Rise of the Machines: Evidence from the Container Revolution

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Abstract

This paper estimates the effect of the container revolution on the development of regions, industries and occupations in the US. Across all ports, the introduction of new technologies had negative impact on the share of workers employed as longshoreman. Job losses were larger in areas that were more dependent on port activities. Despite this direct negative effect, such areas also experienced larger declines in the unemployment rate. The key driving force behind this outcome was the expansion of the relative share of manufacturing jobs. These findings indicate that containerization created new incentives for manufacturing firms to locate closer to ports, where they could benefit from the reduced costs and increased speed of transportation.

Keywords: Containerization; Labor Substitution; Regional Labor Markets.
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1 Introduction

The invention of the international shipping container had dramatic impact on the volumes of international trade. Containerization had even larger effect on longshoremen, whose tasks it came to substitute. The process of handling containers significantly reduced the demand for tasks performed by low-skilled workers. As a result, despite rising volumes of cargo, since early 1960's every major US port experienced unprecedented decline in employment. According to an article published in *New York Times*, in the 1960s, when New York was the world's busiest port, there were more than 35,000 longshoremen on the city's docks. Today, there are 3,500.[1] Although, this topic has gained significant attention in the media, there are no systematic studies that asses the effect of containerization on the distribution of job losses in the water transportation industry, its overall effect on employment in cities and implications for other industries. In this paper I use regional employment data for various industries and occupations for the US to answer these questions.

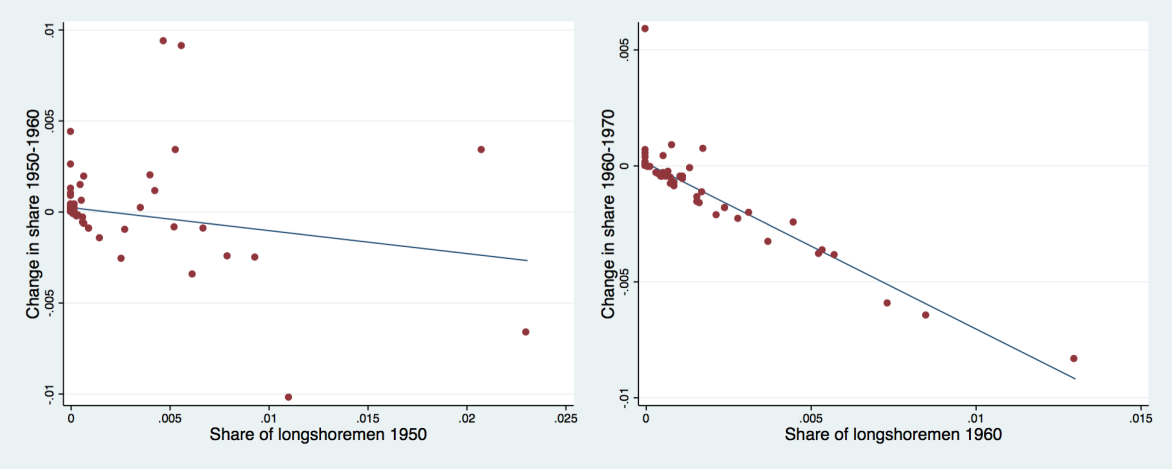
Figure 1 depicts the relationship between net changes in the ratio of workers employed as a longshoreman and their initial level for 1950-1960 and 1960-1970 periods. As can be seen there is a weak negative relationship before the containerization period. The relationship becomes sharply negative after 1960. Similar strong relationship also exist for the 1970-1980 period (not shown here). As can be seen the declines were substantial and given the fact that relatively many workers were employed in this occupation, the process had important implications for cities.

I use a difference-in-differences framework to study more formally the effect of the container revolution on the employment of longshoremen and total employment in port cities. The results of the study show that the share of longshoremen in total employment declined in most US ports and the declines were especially large in those cities which had relatively larger share of workers employed as longshoreman.

