Evaluation of the Commercial Potential of UIPA's Proposed Trans-loading Facility

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Executive Summary

The Utah Inland Port Authority has proposed the development of a trans-loading facility adjacent to the Union Pacific Railroad's intermodal terminal in Salt Lake City. It is envisioned that marine containers of imports entering through the Ports of Long Beach, Los Angeles or Oakland would move by train to UP's Salt Lake City intermodal ramp, then be drayed to the next-door UIPA trans-loading facility, where imports would be de-vanned from marine containers, sorted, and re-loaded into domestic trailers for re-shipment over roads and highways. The facility also is envisioned to handle exports arriving in domestic vehicles, trans-loading them into marine containers heading back to the Ports.

This document is a White Paper analyzing the prospects for import and export business at this facility and its potential contributions to reducing supply-chain emissions. For reasons explained below, the proposed facility would have a very difficult time attracting enough business to fill a typical-size cross-dock. It is unlikely to achieve any significant reductions in supply-chain emissions. There are wiser investments of public monies suggested at the end of this summary.

The vast majority of waterborne, containerized imports from the Far East to the Continental United States are retail goods. There is very little in the way of raw materials or components input to manufacturing in such imports. Moreover, retailing is increasingly concentrated in the hands of large, nation-wide "Big-Box" firms such as Wal-Mart, Target, or Home Depot, and the hands of e-commerce firms such as Amazon. Destinations for marine containers containing imports from Far East countries are much more concentrated than most people realize. The typical import container contains a very narrow variety of retail-ready goods produced at a single Far East factory. One marine container shipment of these goods is far too much for any single retail outlet to consume in a relatively short time frame. For some expensive goods, one marine container shipment is far too much for *all* of the retail outlets of a retailing chain in the entire Intermountain region to consume in a relatively short time frame. Most brick-and-mortar retailers operate a regional distribution center warehouse in the greater Salt Lake City area serving the Intermountain region. Their imported goods are stocked in such warehouses, and trailer trucks (not marine containers) containing their entire product portfolio (not a narrow range of goods) are dispatched from their regional distribution center to replenish their retail outlets as required. For moderate-value and expensive imported goods with slower sales, marine containers

are de-vanned in the hinterlands of the West Coast ports of entry, the contents are allocated across multiple regions and shipped to regional distribution centers in domestic containers or trailers. For on-line retailers, imports sold in the Intermountain region are stocked in a fulfillment center located in the greater Salt Lake City area or perhaps outside the region; shipping to end customers is performed in domestic vehicles. Thus, the lion's share of imports to the Intermountain region either are de-vanned from marine containers in the greater Salt Lake City area or de-vanned in other regions.

The contents of three forty-foot marine containers can be re-stuffed in two fifty-three foot domestic trailers, provided highway weight limits are not exceeded. This suggests some transportation economies may be afforded by trans-loading from marine containers to domestic trucks. However, such economies must be traded off against the expense involved in trans-loading. There are no pallets used in trans-Pacific waterborne containerized shipping. Except for electronics, there is little or no shrink-wrapping of goods nor use of slip sheets. Cartons of goods are hand-stacked in marine containers. Trans-loading to domestic vehicles requires handling cartons one by one. Even very large importers providing steady volumes under annual contracts pay $400 - $500 or more per forty-foot marine container for cross-docking service. To justify trans-loading solely on the basis of transportation savings requires onward hauls of hundreds of miles.

In practice, trans-loading of imports is rarely done solely on the basis of transportation cost savings. It is done when it also achieves substantial inventory economies, i.e., transforming inbound shipments with very narrow portfolios of goods into outbound shipments containing broad portfolios of goods that can be sold much more quickly without suffering clearance markdowns or other inventory-related costs.

The proposed facility is unlikely to capture import volumes destined to other regions. For imports entering through the San Pedro Bay Ports (Long Beach and Los Angeles), routing via Salt Lake City, the imports desired in other regions would entail additional transportation costs. Under terms of business with the ocean carriers, routing marine containers to Salt Lake City must be committed by the importer before booking vessel passage from the Far East. For moderate-value and expensive imports, nation-wide retailers prefer to pool demands in inland regions with demands in West Coast regions and de-van the marine containers in the hinterland of the port of entry, thereby delaying the time of commitment by region until after vessel arrival at the West Coast port. By that time, much more accurate assessments of regional demands can be made. Moreover, imports can be held at an import warehouse near the port of entry if inland demands have not yet materialized, in lieu of guessing to which region they should be shipped. Assigning inland regions to a Salt Lake City trans-load facility foregoes the inventory economies afforded by pooling the demands of West Coast regions with demands of the inland regions.

Thus, for retailers operating regional distribution centers or fulfillment centers in the greater Salt Lake City area or outside the Intermountain region, the proposed facility is simply not a value proposition.

Capturing the export market at the proposed facility is problematic for different reasons. First, it should be recognized that, ranked by dollar value, most Utah exports are high-value goods such as gold bars, semiconductors, aircraft engines and parts, medical instruments and essential oils. Such commodities are shipped via air freight, not as waterborne, containerized cargoes. Unlike waterborne, containerized imports, which are predominantly retail goods moving through supply chains operated by large, nation-wide retailers, the waterborne, containerized exports from the region are primarily agricultural goods, specialty minerals and other basic products produced at disparate points remote from Salt Lake City. Attractiveness of the proposed facility for handling waterborne, containerized exports is seemingly somewhat more promising than for handling imports, albeit the volume of waterborne containerized exports from the Intermountain region is much smaller than the volume of waterborne imports to the region. Ocean carriers are loath to stage and distribute marine boxes in the Intermountain region to garner relatively low-rate export shipments considering that their boxes can be sent back earlier to the Far East empty to collect another much higher-revenue import load. The ability to ship exports using domestic vehicles to Salt Lake City, then trans-load to marine containers, would make a larger fleet of marine containers available to exporters, and at the same time it would decrease container turn times for the ocean carriers. However, there are impediments to realizing any benefits from such an export flow, as discussed below.

Exports of cube-freight commodities, such as corrugated box scrap originating at points distant from Salt Lake City could save approximately 33% in emissions on the way to Salt Lake City by using the proposed trans-load facility. However, the volume of waterborne cube-freight exports generated at points in the Intermountain region hundreds of miles from Salt Lake City is small, and the trucking savings from origins closer to the facility cannot recoup the trans-loading expense. Weight-freight exports such as grain or minerals, if shipped in domestic trucks to the facility, would not realize any emissions reductions because no reduction in truck trips is afforded. If the proposed trans-load facility were equipped with rail carload access and suitable equipment to unload bulk commodities from rail cars and re-load marine containers with bulk commodities, and if the railroads were willing to provide carload service from export origins to Salt Lake City, then it could become possible to realize emissions savings for weight-freight exports over the portion of their journey from origin to Salt Lake City. Unfortunately, the railroads typically are not interested in short-haul carload service for modest-volume, low-value commodities. Thus, it likely will be difficult to realize significant reductions in emissions from export movement of weight-freight commodities.

The proposed facility also is unlikely to foster any significant reduction in emissions of import supply chains in the Intermountain region. While movement of imports via rail to Salt Lake City generates much less emissions than does trucking the imports from the Los Angeles Basin, it does not offer any savings in emissions compared to trans-loading cargoes near the San Pedro Bay ports into domestic containers and moving domestic containers by rail, as some importers now do. Moreover, the proposed facility does not make it any easier or any more economically justifiable for importers to secure rail movement of marine containers from the San Pedro Bay Ports to Salt Lake City. Nearly all warehouses serving the Intermountain region for which routing marine containers via the Salt Lake City rail terminal makes sense are located in the

greater Salt Lake City area. here is just too little dray mileage involved from the rail terminal to the destination warehouse to capture any significant transportation cost savings. If imports were trans-loaded to domestic trailers, there would be approximately a 33% reduction in emissions over these short distances, but, as noted above, the cost of trans-loading far exceeds the trucking cost savings, and thus it is unlikely to be realized. In summary, the proposed facility is unlikely to engender any significant reduction of emissions within the region.

There have been two major trans-loading initiatives in postwar Utah history. Freeport Center at Clearfield was a re-purposed Naval Supply Center built during World War II. During the 1960s and through the 1970s, Freeport became a trans-loading center for virtually all major appliances manufactured in the United States and marketed on the West Coast, as well as a trans-loading center for many of the American farm implement companies. This was achieved by virtue of public policy (no taxes on inventory), transit rates offered by Union Pacific (charging customers carload line-haul rates from factory origin to retail destination with a modest Clearfield stopover fee, even though carloads into Clearfield contained solely outputs of one factory whereas carloads departing Clearfield contained a company's entire appliance product portfolio), and fast, reliable train service providing second morning delivery to retailers and distributors up and down the West Coast. To a much lesser extent, Freeport Center handled distribution of canned goods from Northern California heading east. As manufacture of appliances and farm implements shifted from the United States to the Far East, Freeport Center waned in importance, despite efforts of Center management to promote its use for imports moving in the opposite direction. Today, Freeport Center plays no significant role in Far East – USA import supply chains practiced by the large, nation-wide retailers.

Western Pacific Transport, later rebranded as WPX, was a subsidiary of the Western Pacific Railroad connecting Northern California with Salt Lake City. During the 1970s and early 1980s, WPX offered door-to-door less-than-truckload (LTL) freight service between Northern California points and Intermountain region points, utilizing trailers-on-flat-cars moving on Western Pacific trains for the line haul. The eastbound business for WPX was not imports; instead, much of it was small shipments from manufacturers and distributors in Northern California to retailers and project contractors in the Intermountain region. At Salt Lake City, WPX operated a trans-load facility where goods were de-vanned from the trailers that arrived by train, sorted, and re-loaded into smaller delivery trucks making rounds in the Intermountain region. WPX was able to undercut traditional LTL carriers by consolidating small shipments originating in Northern California into trailer loads and moving the loaded trailers on a train. Eastbound LTL traffic grew to a level of about 12 trailers per weeknight trans-loaded at Salt Lake City. When Union Pacific acquired Western Pacific at the end of 1982, its management decided to shut down WPX in order not to offend LTL companies utilizing Union Pacific intermodal service, as well as not to risk cannibalizing traffic handled in boxcars.

There are alternative initiatives to a trans-load facility UIPA could consider that would be beneficial to the citizens of Utah. First, land under the control of UIPA near the UP's Salt Lake City intermodal terminal is ideal property for locating the regional distribution center or on-line fulfillment center of a large retailer. Centers located further away from Salt Lake City entail

increased emissions and transportation costs. UIPA should encourage the location of such centers close to the UP intermodal terminal. In particular, retail chains that currently supply Utah and Intermountain region retail outlets from a regional distribution center located east of the Front Range in Colorado should be strongly encouraged to split the region and open a distribution center close to UP's Salt Lake City intermodal terminal. Second, specialized trans-loading facilities may be required to serve waterborne, containerized export traffic. For example, export grain is typically blown into a plastic bag inserted in the marine container. A suitable trans-loading facility would include a dumper for grain trucks and a blower mechanism to fill marine containers with dumped grain. Specialty minerals also may require special equipment for efficient bulk handling, perhaps trans-loading not just from trucks but also from rail cars. Third, diesel-powered lift equipment deployed at intermodal terminals generates a surprisingly large percentage of supply-chain emissions. Battery-powered or hybrid equipment is available that would sharply reduce emissions, but at much higher initial cost. While operating costs of battery and hybrid lift equipment are lower than for diesel-powered equipment, the initial cost at present is too great for operators of intermodal terminals to justify investment in them, unless terminal volume is exceptionally high. Public subsidy to help Union Pacific equip the Salt Lake City intermodal terminal with electric or hybrid gantry cranes could make a significant reduction in local emissions. Finally, Union Pacific is expanding its domestic rail intermodal terminal at West Colton, located in the heart of the Southern California Inland Empire warehousing district. Union Pacific should be encouraged to offer intermodal service to Salt Lake City from this terminal, as it would reduce emissions for imports trans-loaded at Inland Empire warehouses to domestic containers and destined to the greater Salt Lake City area by 7.5 – 9.5%, as well as make domestic rail intermodal more competitive with domestic trucking from the Inland Empire warehouses to Salt Lake City.

