Why Containerization Didn't Reduce Ocean Shipping Costs, At First

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Abstract

Containerization did not reduce ocean transportation costs until well after its adoption. Using a previously unused measures of U.S. import freight costs, I show that freight rates did not decline when containers were adopted. Trade in containerizable goods grew since Kennedy Round tariff declines were concentrated in those goods. Data from major U.S. ports show that labor costs did not fall much despite enormous labor productivity gains. Market power in ports meant that dramatic productivity gains did not translate into dramatically lower freight rates. The long delay helps explain the apparent increase in the trade cost-import elasticity in the 1980s.

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1 Introduction

Shipping containers are frequently cited as having a central role in the post-World War Two expansion of world trade. The technology was widely and quickly adopted by the major trading countries in the late 1960s and early 1970s (Rua 2014). Bernhofen, El-Sahli & Kneller (2016) and Cosar & Demir (2018) argue that containerization led to significant trade expansion. Ports changed from places where gangs of men manually unloaded ships over the course of days to places where cranes unloaded (much larger) ships in the course of hours. Given these enormous changes, it is hard to believe that containers did not matter.

The evidence that this revolution reduced freight rates significantly is surprisingly thin. Hummels (2007) examines the evidence and doesn't find much decline. (The title is adapted from a section title in that paper.) Some studies find a relatively small role for transportation costs in post World War Two trade expansion (Baier & Bergstrand 2001, Jacks, Meissner & Novy 2011). However, the available data covering the adoption period are idiosyncratic and unrepresentative. Representative official U.S. data only begin in 1974, when Census data began to report both the FAS (Free Along Side, the value at the foreign port) and CIF (Customs, Insurance, Freight, the value landed in the port of entry) values of merchandise imports. By this point, containers were already widely adopted. Therefore, it is difficult to distinguish between poor data and a lack of an effect.

Were containers important in reducing freight costs and increasing trade? This is an interesting question on its own given contradictory evidence on containers. The answer also has broader implications. Getting trade costs right is important for estimating trade elasticities, which are important for evaluating trade liberalization and the welfare effects of trade.

I use previously unused datasets to examine whether containers reduced freight rates. The main source is a joint U.S. Census Bureau/Tariff Commission (CB/TC) project that gathered data on freight factors of all U.S. imports from 1965 to 1973, the key period for containerization. I also collect port labor data for major U.S. ports that were early adopters of containerization, the Pacific Coast ports and the Port of New York/New Jersey (PONYNJ).

I find that U.S. aggregate freight factors do *not* fall during initial container era (1967–72). Freight factors on containerizable goods fell the least but containerizable goods trade still grew. I find that containers dramatically and immediately increased U.S. port labor productivity, but it did not lead to significant contemporaneous reductions in port labor costs. These data suggest a paradox: There were significant real effects but little impact on freight prices.

The immediate increase in trade of containerizable goods resulted from the fact that the tariff reductions under the GATT's Kennedy Round were concentrated in those goods. In U.S. data, the largest cuts in tariffs as a result of the Kennedy Round were (containerizable) manufactured goods.

I argue that the lack of freight rate declines is a result of the institutional structure of ports. A significant portion of the productivity gains were captured by port workers. The U.S. port industry featured strong unions and little competition. Longshoremen were able to negotiate non-wage benefits to compensate for the loss of work that resulted from the container revolution. The wage part of labor costs, the part of costs most closely related to labor usage, did show large declines that coincide with the increase in productivity. These were offset by increases in fringe benefit costs. This delayed the impact of containers on labor cost a decade.

The delay in falling freight rates can help resolve the apparent increase in the Armington elasticity, the increase in trade from trade cost reductions. Falling tariffs in the 1980s had a bigger trade response than the tariff reductions in the 1960s (Yi 2003). The longer freight series shows that only tariffs had a significant decline in the late 1960s while both tariffs and freight rates fell in the 1980s. Feeding the combined freight and tariff series into a standard CES trade model shows that trade costs can explain U.S. export growth between 1967 and 2000 without changing the Armington elasticity. These results suggest that containers did have a significant role in trade expansion, but only well after containers were adopted.

This paper contributes to the literature that seeks to explain the expansion of trade after World War Two, including Rose (1991), Krugman (1995), Baier & Bergstrand (2001), Bergoeing, Kehoe, Strauss-Kahn & Yi (2004), and Alessandria & Choi (2014). Yi (2003) and Bridgman (2008) examines the inclusion of vertical specialization trade. This paper fills in freight rate data during a crucial episode of trade expansion.

A literature examines the impact of shipping technology on international trade patterns. Clark, Dollar & Micco (2004) and Blonigen & Wilson (2008) show the importance of port productivity for increasing trade. Pascali (2017) argues that steamships were a significant factor in the first wave of globalization. (Hummels & Schaur 2013) argue that containers reduced time in port, reducing shipping time and making shipments more reliable. This paper emphasizes the importance of the institutional environment matters for how a shipping technology translates into prices. Sequeira & Djankov (2014) makes a similar case for corruption, which had a significant impact on port usage and cost in southern Africa.

2 Did Containers Reduce Transportation Costs? Import Costs 1965-1973

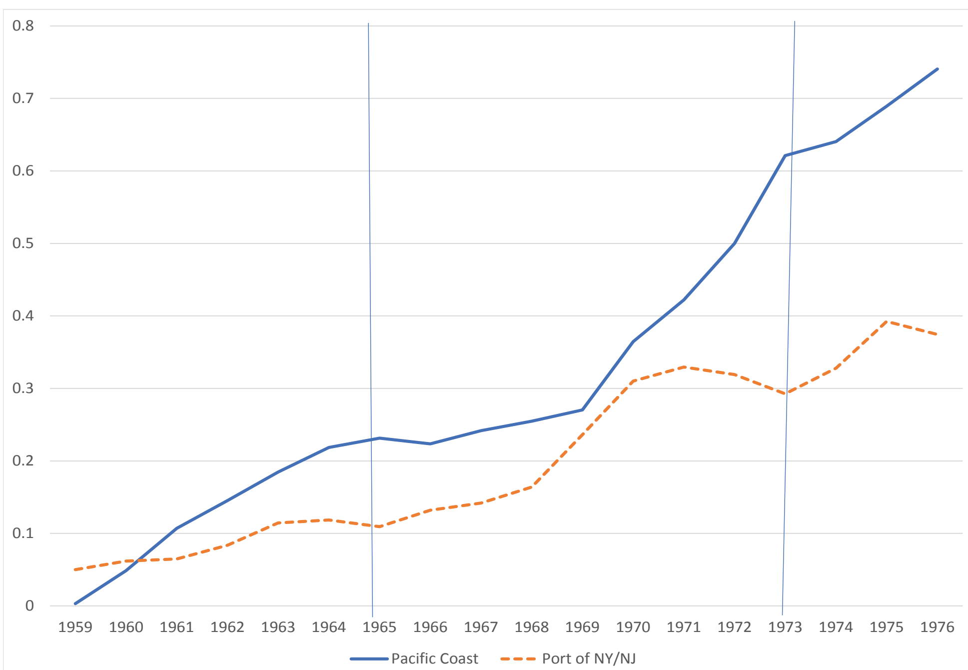
In this section, I examine new data sources to see whether containers reduced freight rates. I begin by establishing the timing of U.S. adoption of containers. I then introduce the new data sources and examine freight rates during the adoption period.

2.1 Adoption of Containers

Before discussing the history of containers, I will briefly describe the technologies that are used in water shipping and define the terms that will be used in the analysis. Waterborne goods can be shipped in a number of different ways, depending on the attributes of the goods. Bulk goods are those that are not packaged and are loaded directly onto specialized carriers. Bulk goods can be further divided into liquid bulk, such as crude oil, and dry bulk, such as iron ore or grain. The remaining goods are general cargo. General cargo can either be containerized, placed in large standardized boxes (containers) which are loaded by cranes, or breakbulk, loaded into ships manually. Containerization is the process of shifting from breakbulk methods to containers.

