future import growth, perhaps one or more sites aggregating to 800 or more acres would be appropriate.

[12] These figures conveyed to the author in private communication with Rail Management Services, contract operator of the terminal.

Marketing and Pricing Strategy

Given the need to compete with trucking, whose costs are approximately linear with mileage, the structure of rail intermodal pricing is typically mileage-based. That is, rates to different destinations are roughly proportional to the mileages to the different destinations. However, rail intermodal costs are not at all proportional to mileage. Extending the operating distance by one mile of a train of 250 containers staffed with a crew of two costs very little per container. But the terminals for the service comprise major cost centers, independent of the mileage of the haul. At the terminals, containers are handled one by one by additional staff using lift equipment, and that equipment must be maintained. The terminals require a lot of space that is located on, and paying property taxes on, relatively expensive property urban or suburban property. The terminals require appropriate lighting, security and staffed gate operations for dray pick-up and delivery. For this reason, rail intermodal service tends to be provided only over long distances where the mileage-based rates can overcome the independent-of-mileage terminal expenses. Rail intermodal services in North America offered for distances less than 500 miles are rare.

Converting a freight flow of 5,000 truckloads per day and a like number of returning empties to rail intermodal is unprecedented in North American railroad history. Establishing a successful rail intermodal service providing a mere 60- to 80-mile haul also is unprecedented.

As a stand-alone business, the short-haul intermodal service would make little or no money. Paradoxically, the service could significantly reduce current supply-chain costs and inefficiencies, as well as significantly reduce the environmental impact of the supply chains.

At present, long-distance inland point intermodal service is marketed and priced by the ocean carriers, with the railroads and draymen acting as subcontractors to the carriers. Because the short-haul intermodal service would serve the trans-load market, it would seem to be at odds with the long-distance IPI product marketed by the carriers. Thus the carriers do not seem to be a good fit as the appropriate agencies to market and price the short-haul service. It is a challenge to align the various parties economically and environmentally benefitting from the short-haul intermodal service with the parties bearing the economic and environmental costs of the service.

The terms of trade would have to be quite different from the status quo. A different service provider is required. Innovation in pricing is required. And a public-private partnership may be required.

It is useful to consider how various stakeholders could benefit from existence of the service:

- Importers could benefit to the extent that the short haul intermodal service is a better value proposition than direct dray.
- The public could obtain a dramatic reduction in truck traffic and associated emissions.
- The ocean carriers would benefit very little if at all. They have little stake in promoting imports via san Pedro Bay, as they can make money no matter which ports of entry are

used. Moreover, they likely would be loath to undertake a new line of business that offers very little or no return and seemingly renders their IPI service product less attractive.
- The railroads (UP and BNSF), their IMC partners, Federal Express and UPS could sustain and grow their long-haul domestic-box intermodal traffic from Southern California that otherwise would be imported via other ports and make shorter landside transits.
- Rail volumes in the Alameda Corridor would dramatically increase, ensuring the bonds for the Corridor could be retired without additional financial input from the SPB ports.
- The SPB ports could sustain and grow their import volumes. Suppliers to the SPB ports would benefit as a consequence.

A pricing instrument that would translate the benefits of short-haul intermodal service into increased long-haul domestic-box is to offer *storage-in-transit credits* on imports moved via the short-haul service and re-shipped in long-haul intermodal service. This could work as follows.

Suppose the railroads and/or their IMC partners market the short-haul intermodal service. Although their involvement would be limited to loading and unloading railroad well cars at marine terminals, the ocean carriers would need to identify the short-haul intermodal service as a separate service offering in their catalogs of service. It could be priced somewhat akin to their CY service product, accounting for loading import containers into railroad well cars in lieu of dray pick-up by the importer.

Suppose the service is priced by the railroads and their IMC partners to be fully compensatory, but a credit equivalent to the margin on a 40-ft box is provided to the importer that can be redeemed on subsequent long-haul domestic-box shipping of the same cubic quantity. (Two TEUs of credit would be earned for short-haul transit of a 40-foot marine box, applicable towards shipment in a 53-ft box accommodating 3 TEUs.) Credits would be transferrable between an OEM and its retailing clients (who pay for onward transportation). For retailers building mixed domestic-box loads from multiple OEM sources, fractional credits could be combined to tender up to 3 TEUs of credits partially deferring the shipping costs of a 53-foot domestic container or trailer.