Introduction

The Utah Inland Port Authority has proposed the development of a trans-loading facility adjacent to the Union Pacific Railroad's intermodal terminal in Salt Lake City. It is envisioned that marine containers of imports entering through the Ports of Long Beach, Los Angeles or Oakland would move by train to UP's Salt Lake City intermodal ramp, then be drayed over to the UIPA trans-loading facility, where imports would be de-vanned from marine containers, sorted, and re-loaded into domestic trailers for re-shipment over highways. The facility also would be used to trans-load exports arriving at the facility in domestic vehicles and departing the facility in marine containers transferred to UP's intermodal ramp. I have been asked to evaluate this proposal in terms of the volume it can be expected to handle and the emissions associated with it. I was also asked to make recommendations concerning specific activities, investments and initiatives UIPA could pursue that would be economically viable and beneficial to the greater Salt Lake region.

Personal Background

I have been a member of the UC Berkeley faculty since 1979, teaching and researching supply chain management. I also serve as the principal of Leachman & Associates LLC, a consultant to governments and corporations worldwide concerning supply chain economic analysis, supply chain design, and supply chain management. Leachman & Associates prepared the first proposal

for what became the Alameda Corridor, a new 25-mile grade separated main line railroad serving the Ports of Long Beach and Los Angeles, and conducted the operational and environmental analyses supporting the environmental impact statement that enabled funding and construction of the Corridor. For a number of West Coast ports and other agencies, Leachman & Associates has conducted elasticity analyses of import volumes as a function of potential changes to port or government fees, transportation rates, transportation and logistics services, and infrastructure. Leachman & Associates also has formulated and analyzed plans to restructure supply chains for major American importers. Before joining the UC Berkeley faculty, I worked in marketing and transportation management at Union Pacific Railroad. Currently I serve as President of the Union Pacific Historical Society.

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.

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. 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 will depend on the relative magnitudes of shipping-related and inventory-related costs.

Table 1 provides a glossary of supply-chain acronyms and terminology used in this report.

Table 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.
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	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 rail 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 those in the trans-Pacific trade accommodate 2,700 cubic feet of cargoes.
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 the OEM companies who market such goods rather than by the OEM"s retailing customers. In such cases, the OEM carriers handle the international transportation. Once goods are purchased from the OEM by a retailer, further transportation is typically 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.
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 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).

Overview of Contemporary Far East – USA Import Supply Chains

Containerization and intermodal transportation dramatically lowered the costs of international shipping, enabling American companies to tap low-cost Asian manufacturing. The resulting 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. In 2015, there were about 15 million TEUs of containerized imports from the Far East, of which 51% passed through the San Pedro Bay ports, 33% passed through East Coast or Gulf Coast ports, and 16% passed through the 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 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.

[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.

Figure 1: Total Containerized Imports through US and Canadian West Coast Ports 1994-2015 (TEUs)

Sources: Port web sites.

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. 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, and they secure chasses and containers from the railroad.

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 (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.

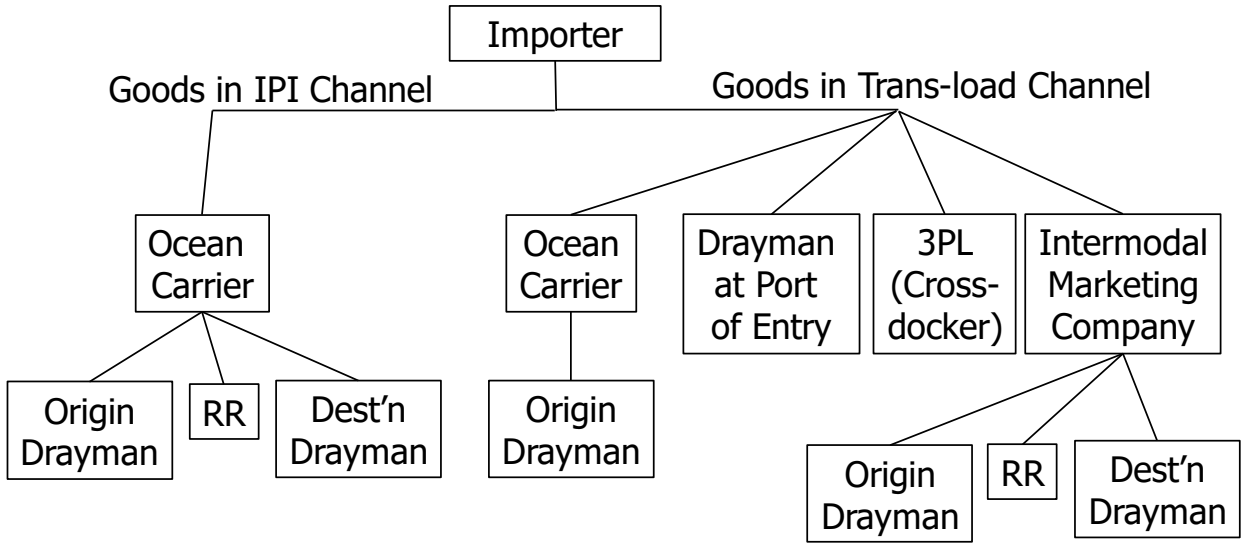

Figure 2. Contractors and Sub-contractors in Far East – USA Waterborne, Containerized Supply Chain

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 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.[2]

The average time until sale of goods is thereby reduced, ad, consequently, the average pipeline inventory is reduced, and the required safety stocks at RDCs are sharply reduced. Thus, this sort

[2] 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.

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 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.

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.

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[1] 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).

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)[3] 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 2 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 the volume, is electronics.

There are three important takeaways from Table 2. 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 much more of spare parts flowing to the dealer network and to auto parts retailers than of 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 different from the least costly supply chain for electronics, with declared values averaging about $59,000 per TEU.

Table 3 lists the top ten 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.

[3] PIERS-TI and GTA are commercial data service products of IHS Markit.

Table 2: 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).

Table 3: Far East – USA Waterborne Containerized Import Volumes by Importer

Importer	**2019 Volume in TEUs**	**% Share**
Wal-Mart	893,000	7.63
Target	600,000	5.12
Home Depot	400,000	3.42
Lowe's	292,000	2.49
Ashley Furniture	270,000	2.30
Samsung	181,000	1.55
Family Dollar/Dollar Tree	172,000	1.47
LG	156,000	1.33
Ikea	132,000	1.12
Nike	118,000	1.01
Subtotal, Top Ten	3,214,000	27.46
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,

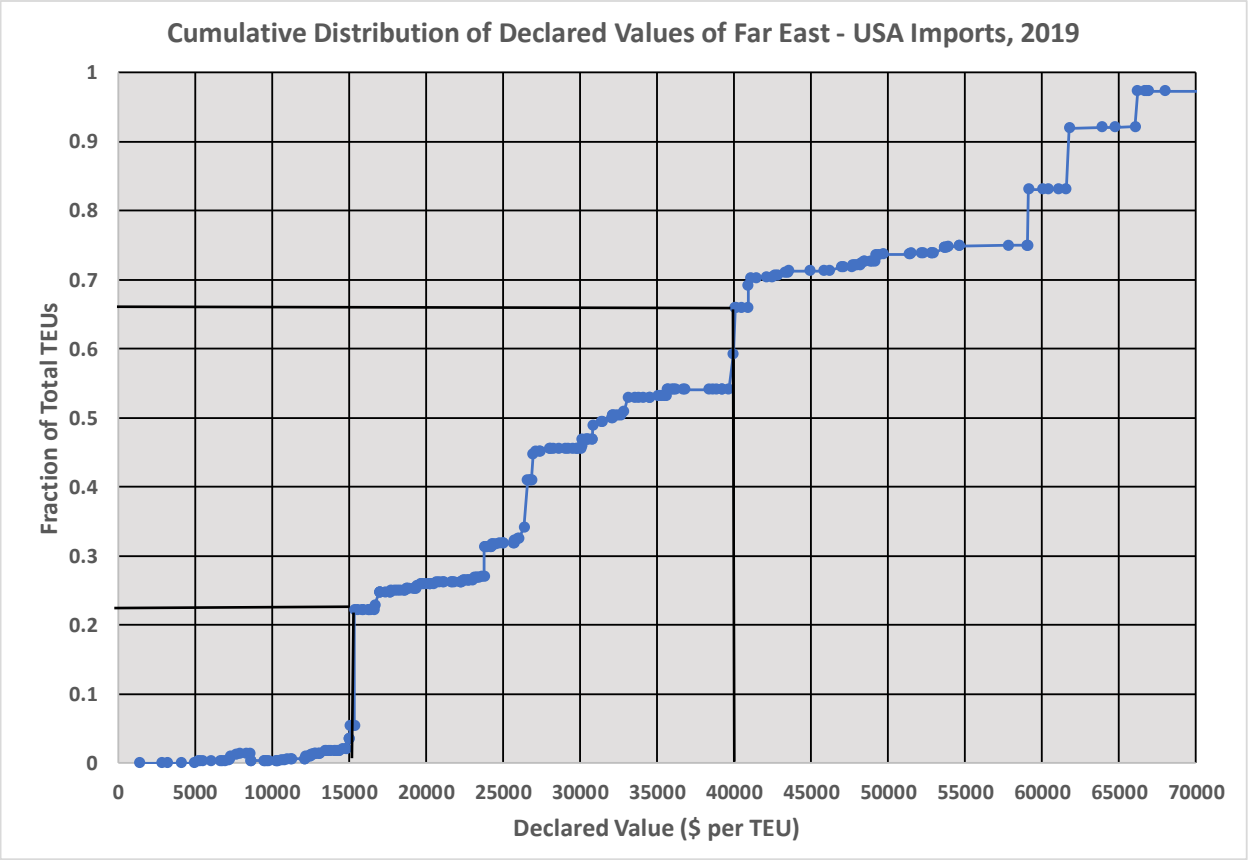


Figure 3: Value Distribution of 2019 Asia-USA Waterborne Containerized Imports

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

moderate-value and expensive, for reasons that will become clear below. Up to about $15,000 in declared 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 investment.

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.[4]

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

[4] 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.

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 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.[5] 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

[5] 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.

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 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.[6] Table 4 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.