The invention of containerization is popularly timed as the sailing of the *Ideal X* from Newark to Houston in 1956. However, widespread use took another decade as a host of regulatory and technical issues were worked out. Once these barriers were solved in the mid-1960s, that containers were rapidly adopted in U.S. maritime foreign trade (Levinson 2006). Global adoption of containers was more rapid than other major transportation innovations, such as air freight (Rua 2014).

Figure 1: Container Share of General Cargo, 1959-1976



The period that the Census/Tariff Commission study covers (1965-1973) includes the adoption of containers in U.S. foreign trade. Figure 1 shows the share of general cargo that was containerized. The Port of New York/New Jersey alone represented 37 percent of containers and 38 percent of total tonnage handled by U.S. ports in 1973. Together with the Pacific Coast ports, the ports in the figure represent 70 percent of U.S. container traffic[1]. The share of New York/New Jersey general cargo that was containerized more than doubled between 1967 and 1970, from 14 to 31 percent. The Pacific Coast shows a similar jump, increasing from 17 percent in 1969 to 37 percent in 1973. Prior to these jumps in usage, most container traffic was in domestic trade. One line had a West Coast-Hawaii service and another had Newark-Puerto Rico/Houston routes (Levinson 2006). Containers were considered a specialized domestic trade technology and were not discussed in the West Coast ports' 1960 negotiations over work rules (Hartman 1969).

If containers were to have an impact, we would expect to see it after 1967. Bernhofen et al. (2016) date the U.S. adoption date in international trade as 1966. Its major trading partners had all adopted it by 1970. Official U.S. data begin in 1974, when over 70 percent of Pacific Coast general cargo was already containerized.

2.2 Data Description

The main data source I use is a joint study of freight factors on U.S. imports conducted by the Census Bureau and Tariff Commission. To study the possibility of moving from FAS to CIF methods of import valuation, they began collecting FAS and CIF ratios in 1965[2]. After the initial report for 1965, these data were reported as special articles in the Census Bureau's Highlights of U.S. Export and Import Trade (FT990) publication until they were added to the

[1] *Containerized Cargo Statistics 1973*, U.S. Maritime Administration.

[2] Most countries collected tariffs on a CIF basis while the U.S. collected tariffs on a FAS basis. The U.S. needed to provide CIF equivalent tariff rates to the GATT for comparison purposes during trade negotiations.

official trade statistics in 1974[3]. These data are estimated from a representative sample of U.S. imports. (The data appendix provides details on the data used throughout the paper.)

These data are reported in disaggregated classifications. The classification I use in the baseline analysis is an abbreviated version of the Tariff Schedule of the United States (TSUS). This system aggregates the TSUS into 21 groups of goods, which are reported in the appendix. I match these data with tariff rates, which are available for 1964 (which I carry forward to 1965), 1970, and 1974 to 1988[4].

I use these data to calculate the freight factor, the *ad valorem* freight rate. The freight factor for good i at time t is:

$$F_t^i = \frac{CIF_t^i}{FAS_t^i} - 1 \tag{1}$$

where CIF_t^i and FAS_t^i are trade valued in CIF and FAS terms respectively.

2.3 Freight Rates during the Adoption of Containerization

I begin the analysis by calculating the aggregate U.S. import freight factor during the adoption of containerization. Figure 2 reports the CB/TC data for 1965 to 1973 and official Census data for 1974 to 1988. (The vertical line marks when the CB/TC series ends.)

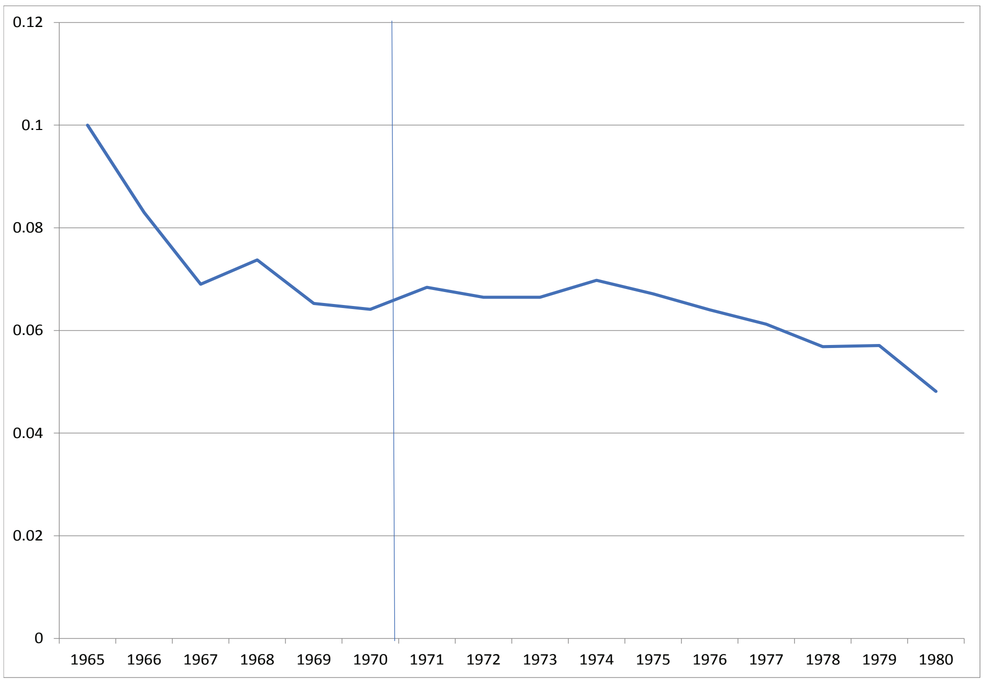
The data do show a decline in transportation costs. The trade weighted import cost falls from 10 percent in 1965 to 6.7 percent in 1973. However, the timing of the decline makes it unlikely to have been the result of containers. Most of the decline occurs in 1965-66, while containers were introduced in international trade in 1966 and expanded rapidly after 1967. Freight factors are flat during the period when containers are taking over U.S. international trade.

The CB/TC data cover all modes of entry, so one might be concerned that changes

[3]The initial 1965 study has been used, e.g. Finger & Yeats (1976). I know of no instance where the follow up years' data were used.

[4]The data are also reported separately by major trading partner and one digit Schedule A classification, which has 10 groups of goods. I use the TSUS data since they are the most disaggregated.

Figure 2: Trade Weighted Import Cost 1965-1988



in water transportation are hidden in the aggregate data. About two thirds of import value was waterborne during the 1970s, so significant changes in this segment should be seen in the aggregate data. Based on this evidence, I conclude that containers did not have a significant effect on aggregate freight rates.

The CB/TC study reports disaggregated data, which allows us to examine whether containers affected the rates of some subsectors. To proceed, we need a measure of containerizability. Whether or not a good are containerized depends on a number of factors. Some goods simply do not fit into containers. There are alternative technologies that are more economical for some goods that could fit into a box: Many bulk goods would fit into boxes, but are cheaper to ship in bulk carriers.