Despite large losses in jobs among workers employed as longshoreman, there is no evidence that containerization had negative impact on total employment in cities that had relatively higher share of workers employed as longshoreman. This is not surprising because containerization and higher volumes of trade also create jobs in many other industries, which may offset the negative direct effect. Actually, containerization had negative effect on the unemployment rate in areas with relatively larger share of workers employed as longshoremen.

The result of the study show that the share of manufacturing jobs expanded relatively faster in cities with higher share of longshoremen. Firms in the manufacturing sector may be enticed by lower transportation costs and access to new markets. This

[1] "On the Waterfront, Rise of the Machines", New York Times, September 30, 2012.



Notes: This graph reports the net decennial change in the ratio of workers employed as a longshoreman to total workforce and the initial level. The left panel reports the results for the period 1950-1960 (before containerization) and the right panel for the period 1960-1970 (after containerization). Source: Census Integrated Public Use Micro Samples and author's calculations.

Figure 1: Changes in the share of workers employed as longshoreman before and after containerization.

idea is related to Harris (1954)'s influential market-potential function, which states that the demand for goods produced in a location is the sum of purchasing power in other locations, weighted by transport costs. Cities around efficient ports are ideal locations that provide access to vast markets. Firms that depend on imported intermediate inputs also have incentives to locate in areas with lower transportation costs.

The paper is related to several strands of the literature. First, Bernhofen, El-Sahli, and Kneller (2016) study the effect of the container revolution on international trade. According to the authors containerization had economically large effect and served as a key driving force in the process of globalization.

Second, the paper is related to the growing strand of the literature that studies consequences of labor substituting technical change. (see Katz and Murphy (1992), Acemoglu (1999) and Acemoglu and Autor (2011)). Autor and Dorn (2013) show how advances in computational technology have substituted out workers, performing routine tasks and contributed to the polarization of the labor market.[2] Containerization is another example of technological change that substituted the tasks performed by longshoremen with cranes, which require much lower labor input. Similar to those studies, I find that the introduction of the shipping container had negative effect on low-skilled workers in a specific sector. Nevertheless, the overall effect on the unemployment rate was negative, i.e. it decreased.

Third, the paper bears some relationship with studies that investigate the role of

[2]Along these lines Berger and Frey (2016) investigate the effect of computational technologies on the development of US cities.

transportation infrastructure investments on economic growth and regional development. Duranton, Morrow, and Turner (2014) estimate the effect of interstate highways on the level and composition of trade for US cities. Blonigen and Cristea (2015) study the relationship between air traffic growth and urban development using the 1978 Airline Deregulation Act as a quasi-natural experiment. Giroud (2013), using the introduction of new airline routes as a source of exogenous variation in proximity, finds that new airline routes that reduce the travel time between headquarters and plants lead to an increase in plant-level investment and total factor productivity.

Finally, the paper is related to Moretti (2010), who shows how the creation of new jobs in the tradable sector of local economy may serve as a multiplier and create new ones, mainly through higher demand for local goods and services. By studying a specific event, in this paper I show that the destruction of jobs in a specific industry does not necessarily lead to negative spillovers on other industries. The effect crucially depends on the nature of the shock.

The rest of the paper is organized as follows: Section 2 discusses historical events related to the invention and adoption of the shipping container. Section 3 presents the estimation strategy and describes the data used in the paper. Section 4 presents the results of estimations. The last section offers concluding remarks and discusses implications for future research.

2 Historical Background

Bernhofen et al. (2016) provide an interesting discussion of the historical background of containerization, its economic impact and the diffusion process. In this section I provide some additional facts primarily focusing on labor market developments to complement their discussion.

The first loaded containership traveled from Port Newark to Port of Houston in 1956. At this stage the volumes of container shipments were very small and the effect of container revolution could not be found on either trade volumes or employment in ports. Improvements in labor efficiency came rather gradually. Every aspect of the operation needed to be redesigned for faster handling. Improvements were introduced to speed up the process of moving containers within ports, from ships to trailers and the other way. One example of such a process automation was the new locking system which allowed a longshoreman to secure or release the container by raising or lowering a handle at each corner of the chassis, doing away with the labor-intensive routine of using iron chains to prevent the box from slipping off the truck. Another example is the world's first purpose-built container crane, which went into operation in 1959.