Under this scheme, the railroads perform the short-haul intermodal service on a break-even basis for the portion of imports that are re-shipped in long-haul domestic intermodal service. For the rest, the railroads collect a compensatory price for the short-haul service. If there is no growth in import volume at San Pedro Bay, the railroads and their IMC partners would be as well off as at present, enjoying the same margins and same volume on long-haul domestic intermodal traffic. If the credits are large enough to induce importers to re-structure their supply chains to favor the San Pedro Bay ports, then the pricing scheme will have worked to secure the railroads and their IMC partners increased traffic at the same long-haul margins. As discussed above, if the credits amount to $400 per FEU compared to direct dray prices, the author predicts SPB volume would grow by about one million TEUs per year, all of it trans-load traffic.

An added bonus of this scheme, is a reduction in the required marketing effort to find domestic-box long-haul customers. Instead of the railroads and/or their IMC partners having to find customers, customers will come to them in order to redeem the short-haul credits.

Numerical Example

Suppose a large retailer (BB1) tenders a 53-foot container for shipment to an inland RDC. The domestic container contains a mix of imports stored in its import warehouse and imports it purchased from two OEMs (OEM1 and OEM2) who warehoused those imports in their NDCs before sale to BB1. Suppose all of these imports were shipped in 40-foot marine containers utilizing the short-haul intermodal service. To apply storage-in-transit credits for long-haul re-shipment, the retailer would submit the following information electronically:

Shipper_ID	Importer_ID	Import_container_ID	Import_receipt_date	Quantity (TEUs)
BB1	BB1	ABCU 4501893	21-April-2023	0.5
BB1	BB1	ABCU 7831006	10-April-2023	0.8
BB1	BB1	ABCU 5602813	8-April-2023	1.2
BB1	OEM1	ABCU 2037815	15-May-2023	0.2
BB1	OEM2	ABCU 3991620	1-May-2023	0.3
Total				3.0

Up to 3 TEUs of credits can be applied to re-shipment of imports in one 53. Where Shipper_ID and Importer_ID are different, a copy of the bill of sale from OEM to retailer must be submitted. The re-shipped TEUs of imports are debited against the 2 TEUs that arrived in the Import_container_ID. Once 2 TEUs of credits are used or the Import_receipt_date becomes twelve months old, the Import_container_ID cannot be used as a credit source for re-shipment.

Suppose the fully compensatory rate per FEU for the short-haul intermodal service is $800, and suppose the break-even rate is $600. Then the retailer is entitled to a discount of $100 per TEU of imports re-shipped long-haul, i.e., $300 per 53-foot container.

Public-Private Partnership

The short-distance line haul of the service, and the relatively short dray distances to greater Inland Empire warehouses from the inland terminal(s) for the service, suggest that the service could be operated with battery-powered locomotives and battery-powered dray tractors. Infrastructure could be arranged to recharge locomotive batteries during the 2-3 hours a train is unloaded and reloaded at the inland terminal(s). Warehouses of large importers also could be equipped with charging stations for dray tractors. All-electric or battery-powered lift equipment at the inland terminals for the service could be employed. It seems within reach that the entire service from departure from marine terminals to delivery at Inland Empire warehouses to return

of empty boxes to marine terminals could be done with zero emissions. This suggests a potential marketing acronym for the service: ZERO (zero emissions railroad operation).

The public stands to benefit from a successful short-haul intermodal service. The service would enable a dramatic reduction in truck traffic on Basin freeways. If, as suggested above, the entire service is operated without emissions, the improvement in air quality along freeways connecting the SPB ports to the Inland Empire would be dramatic.

Development of inland terminal(s) for the service would be expensive and may require public approval. Given they would represent critical infrastructure supporting international trade, low-interest tax-free public-agency bonds should fund their development, as was done for the ICTF and the Alameda Corridor.

If expanded track capacity were arranged enabling to a large extent the separation of Metrolink and heavy freight movements onto separate routes or tracks, both Metrolink and the freight railroads could benefit.