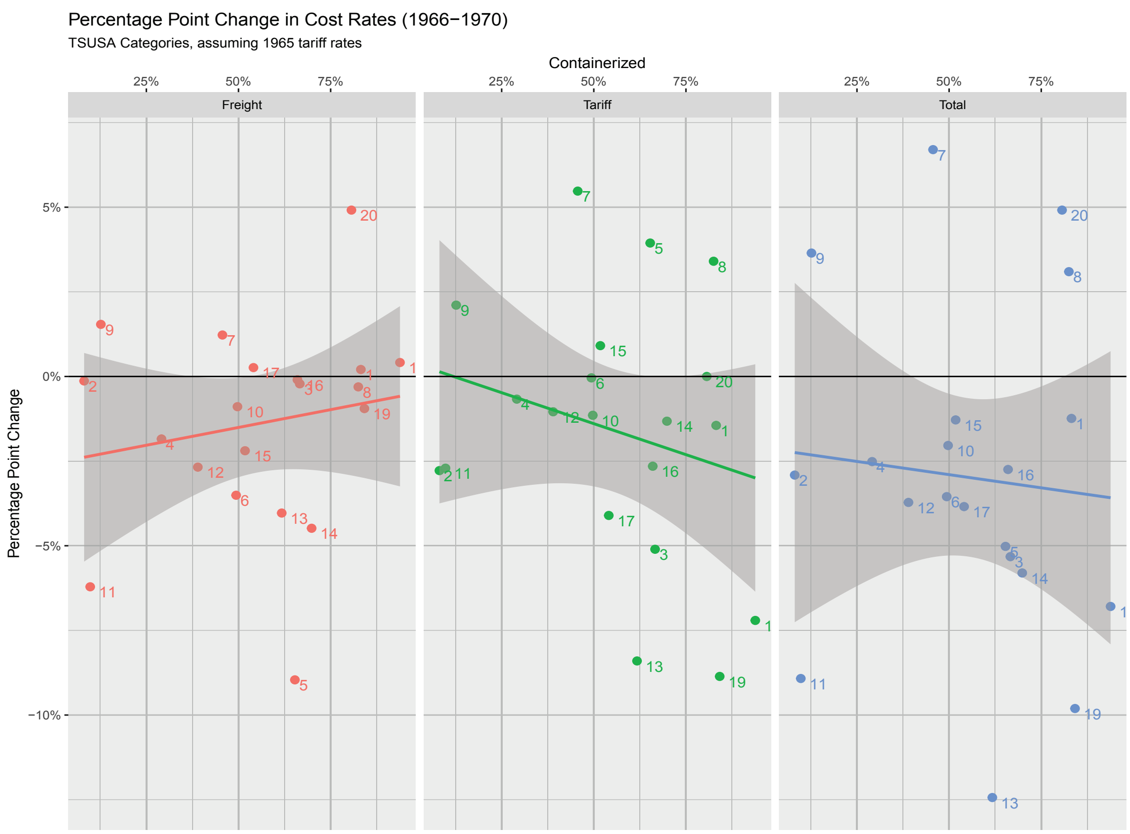
I use Canadian data on container share of goods by category as my measure of containerizability. The advantage of these data is that they are available beginning in 1980, whereas U.S. data are only available beginning in 2003. Therefore, they are much closer to the pattern of goods that were containerized in the initial wave of adoption. They better reflect the economic and technical environment shippers faced when deciding whether to containerize a good.

I digitized data for the Port of Montreal. The data have a high degree of disaggregation, so it is costly to digitize. I selected Montreal since it was the largest port close to major population centers with ocean access that also had significant container traffic. (Vancouver did not containerize until the later 1980s. Toronto is primarily a bulk goods port.) I concord the Canadian codes with the U.S. codes and create the share of the U.S. codes that are containerized.

More disaggregated data do not support the idea that containerization was important during this period. Figure 3 shows the percentage point decline for Abbreviated TSUS codes for 1966 to 1970 sorted by the containerization rates of goods. This period covers the initial adoption period of containers in U.S. oceanborne trade. The relationship between containerizability and freight rates are negative.

The category with the largest drop, "Wood and Wood Products" (code 5), is a combination of non-containerizable timber and containerizable wood products. The timing of the fall suggests that containers are not driving this decline. Freight factors show a strong decline beginning prior to containerization and no decline from 1969 onward. The category with second biggest drop in freight factor, petroleum (code 11), has a low containerization rate as most of these liquid bulk products that are shipped in tankers. In contrast, many highly containerizable goods such as apparel (code 8) and miscellaneous consumer goods (codes 18 and 19) show little decline or even a slight increase. While these data point to an underappreciated transportation revolution in bulk handling, they do not show evidence for a first order role for

Figure 3: Change in Trade Costs by Abbreviated TSUS Code 1966-1970



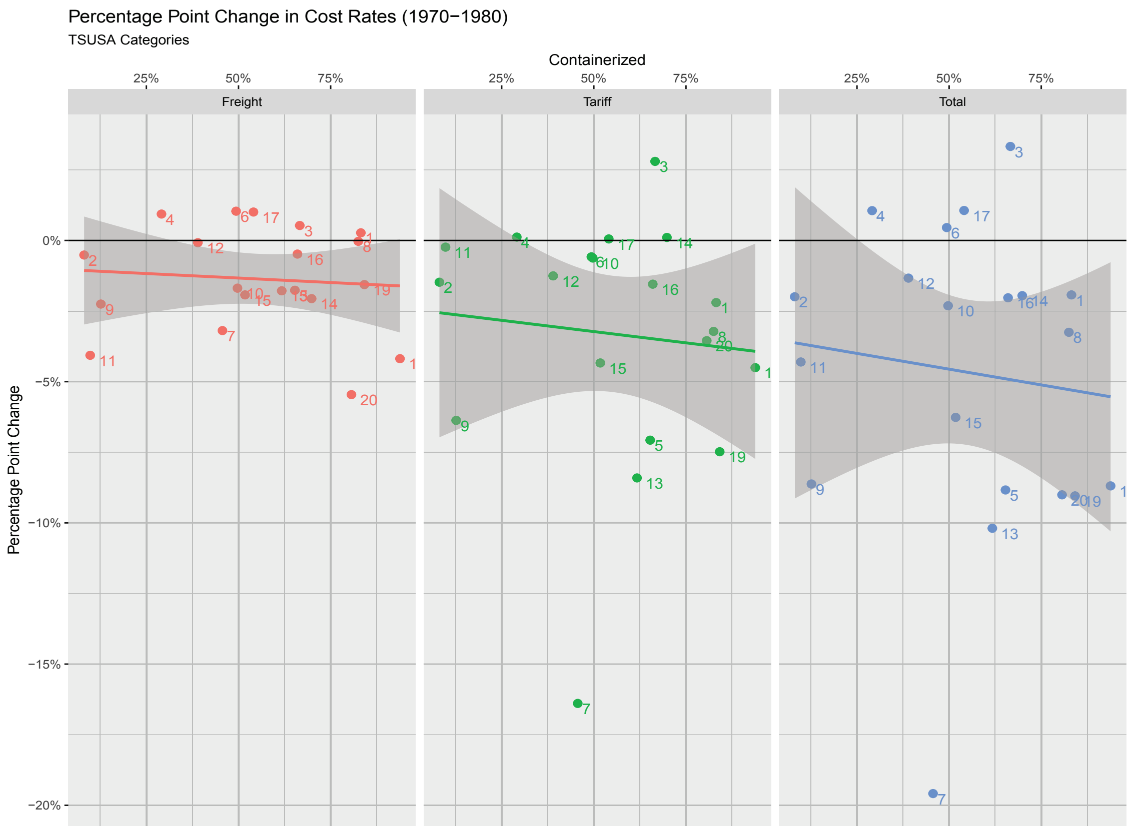
containers during the initial adoption period[5].

Overall trade costs decline is correlated with containerizability, but only because of tariff declines. The Kennedy Round of the GATT, which was implemented between 1967 and 1972, had significant reductions in tariffs on manufactured goods. Such goods tended to be very containerizable. The miscellaneous consumer goods categories (codes 18 and 19) have very large tariff declines which cause their overall trade costs to fall significantly.