The crane was loading one 40,000-pound box every three minutes. At that rate, the Alameda terminal (Houston, TX) could handle 400 tons per hour, more than 40 times the average productivity of a longshore gang using shipboard winches. There are many other example of such processes automations and they continue until the present day, however the incremental efficiency gains and the destruction of jobs that came as a result of computerization and automation after 1980 are not comparable to those that took place in the earlier stages.

As with many other new technologies people frequently resist change. In the case of containers this resistance was especially strong because longshoremen were unionized. There were a number of episodes before 1960 when labor unions refused to unload containerships because they were recognizing imminent threats. The key players on stage were the International Longshoremen's Association (ILA) on the East Coast and the International Longshore and Warehouse Union (ILWU) on the West Coast. A period of intense negotiations started between interested parties. The outcome, in December 1959, was a three-year contract stating that New York employers would have the right to automate in return for protecting longshoremen's incomes. On the West Coast, dozens of bargaining sessions followed before the landmark Mechanization and Modernization Agreement was finally signed on October 18, 1960. Despite this agreements, Weir (2004) notes that these developments did not lead to an immediate destruction of all jobs, breakbulk cargo continued to provided many jobs for longshoremen until the late 1960's.

Although, technological advances have been made by 1960 the use of the container was not widespread. Only few maritime companies were engaged in the business of moving cargo in containers and most ports lacked facilities. The fact that the industry was tightly regulated and the level of competition was low served as a huge drag on the dissemination of new technologies and practices. Levinson (2008) points out that by 1964 everyone in the industry was talking about containers but the talk, far outstripped action. Many experts were considering the container as a niche technology. The future of containers depended not only on shipping lines and ports but also on land transportation industries. Full benefits of containerization could materialize only if every participant in the transportation chain adopted them. The railroads were so uninterested in the concept that even in 1970 they had not designed equipment more efficient than their standard flatcars. It was also essential for other countries to build container terminals. Bernhofen et al. (2016) choose 1983 as the end of the container revolution because some countries built their container terminals very late. But those countries that built container terminals after 1980 were developing countries, which had relatively small economies and their adoption, although affected bilateral trade, had negligible effect on US total trade. Following these developments, I divide the sample

into two sub-periods 1950-1960 as the pre-treatment (before containerization) and 1960-1980 as the post-treatment (after containerization). As will be discussed below the choice of the sample periods are partly dictated by data availability (only decennial data is available), but in general my division into sub-periods seems to coincide rather well with the the account of historical events.

It is also important to discuss the implications of containerization on ports of various sizes. The process of handling containers is a capital intensive business and requires large investments in infrastructure. To maximize their profits, shipping lines started to order larger ships, which could only harbor in deepwater ports. Larger cranes in turn reduced the cost of labor and increased the speed of operations. The advantages of larger ports were obvious. First, despite the advances in construction and digging technologies, the natural advantages of existing ports made the accommodation of large ships possible and in the case of expansion much cheaper. Second, such areas had already developed significant infrastructure, in the form of railroads, highways, etc. Third, they were closer to specialized labor who had expertise in the industry. In the presence of increasing returns to scale technologies, larger ports had more advantages and incentives to adopt new technologies. As a result, almost all modern container ports were among the major US ports in 1950.[3] But this does not mean that containerization was an opportunity only for top few. There was significant heterogeneity between large ports when it came to the construction of container terminals. For example, the Port of Savannah (GA), which was not very large in 1955, currently is ranked fourth in terms of container cargo, only behind the ports of Los Angeles, Long Beach and New York.