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

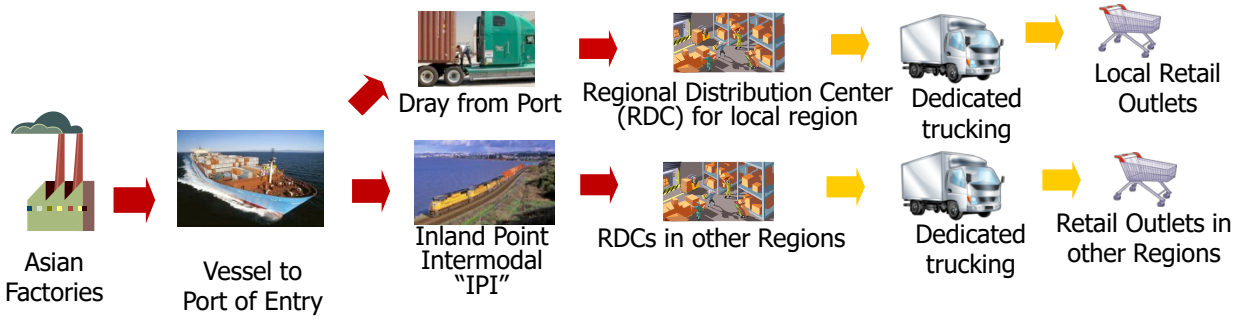


Figure 4: Push Supply Chain

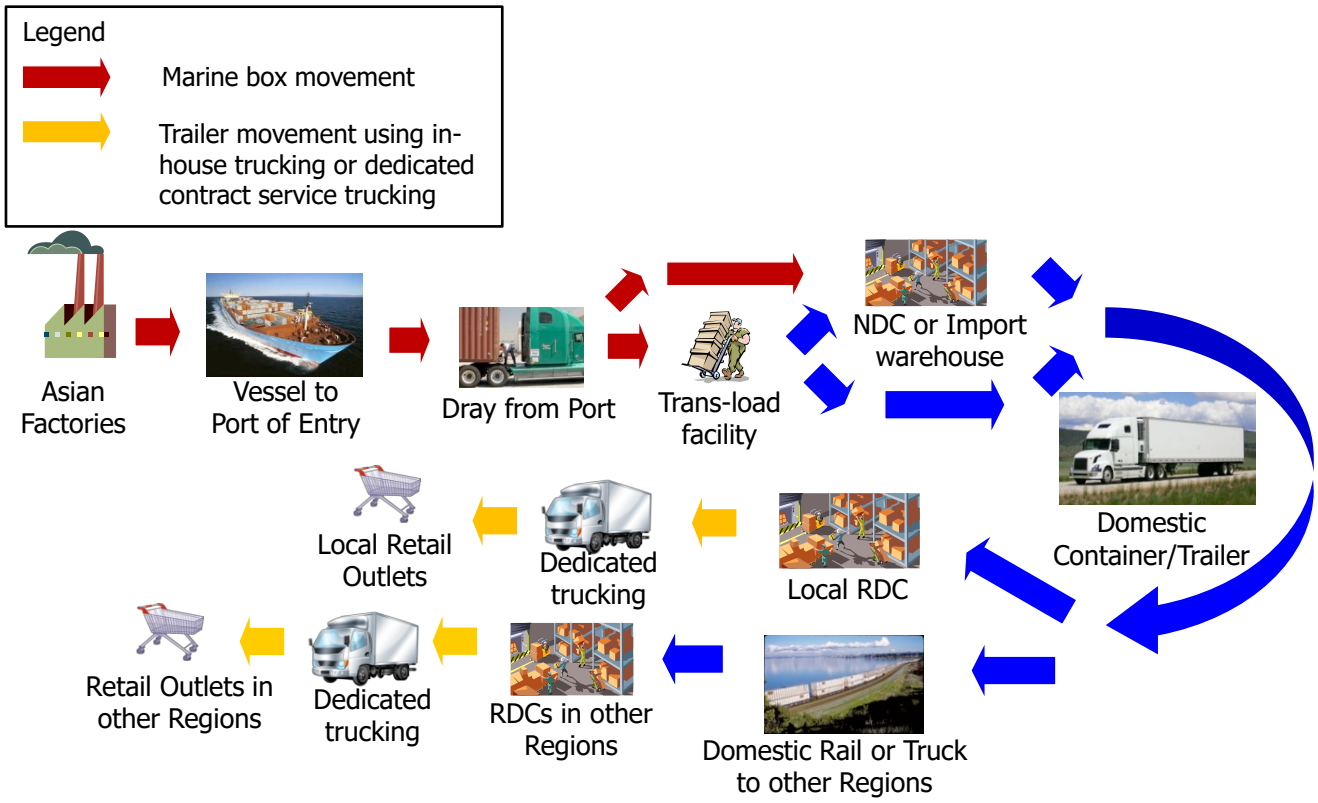
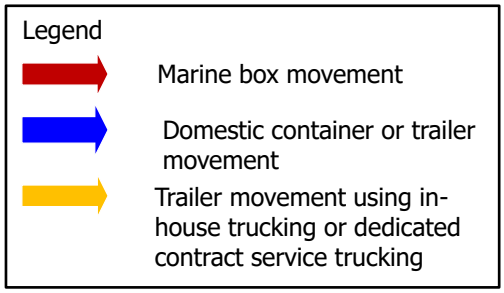