Moving to the 1970s, containerizable goods remain those with the biggest declines in

[5]Lundgren (1996) documents significant changes in ocean bulk shipping, including increasing ship size and falling crew sizes, that coincided with falling freight rates for bulk goods.

Figure 4: Change in Trade Costs by Abbreviated TSUS Code 1970-1980



trade costs but tariffs remain the driving force for this correlation. As seen in Figure 4, the correlation between containerizability and freight factor declines is no longer negative but tariffs are still a significant driver of trade costs.

3 Containers and Port Labor Costs

The lack of movement in freight rates suggests that the container revolution may not have been all that revolutionary. This section examines port labor costs and productivity for major U.S. ports. Port labor is where containers changed the technology of maritime trade the most.

Therefore, if containerization had an impact on trade costs we would expect it to show up there.

Using detailed data from the employers of longshoremen, I find that cost did not fall much in the first wave of containerization. This finding obtains despite an immediate, strong increase in labor productivity and a coincident decline in unit wage costs (wage cost per ton). However, non-wage labor payments expanded to limit the decline in total unit labor cost. These payments increased to compensate longshoremen for the loss of work that containers brought. These payments were important in the 1970s but were reduced or eliminated in the 1980s. Containerization's labor savings were not realized in labor cost until a decade after the adoption of containers.

This section begins by describing the longshore data. I then document port labor costs and productivity. I compare the change in labor costs with what would be predicted by a perfectly competitive market. I conclude the section by describing how labor contracts can explain the empirical patterns.

3.1 Port Data Description

I collect data from employer organizations that employ longshoremen in the Port of New York/New Jersey (PONYNJ) and the U.S. Pacific Coast. These organizations negotiate contracts with the longshoremen's unions and process labor payments to members of those unions. I collect data about port labor from the employer organizations that negotiate contracts/manage benefits. Employers in the Port of New York/New Jersey are represented by the New York Shipping Association (NYSA) and those on the Pacific Coast by the Pacific Maritime Association (PMA). These data include hours worked, tonnage handled, wage payments, and fringe benefits. The data appendix gives the sources in detail.

The ports in the dataset cover a significant portion of U.S. trade. They handled half of 1965 U.S. waterborne exports by value. Much of this coverage comes from PONYNJ alone. It was the dominant U.S. port, handling 33 percent of 1965 U.S. waterborne export value.

This is more than the entire U.S. Pacific Coast, which only handled 13 percent. PONYNJ was the main port for the industrial Northeast and Midwest. It was so big that its waterborne trade accounted for 21 percent of *all* 1965 U.S. merchandise exports. It was also particularly important as a container port. It was the first container port and handled 37 percent of U.S. container tonnage in 1973. Finally, what happened in New York Harbor had a lot of impact on the costs of other East Coast ports. The common coastal Master Contract equalized wages across ports. The institutions of wage setting will be discussed in detail below.

The Pacific Coast, particularly the ports of Los Angeles and Long Beach, became more important over time. However, the Pacific Coast did not overtake PONYNJ until very late in the period I examine. Especially during the initial adoption period, PONYNJ was far and away most important U.S. port.

3.2 Port Labor Cost

The main measure of port labor cost I use is labor compensation per ton handled. This is a nominal indicator at a time when there was significant inflation. There is no single perfect price series in this context, so I will report two deflators.

One deflator is the export unit value by port, which I will refer to as the UV indicator. These are the items that *are* traded and provides an *ad valorem* measure for traded goods. While this is the closest analog to trade costs used in models, it is vulnerable to shifts in export mix. Trade liberalizations, like the Kennedy Round that coincides with container adoption, may radically change export mix. Kehoe & Ruhl (2013) show that the least traded goods contribute disproportionately to trade growth. As seen above, the Kennedy Round tariff cuts were concentrated in manufactured goods that tend to be high value per ton. Growing trade in these items could cause trade weighted freight rates to fall even if the underlying freight rates did not change.

Therefore, I also deflate by the U.S. Goods GDP price index, which I will refer to as the PI indicator. This is an indicator of freight costs relative to price the overall goods basket.

These are items that *could* be traded and is less vulnerable to export mix.

Figure 5 shows total labor costs for PONYNJ deflated by these two variables. Neither indicator shows much of a decline during the initial adoption period (1967-72), which is marked by the vertical lines. In both cases, the 1970 cost is nearly the same as it was in 1962 despite the fact that container use exploded during those years. The initial impact of containers in an increase in labor cost in the PI series.

Figure 5: PONYNJ Labor Costs, 1953–1989

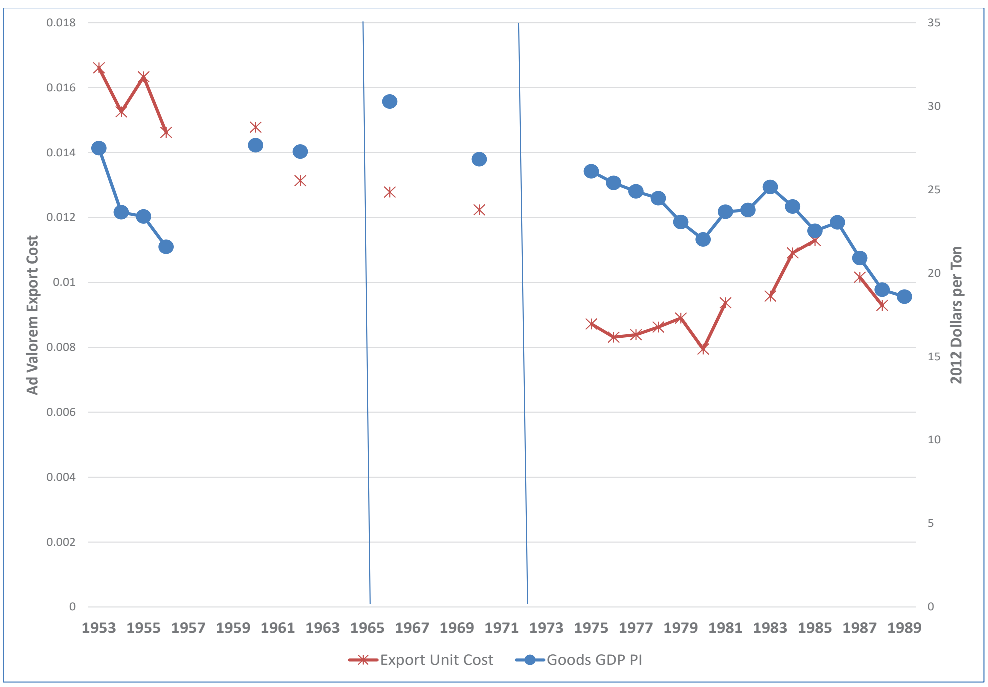
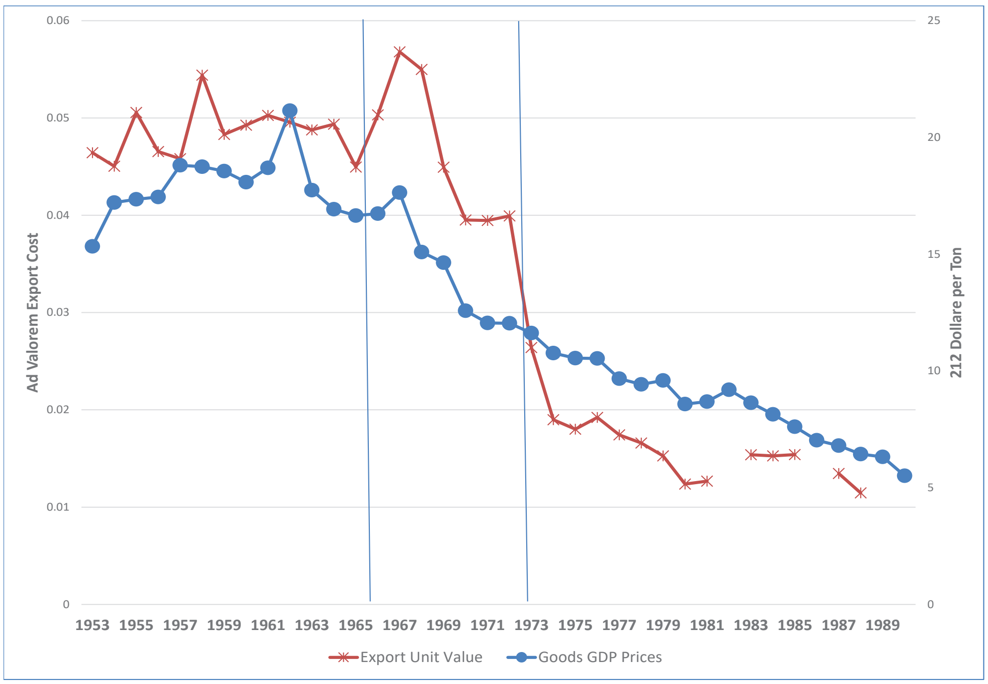