3 Empirical Strategy and Data

3.1 Empirical Strategy

In this paper I'm interested in estimating the effect of the container revolution on the share of longshoremen in total workforce and other economic indicators (the share of unemployed workers, the share of employment in a specific sector, etc.). Using the notation $\Delta Y_{it} = Y_{it_1} - Y_{it_0}$ to denote the change of variable Y in location i over the time period $t = [t_0, t_1]$, the resulting difference-in-differences specification can be written as follows:

$$\Delta Y_{it} = \beta_1 d_t + \beta_2 Longshore_{it_0} + \beta_3 (Longshore_{it_0} \cdot d_t) + X'_{it_0}\beta_4 + \delta_t + \gamma_s + \epsilon_{it}, \quad (1)$$

[3]The data for major ports and the volume of commerce are available from the Statistical Abstracts of the United States. The list of modern container ports and can be obtained from the United States Maritime Administration.

where d_t is a dummy that takes a value of 1 after 1960, which is the start of containerization period, $Longshore_{it_0}$ denotes the initial share of workers employed as longshoreman in total workforce in location i, X_{it_0} is vector of start-of-period controls and ϵ_{it} is the error term. The specification also includes location- and time- fixed effects. Based on the studies mentioned above, the vector of controls includes the following variables: log size of workforce, share of employment in agriculture, share of employment in manufacturing, share of employment in services[4], share of blacks, share of foreign borns, share of non-college educated workers and the unemployment rate.

In equation (1) the coefficient β_2 captures the overall trend effect from the initial share of longshoremen during the entire study period; the coefficient β_3, in turn, captures the effect after the adoption of the shipping container. I expect the coefficient β_3 to be negative. Clearly those ports that had relatively larger share of workers employed as longshoreman were more vulnerable to job losses due to new technologies because there were more jobs in this occupation after all. It also should be mentioned that containerization did not bring to complete elimination of traffic in those ports that did not build container terminals. Such ports continued their operations by handling bulk cargo, metals and other types of goods, which cannot be put into containers and require relatively more labor to handle.

Equation (1) is also estimated for a number of other regional economic indicators such as, changes in the unemployment rate, share of workers in manufacturing and other industries. In all these specifications the coefficient of interest remains the interaction between the share of longshoreman and containerization dummy. Since those ports that had higher share of workers employed as longshoremen were more likely to construct container terminals, both positive and negative effects of containerization are expected to be more pronounced in locations with relatively higher share of longshoremen.

Additionally, I estimate equation (1) by replacing the share of longshoremen with their total number. As mentioned in the previous section larger ports had more advantages to adopt container technologies and the number of longshore workers is a good proxy for port size. The problem with this specification is that such numbers are largest in big cities such as New York, which had the largest port in the world in 1950's. Although, New York's port was an essential part of its local economy, the city was not as dependent on its port as was New Orleans. Consequently, technological changes affecting the shipping industry had larger effects on the structure of New Orleans' economy compared with New York's. For this reason, I report the results for specifications with the share of longshoreman as the explanatory variable as a baseline, and then repeat the same estimations, using the number of longshore workers, to verify

[4]The definition of services includes only private sector industries. Public administration, defense on other related industries are excluded.

the robustness of my findings. The results do not differ much, which is due to the fact that there is a high correlation between these two variables.

Containerization was a major exogenous and long-lasting shock to the shipping industry which makes the identification of equation (1) valid. Furthermore, figure 1 provide suggestive evidence of substantial variation in changes in the shares of longshoreman before versus after the container revolution. By including a number of control variables describing the economic and demographic characteristics of locations also allows me to control for various factors that affect regional growth and industry demand.

3.2 Data

To construct regional data for employment I closely follow Autor and Dorn (2013) and use Census Integrated Public Use Micro Samples for the years 1950, 1960, 1970 and 1980. The 1980 Census samples includes 5 percent of the US population, the 1970 and 1960 Censuses include 1 percent of the population, and the 1950 Census sample includes approximately 0.2 percent of the population. The Census samples are decennial. Given this I construct three sub-samples (1950-1960, 1960-1970 and 1970-1980). The choice of 1980 as the end of the period rather than 1970 is based on the historical developments discussed above. Some major ports did not have purpose-built container terminals in 1970. Furthermore, in order the construction of container terminals to have full effect on regional economies and industries, longer time perspective is required.