The disparate private parties participating in the supply chains cannot expend monies to develop the short-haul service and at the same time gain the financial benefits from it that flow to other supply-chain participants.

These factors suggest a Public-Private Partnership should be developed with appropriate commitments from all stakeholders so that all would fairly benefit from development of the service while appropriately sharing its costs. The stakeholders involved include the SPB ports, local governments, major importers, ocean carriers, railroads and their IMC partners, and chassis and dray providers. The elements of a Partnership deal could be as follows:

- Importers commit to using the service
- Ocean carriers commit to cooperate by listing the short-haul intermodal service in their service catalogs, fairly priced, and identifying with appropriate lead time to marine terminals and the railroads/IMCs the incoming containers using the service
- Railroads and their IMC partners commit to marketing the service with storage-in-transit credits corresponding to break-even operation and compensatory rates for traffic not redeeming the credits
- Space for inland terminal(s) found and construction funded with public bonds
- Chassis providers and dray operators commit to providing service at inland terminal(s)
    - Battery-powered dray tractors provided for Inland Empire drays
    - Battery-powered locomotives for line-haul
    - Battery-powered or straight-electric lift equipment for inland terminal(s)

- Expanded track capacity and increased separation of Metrolink operations from heavy freight intermodal operations
- Footprint of downtown intermodal terminals reduced as the service grows market share and domestic intermodal traffic shifts to use Inland Empire terminals

Again, such a public-private partnership involving all major stakeholders is unprecedented. But the potential benefits for all are extraordinary.

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Appendix 1. Glossary of Supply Chain Acronyms and Terminology

Term or Acronym	Meaning
Cross-dock or trans-load facility	A facility for unloading cargoes from inbound vehicles, sorting them, and re-loading the cargoes in outbound vehicles. The typical cross-dock is not designed to hold inventory for extended periods of time, so the arrival of inbound and outbound vehicles must be coordinated.
Cube freight	A cargo which entirely fills the cubic capacity of a trailer or container before reaching the weight limit for highway movement.
DCS	Dedicated Contract Service. For regular, periodic re-stocking of its regional retail outlets from a regional distribution center, a large retailer may charter drivers, truck tractors and sometimes trailers for long periods of time to carry out such transportation.
Drayman, Dray carrier	Containers or trailers moving in rail intermodal service may require over-the-road movement between origin and initial rail terminal and between final rail terminal and destination. A company operating a fleet of truck tractors making such short, same-day trips is a dray carrier. Some such companies are essentially dispatch coordinators for a group of owner-operators, each of whom is known as a drayman.
Domestic container	A shipping unit for truckload-sized intermodal shipments within North America, using the railroad for line haul. Domestic containers are fifty-three feet in length and accommodate 4,000 cubic feet of cargoes. For movement from origin to initial rail terminal and for movement from final rail terminal to destination, the container is mounted on a chassis and pulled by a dray tractor on roads and highways.
Domestic trailer	A shipping unit for truckload-sized shipments within North America. Domestic trailers are fifty-three feet in length and accommodate 4,000 cubic feet of cargoes. A trailer may be towed by a truck tractor for over-the-road movement, or it may be drayed to and from rail intermodal terminals for line-haul movement in trains. Wheels and undercarriage are permanently attached so trailers cannot be double-stacked.
Domestic rail service	The shipping of a domestic 53-foot container or trailer using a train for much of the line haul. IMCs, LTL companies, package express and parcel shipping companies utilizing domestic rail service.
FEU	Forty-foot equivalent unit. Most marine containers have 40-foot lengths, accommodating one FEU of cargo. For cube freight, a domestic 53-foot container or trailer accommodates 1.5 FEUs of cargo.