Figure 6 shows the corresponding data for the Pacific Coast ports. In both the UV and PI cases, the initial container period leads to an increase in labor cost. The freight rates fall in the early 1970s, but remain close to where they were in the early 1950s.

Figure 6: Pacific Coast Labor Costs, 1953–1989



The period of particular interest is after containers and before official freight data are available (1967–73), the period that the new CB/TC data show no decline in freight rates. The UV series fall significantly for both the PONYNJ and the Pacific Coast at the onset of the oil shocks. Export values increase much faster than both overall goods PI and labor cost. By the end of the 1980s, the PI and UV show similar declines. Due to the sparse data, we do not have a PONYNJ observation for 1973 before the oil shocks. The Pacific Coast data suggest that a lot of the PONYNJ decline in the UV series between 1966 and 1975 may have occurred after 1973.

Broadly, the evidence is that the container adoption period led to modest declines in unit labor costs. This effect is particularly strong in the PONYNJ, which was the dominant port in U.S. international trade. I argue that this modest impact was due to the institutional structure of port labor. Longshoremen were able to negotiate compensation deals that captured much of the initial benefit of increasing productivity. These deals took the form of increased fringe benefits.

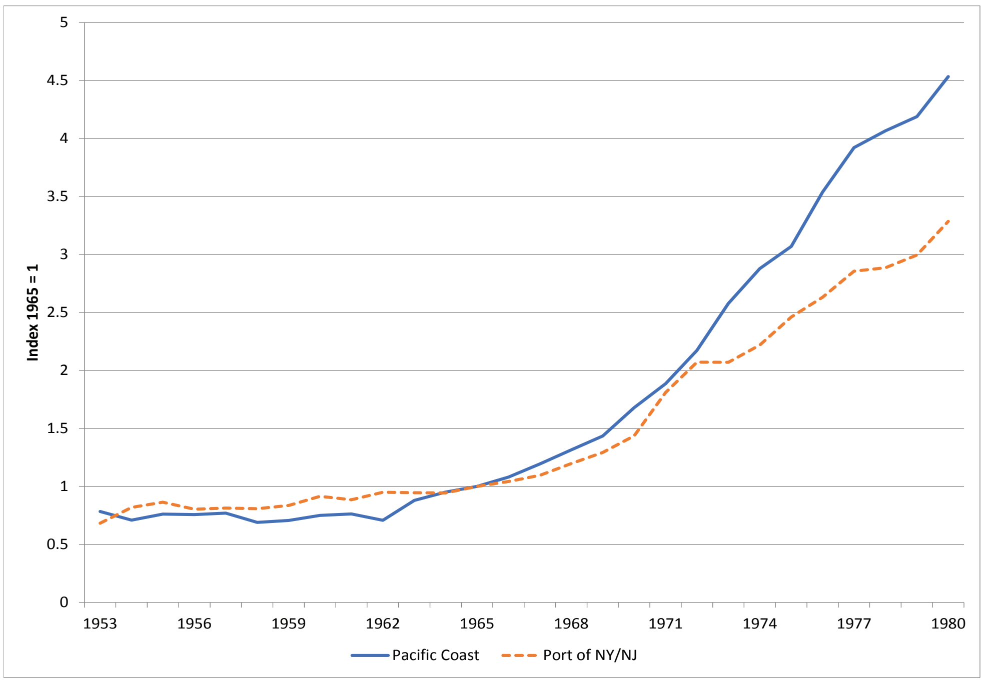
The rest of this section will set out the facts to support this theory. I argue that the initial decline labor costs was small relative to what we would expect given the productivity impact. I proceed by showing that containers did lead to enormous increases in productivity. I then calculate what labor costs would have been in a simple competitive model. I show that the observed rate declines were much smaller than the huge productivity increase implies. I then show that the wage part of labor costs, the part of costs most closely related to labor usage, did show large declines. These were offset by increases in fringe benefit costs.

The adoption of the container is visible in port labor productivity. After over a decade of stagnant productivity, the advent of the container coincides with enormous gains in labor productivity. Figure 7 shows tons handled per hour worked for the PONYNJ and U.S. Pacific Coast ports. PONYNJ productivity increased 38% in the first four years of containerization (1966-70) and more than doubled by 1975, up 136% in the period 1966 to 1975. The Pacific Coast shows even stronger gains. Containers did not suffer from Solow's Paradox, where revolutionary technologies do not show up in productivity statistics (Solow 1987).

In perfectly competitive markets, such a surge in productivity should have led to a massive decline in unit labor costs. The theory appendix provides a model to provide a baseline of what costs should have done if all the productivity declines were embodied in prices. The model predicts that the unit cost should decline at the rate of the inverse of Y/H.

Table 1 compares labor cost changes with the predicted change in prices from the perfectly competitive model. It reports changes during the container adoption period and the longer term changes. The time periods are dictated by the limited data available from the PONYNJ. In almost every case, the change in total cost is much smaller than what would be

Figure 7: Port Productivity 1953-1980



predicted by productivity change. Even impressive declines in labor cost, like the 33.1% in PONYNJ UV series from 1966 to 1975, is about half of what it should have been.

The data allow us to separate labor cost into wage and fringe benefits. Table 1 shows that the change in wage cost is much closer to the predicted decline. While total cost in the PONYNJ only fell about 10 percent from 1966 to 1970, wage cost fell twice as fast matching the decline predicted by productivity growth. Wages, the labor costs that vary directly with production, do fall with adoption. However, fringe benefits increase to counteract this effect.