Autor and Dorn (2013) describe how to construct Commuting Zone (CZ) level data based on the Census samples. The authors describe several advantages of this new approach in comparison to the Metropolitan Statistical Area concept conventionally used in the literature. In addition, I need to emphasizes that for the purposes of the current paper the Census samples have an important advantage over other data sources. The Census provides detailed information on industries and occupations. As will be seen below, both of these factors play important role in the analysis.

The worker sample consists of male individuals who were in the workforce and aged between 16 and 64. All calculations are weighted by the Census sampling wight and multiplied by a weight derived from the geographic matching process described in Autor and Dorn (2013) in more detail. As a result of this matching process and the fact that the 1950 sample is not very large I have to drop some CZs.

Next I need to identify those CZs that contain ports. There are numerous ports in the US most of which are small. To identify all ports I select those CZ that have workers for each of which two criteria are simultaneously satisfied. First, the worker is employed in the water transportation industry; second, his occupation is "Materials movers: stevedores and longshore workers" as defined in the Census. In this paper I

refer to workers in this category as longshoremen. This procedure identifies 55 CZs, which include almost all CZs on the coastline, several CZs on the Great Lakes, and major rivers. All these CZs are listed in table 1. In the table ports are ranked according to the share of workers employed as longshoreman.[5] As can be seen the share of longshoremen is highest in costal areas. In the first column all CZs are located on the coastal line. Despite the fact that table 1 is based on 1950 and 1960 data, almost all ports in column 1, currently are container ports. This is in line with the arguments provided above that those CZs that historically had good locations and were more specialized in waterborne commerce were more likely to adopt container technologies. In the second column there is a mix of smaller costal ports and inland ones. Finally, in the last column there are mostly inland ports.[6]

Summary statistics for the CZs that host ports is presented in table 2. Changes in variables that are used as dependent variables for the pre-treatment and post-treatment periods are presented separately. The post-treatment period includes 1960-1970 and 1970-1980 samples, for this reason there are twice more observations. The table also presents start-of-period values of control variables for three periods.

4 Results

4.1 Longshoremen

Table 3 reports the results of regressions that estimate the effect of containerization on the decline in the share of workers employed as longshoreman. In the first specification control variables are the initial share of workers employed as longshoreman and its interaction with the dummy for the containerization period. The results confirm what was presented in figure 1. Both coefficients are negative and statistically significant. This mens that overall there was a decline in the share of workers employed as longshoreman but this decline accelerated after the introduction of the container. Levinson (2008) points out that small improvements in ports were taking place, such as the more extensive use of forklifts, before the adoption of the container. Next specification adds the initial size of workforce in CZs and sector shares, which turn out

[5] As mentioned earlier if ports are ranked according to the number of longshoremen the ranking does not change much.

[6] It should be mentioned that CZs of San Antonio, Fort Wayne, Nashville, Birmingham, Mansfield, Kankakee, Indianapolis, and Youngstown are not located on the coastline nor on the major rivers or lakes, but they have workers employed as longshoreman. There are several possibilities. First, most of these CZs in their neighborhood have a CZs that have access to oceans or lakes. So, some people who live close to the boarders of their CZs may make relatively long commutes. Second, in these CZs there may be relatively small internal rivers (this may be the case for Nashville). To make sure that these factors do not distort my results I drop all these CZs and redo all estimation presented below. I obtain almost equivalent results.