Figure 5: Push-Pull Supply Chain



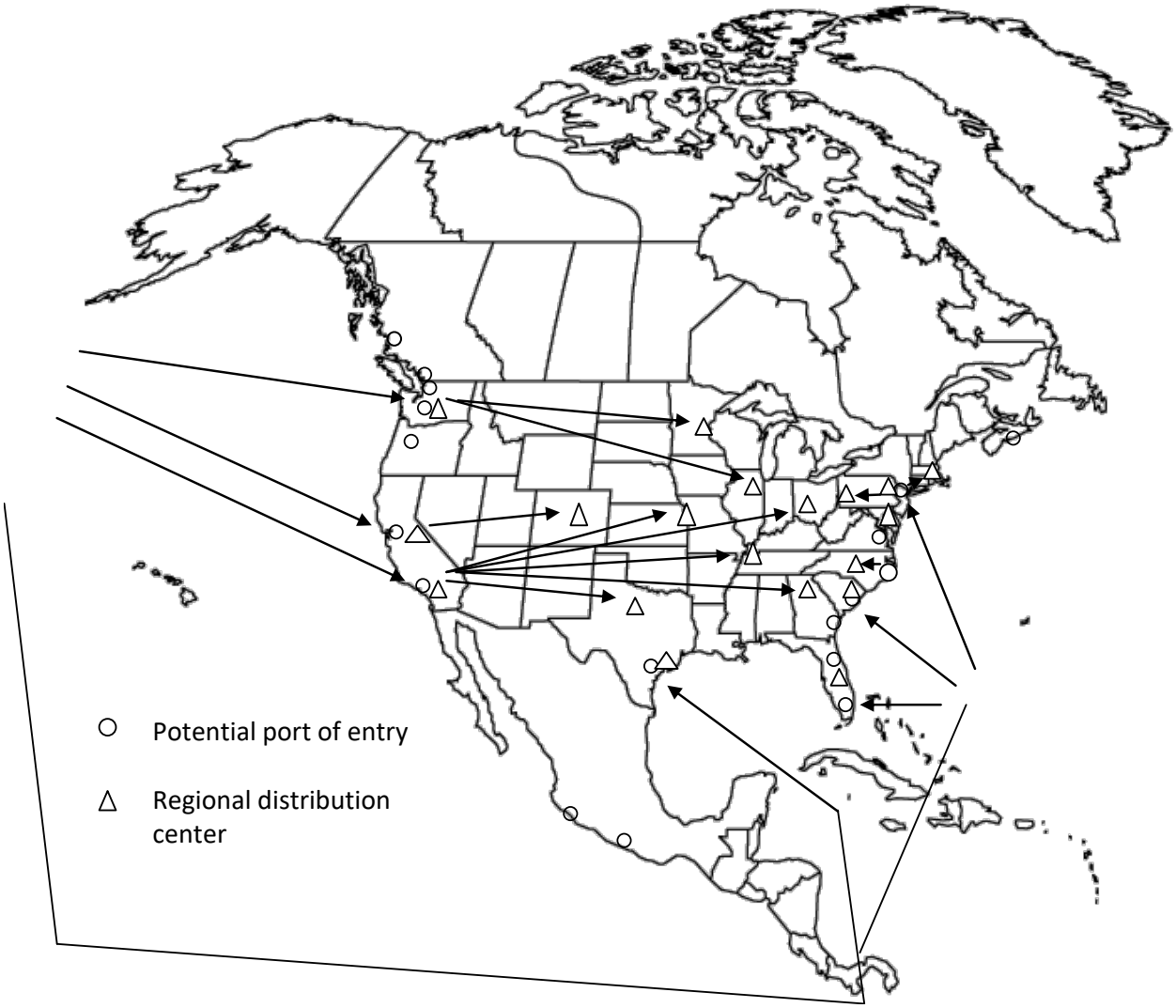


Figure 6: Push Supply-Chain Strategy

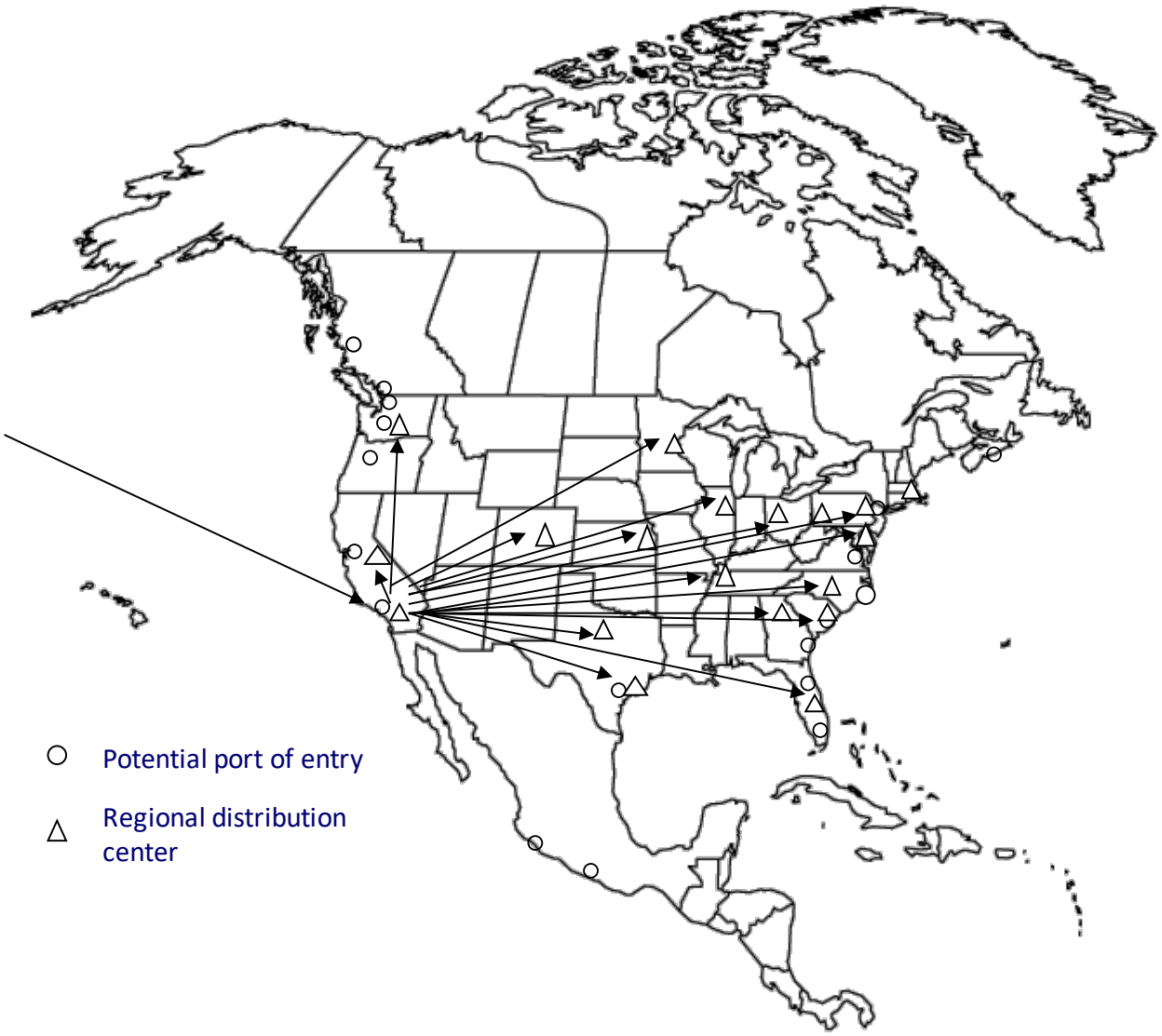


Figure 7: Push-Pull-All-at-San-Pedro-Bay Supply Chain Strategy

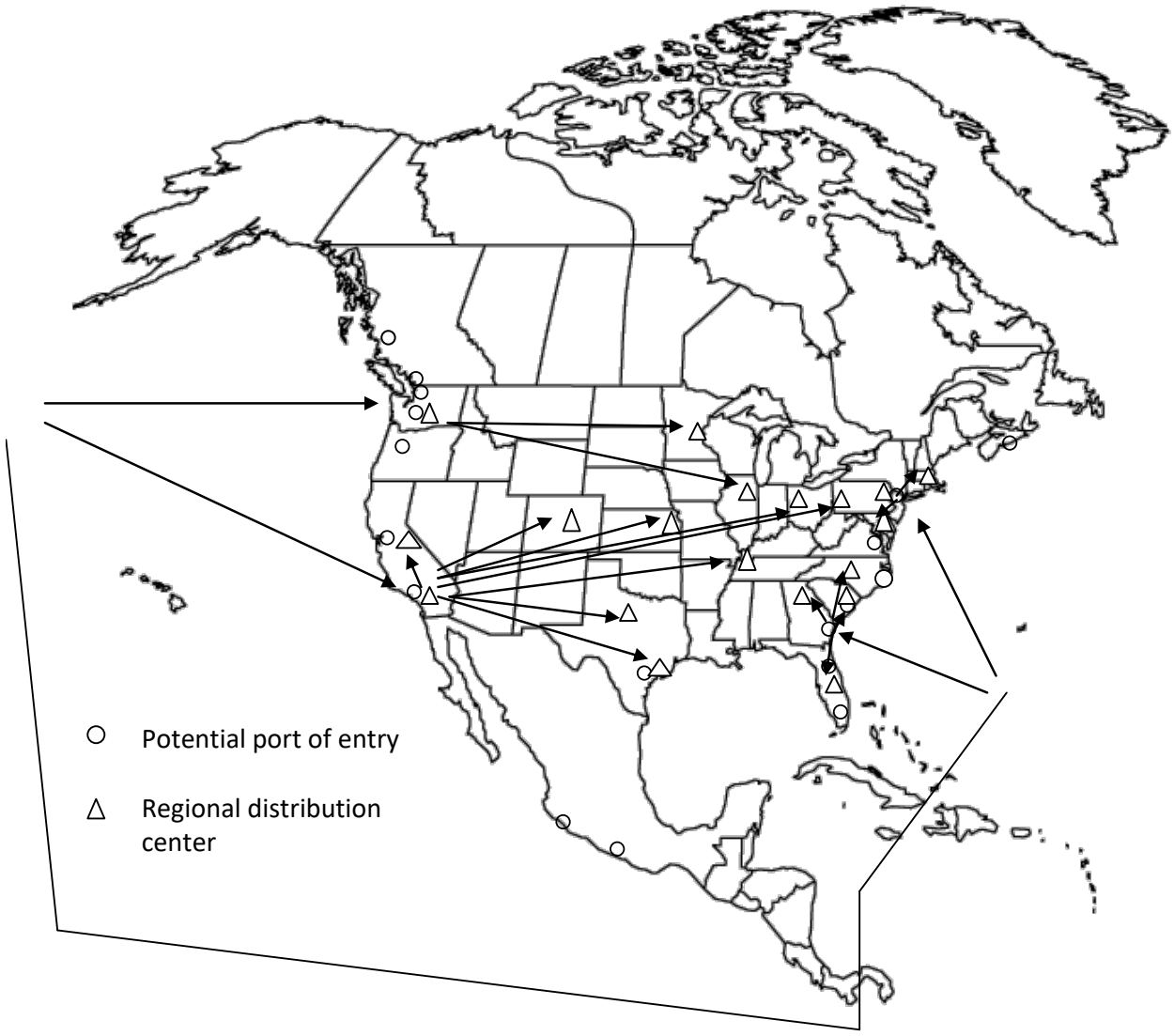


Figure 8: Four-Corner Push-Pull Supply Chain Strategy

Table 4: 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.

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 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

The most effective supply chain for a given importer depends on (1) whether the importer possesses the scale and 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 general distribution of supply-chain strategies calculated by the author in his research is summarized in Table 5. Push-Pull using Three, Four or Five Corners is practiced by large, nationwide retailers importing broad portfolios of goods with a moderate average declared value. Such strategies are used by large importers such as Wal-Mart, Target, and Home Depot. This segment accounted for approximately 31.25% of total imports in 2019. A Push-Pull 1 Corner supply chain is practiced by large OEMs importing expensive goods re-sold to retailers throughout the Continental USA, and the lowest-cost supply chain of this type is realized if the Corner is located at San Pedro Bay. We refer to such a supply chain serving this segment as Push-Pull-All-at-San-Pedro-Bay. This segment accounted for approximately 12.75% of total imports in 2019 and includes commodities such as electronics, fashion apparel, auto parts, and shoes.

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. The segment

Table 5: Supply Chains Practiced by Various Types of Importers

Push to RDCs	Push-Pull 3, 4 or 5 Corners	Push-Pull All at San Pedro Bay
One-time-sale Goods and inexpensive goods imported by Large, Nation-wide Retailers (11.6%)	Moderate-value goods imported by Large, Nation-wide Retailers (29.6%)	Imports of Expensive Goods by Large Original Equipment Manufacturers with nation-wide sales (12.8%)
Imports by Small and Regional Retailers, Contractors (46%)		

for which a Push supply chain is most suitable accounted for approximately 58% of total imports in 2019.

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. For the purposes of this analysis, excluding the imports drayed directly from the port to the local RDC, it is assumed the yearly average split of port volume is 36% to the import warehouse and 64% to the cross-dock. It is further assumed that 12% of the import volume is first routed to the cross-dock and then drayed from the cross-dock to the import warehouse for temporary storage before allocation to RDCs served by the San Pedro Bay Corner. (This 12% is included in the 64% routed to the cross-dock.)

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 2015 the split was 55% Push and 45% Push-Pull. That is, the share of Push-Pull climbed nine points over a decade. For 2019, as noted above, the estimates are 50% Push and 50% Push-Pull.

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.[7]

Brief History of Significant Utah Trans-loading Initiatives

There have been two very successful trans-loading initiatives in postwar Utah history: Freeport Center and Western Pacific Transport, discussed in turn below.

Freeport Center

In the small city of Clearfield, Utah, located along the east shore of Great Salt Lake about halfway between Salt Lake City and Ogden, sits a vast array of World War II-vintage warehouses that became known as the Freeport Center. Clearfield is not highlighted on maps of the United States, but Clearfield is a point of great significance in American supply-chain history. The synergistic combination of shrewd rate-making, excellent train service, generous warehouse capacity, high-quality distribution services, and no inventory taxes, coupled with aggressive marketing by the owners of the Center, enabled Freeport Center and Union Pacific Railroad to capture a disproportionate share of the distribution of eastern US manufactures among retailers up and down the West Coast and across the Intermountain region.

The complex of warehouses at Clearfield was constructed in 1942 by the U. S. Navy as a back-up supply point for the entire Pacific Fleet. On first thought, Utah might seem like a strange choice for a naval supply center. But, actually, it was a very wise choice. The Navy selected Utah for several reasons: (1) it was out of reach of potential Japanese air or water attacks,and, (2) it was unclear how the war in the Pacific would unfold, and therefore it was unclear what quantities of naval supplies would be needed at San Diego, Long Beach, Alameda (San Francisco Bay), and Pacific Northwest ports. Yet, from a Utah supply base, any of those ports were accessible. Clearfield is roughly equidistant to Portland/Seattle, San Francisco, and Los Angeles/San Diego, with main-line rail connections to all of those points. (3) Regardless of how the war unfolded, there would need to be at least some naval presence in all the ports on the

[7] The rise in IPI rates also promoted 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.

Pacific Coast, and so supplies would be requisitioned at all ports up and down the Coast. Many supplies were essentially spare parts, and it was impossible to predict which ships based at which ports would end up with combat damage. In lieu of maintaining separate inventories at each port or naval base, maintaining a centralized inventory at a single point would sharply reduce the likelihood of shortages of items with irregular or unpredictable demands, as well as economize on the total production needed to support the naval war effort.

On a 700-acre site at Clearfield, the federal government built 9.2 million sq. ft. of industrial buildings (almost all warehouses), 27 miles of paved roads, and 37.5 miles of railroad trackage, including classification yards able to accommodate up to 750 cars. It served the war effort very well. After World War II, activity at the Clearfield naval supply center diminished, until by the end of the 1950s, it was largely dormant.

In June, 1963, the complex was sold by the federal government to the highest bidder. The reasons why Clearfield became attractive for use in industrial distribution in the 1960s were similar to why it had been attractive to the Navy in World War II: the economies and efficiencies of utilizing a single stockpile serving the entire West Coast. The new owners christened their purchase the Freeport Center and incorporated themselves as Freeport Center Associates.

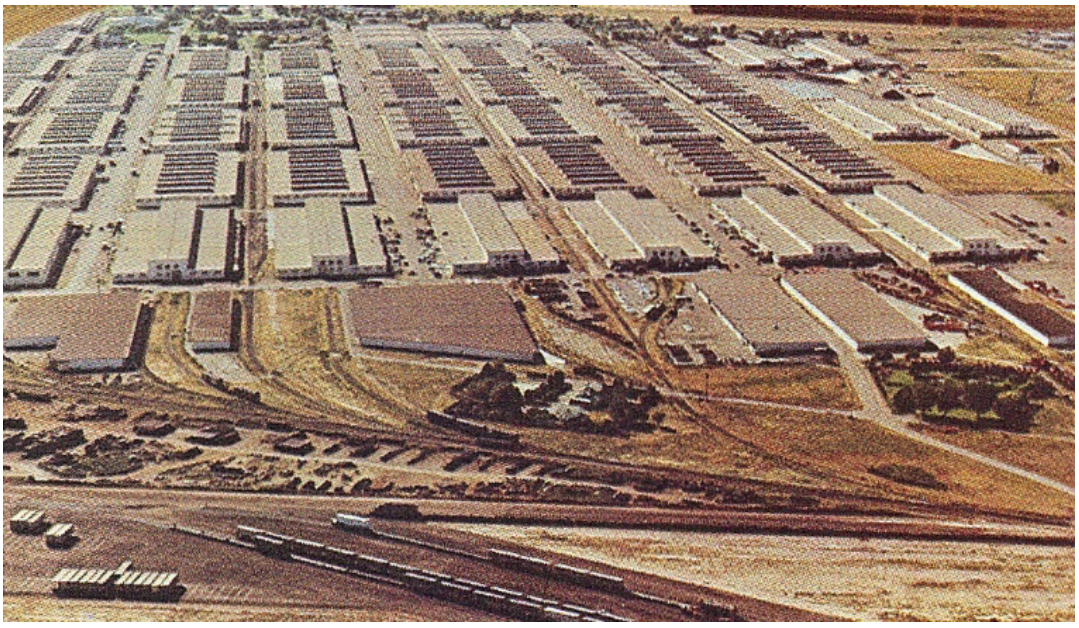


Figure 9. Aerial View of the Freeport Center

Even before the sale, a number of companies had approached the federal government for permission to use the Center's empty buildings for commercial distribution. Westinghouse

Electric, Del Monte Foods, Hercules Powder, Sperry Rand and others persuaded the government to allow them to conduct distribution activity using warehouses at Freeport.

Significantly, Westinghouse had worked with Union Pacific to develop a number of advantageous rail tariff provisions. Westinghouse sought and obtained provisions for transit credit on a weight basis for its appliances and other items trans-shipped through the Freeport warehouses. The provisions also allowed free interchanging of inbound boxcar freight into piggyback (intermodal) trailers used in outbound moves from Clearfield. These and related tariff provisions became instrumental in attracting additional occupants to the Center.