The fall in wage cost coincides with the rapid productivity growth that begins after 1965. Figure 8 breaks out total labor cost in PONYNJ deflated by the goods GDP deflator

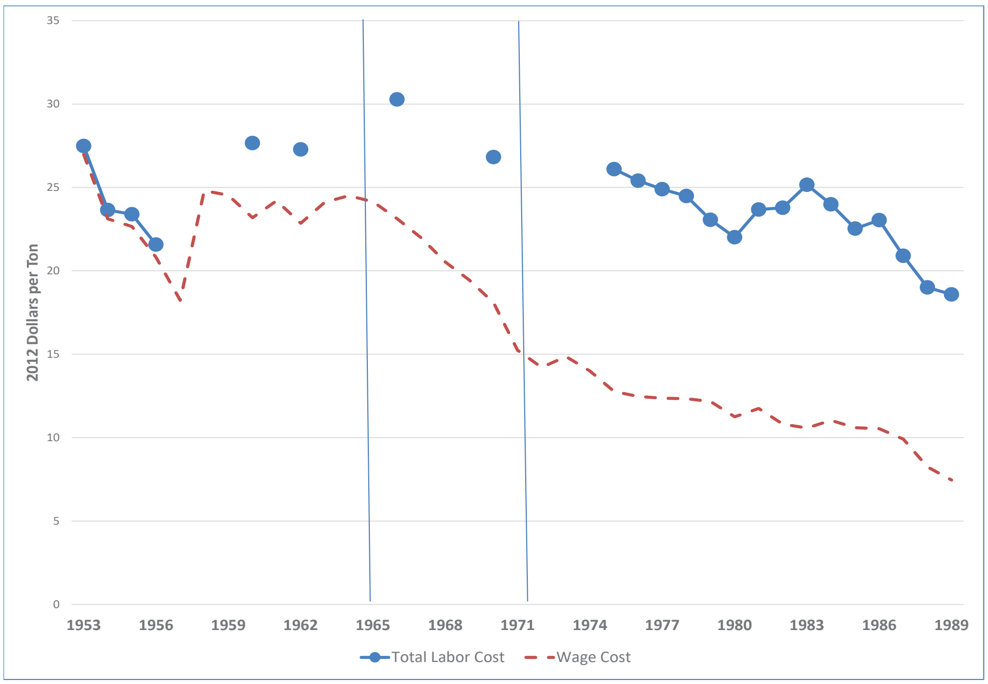
Table 1: Labor Costs and Productivity

	1966-70	1966-75	1960-88
PONYNJ			
Total Cost (PI)	-11.4%	-13.8%	-31.2%
Total Cost (UV)	-9.6	-33.1	-37.1
Wage Cost (PI)	-21.8	-44.8	-64.4
Wage Cost (UV)	-22.3	-59.3	-67.5
Y/H Predicted Fall	-27.4	-57.7	-85.2
Pacific Coast			
Total Cost (PI)	-37.0%	-37.0%	-64.4%
Total Cost (UV)	-36.4	-61.0	-76.7
Wage Cost (PI)	-47.8	-47.8	-76.7
Wage Cost (UV)	-41.4	-67.7	-81.8
Y/H Predicted Fall	-35.7	-64.8	-91.1

into these components. Wage cost per ton falls rapidly right as containers are adopted while the fall in total cost is modest. (Wage coverage is better than the total cost.)

Figure 9 shows the corresponding data for the Pacific Coast ports. Costs fell more on the Pacific Coast, but its very rapid productivity growth would have predicted an even stronger impact. Total wage costs show different time series. Wage cost show a strong decline in the late 1960s while total costs show an initial increase. In 1969, total costs are about where they were in the early 1950s while wage cost had fallen.

Figure 8: PONYNJ Labor Costs (PI): Wage vs. Fringe Benefits

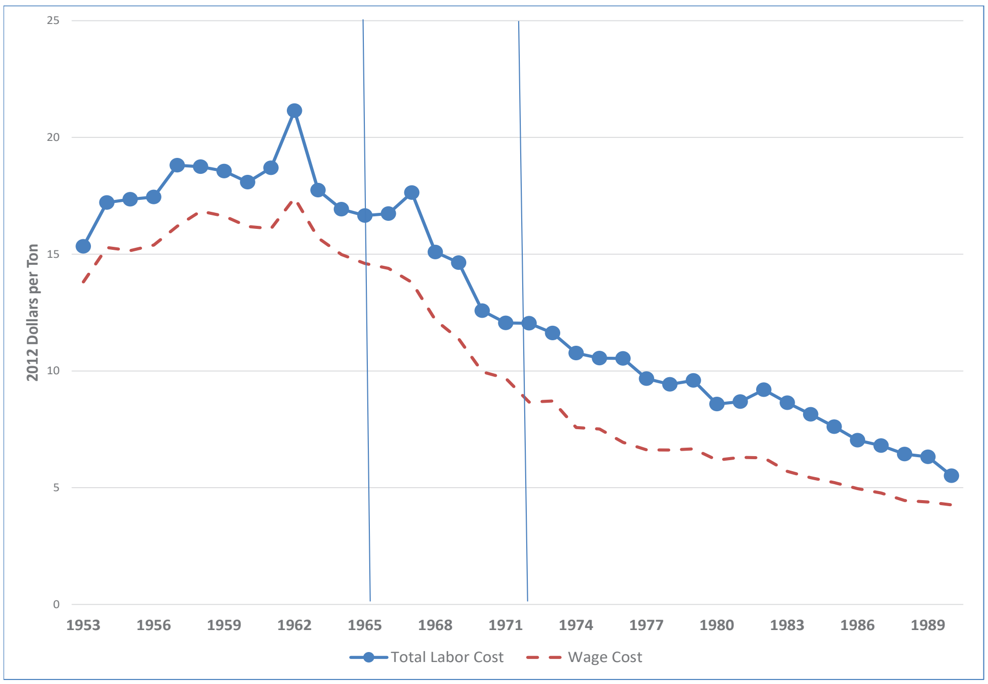


3.3 Compensation Deals

In this section, I argue that patterns documented above can be explained by the institutional structure of the ports. Workers anticipated the loss of work from the new technology and set up compensation deals that increased the cost of fringe benefits and kept total cost from falling with productivity. The cost of these deals diminished in the late-1970s and early 1980s, coincident with the aggregate decline in trade weighted freight rates.

On both coasts, port workers were able to negotiate deals that captured a significant portion of the productivity gains. Longshoremen in the Port of New York/New Jersey are

Figure 9: Pacific Coast Labor Costs: Wage vs. Fringe Benefits



represented by the International Longshoremen's Association (ILA). The ILA negotiated payments to compensate longshoremen for the anticipated loss of work that containers would bring. Beginning in 1966, ILA members received a Guaranteed Annual Income that paid enrolled longshoremen for a minimum of 1,400 hours a year. West Coast longshoremen are represented by the International Longshoremen's and Warehousemen's Union (ILWU). All ports on the West Coast are unionized by the ILWU and are subject to a single contract. The ILWU received compensation through a 1960 agreement that paid its members in exchange for loosening restrictive work rules. Though that agreement was not focussed on containers (it does not mention them at all), it set a precedent for sharing the gains of productivity growth with longshoremen. The

1966 contract increased payments and a guaranteed income plan was added in 1972.

Why is there a disconnect between port productivity and costs? If markets are competitive, the two should be strongly linked since output price is directly linked to the cost of inputs. Productivity reduces the cost of producing a unit of output so output price should also fall. This relationship need not hold when markets are not competitive and ports have features that reduce competition. Due to geography and large capital requirements, it is difficult or impossible to open a competing nearby port (Holmes & Schmitz 2001). Other modes of transportation, such as airplanes, were too costly to be serious competitors except for the most valuable freight.

The theory appendix gives a theoretical example that demonstrates how a lack of competition limits the price effects of productivity gains. A key feature of the model is that workers share the rents. Some of the productivity gains accrue to labor as higher wages rather than to consumers as lower prices. Longshoremen were in a particularly strong position to capture the rents generated by this non-competitive market. Since a single union represented longshoremen in all ports on each coast, shippers could not divert traffic to a neighboring port to avoid the union. On the West Coast, all ports were subject to a single contract which meant that port labor costs were uniform across ports.

The forces that drove up U.S. port costs were common throughout the world. Employment protections for longshoremen were found around the world, including very strict protections in the United Kingdom (El-Sahli & Upward 2017) and New Zealand (Reveley 1997). Contemporaneous discussion of ports centered on why costs were so high (United Nations Conference on Trade and Development 1977).