Fulfillment Center	On-line retailers dispatch delivery vehicles and customer shipments from warehouses termed Fulfillment Centers. Typically, imports pass through a regional distribution center (RDC) and are re-shipped to Fulfillment Centers, much the same as imports are re-shipped from RDCs to stores by brick-and-mortar retailers. (And some retailers perform a mixture of in-store and on-line sales.)
IMC	Intermodal Marketing Company. A company marketing door-to-door transportation within North America of domestic 53-foot containers and utilizing domestic rail service. An empty container and a chassis are retrieved from a rail intermodal terminal in proximity to the origin warehouse or cross-dock, and delivered to the origin for loading. After loading the container-on-chassis, it is drayed back to the rail terminal where the container is transferred using an overhead crane to a railroad well car. The container is moved in a double-stacked train 600 miles or more to a destination rail terminal, then drayed from the rail terminal to the destination warehouse. The IMC subcontracts with dray companies to provide the origin and destination drays and with a railroad to provide the line haul.
Import Warehouse (IW)	Large nation-wide retailers typically operate an import warehouse in the hinterland of one or more ports of entry. Goods imported months in advance of time of sale may be held in the import warehouse, and later allocated and shipped to RDCs closer to the time the goods can be sold.
ICTF	Intermodal Container Transfer Facility. The ICTF is a Union Pacific Railroad intermodal terminal located close to the San Pedro Bay Ports, handling both domestic-box and IPI shipments.
IE	Inland Empire region of Southern California, located 60-90 miles from the SPB Ports. The Inland Empire hosts the largest concentration of import warehouses, NDCs and RDCs in Southern California.
IPI	Inland Point Intermodal. A transportation service marketed by ocean carriers in which marine containers move via vessel, railroad double-stack train, and highway dray movement. In the case of a marine container shipped from a Far East origin to an inland North American destination, the container is transferred from a vessel to a railroad well car at a West Coast port of entry, moved 600 miles or more in a double-stacked train to an inland rail intermodal terminal, then drayed from the rail terminal to the destination warehouse. The ocean carrier subcontracts with dray companies to provide the destination dray and with a railroad to provide the line haul. IPI service also is available for exports.

LTL	Less-than-truckload. LTL carriers provide door-to-door shipping of pallet-sized shipments, using small trucks to pick up and deliver, consolidating multiple shipments into domestic containers or domestic trailers for line-haul movement, and de-consolidating the multiple shipments for final delivery.
Marine container	The shipping unit for waterborne, containerized international shipping. Marine containers come in twenty, forty and forty-five foot lengths. Over 80% are forty feet in length, and nearly all of the forty-foot containers in the trans-Pacific trade accommodate 2,700 cubic feet of cargoes.
Marine terminal	A facility at a port unloading containers from vessels, staging them, and re-loading the containers into railroad well cars or onto truck chassis for inland movement. The facility also handles the reverse movement of export containers. Marine terminals may be operated by a subsidiary of a single ocean carrier or by an independent operator with several ocean carriers as clients. For the purposes of this report, a port is a collection of marine terminals.
NDC	National Distribution Center. An OEM may operate a single distribution center serving all its North American retailing customers, who must arrange transportation from the OEM's NDC to their own RDCs.
Ocean Carrier	In the context of this report, a company providing trans-Pacific shipping of marine containers.
On-Dock Rail	A marine terminal equipped to transfer marine containers to railroad well cars without need to dray outside the terminal is said to have on-dock rail capability. On-dock rail is exclusively for IPI shipments.
OEM	Original Equipment Manufacturer. Waterborne, containerized imports of certain relatively valuable goods are made by OEM companies who domestically market such goods to retailing firms. In such cases, the OEM purchases the international transportation. Once goods are purchased from the OEM by a retailer, further transportation is made in domestic containers or trailers and typically is the responsibility of the retailer.
Package Express and Parcel carrier	Package Express and Parcel carriers provide door-to-door shipping of carton-sized shipments, using small trucks to pick up and deliver, consolidating multiple shipments into domestic containers or domestic trailers for line-haul movement, and de-consolidating the multiple shipments for final delivery using smaller vehicles. Examples include United Parcel Service and Federal Express Ground.