In managing its supply chain, Westinghouse made use of the tariffs as follows. Boxcars were loaded at the company's eastern production facilities with appliances as they came off the company's assembly lines. One factory loaded refrigerators, another loaded stoves, another loaded washers and dryers, etc. These carloads were dispatched to Clearfield and unloaded where the goods were temporarily stored. As orders from West Coast and Intermountain dealers and retailers were received, mixed carloads were built at Clearfield consisting of any and all types of appliances produced at Westinghouse's various production facilities. For each type of appliance, Westinghouse would pay the railroad a freight bill, computed on a weight basis, as if full carloads of that appliance had been shipped from the Westinghouse factory direct to an appliance dealer or retailer on the West Coast, even though the dealer may have ordered as little as 1/4th carload of that particular appliance as part of his overall carload order. The carload shipment of that particular appliance from the origin factory to Clearfield might have ended up being spilt into as many as four different boxcars traveling from Clearfield to four different West Coast destinations. In addition to the through-freight charge there was a modest trans-loading charge. Dealers and retailers were happy with the arrangement, as they could order less-than-carload quantities of each appliance from Westinghouse yet Westinghouse could price based on the full-carload rate on each appliance in lieu of more expensive less-than-carload (LCL) rail shipping, trucking or express shipment. This saved Westinghouse between half and 2/3rds of the transportation bill.

In that era of rail regulation, every published rail rate had to be made available to any shipper seeking to use the specified origin, destination and trans-loading point. Thus, the rail rates developed for Westinghouse by Union Pacific were immediately available to any new tenants moving into Freeport Center.

Concurrent with the sale of the Clearfield "Navy Base", certain Utah legislators and private groups sought to remove inventory taxes. Specifically, they wanted to abolish inventory taxes on goods warehoused within the State of Utah destined for sale outside the state. This was finally accomplished by a statewide referendum in 1964. The "Freeport Law", as it came to be known, made Freeport Center even more attractive to industry. A company warehousing a ten million dollar inventory in California, for example, paid about $400,000 annually in inventory taxes. By relocating this inventory to Freeport Center, this expense could be eliminated.

After purchase of Freeport Center, the new owners could boast they had the world's largest privately owned distribution center. But with that endowment came considerable responsibility. They immediately inherited all the expenses for utilities, maintenance, and security for the vast complex. So, the new management began a crash program to secure tenants for the many empty buildings. Fortunately, Westinghouse, in its pioneering effort, had developed and proven the concept of efficient appliance distribution to West Coast markets from Freeport. All major American appliance manufacturers were approached by Freeport Center Associates and Union Pacific. The manufacturers were asked to review a distribution plan utilizing Freeport and compare it to their existing program. Most immediately grasped the advantages, and redesigned their supply chains around a Freeport Center distribution point.

Before Freeport, appliance manufacturers and other eastern manufacturers marketing on the West Coast maintained inventories at distribution centers in the Los Angeles Basin, the Bay Area, Portland or Seattle, and typically one other location somewhere in the Intermountain region. Utilizing Freeport Center and the storage-in-transit rates provided by Union Pacific, these warehouses could be eliminated and replaced with one central inventory point in Freeport supplying all West Coast appliance dealers and retailers. Typically, total supply chain inventory for a participating appliance manufacturer was reduced by $1/4^{th}$ to $1/3^{rd}$ and its capital costs for distribution facilities reduced 6 – 10%. But the benefits did not stop there. The centralization of inventory enabled a reduction in stock-outs of items with irregular or occasional sales and thus increased the manufacturer's sales to dealers. This was because a larger stock of an item with irregular demand could be carried in the single centrally located inventory than was affordable to be simultaneously carried at the several smaller-market warehouses.

With excellent rail service, substantial inventory advantages, and reduced transportation costs, Freeport Center quickly became the "Appliance Capital of the West." Nearly every US manufacturer of household appliances changed its Western USA distribution pattern and moved lock, stock and barrel to Freeport Center.

Following this success in the appliance business, other industries were approached by Freeport Center Associates and Union Pacific. In particular, the farm implement manufacturers were intrigued by the distribution advantages the appliance makers were enjoying. Though the products were quite dissimilar, the distribution patterns were similar and the potential distribution economies were comparable. Before long, four of the six large USA implement companies had leased space and located centralized distribution warehouses at Freeport Center. Manufacturers of foodstuffs, toys, clothing, rubber products, and other goods produced in the eastern US followed suit.

Public warehousing services also became interested in serving customers using Freeport Center, hoping to extend the supply chain economies achieved by large manufacturers to smaller manufacturers. Three public warehousing firms leased space in Freeport Center and made use of the trans-loading and storage-in-transit rates from UP on behalf of their clients. Collectively,

these companies leased almost 3 million square feet of warehouse space, providing warehousing and trans-loading services for more than 60 corporate clients.[8]

Distribution of eastbound goods using Freeport Center also developed. Del Monte had been an early pioneer at Freeport Center, leasing space before the federal government privatized the site. Eventually, Del Monte was able to stock its full line of canned goods at Freeport Center, including salmon from Alaska, fruit cocktail from Oregon, potatoes and onions from Idaho, peas from Utah, and tomatoes from California. Wholesaler customers of Del Monte could order a single carload including cases of canned goods spanning Del Monte's complete product line, avoiding the need to purchase whole carloads of individual products and thereby reducing transportation costs, reducing inventories and better matching their supplies to retail demands. Plywood, dimensional lumber stock, canned tuna fish, olives and other California food products also were stored and trans-loaded in Freeport.

The huge Clearfield volume enjoyed by Freeport Center Associates and Union Pacific eventually eroded. It was not so much brought down by other distribution centers and carriers offering a superior transportation/distribution product; instead, it was primarily a victim of changes in distribution patterns, notably, the off-shoring of manufacturing from USA to Asia and Mexico. U.S. production of appliances and other goods declined beginning in the 1980s, and this decline accelerated through the 1990s and thereafter. In the case of GE, employment at Appliance Park, KY, reached a peak of about 23,000 in 1973. After the 1980-1981-1982 recession, employment was down to 11,800. In 1982 GE sold its air conditioning business. In 1987 GE formed joint ventures to manufacture appliances in Mexico and China. By 1999, Appliance Park employment was down to about 4,200. Other U.S. appliance manufacturers gradually shifted their production out of the U.S.A, as well.

Another change working against Freeport Center was the shift in retailing from small and mid-size specialized dealers to large, broad-scope nation-wide chains operating "big-box" stores. Supply chain shipments were increasingly arranged by the large retailers rather than by the manufacturers.

In response to these changes, attempts were made to promote Freeport Center as a distribution point for goods imported from Asia through West Coast ports. An intermodal ramp was opened at Clearfield, and advertising images appeared showing Sea Land marine containers on site. But in this case, supply-chain economics worked against Freeport rather than in favor of it.

When sourcing goods from an Asian factory, a large American retailer faces the choice of whether to pre-allocate the imported goods to USA regions before booking vessel passage or keep its imports consolidated until after they pass through the port of entry. When pre-allocating goods to USA regions before shipment from Asia, marine containers can be moved intact from Asian factory to inland USA regional distribution centers (RDCs). The lowest possible

[8] Nowadays, firms providing such services are termed "third party logistics" firms, or "3PLs" for short.

transportation and handling cost is thereby realized. But with the long lead time to book vessel passage and ship from Asia, it is difficult to manage inventory tightly in such a supply chain. This kind of supply chain is termed a "Push" distribution system, because goods are sent to each RDC whether or not the stores in its region are ready to sell those goods. It is thus best suited for low-value goods (whose inventories are relatively inexpensive) and for goods with one-time or seasonal sales (e.g., patio furniture, back-to-school personal refrigerators, Halloween costumes).

When imports are kept consolidated until they pass through the port of entry, then there is the opportunity to re-allocate the goods to better match regional demands. Upon vessel arrival at port of entry, the inventory status and sales activity across the regions can be assessed, and the best allocation can be deduced. In such a supply chain, imported goods arriving in marine containers are assigned inland destinations and trans-loaded near the port of entry into domestic containers or trailers for inland movement; if there is a surplus of imports compared to current demands, the surplus can be held in a warehouse until demand materializes at some RDC in lieu of "pushing" the goods on one or several RDCs. This sort of supply chain is thus termed a "Push-Pull" distribution system, because goods are pushed from Asian factory only as far as the port of entry; beyond there, goods move to RDCs only if and when their inventories are depleted, i.e., when demand "pulls" them. In this way, inventories are managed much more tightly, albeit for somewhat increased shipping and handling costs. A Push-Pull supply chain is the best choice for moderate-value and high-value goods with on-going demands, such as appliances.

An import distribution system making use of Freeport Center to distribute goods to be sold in eastern and midwestern regions would have to separate goods to be sold on the West Coast from those to be handled through Freeport. To avoid redundant shipping, this would need to be done in Asia or at the West Coast port of entry. Thus, using Freeport Center for imports would require double-handling. For high-value imports, using Freeport Center does not achieve inventory savings as great as achieved by Push-Pull supply chains based on a hub in Southern California, because there is no possibility of centralizing inventory of goods to be sold in the huge Southern California market with goods to be sold inland. Moreover, transportation costs from Asia via Southern California to destinations like Arizona, Texas and the Southeast are much lower than via Utah.

Nowadays, the vast warehouse parks in the Inland Empire of Southern California are the contemporary equivalents filling the role played by Freeport Center in earlier decades, efficiently handling imported appliances and other goods much the same way Westinghouse Electric handled them five decades earlier. Technical details of shipping have changed, e.g., inbound shipments are made in 40-foot marine containers and outbound shipments in 53-foot domestic containers rather than boxcars, but the supply chain design and the efficiencies achieved are much the same.

It is fair to say that Freeport Center served as the hub of the first great American transcontinental Push-Pull distribution system. Today's efficient supply chains for imports from the Far East emulate the innovations developed at Freeport two generations ago. Sadly, as manufacturing in

the Midwestern and Eastern part of the USA was replaced by manufacturing in the Far East, Freeport Center lost favor and today is a relatively insignificant player in international supply chains.

Western Pacific Transport

With the notable exception of the appliances and farm implements handled through Freeport Center, over the course of the 1970s most westbound merchandise freight moving via rail converted from movement in boxcars to TOFC (trailer on flat car, the early name for rail intermodal). Westbound merchandise traffic was generally "cube freight" (if stackable) or "floor freight" (if not) that ran out of space in a boxcar or a trailer before the weight capacity of the vehicle was reached. On the other hand, eastbound freight traffic on the railroads included considerable "weight freight" such as lumber, paper, plywood, and canned goods. Two or three truckloads of such commodities could be accommodated in one boxcar, and so such eastbound rail traffic was resistant to shift to trailers. This put the western US railroads in the awkward position of running trainloads of empty trailers eastbound while running trainloads of empty boxcars westbound.

John J. Gray joined the management of Western Pacific Railroad in 1972 and sought to address this problem. Western Pacific operated from various Northern California points to connections with Union Pacific and Rio Grande railroads in Salt Lake City. It seemed to Gray that a continuing transition of rail traffic into intermodal movement was inevitable, and so to improve profitability, something had to be found to fill the eastbound empty trailers. Ideally, this should be done without cannibalizing the profitable movement of canned goods, plywood, lumber, etc. in boxcars.

Gray discovered that there was a significant volume of LTL (less-than-truckload) freight moving from Northern California producers and distributors to retailers located in the Intermountain region. LTL rates were (and are) higher than truckload rates, but the typical Intermountain retailer did not have enough sales to warrant truckload-sized replenishments of inventory.

Gray organized the Western Pacific Transport Company, an LTL carrier, as a subsidiary of the railroad. Trans-load centers were developed at Oakland, CA, and Salt Lake City, UT, and WPT invested in a fleet of small pick-up and delivery trucks. Gathering small shipments originating in the greater San Francisco Bay Area, the shipments would be consolidated into trailers at the Oakland trans-load center. The loaded trailers were handled in a dedicated intermodal train operating from Oakland to Salt Lake City symbolled as the TOF (short for trailers on flat cars). At Salt Lake City, the trailers were drayed to the WPT trans-load center where the shipments were de-consolidated and loaded into WPT delivery trucks. In this way, WP Transport, later renamed WPX, offered merchandise shippers door-to-door service while using the railroad for most of the line haul. The trailers emptied at the Salt Lake City trans-load center were delivered to Union Pacific or Rio Grande for continued movement east as empties.