Table 1: List of Commuting Zones hosting ports*

(1)	(2)	(3)
New Orleans city, LA	Miami city, FL	Nashville-Davidson, TN
Mobile city, AL	Eugene city, OR	Memphis city, TN
Portland city, OR	Daytona Beach city, FL	St. Louis city, MO
Virginia Beach city, VA	Providence city, RI	Birmingham city, AL
Beaumont city, TX	Wilmington city, DE	Toledo city, OH
Savannah city, GA	San Diego city, CA	Mansfield city, OH
Houston city, TX	Duluth city, MN	Buffalo city, NY
Newport News city, VA	Lorain city, OH	Bridgeport city, CT
Seattle city, WA	Santa Rosa city, CA	Grand Rapids city, MI
Baltimore city, MD	Milwaukee city, WI	Detroit city, MI
San Francisco city, CA	Erie city, PA	Kankakee city, IL
Brownsville city, TX	Chicago city, IL	Gary city, IN
Tampa city, FL	Cincinnati city, OH	Minneapolis city, MN
Newark city, NJ	Albany city, NY	Omaha city, NE
New York city, NY	San Antonio city, TX	Indianapolis city, IN
Philadelphia city, PA	Cleveland city, OH	Youngstown city, OH
Greenville city, NC	Fort Wayne city, IN	San Jose city, CA
Sacramento city, CA	Saginaw city, MI	Pittsburgh city, PA
Los Angeles city, CA		

Notes: *Name of the largest place in Commuting Zone. Ports are ranked according to their share of workers employed as longshoreman.

to be insignificant. The coefficients on the share of longshoremen are not affected. In column 3, I add a number of socio-demographic measures, all of which turn out to be insignificant. The following column estimates the same specification with state-level fixed effects. The last column adds CZ-level fixed effects. In this last specification both coefficients of interest remain highly significant and their values increase further. So, the overall conclusion is that in US ports during the period 1950-1980 there was a declining trend in the share of workers employed as longshoreman, the adoption of the shipping container after 1960 contributed significantly to this trend and resulted in a significant reduction of such jobs.

According to Weir (2004) the first victims of containerization were not regular longshore workers but casuals. These people worked on the waterfront by the day and received the hourly wage. It is unlikely that the Census data captures job losses among these workers. So the results presented in tables tab:stats and tab:panel provide a lower bound on total job loses among longshoremen.

The specification in column 5 is the most preferred one. For this reason, I estimate the same specification, with the same control variables and fixed effects, for a number of other variables to better understand the effect of containerization on the development

Table 2: Summary statistics

	Obs.	Mean	Std. Dev.	Min	Max
Changes in shares 1950-1960					
Longshoremen	55	0.000	0.003	-0.010	0.009
Services	55	-0.019	0.056	-0.174	0.108
Consumer services	55	-0.013	0.031	-0.101	0.083
Manufacturing	55	0.022	0.072	-0.236	0.272
Trucking	55	0.002	0.005	-0.014	0.013
Railroads	55	-0.016	0.012	-0.043	0.006
Non-college	55	-0.145	0.041	-0.253	-0.034
Unemployment	55	0.009	0.022	-0.053	0.068
Changes in shares 1960-1970 & 1970-1980					
Longshoremen	110	-0.001	0.003	-0.015	0.006
Services	110	0.044	0.047	-0.129	0.201
Consumer services	110	0.026	0.023	-0.019	0.084
Manufacturing	110	-0.022	0.035	-0.124	0.120
Trucking	110	0.002	0.005	-0.008	0.019
Railroads	110	-0.006	0.008	-0.043	0.018
Non-college	110	-0.089	0.046	-0.226	0.044
Unemployment	110	0.009	0.029	-0.057	0.091
Base year variables					
Share longshoremen$_{t_0}$	165	0.002	0.004	0.000	0.024
Share agriculture$_{t_0}$	165	0.097	0.083	0.013	0.448
Share manufacturing$_{t_0}$	165	0.309	0.131	0.015	0.590
Share services$_{t_0}$	165	0.423	0.085	0.086	0.678
Share cons. services$_{t_0}$	165	0.219	0.043	0.059	0.366
Share trucking$_{t_0}$	165	0.016	0.006	0.001	0.032
Share railroads$_{t_0}$	165	0.025	0.018	0.000	0.095
Share non-college$_{t_0}$	165	0.827	0.100	0.571	0.980
Share black$_{t_0}$	165	0.098	0.088	0.000	0.375
Share foreign$_{t_0}$	165	0.038	0.139	0.000	0.812
Unemployment$_{t_0}$	165	0.043	0.018	0.005	0.106
Size$_{t_0}$	165	12.034	1.186	8.652	14.834

Notes: This table reports the summary statistics of variables that are used in regressions. Data for Size are in logs.

on CZs that host ports. The results are presented in table 4.