Push supply chain	In the context of this report, an import strategy in which there are steady shipment volumes from Far East factories to RDCs so as to minimize total shipping costs. IPI service is used for RDCs located more than 600 miles from West Coast ports of entry, while dray movement of marine boxes is used for RDCs located closer to ports of entry. Typically, many ports of entry are utilized, assigning each RDC to the closest port of entry in order to economize on landside shipping costs.
Push-Pull-all-at-San-Pedro-Bay supply chain	An import strategy in which all imports from Far East factories for the Continental USA market are routed through the SPB Ports, then re-shipped in domestic containers and trailers to RDCs. Imports may be held for some time at an NDC (OEM case) or an import warehouse (case of large, nation-wide retailer) before re-shipment to an RDC.
Push-Pull-3[4][5]-Corners supply chain	An import strategy in which goods manufactured in the Far East are allocated to 3, 4 or 5 pre-specified North American ports of entry before booking vessel passage, but not allocated to specific RDCs. After arrival at port of entry, goods are allocated to RDCs served by the port of entry, and re-shipped to distant RDCs in domestic containers or trailers. Imports may be held for some time at an import warehouse in the hinterland of the port of entry before re-shipment to an RDC.
RDC	Regional Distribution Center. A typical brick-and-mortar retailer utilizes an RDC to warehouse goods sold by retail outlets within a geography served by the RDC. Typically, an RDC serves a set of retail outlets reachable within an overnight drive from the RDC (but sometimes longer distances in some sparsely populated regions).
SPB ports	The San Pedro Bay ports, i.e., the Port of Long Beach and the Port of Los Angeles in Southern California
TEU	Twenty-foot equivalent unit, a metric of waterborne containerized shipping. One forty-foot marine container equals two TEUs.
Weight freight	A commodity which, when loaded in a container or trailer, causes the vehicle to reach the highway weight limit before the cubic capacity of the vehicle is reached.
West Colton	An industrial community in the Inland Empire of Southern California and site of a Union Pacific Railroad domestic rail terminal.
3PL	Third-party logistics operator. Cross-docks and trans-load facilities may be operated by 3PLs in lieu of the beneficial owner of the cargoes handled (first party) or the transportation carrier (second party).

Appendix 2. Major Importers

- Large nation-wide retailers (ordered by import volume): Wal-Mart, Target, Home Depot, Lowe's, Ashley Furniture, Family Dollar/Dollar Tree, Ikea, Amazon, Dollar General, Costco, Williams Sonoma, Best Buy, Gap, J C Penney, Michael's Stores, Ross Stores, 99 Cents Only Stores, Joann Fabric & Crafts.
- Large OEMs of expensive goods (ordered by import volume): Samsung, LG, Nike, Newell Brands, Electrolux, Kubota Tractor, Haier, Bissel Homecare, Adidas Group, Conair, PVH, Shark Ninja, Panasonic, Gildan Activewear, QVC, Epson, Philips Electronics, H&M, Columbia Sportswear, Philips Van Heusen, Skechers, and American Power Conversion.
- Large OEMs of moderately expensive goods (ordered by import volume): Rooms to Go, Hyundai Motor, Mercedes Benz USA/Daimler Trucks, Sumitomo, Hankook Tire, Toyota Tsusho America, Bridgestone Tires, Dorel Industries, Mitsubishi Motors, Continental Tire, At Home Procurement, American Honda, American Tire Distributors, Subaru, Michelin North America, Coaster of America, John Deere, Euromarket Designs, Yokohoma Tire, Living Spaces, Keter North America, Toyo Tires, Samsonite, Mattel, Liberty Procurement, Q Cells, Hyosung Motors, E&E, Nissan North America, Raymour & Flanigan Furniture, Spectrum Brands, BJ's Wholesale, Pirelli, Bob's Discount Furniture, DAK Americas, Badcock Home Furniture, Michael Kors, Yazaki North America, Safavieh, American Furniture Warehouse, American Omni Trading, Giti Tire, LG Chemical America, Icon Health & Fitness, Sentury Tire, Belnick, Volkswagen Group, Standard Furniture.