Taking advantage of the economies of rail movement Oakland – Salt Lake City, WPT undercut other LTL trucking companies and captured the largest share of Northern California – Intermountain LTL freight traffic. The nightly TOF train grew to a train of 100 trailers, about 20 of which contained WPT LTL traffic. About 12 trailers per day were de-vanned at the Salt Lake City trans-load center for local delivery in the Intermountain region. Another 8 trailers per day were hauled to Denver by the connecting Denver, Rio Grande and Western Railroad, whose LTL subsidiary Rio Grande Motorways operated a trans-loading facility in Denver. Gray was promoted to positions of President of WPX and Senior Vice President – Intermodal of the railroad.

When Union Pacific acquired Western Pacific at the end of 1982, Gray proposed expanding his LTL service network further east. However, UP rejected the WPX door-to-door, "retail" business model. UP management feared that the WPX business model offended the railroad's LTL trucking company customers and its traditional, wholesale intermodal customers,[9] as well as potentially displacing more profitable boxcar movement of eastbound freight traffic. Gray did not join UP management. Shortly after the merger, WPX was dissolved and the trans-load centers were sold off and repurposed.

Pre-Pandemic Import Volumes to the Intermountain Region by Channel

Considering the distribution shown in Table 5, 2019 imports flowing to the Intermountain Region can be classified by transportation channel as follows:

30%: moderate-value goods imported by large, nation-wide retailers in 3[4][5] Corner Push Pull supply chains. These goods moved in domestic containers on rail or in domestic trailers trucked from the Los Angeles Basin to Salt Lake City.

12%: low-value goods and one-off goods imported by large, nation-wide retailers in Push supply chains. These goods moved in marine containers on rail to Salt Lake City.

13%: expensive goods imported by OEMs via the San Pedro Bay ports, then re-sold to retailers (both large and small) and re-shipped in domestic containers or trailers to Intermountain Region distribution centers operated by the retailers, located either in the greater Salt Lake City area or the greater Denver area. Some such shipments were made via truck in 53-foot trailers, and some were made in domestic containers via rail.

46%: imports by small and regional retailers. These goods predominantly moved in marine containers on rail to Salt Lake City. Some urgent shipments may have been made via truck.

Ignoring the urgent shipments made by truck, we see about 58% of imports arrived in the Intermountain region in marine containers and 42% of imports arrived in domestic containers or trailers. The IPI volume would have come from either the San Pedro Bay Ports or from the Port

[9] These wholesale customers were Shippers' Agents who retailed the door-to-door transportation and purchased line haul transportation from the railroads, similar to the role played by contemporary IMCs.

of Oakland (at the discretion of the ocean carriers), while the domestic-box-rail and domestic-trailer volume would have come predominantly from the Los Angeles Basin, with perhaps a minor amount from Oakland.

Impacts of the Pandemic

The 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 10. 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. Since March, 2021 retail sales have been 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 11. 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, to the present, they have been 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

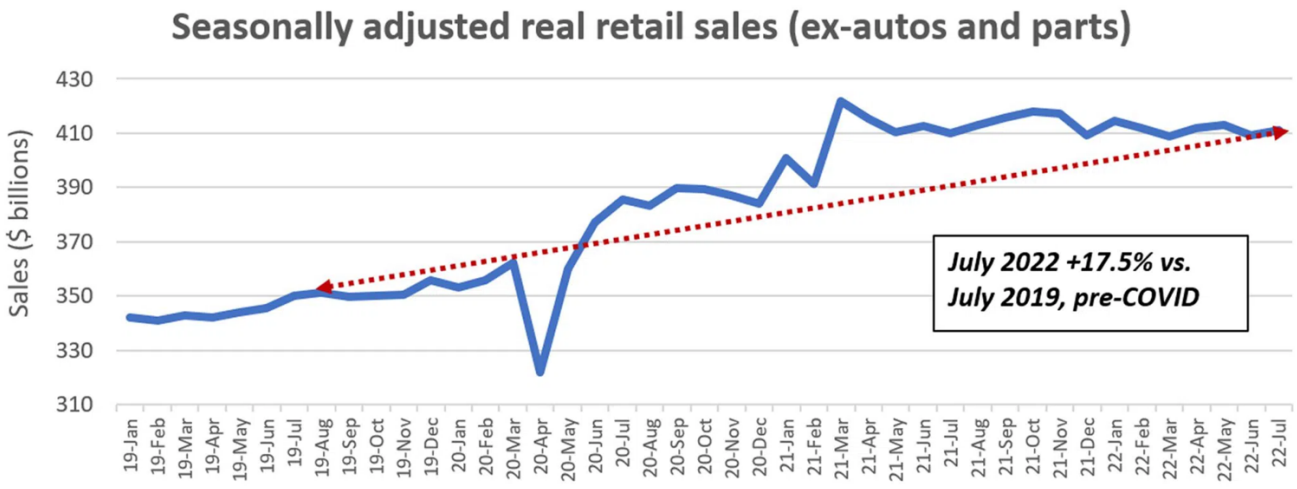


Figure 10. Monthly USA Retail Sales, 2019 - 2022

Sales figures shown are inflation-adjusted to 2019 dollars.

Source: *American Shipper*

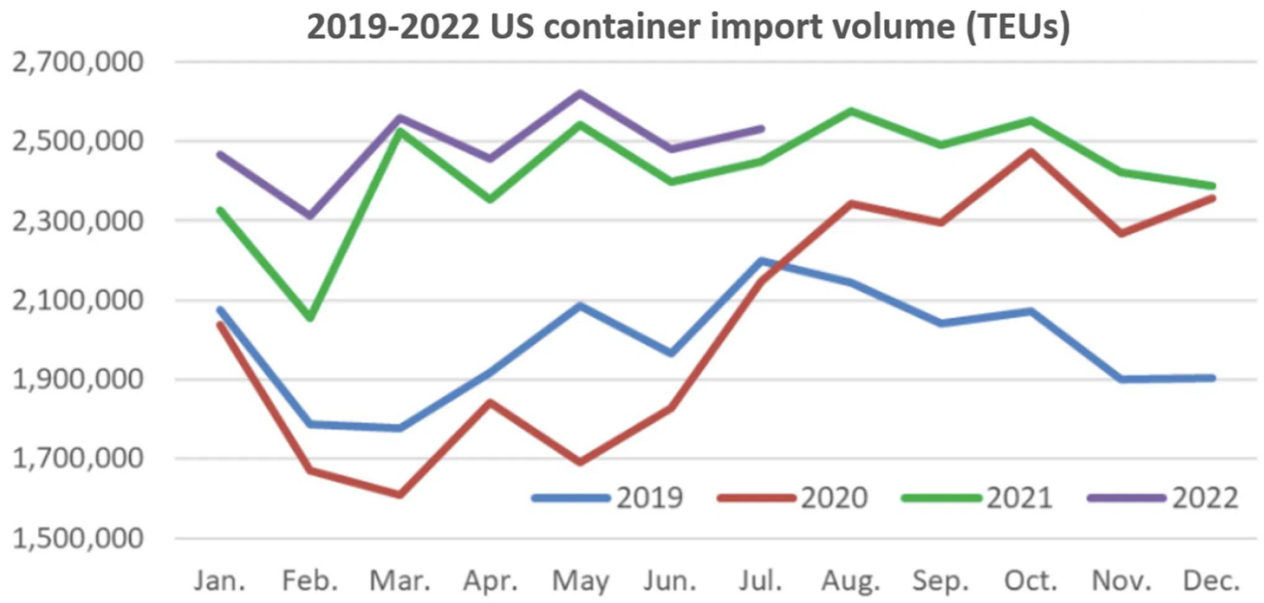


Figure 11. Monthly Waterborne Containerized Imports to the USA, 2019 - 2022

Source: Descartes Datamyne

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.

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. In recent months, as many as 20 loaded marine container trains have been holding at one time at the San Pedro Bay ports for lack of train crews.

While at present the queues of vessels awaiting unloading and piles of containers awaiting dispatch are somewhat reduced from pandemic peaks, they are still way above pre-pandemic levels at West Coast ports. Retailers have been desperate to get imports in any way they can, 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 have been 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. As this is written, rail unions are threatening a strike and will surely be getting higher wages and benefits (and perhaps improved working schedules). Serious inflation, so long dormant in the USA, has returned.

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

Eventually, if the pandemic should pass, a larger share of consumer spending will once again be allocated to dining, entertainment and travel, and the ports, railroads and warehouses will catch up on their backlogs.

Investments based on the extraordinary level of imports or based on diversion of imports to channels that serve as temporary expedients during the pandemic seem ill-advised.

Current Rail Volumes of Imports to Salt Lake City

Union Pacific advises the author that in the first 24 weeks of 2022, total intermodal volume from West Coast origins to Salt Lake City was about 25,000 units. About 75% of this volume was marine boxes, and 25% was domestic. Of the domestic volume, about 50% was premium customers (parcel and LTL carriers), and 50% was IMC shipments of 53-foot containers. Of the marine box volume, about 75% came from the San Pedro Bay ports and 25% came from Oakland. Almost all of the domestic-box volume came from the Los Angeles Basin.[10]

If volume is sustained at this rate for the remainder of the calendar year, it would amount to 40,650 marine boxes (about 782 per week) from the San Pedro Bay ports, 13,550 marine boxes (about 261 per week) from the Port of Oakland, and 18,100 domestic boxes (about 347 per week) from the Los Angeles Basin.

Assuming 100% of the marine-box import volume to Salt Lake City moved by rail, the 25% share for domestic-box intermodal to Salt Lake City suggests that about 44% of the volume of imports destined to Salt Lake City that was trans-loaded out of marine containers in the Los Angeles Basin moved by rail to Salt Lake City, and the other 56% was trucked in domestic trailers.

In general, rail intermodal service is provided in corridors at least 600 miles in length. Shorter hauls render intermodal service unprofitable for the railroads if priced at rates competitive with trucking, considering the costs of mechanized terminals lifting boxes one by one between railroad well cars and trucking chasses at either end of the rail haul. As the distance grows, rail intermodal service becomes increasingly attractive. Imports made at West Coast ports destined to points east of the Rockies predominantly move by rail, but to closer destinations, highway trucking has a more significant or dominant role.

At present, the only rail intermodal terminals in the Los Angeles Basin serving Salt Lake City are the on-dock rail terminals at the San Pedro Bay Ports (IPI shipments only) and the Intermodal Container Transfer Facility (ICTF for short, handling both IPI and domestic container shipments), the latter located just outside the Ports. While imports cross-docked in the vicinity of the SPB Ports for immediate re-shipment are efficiently handled through the ICTF, imports handled through OEM or nation-wide-retailer warehouses located in the Inland Empire district of Southern California require a 50-80 mile dray back almost to the Ports in order to use rail intermodal service to Salt Lake City. Thus, a 56% domestic trucking share of imports trans-loaded in the Los Angeles Basin and re-shipped to Salt Lake City warehouses is not surprising.

The Economics of Trans-loading

[10] Private communication from Union Pacific.

The vast majority of containers hauling goods manufactured in the Far East to the United States are loaded at a single factory and thus contain a very narrow variety of goods. For most retail goods, it would take many months of sales at a particular retail outlet to exhaust one import container of goods. For some imported retail goods, it would take many months for an entire region (as in Table 4) to exhaust the supply of one container. To reduce the time until the goods can be sold, it is desired by large nation-wide retailers to de-van import containers in the hinterland of the port of entry and spread them out across regions so they can be sold much more quickly without having to discount prices to clear old stock. To fill domestic trailers and containers to capacity, a large number of marine containers containing a wide variety of goods from many different factory origins need to be routed simultaneously to a single cross-dock, in turn requiring the cross-dock to be sized to handle such volume. This drives the inventory economics underlying trans-loading.