This analysis only covers the labor portion of port costs. The transition lead to a significant, costly reshaping of ports. Containerships required deep drafts and space to store the boxes (Ducruet, Juhasz, Nagy, & Steinwender 2021). Ports without those features lost business to those that could accommodate the new technology (Brooks, Gendron-Carrier & Rua 2018). Capital costs likely increased, as ports needed to build gantry cranes and other infrastructure to move and store containers. Breakbulk ships also needed to be replaced with container ships and the oil shocks of the 1970s drove up the cost of sailing (Sletmo & Williams 1981, Bridgman 2008). Therefore, the initial response to containerization may have been an increase in shipping costs.

4 Did Containers Increase International Trade?

Did containers have an effect on expanding trade? Above, I argue that containers did have an impact on freight rates but only a decade after they were adopted. In this section, I examine the predictions of a standard aggregate trade model once we include the extended CB/TC freight rates. I show that freight rates matter for trade expansion after 1973. I argue that containers were important to trade expansion since containers had a major role that freight rate decline.

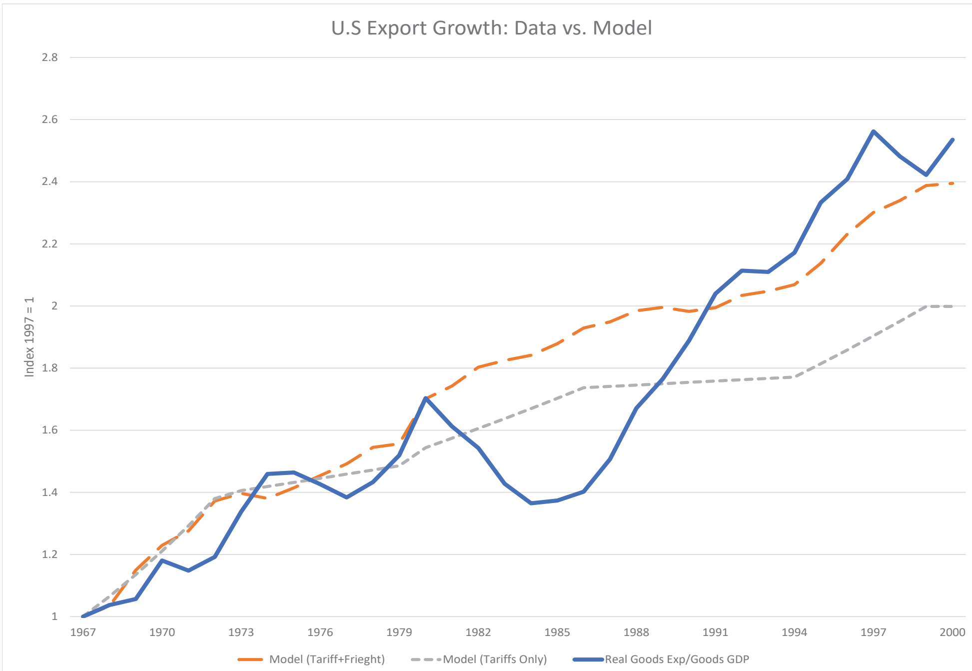
Further, this delayed impact can explain the apparent change in Armington elasticities[6]. The response of trade of falling tariffs is much stronger beginning in the late 1980s, which requires either a strong non-linear response to trade costs (a feature absent from standard models) or a large shift in import-price elasticity in the mid-1980s (Yi 2003).

Table 2 reports the percentage point declines in trade costs and the percentage increase in U.S. real export share. Tariffs are the "World Tariffs" series from Yi (2003). Freight is the expanded CB/TC trade-weighted import freight factor, as reported in Figure 2. Export share is goods exports growth rate less the growth rate of goods GDP, as reported by the BEA.

The table demonstrates the Yi (2003) puzzle clearly. Export share growth was nearly equal in the 1967–73 and 1973–88 periods but tariffs declined much less in the second period. In standard trade models, export growth is proportional to trade cost declines. Therefore, the

[6] Progress has been made in resolving the difference in Armington elasticities between micro and macro estimates, including firm entry (Ruhl 2008), innovation (Rubini 2014), small sample estimation issues (Simonovska & Waugh 2014), and aggregation bias (Imbs & Mejean 2015). However, these explanations do not explain the apparent *change* in the elasticity over time.

Figure 10: Trade Expansion Simulations



standard model would require a change in the Armington elasticity.

The table also demonstrates how freight rates can help resolve this puzzle. Freight rates fall very little in the first period and fall significantly in the second period. This is the opposite pattern of tariff declines, so the sum of the two trade cost declines is nearly equal across the two periods.

The fit of the standard model is much improved when my extended series of freight costs in included. The contribution of trade costs to trade growth in standard CES model is

Table 2: Trade Costs and Export Share Data

p.p. fall in:	1967-73	1973-88
Tariff	5.6	3.3
Freight	0.3	2.4
Tariff+Freight	5.8	5.7
Export share growth	33.8%	33.3%

given by:

$$\Delta \ln(GoodsExports) - \Delta \ln(GoodsGDP) = (1-\sigma)\Delta \ln(1+\tau+F) \tag{2}$$

I feed my measures of tariffs (τ) and freight factor (F) into this equation for the years 1967–2000. This sample is dictated by the data. Real trade data begin in 1967 and the Yi (2003) tariff data end in 2000.

This exercise requires a value of the Armington elasticity σ. I use a value of 8 since this value generates the empirical increase in exports. This value is firmly in the range for permanent changes in the literature (Head & Ries 2001, Romalis 2007, Alessandria, Khan, Khederlarian, Ruhl & Steinberg 2021). It is reasonable to think that shippers would think the freight rate declines due to containers were permanent. Once the longshoremen that had been employed when containers were introduced began to retire, the compensation schemes were phased out and new workers were not eligible for them.

Figure 10 compares real U.S. export share with the predicted trade share from tariff and tariff plus freight costs. The large decline in tariffs in the Kennedy Round generate export growth close to the data, but tariffs alone significantly undershoot later trade growth. The delayed impact of containers on freight rates greatly improves the fit of the standard model. Freight rates did not fall in the initial containerization wave, coincident with the Kennedy Round. Tariffs alone do well for that period. The impact of containers was not felt until the

Tokyo Round, leading to stronger trade expansion than the tariffs only simulation.

Containerization was correlated with trade expansion in the late 1960s because trade policy was correlated with containers. Containers likely had a major role in the decline in freight rates that began in the late 1970s, when labor costs began to fall more rapidly. Therefore, the rapid increase trade in the 1980s was the result of both tariffs and freight rates falling together. This supports a lower Armington elasticity than the very high estimates found from tariff time series analysis, such as Baier & Bergstrand (2001) or Head & Ries (2001). Therefore, welfare gains from trade expansion are higher than would be implied using those elasticities (Arkolakis, Costinot & Rodriguez-Clare 2012).

5 Conclusion

Shipping containers are popularly given a central role in the post-World War Two trade expansion. However, the data supporting this idea is surprisingly thin. I use novel data sources to show that while containers led to massive increases in labor productivity, they had a muted impact on labor costs. Workers were able to capture a significant portion of the benefits of this innovation. Despite the small initial impact on fright rates, containerizable goods trade increased. Trade policy on these goods was liberalized at the same time containers were adopted. The delayed impact of containers on freight rates can help resolve the puzzle of why trade increased significantly in the 1980s despite modest tariff declines.

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6 Data Appendix

6.1 Census/Tariff Commission Freight Factor Data

1965 Ficker (1968).

1966-1973 *Highlights of U.S. Export and Import Trade (FT990)*, U.S. Bureau of the Census. September 1967, March 1969, July 1970, May 1971, January 1972, December 1972, and February 1974 issues.

6.2 U.S. TSUS Tariff Data

1966 I use the 1964 TSUS tariffs from 1964 issue of *Foreign Commerce and Navigation of the United States*, Table 14, under the assumption that tariffs were unchanged between 1964 and 1966.