Appendix 3. Major Inland Empire Distribution Centers

Ontario airport area DCs

- Target RDC 800K sq ft
- Target IW 8.75M sq ft
- Electrolux NDC 800K sq ft
- Staples Fulfillment Center 500K sq ft
- Lay-Z-Boy RDC 650K sq ft
- Ingram Micro (Chinese-owned computer products distributor) NDC 750K sq ft
- Prompt Apparel NDC 500K sq ft
- Nordstrom RDC 225K sq ft
- Toyota North America NDC 975K sq ft
- Hyundai Mobis NDC 585K sq ft
- Bridgestone/Firestone NDC 1.2M sq ft
- Converse NDC 675K sq ft
- Auto Zone RDC 400K sq ft
- Home Depot RDCs (3 buildings) 1.4M sq ft, 800K sq ft and 650K sq ft
- Toyo Tires NDC 900K sq ft
- Wal-Mart Cross-docks (2) Aggregate of 385K sq ft
- Wal-Mart RDCs (3 buildings) 1.4M sq ft, 1.0M sq ft and 575K sq ft
- Cosco RDC 1M sq ft
- Cosco cross-docks (3) Aggregate of 1.5M sq ft
- Newell Brands NDC 1M sq ft
- Dorel Home Furnishings NDC 800K sq ft
- Mercedes Benz USA NDC 2.5M sq ft
- 3PL Warehouses and Cross-Docks: Expeditors International, NFI, American New Logistics, Neovia Logistics, Ceva Logistics, Geodis Logistics, APL Logistics, Cal Cartage, Exel Logistics, National Retail Transport

Rialto DCs

- Target RDC (2 buildings) 1.5M sq ft and 1.5M sq ft
- Zara NDC 500K sq ft
- West Elm NDC 500K sq ft
- Pirelli NDC 775K sq ft
- Amazon Fulfillment Center 1.2M sq ft
- Amazon IW 1.9M sq ft
- Ricoh USA NDC 325K sq ft
- Staples RDC 400K sq ft
- 3PL Warehouses: Fed Ex, Geodis, Monster, APL Logistics, Distribution Alternatives

North San Bernardino DCs

- Michelin NDC 870K sq ft
- Family Dollar RDC 475K sq ft
- J C Penney RDC 630K sq ft

San Bernardino DCs

- Mattel NDC 2.2M sq ft
- Kohl's RDC 800K sq ft
- Amazon Fulfillment Center 2.5M sq ft

North Redlands DCs

- Amazon Fulfillment Centers (2) 1.4M sq ft and 1.2M sq ft
- Ashley Furniture RDC 1.7M sq ft
- 3PL Warehouses and Cross-docks: Geodis, Lean Supply Solutions, XPO Logistics, DCG Distribution, PT Logistics, DSC Logistics, APL Logistics, Aspen Distribution, ODW Logistics, World Class Distribution, Komar Distribution Services

Moreno Valley DCs

- Skechers NDC 475K sq ft
- Big 5 RDC 1.5M sq ft

- 3PL Warehouses and Cross-docks: Ozburn-Hessey Logistics

Perris DCs

- Lowe's RDC 1.1M sq ft
- Amazon Fulfillment Center 2.2M sq ft
- O'Reilly Auto Parts RDC 500K sq ft
- Lowe's IW 1.9M sq ft
- Ross Stores IW 1.8M sq ft
- Ross Stores RDC 560K sq ft
- Walgreens RDC 800K sq ft
- H&M NDC 800K sq ft
- Home Depot IW 8M sq ft
- Home Depot Fulfillment Center 1.5M sq ft
- Amazon Fulfillment Center 1.4M sq ft
- Staples IW 1M sq ft
- Whirlpool NDC 2.8M sq ft
- Ross Stores IW 2M sq ft
- Lowe's IW 1.6M sq ft
- 3PL Warehouses and Cross-docks: National Retail Transport, Geodis, NFI

Chino DCs

- Honda NDC 500K sq ft
- 3PL Warehouses: NFI, B Logistico, Whiplash

Walnut DCs

- Williams Sonoma NDC 1.7M sq ft
- 3PL Warehouses: APL Logistics, Whiplash, Dart Logistics

City of Industry DC

- Amazon Fulfillment Center 1.2M sq ft
- 3PL Warehouses: Whiplash

Appendix 4. Derivation of Import Market Share Parameters

In the text it is asserted that, given the total share of Far East – USA imports at San Pedro Bay, given the IPI fraction at San Pedro Bay, given the fraction of total Far East – USA imports consumed in the local region, given the shares of total Far East – USA imports moving in Push-Pull 3[4][5] Corners supply chains and in Push-Pull 1 Corner supply chains, and given the fraction of Push-Pull 1 Corner importers whose national distribution center is located in Southern California, then the fraction of imports in Push-Pull 3[4][5] Corners supply chains moving through San Pedro Bay, the fraction of imports in Push supply chains moving through San Pedro Bay, and the overall fraction of Far East – USA imports moving in Push supply chains may be deduced. This appendix develops the equations proving this assertion.