There are no pallets used for waterborne, containerized cargoes coming from the Far East to the USA. With the exception of electronics, goods are not shrink-wrapped nor placed on slip sheets. To maximize the imports accommodated in each container, the containers are entirely filled with loose cartons that must be unpacked carton-by-carton by hand. As a result, trans-loading is not cheap. As of 2015, the typical charge to large-volume importers by 3PLs for cross-docking steady volumes under annual contract was $400 - $450 per forty-foot marine container, more for small-volume importers and for spot work. Confidential trucking rates in 2019 for sustained contract volumes from large importers averaged about $2.20 per mile for both marine container and domestic trailer movements.[11]

Trans-loading the contents of three 40-foot marine boxes into two 53-foot trailers thus costs $1,200 - $1,350, probably more given recent inflation. To justify trans-loading solely on the basis of truck transportation savings (i.e., two truck trips instead of three) requires transportation over distances on the order of 500 miles or more, and there have to be sufficient import volumes so that full truckloads to the desired destinations may be dispatched. Most imports assigned to the Intermountain region are shipped by the retailers to warehouses in the greater Salt Lake City area or the greater Denver area before final shipment to retail outlet (brick-and-mortar sales) or directly to the customers (on-line sales). Given the proximity of rail intermodal ramps at Denver and Salt Lake City, there is no value to such retailers afforded by trans-loading facilities in Salt Lake City. Only those with a known, committed need for truckload quantities of particular imports at very distant points could benefit from such a service.

Let us now consider the value of the proposed trans-loading facility to the various importer types discussed above. For the moment, assume there is no change from the distribution regions displayed in Table 4.

[11] A handful of automated cross-docks exist on the West Coast, including a facility operated by Maersk Logistics in Wilmington, CA, and one operated by J C Penney in Lathrop, CA. A network of conveyor belts connects the doors where inbound marine containers are spotted and the doors where outbound domestic containers and trailers are spotted. Computers read the bar code on a carton and align switches in the conveyor network to route the carton to the correct outbound door. Such a facility still requires workers present in every inbound and outbound vehicle, presenting inbound cartons to the conveyor system by hand and hand-stacking cartons in the outbound vehicles.

For importers practicing 3[4][5] Corner Push-Pull supply chains: They desire all of their imports retailed in the Intermountain region to be routed through their RDC serving the Intermountain region. They have an internal or DCS fleet of trucks that will re-stock their retail outlets with their entire product line from this RDC. Given this sunk investment, they do not desire to pay for additional, separate transportation. The lion's share of their imports are de-vanned in the Los Angeles Basin and re-shipped to the Intermountain region in domestic containers or trailers. Only their one-time-sale and low-value items move in IPI service from the San Pedro Bay ports to Salt Lake City. If the RDC is located in the greater Salt Lake City area, it does not pay to trans-load such imports from marine containers to domestic trailers, because the remaining mileage is too short to recoup the trans-loading costs. If their RDC is located in the greater Denver area, it is cheaper to send the imports in IPI service to Denver than to send them in IPI service to Salt Lake City, trans-load them, and then truck to the RDC on the other side of the mountains. Thus a trans-loading facility in Salt Lake City is not a value proposition for such importers. This category accounts for about 40% of imports.

Similarly, imports moving in 1 Corner Push-Pull supply chains also move from the Los Angeles Basin to the Intermountain region in domestic containers or trailers. (Once unloaded from marine containers by the importing OEM, they cannot be re-loaded in marine containers, which are reserved for international transport.) A trans-loading facility in Salt Lake City is not useful for such imports. This accounts for about 20% of total import volume.

That leaves imports in Push supply chains imported by small and regional importers or contractors. As discussed above, trans-loading out of the marine containers to domestic trailers is a value proposition only if the imports are destined to points hundreds of miles from Salt Lake City. Nearly all such retailing importers maintain a single distribution center in the Intermountain region. Some will have located this center east of the Rockies in the greater Denver area; it is not a value proposition to route their imports via Salt Lake City. For those that chose to locate their distribution center west of the Wasatch Range, most will have located it well within 500 miles of Salt Lake City. Only those whose distribution center (or project site) is further away, and who are importing volumes of marine containers sufficient to make the three-to-two conversion without remainders resulting in partial truckloads, would seem to find the proposed facility a value proposition.

Western Idaho retail outlets are assigned to the Pacific Northwest region in the scheme depicted in Table 4. There is no rail intermodal service from the Pacific Northwest ports to Western Idaho (and for that matter, none to Salt Lake City, either). So imports to Western Idaho points via the Seattle, Tacoma or Portland Ports must be trucked. Western Idaho is growing, particularly around Boise. At some point, large retailers may justify locating a distribution center or fulfillment center in the greater Boise area. Let us consider whether a trans-load capability in Salt Lake City could influence retailers to re-assign Boise from the Pacific Northwest region to the Intermountain region.

Highway mileage from the Port of Tacoma to Boise is about 513 miles; from the Port of Portland to Boise is about 433 miles. Mileage from Salt Lake City to Boise is about 340 miles, i.e., 173 miles less than from Tacoma and 93 miles less than from Portland. 173 miles saved is not

enough to pay for trans-loading. Moreover, routing imports via Oakland or San Pedro Bay will take longer than if routed via the PNW ports. So it seems difficult to penetrate a Boise market, present or future.

The last import-related market to consider is the volume handled by existing trans-load operators (LTL carriers, parcel carriers). One might wonder if such operators could be induced to share the public trans-load facility. A difficulty in this regard concerns interfacing computer systems issuing instructions for trans-loading. Each carrier has its own custom databases and software for planning trans-load activity and issuing carton-by-carton trans-loading instructions. It is unrealistic to believe a common data architecture and software could be used by multiple carriers. Carriers can be expected to be very reluctant to lose control over their time-sensitive trans-loading operations, and entrust it to a third party. This would be a difficult market to penetrate.[12]

Export Market

The waterborne, containerized export market is much smaller than the import market. On a nation-wide scale, the number of waterborne, containerized export loads to the Far East compared to the number of waterborne, containerized import loads from the Far East, has ranged from 1:4 up to 1:2 over the past decade. The ratio for the Intermountain region is at least as weak as the national ratio and probably is even weaker.

It should be recognized that, ranked by dollar value, most Utah exports are high-value goods such as gold bars, semiconductors, aircraft engines and parts, medical instruments and essential oils. Such commodities are shipped via air freight, not as waterborne, containerized cargoes. Unlike waterborne, containerized imports, which are predominantly retail goods moving through supply chains operated by large, nation-wide retailers, the waterborne, containerized exports from the region are primarily agricultural goods, specialty minerals and other basic products produced at disparate points remote from Salt Lake City.[13] Attractiveness of the proposed facility for handling waterborne, containerized exports is seemingly somewhat more promising than for handling imports, albeit the volume of waterborne containerized exports from the Intermountain region is much smaller than the volume of waterborne imports to the region.

Ocean carriers are loath to stage and distribute marine boxes in the Intermountain region to garner relatively low-rate export shipments when their boxes can be sent back earlier to the Far East empty to collect much higher-revenue import loads. The ability of exporters to ship their goods to Salt Lake City using domestic vehicles then trans-load them to marine containers, would make a larger fleet of marine containers available to exporters. At the same time, it would decrease container turn times for the ocean carriers. Moreover, the economies afforded by using larger-capacity domestic vehicles from shipment origin to Salt Lake City could partially or fully

[12] A similar problem is faced by 3PLs operating automated trans-load facilities. To accommodate a new customer, custom database software to interface to the customer's unique database structure must be developed. When asked how long this takes, one 3PL responded to the author, "We have never done it in less than 6 months."

[13] Coal is not a containerized export. It is shipped in bulk unit trains to West Coast ports for trans-loading into bulk vessels.

defray the costs of trans-loading for cube freight exports, depending on the commodity and the distance involved.

The proposed UIPA trans-load facility presents more of a value proposition for Intermountain region exports than it does for imports. Securing a supply of marine containers at points far from Salt Lake City is difficult. Moving exports by domestic truck or rail carload to Salt Lake City, then trans-loading to marine containers for backhaul rail movement to the San Pedro Bay Ports or the Port of Oakland, is much less expensive than trucking to the West Coast ports.

The author does not have data on the Intermountain region export volume, but it would seem to be small compared to, say, the large agricultural export volume from California. Nonetheless, it seems clear that the proposed facility could be beneficial to those Intermountain region exporters located at significant distances from Salt Lake City, considering the difficulties they encounter trying to secure a supply of empty marine boxes.

Emissions Analysis

We now turn to emissions from various import supply chain channel alternatives to the Intermountain region. Table 6 provides assumed unit emissions from various transport and container handling activities, as estimated by the Port of Los Angeles and other sources.

Table 6: Assumed Unit Emissions

Activity	CO_2 (grams)
Top-picker lift	7,100
Diesel RTG lift	13,900
Hybrid RTG lift	4,000
Loaded marine-box double-stack train, per container-mile	372
Loaded domestic-box double-stack train, per container-mile	498
Long-haul trucking, per mile	1,700
Dray SPB ports to ICTF rail ramp	17,000
Dray SPB ports to nearby cross-dock or warehouse	18,000
Dray SPB ports to Sou Cal Inland Empire (IE) warehouse	144,000
Dray IE warehouse to IE rail terminal	15,500
Dray cross-dock to ICTF	5,000
Dray cross-dock to warehouse in ICTF area	5,000
Dray ICTF area cross-dock to IE warehouse	90,000
Dray IE warehouse to ICTF	90,000
Dray Oakland port terminal to UP ramp	5,000
Dray SLC ramp to nearby cross-dock or warehouse	5,000

Notes: A top-picker crane can lift a container off a chassis or rail well car or off the front-top corner of a block-pile containers. A rubber-tired gantry (RTG) crane can retrieve a container buried beneath other containers. Typically, lifts at port terminals of rail-borne marine boxes are made by top-pickers, while lifts of dray-borne marine boxes are made by RTGs. Lifts at off-dock rail terminals are typically made by RTGs. A marine-box double-stack train is assumed to consist of 290 forty-foot containers in 29 five-unit well cars drawn by 4 Tier 3 locomotives. A domestic-box double-stack train is assumed to consist of 222 fifty-three-foot containers in 37 three-unit well cars drawn by 4 Tier 3 locomotives.

Sources: *Port of Los Angeles Inventory of Air Emissions – 2011*, published by the Port of Los Angeles. Figure for long-haul trucking emissions from *The Green Freight Handbook*, published by the Environmental Defense Fund. Total emissions for various dray movements within Los Angeles Basin are from the author's calculations, accounting for congested freeway and street traffic conditions.

Various supply chain channels have the following components after delivery of container from vessel to staging areas (on-dock rail loading area or dray yard) at marine terminals:

IPI (marine box on rail) via San Pedro Bay ports: top-picker lift into rail well car, rail movement of marine container from SPB port terminal to Salt Lake City (802 rail miles), RTG lift at SLC terminal, dray from SLC rail terminal to destination warehouse.

IPI (marine box on rail) via Port of Oakland: RTG lift to dray chassis, dray from port terminal to Oakland rail terminal, RTG lift to railroad well car, rail movement of marine container from Port of Oakland to Salt Lake City (826 rail miles), RTG lift at SLC terminal, dray from SLC rail terminal to destination warehouse.

Domestic-box rail for goods imported in 3[4][5] Corner Push-Pull supply chains via San Pedro Bay: RTG lift to dray chassis, dray from port terminal to cross-dock near the Intermodal Container Transfer Facility (ICTF)[14] rail terminal (76%), dray from cross-dock to ICTF (64%), dray from cross-dock to import warehouse (12%), dray from port terminal to import warehouse in the Inland Empire of Southern California (24%), dray from import warehouse to ICTF (36%), RTG lift at ICTF, rail movement of domestic container from ICTF to Salt Lake City (794 rail miles), RTG lift at SLC terminal, dray from SLC rail terminal to destination warehouse.

Movements after the cross-dock or import warehouse are in domestic vehicles, accommodating 150% of the imports accommodated in marine container movements.