1970 U.S. Tariff Commission, "Customs Valuation," T.C. Publication 501, July 1972, Table 1.

1974-1988 Census merchandise import data, as reported in Feenstra (1996).

6.3 Canadian Container Data

Data were digitized from Statistics Canada "International seaborne shipping port statistics," Catalog number CS 54-211, 1980 Edition.

These data are reported using Canada's Standard Commodity Classification, which is closely related to the SITC. The data are concorded with the other classifications by manually matching goods descriptions. The rates of containerization were then calculated by summing containerized tonnage for each classification and dividing that by total tons loaded for each classification.

6.4 Abbreviated TSUS Codes

1. Live animals, meats, fish and shellfish, dairy products, eggs, hides, skins, and leather.
2. Live plants, seeds, cereal grains, milled grain products, malts, starches, vegetables, edible nuts and fruits, sugar, cocoa, and confectionery.
3. Coffee, tea, mate, spices, beverages, tobacco, and tobacco products.
4. Animal and vegetable oils, fats and greases, and misc. other animal and vegetable products.
5. Wood and wood products.
6. Paper, paper products, and printed matter.
7. Textile fibers and fabrics.
8. Textile furnishings, wearing apparel and accessories, and miscellaneous textile products.
9. Chemicals and chemical compounds and mixtures.
10. Drugs, synthetic resins, plastics, rubber, essential oils, cosmetics, soaps, synthetic detergents, inks, paints, etc.
11. Petroleum, petroleum products, natural gas, fertilizers, explosives, fatty substances, camphor, carbons, isotopes, waxes, etc.
12. Nonmetallic minerals and products, except ceramic products, glass and glass products.
13. Ceramic products, glass, and glass products.
14. Metal-bearing ores and other metal-bearing materials.
15. Metals, their alloys, their basic shapes and forms, and metal products.

16. Electrical and mechanical machinery and equipment.
17. Transportation equipment.
18. Footwear, headwear, gloves, luggage, handbags, scientific and professional instruments, timing devices, photographic equipment, etc.
19. Musical instruments, furniture, arms and ammunition; sporting goods, toys, jewelry, fastening devices, ornaments, brooms, pyrotechnics, pens, pencils, etc.
20. Works of art, antiques, rubber and plastic products, and miscellaneous other products:
21. Articles, subject to special classification provisions, temporary legislation, etc.

6.5 Port Data

The productivity measure is tons handled over hours paid. The real cost is current period employer outlay for labor payments (earnings, benefits and guaranteed income fund payments) per ton. Payments to benefit funds are booked in the year of the payment.

6.5.1 Pacific Coast Ports

All data are drawn from the Pacific Maritime Association's Annual Reports. Labor costs and hours cover total ILWU shoreside workers: Longshoremen, clerks and foremen.

6.5.2 Port of New York/New Jersey

Data cover longshoremen and checkers.

Tonnage, Hours and Wage Cost Waterfront Commission of New York Harbor Annual Reports.

1953-55 Benefits *Your Welfare Fund* New York Shipping Association-International Longshoremen's Association, 1957.

1956 Benefits "Dock Employers Offer 'Package'." Jacques Nevard, New York Times, Nov 8, 1956, p. 78. Fringe benefits cost 9 cents an hour.

1960 Benefits "Dock Union Urged to Help Cut Costs" George Horne, New York Times, August 12, 1962, p. B11. Total hourly cost was $3.995. Benefits calculated as hours times total hourly cost less wage cost.

1962 Benefits "28-Cent Item in Bargaining Keeps Big Ships Tied Up at New York Piers" George Horne, New York Times, Jan 3, 1963, p. 1. Fringe benefits cost 0.68 per hour.

1966 Benefits "Pay Record Set by Longshoremen: City Piers Also Had Most Work Hours in 7 Years" George Horne, New York Times, Jan 9, 1967, p. 48.

1970 Benefits New York Shipping Association 1987 Annual Report reports total hourly cost as $7.60. Benefits calculated as hours times total hourly cost less wage cost.

1975-1989 Benefits Waters (1993), Table 2.

1998-9 Benefits NYSA Annual Report, report on Nysanet.org, Oct 16, 2000. Accessed from Internet Archive Wayback Machine.

2005-2019 Benefits The member benefits line from the New York Shipping Association's IRS 990 filing.

Guaranteed Annual Income Cost Levinson (2009).

6.5.3 Price Data

Export unit values are total export value divided by export tonnage from the Census Bureau's *U.S. Waterborne Exports and General Imports*. PONYNJ data cover the New York City customs district. U.S. Pacific Coast is the sum of the North and South Pacific customs areas.

Goods GDP PI is from BEA's NIPA Table 1.2.4. Price Indexes for Gross Domestic Product by Major Type of Product, line 4. July 29, 2021 release.

7 Theory Appendix

This appendix sets out a simple model to demonstrate the relationship between technical change and prices with and without market power.

7.1 Environment

Consider an atomless industry that uses labor N and capital K to produce output Y according to the Cobb-Douglas production function:

$$Y = AK^{\alpha}N^{1-\alpha} \tag{3}$$

The costs of the factors of production are rental rate r for capital and wage w for labor. Firms face the demand function

$$Y = p^{-\rho} \tag{4}$$

where p is the price of output and $\rho > 1$.

I will compare the outcomes of an increase in productivity under different competitive environments. Specifically, I examine the changes in cost per unit of output when the productivity factor increases from A to A' with $A < A'$.

7.2 Productivity and Price: Perfect Competition

Under perfect competition, firms take all prices as given and maximize profits. The solution to this problem generates the pricing equation:

$$p = \frac{1}{A}\left[\frac{r}{\alpha}\right]^{\alpha}\left[\frac{w}{1-\alpha}\right]^{1-\alpha} \tag{5}$$

The labor cost per unit of output (LCU) is:

$$LCU = \frac{wN}{Y} = \frac{1-\alpha}{A}\left[\frac{r}{\alpha}\right]^{\alpha}\left[\frac{w}{1-\alpha}\right]^{1-\alpha} \tag{6}$$

Since the industry is atomless, the new technology does not affect the prices of inputs ($w = w'$ and $r = r'$).

$$\frac{LCU'}{LCU} = \frac{A}{A'} \tag{7}$$

There is a one-to-one relationship between productivity A and labor cost per unit. A doubling of productivity cuts the cost in half.

7.3 Productivity and Price: Market Power

I now consider the case where the industry is monopolistically competitive. The price equation becomes

$$p = \left[\frac{\rho - 1}{\rho}\right]^{\rho} \frac{1}{A} \left[\frac{r}{\alpha}\right]^{\alpha} \left[\frac{w}{1-\alpha}\right]^{1-\alpha} \tag{8}$$

The labor cost per unit of output (LCU) is unchanged.

There are many ways in which the rents from market power can be shared. In this section, I examine a particular case that is inspired by the ports case. I examine the case where workers are represented by a union that can block new technology. They use this ability to increase wages. I assume that the union asks for a wage increase the keeps labor demand constant. Specifically, they choose w' such that labor demand $N(A', w') = N(A, w)$[7].

$$\frac{LCU'}{LCU} = \left[\frac{A}{A'}\right]^{\frac{1}{1+(\rho-1)(1-\alpha)}} \tag{9}$$

In this case, there is a less than one-to-one relationship between productivity A and labor cost per unit. The first order effect of the new technology is to increase labor demand. This allows the union to increase wages without putting its members out of work. The size of the rent sharing effect depends on the elasticity of demand. If demand is very inelastic (ρ is large), the effect is large. For low elasticities (ρ close to one), it resembles the competitive case.

[7] Union preferences for maintaining employment, particularly of members, even at the cost of wages has strong empirical support in many industries (Bridgman 2015). Concern over maintaining employment opportunities was a first order concern of longshoremen.