Notation

SPB – fraction of total Far East – USA imports moving through San Pedro Bay

L – fraction of total Far East – USA imports consumed in the Southern California region

IPI – fraction of San Pedro Bay imports from the Far East moving in inland point intermodal service

s_R – fraction of total Far East – USA imports moving in Push supply chains. Such chains are utilized by small and regional retailers for all of their imports as well as by large, nation-wide retailers for their "one-off" goods that are not re-stocked.

s_M – fraction of total Far East – USA imports moving in Push-Pull 1 Corner supply chains. Such chains are utilized by large, nation-wide original equipment manufacturers.

s_B – fraction of total Far East – USA imports moving in Push-Pull 3[4][5] Corners supply chains. Such chains are utilized by large, nation-wide "Big-Box" retailers.

x_R – fraction of total Far East – USA imports moving in Push supply chains that pass through San Pedro Bay.

x_M – fraction of total Far East – USA imports moving in Push-Pull 1 Corner supply chains that pass through San Pedro Bay.

x_B – fraction of total Far East – USA imports moving in Push-Pull 3[4][5] Corners supply chains that pass through San Pedro Bay.

Initial Conditions

Suppose we are given *SPB*, *L*, *IPI*, s_M, s_B, and x_M. We now proceed to solve for s_M, x_B and x_R.

Derivation

The shares of the three supply chain types account for all Far East – USA imports:

(1) $s_M + s_B + s_R = 1$; therefore, $s_R = 1 - (s_M + s_B)$.

Considering the Push supply chain, we have:

(2) $x_R s_R = s_R * L + IPI * SPB$.

Considering San Pedro Bay's share of overall Far East – USA imports, we have:

(3) $x_R s_R + x_M s_M + x_B s_B = SPB$.

Equations (1) and (3) imply

$x_R = [1/(1 - s_M - s_B)] * IPI * SPB + L$.

Substituting this result into equation (3), we have:

$x_M s_M + x_B s_B = SPB - x_R s_R = SPB - x_R(1 - s_M - s_B) = SPB - IPI * SPB - (1 - s_M - s_B) * L$.

Solving for x_B, we have:

$x_B = (1/s_B)[\ (SPB - IPI * SPB - L) - (x_M - L) * s_M\ ] + L$.

Numerical Results

For $SPB = 0.457$, $L = 0.108$, $IPI = 0.328$, $s_M = 0.137$, $s_B = 0.284$, and $x_M = 0.85$, we obtain $s_R = 0.579$, $x_B = 0.451$ and $x_R = 0.259$. The shares of imports by supply chain type at San Pedro Bay become $x_R s_R/SPB = 46.5\%$ for Push supply chains, $x_B s_B/SPB = 28.0\%$ for Push-Pull 3[4][5] Corners supply chains, and $x_M s_M/SPB = 25.5\%$ for Push-Pull 1 Corner supply chains, as reported in the text.

Appendix 5. Biosketch for Dr. Leachman

Robert (Rob) C. Leachman has been a Professor of Industrial Engineering and Operations Research at the University of California at Berkeley since 1979. He is the author of more than 90 technical publications on supply chain, logistics and manufacturing improvement. He is the recipient of the Franz Edelman Award from the Institute for Operations Research and the Management Sciences (INFORMS). The Edelman Award is the highest accolade from INFORMS, recognizing outstanding industrial practice of the management sciences.

Prior to serving on the U C Berkeley faculty, Rob worked in operations and marketing at Union Pacific Railroad and subsequently served as a transportation consultant for PRC Voorhees.

In 1983 Rob founded Leachman & Associates LLC, providing consulting services and software for operations analysis and supply-chain management to corporations and governments worldwide. Among projects performed by Leachman & Associates, Rob's 1984 report for the Southern California Association of Governments was the first documented proposal for, and analysis of, the Alameda Corridor.