Domestic-box rail for goods imported in 1 Corner Push-Pull supply chains via San Pedro Bay (typically imported by OEM and re-sold by OEM to retailers, who are responsible for onward transport from OEM warehouse): RTG lift to dray chassis, dray from port terminal to OEM distribution center in the Inland Empire of Southern California, dray from OEM distribution center to ICTF, RTG lift at ICTF, rail movement of domestic container from ICTF to Salt Lake City (794 rail miles), RTG lift at SLC terminal, dray from SLC rail terminal to destination warehouse. Movements after the OEM warehouse are in domestic vehicles, accommodating 150% of the imports accommodated in marine container movements. Domestic trucking for goods imported in 3[4][5] Corner Push-Pull supply chains via San Pedro Bay: RTG lift to dray chassis, dray from port terminal to cross-dock near ICTF, truck from cross-dock to destination warehouse (702 miles). Movement after the cross-dock is in domestic vehicles, accommodating 150% of the imports accommodated in marine container movement.

Domestic trucking for goods imported in 1 Corner Push-Pull supply chains via San Pedro Bay: RTF lift to dray chassis, dray from port terminal to OEM distribution center, domestic truck from

[14] The ICTF functions as Union Pacific's domestic-box intermodal terminal in Los Angeles Basin for the Salt Lake City market. UP also has a ramp at West Colton in the Inland Empire, but at present it does not serve Salt Lake City.

OEM distribution center to destination warehouse (654 miles). Movement after the OEM warehouse is in domestic vehicles, accommodating 150% of the imports accommodated in marine container movement.

Truck marine box from San Pedro Bay ports to destination warehouse: RTG lift to dray chassis, truck from port terminal to destination warehouse (712 miles).

Table 7 tabulates CO_2 emissions per FEU (forty-foot equivalent unit) for various alternative landside channels based on the assumed unit emissions in Table 6. Trucking marine boxes direct from the San Pedro Bay ports creates excessive emissions, 1,224 kilograms per 40-foot container. Trans-loading to domestic (53-foot) trailers in the vicinity of the SPB ports is much better, reducing emissions to 828 kg per FEU, assuming fully loaded trailers can be dispatched. IPI service offered by the ocean carriers is considerably better, at 359 kg per FEU via the Port of Oakland and 322 kg per FEU via the SPB ports. If the imports are trans-loaded in the vicinity of the SPB ports to domestic containers shipped by rail to Salt Lake City, emissions are about the same, at 321 kg per FEU. The typical four corners supply chain, with some imports moving into and out of an import warehouse before final landside shipment to Utah, averages 377 kg per FEU if domestic rail is used, dropping to 351 kg per FEU if Union Pacific extends its intermodal service from its West Colton ramp to include Salt Lake City. The typical one corner supply chain, with imports moving into and out of an OEM warehouse before landside shipment to Utah, averages 442 kg per FEU, dropping to 427 kg per FEU if Union Pacific extends its intermodal service from its West Colton ramp to include Salt Lake City.

Table 7: Estimated CO_2 Emissions from Alternative Landside Supply Chain Channels for Movement of Imports to Warehouses Located Close to Union Pacific's Salt Lake City Intermodal Terminal

Channel	CO_2 Emissions per FEU (kg)
1. Truck Marine Box from SPB Ports	1,224
2. Trans-load to Domestic Trucks in Vicinity of SPB Ports	828
3. IPI via Port of Oakland	359
4. IPI via SPB Ports	321
4. Using electric top-picker and hybrid RTGs	304
5. Trans-load to Domestic Rail in Vicinity of SPB Ports	321
5. Using hybrid RTGs	298
6. Typical 4 Corner Supply Chain Using Domestic Rail via SPB Ports (using diesel lift equipment)	379 (351 if West Colton ramp becomes available)
7. Typical 1 Corner Supply Chain Using Domestic Rail via SPB Ports (using diesel lift equipment)	449 (427 if West Colton ramp becomes available)

Compared to trucking, rail movement of imports to Salt Lake City in IPI service offers substantial reductions in emissions. But compared to imports handled in domestic double-stack service from the vicinity of the SPB ports to Salt Lake City, it offers no reduction. Compared to supply chains moving imports through warehouses located within the Los Angeles Basin before shipment to Utah, IPI service offers modest reductions in emissions, but at the expense of inferior inventory management with consequent poorer customer service from retailers in the Intermountain region or the requirement to maintain much higher inventory levels to secure the same level of customer service. In summary, for imports, the proposed facility offers little if any promise of a significant reduction in supply-chain emissions.

For exports, the replacement of marine-box movement by domestic trailer movement from distant Intermountain points of origin to the Salt Lake City trans-load facility can serve to reduce emissions by about 33% over that portion of the journey for cube-freight commodities such as corrugated box scrap. Unfortunately, corrugated box scrap is mostly generated in the large urban centers, such.as the Greater Salt Lake Metropolitan Area. For weight-freight commodities, such as grain or minerals, no reduction in emissions is afforded by movement in domestic trailers to the trans-load facility, because no reduction in trucking is afforded. However, if weight-freight export commodities could be shipped in rail cars to the trans-load facility and then trans-loaded to marine containers, there could be emissions savings on the export of such commodities, proportional to the weight capacity gain of the rail car over that of the highway trailer and the distance traveled to Salt Lake City. Unfortunately, the railroads have little or no interest in accepting relatively short-haul, low-value loose carload freight traffic. It likely will be difficult to realize significant reductions in emissions from export movement of weight-freight commodities.

In summary, the prospects are weak for significant reductions in emissions afforded by the proposed facility. Imports already move out of the greater Salt Lake City area in domestic trailers, hardly any are distributed over the rest of the Intermountain region in marine containers. Cube-freight exports could benefit from the facility, but the region has little or no cube-freight exports generated outside the greater Salt Lake City area. Weight-freight exports could benefit from the facility if the railroad would accept carload shipments from export origin to the facility, and if the facility is equipped to trans-load bulk commodities from rail cars to marine containers. At this point, the author must assume that will not be the case.

Conclusions and Recommendations for UIPA

The proposed UIPA facility will have a difficult time securing a substantial amount of business. The facility is unlikely to attract imports destined to points outside the Intermountain region. Large nation-wide retailers practice supply chains that pool demands of the Intermountain and other inland regions with demands of West Coast regions (thereby realizing significant inventory economies), de-van marine containers coming from the Far East stuffed with narrow product mixes and re-load those imports into domestic containers stuffed with wide portfolios of imported goods at West Coast trans-loading facilities, or alternatively move goods in marine containers via rail direct to regional distribution centers serving inland regions. Such supply

chains offer lower supply chain costs than can be realized handling the goods via Salt Lake City. Destinations within the Intermountain region for marine containers from the Far East are predominantly warehouses located in the greater Salt Lake City area or the greater Denver area. Although the contents of three marine containers will fit in two domestic trailers, offering the potential to reduce trucking requirements on the last leg beyond the proposed terminal, the distances from the proposed terminal to such warehouses serving the Intermountain region are too short to re-coup the labor costs of de-vanning marine containers and re-loading imports into domestic trailers. It will be difficult for the proposed facility to secure a steady, ongoing import business large enough to fill a typical-sized facility.

Attractiveness of the proposed facility for waterborne, containerized exports is more promising. Unlike imports which are predominantly retail goods moving through supply chains operated by large, nation-wide retailers, waterborne containerized exports are primarily agricultural goods, specialty minerals and other products produced at disparate points remote from Salt Lake City. Ocean carriers are loath to stage and distribute marine boxes in the Intermountain region to garner relatively low-rate export shipments, considering that their boxes can be sent back earlier to the Far East empty to collect another much higher-revenue import load. The ability to ship exports using domestic vehicles to Salt Lake City and then trans-load them to marine containers, would make a larger fleet of marine containers available to exporters, and at the same time it would decrease container turn times for the ocean carriers. Moreover, the economies afforded by using larger-capacity domestic vehicles from shipment origin to Salt Lake City could partially or fully defray the costs of trans-loading for cube-freight commodities, depending on the distance involved. However, the waterborne, containerized export market is much smaller than the import market. Even with success in routing export shipments via the facility, the volume would be quite modest.

The proposed facility is unlikely to foster a significant reduction in emissions associated with imports. While movement of imports via rail to Salt Lake City generates much less emissions than does trucking the imports from the Los Angeles Basin, it does not offer any savings in emissions compared to trans-loading cargoes near the San Pedro Bay ports into domestic containers and moving domestic containers by rail, as some importers now do. Moreover, the proposed facility does not make it any easier or any more economically justifiable for importers to secure rail movement of marine containers from the San Pedro Bay Ports to Salt Lake City. It cannot be expected to induce increased rail movement of imports to Salt Lake City. Because nearly all warehouses serving the Intermountain region for which routing marine containers via the Salt Lake City rail terminal makes sense are located in the greater Salt Lake City area, there is little dray mileage involved from the rail terminal to the destination warehouses. If imports were trans-loaded to domestic trailers, there would be approximately a 33% reduction in emissions over these short distances, but, as noted above, the cost of trans-loading far exceeds the trucking cost savings, and thus it is unlikely to be realized.

Exports of cube-freight commodities, such as corrugated box scrap originating at points very distant from Salt Lake City could save approximately 33% in emissions on the way to Salt Lake City by using the proposed trans-load facility. However, volume of cube-freight waterborne

exports originating far enough away from Salt Lake City to overcome the trans-loading expense is small. Weight-freight exports, such as grain or minerals, if shipped in domestic trucks to the facility, would not realize any emissions reductions because no reduction in truck trips is afforded. If the proposed trans-load facility were equipped with rail carload access and suitable equipment to unload bulk commodities and re-load marine containers with bulk commodities, and if the railroads were willing to provide carload service from export origin to Salt Lake City, then it could become possible to realize emissions savings for weight-freight exports over the portion of their journey from origin to Salt Lake City. Unfortunately, the railroads typically are not interested in short-haul carload service of modest-volume, low-value commodities. It likely will be very difficult to realize any significant reductions in emissions from export movement of weight-freight commodities.

There are other steps UIPA could consider that would be beneficial to the citizens of Utah. First, land under the control of UIPA near the UP's Salt Lake City intermodal terminal is ideal property for locating the regional distribution center or on-line fulfillment center of a large retailer. Centers located further away from Salt Lake City entail increased emissions and transportation costs. UIPA should encourage the location of such centers close to the UP intermodal terminal. In particular, retail chains that currently supply Utah and Intermountain region retail outlets from a regional distribution center located east of the Front Range in Colorado should be strongly encouraged to split the region and open a distribution center close to UP's Salt Lake City intermodal terminal. Second, specialized trans-loading facilities may be required to serve export traffic. For example, export grain is typically blown into a plastic bag inserted in the marine container. A suitable trans-loading facility would include a dumper for grain trucks and a blower mechanism to fill marine containers with dumped grain. Certain minerals also may require special equipment for efficient bulk handling, perhaps trans-loading not just from trucks but also from rail cars. Third, diesel-powered lift equipment deployed at intermodal terminals generates a surprisingly large percentage of supply-chain emissions. Battery-powered or hybrid equipment is available that would sharply reduce emissions, but at much higher initial cost. While operating costs of battery and hybrid lift equipment are lower than for diesel-powered equipment, the initial cost at present is too great for operators of intermodal terminals to justify investment in them, unless terminal volume is exceptionally high. Public subsidy to help Union Pacific equip the Salt Lake City intermodal terminal with electric or hybrid gantry cranes could make a significant reduction in local emissions. Fourth, at present the only rail intermodal terminals within the Los Angeles Basin serving Salt Lake City are located within or adjacent to the San Pedro Bay Ports. Union Pacific is expanding its intermodal terminal at West Colton, located in the heart of the Southern California Inland Empire warehousing district. Finally, Union Pacific should be encouraged to offer intermodal service to Salt Lake City from this terminal, as it would reduce emissions for imports trans-loaded at Inland Empire warehouses and destined to the greater Salt Lake City area by 7.5 – 9.5%.

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