Table 3: The effect of containerization on longshoremen

	(1)	(2)	(3)	(4)	(5)
Share longshoremen$\cdot d_t$	-0.463***	-0.470***	-0.467***	-0.547***	-0.605***
	(0.072)	(0.064)	(0.076)	(0.127)	(0.113)
Share longshoremen	-0.149***	-0.161***	-0.175***	-0.424**	-0.662***
	(0.055)	(0.054)	(0.066)	(0.172)	(0.236)
Size		-0.002	-0.002	-0.002	-0.001
		(0.002)	(0.002)	(0.002)	(0.004)
Size2		0.000	0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)
Share agriculture		-0.001	0.000	-0.002	-0.001
		(0.002)	(0.002)	(0.003)	(0.003)
Share manufacturing		-0.001	-0.001	-0.001	-0.007
		(0.002)	(0.002)	(0.004)	(0.004)
Share services		0.002	0.003	0.006	0.003
		(0.002)	(0.002)	(0.006)	(0.007)
Share non-college			0.003	0.007	0.007
			(0.004)	(0.006)	(0.007)
Share black			0.001	0.003	0.000
			(0.002)	(0.006)	(0.009)
Share foreign			-0.002	-0.032	-0.071
			(0.001)	(0.023)	(0.054)
Unemployment			0.003	-0.010	-0.002
			(0.010)	(0.017)	(0.014)
Time fixed effects	Yes	Yes	Yes	Yes	Yes
State fixed effect	No	No	No	Yes	No
CZ fixed effects	No	No	No	No	Yes
R-squared	0.541	0.547	0.563	0.684	0.803
N	165	165	165	165	165

Notes: This table reports the results from a series of regressions based on equation (1). The dependent variable in all models is the change in the share of workers employed as a longshoreman. All models include an intercept. Explanatory variables are start-of-period values. Robust standard errors in parentheses are clustered on CZ. * (**) (***) indicates significance at the 10 (5) (1) percent level.

Table 4: The effect of containerization on the development of regions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Share longshoremen·d_t	-1.250***	0.218	-0.596	3.481***	-3.624*	-1.729*	-0.345	-0.018
	(0.403)	(1.511)	(1.319)	(1.090)	(1.952)	(0.909)	(0.329)	(0.173)
Share longshoremen	2.128***	-2.054	1.002	-4.581**	2.771	2.391**	-0.469	0.029
	(0.640)	(2.462)	(2.120)	(1.732)	(3.103)	(1.034)	(0.407)	(0.199)
Size	-0.001	-0.118***	0.000	0.003	0.006	-0.001	0.001	0.000
	(0.002)	(0.005)	(0.006)	(0.006)	(0.007)	(0.003)	(0.001)	(0.000)
Share agriculture	-0.060**	0.001	-0.028	0.041	0.039	0.032	-0.001	-0.006
	(0.026)	(0.030)	(0.036)	(0.052)	(0.057)	(0.030)	(0.008)	(0.005)
Share manufacturing	-0.015	0.070	0.130	-1.044***	-0.165*	-0.041	-0.011	-0.003
	(0.039)	(0.096)	(0.095)	(0.073)	(0.098)	(0.047)	(0.016)	(0.009)
Share non-college	0.093**	-0.201*	0.165*	0.032	0.069	0.006	0.047**	0.021
	(0.036)	(0.119)	(0.097)	(0.120)	(0.116)	(0.075)	(0.019)	(0.014)
Share services	0.022	-0.279*	0.228**	0.098	-1.355***	-0.058	0.012	-0.033**
	(0.049)	(0.141)	(0.100)	(0.154)	(0.152)	(0.102)	(0.022)	(0.013)
Share black	0.114**	0.088	-0.180	-0.414**	0.081	-0.001	0.021	-0.007
	(0.045)	(0.237)	(0.146)	(0.179)	(0.213)	(0.071)	(0.035)	(0.013)
Share foreign	0.206	-1.390*	0.281	-0.019	0.385	0.622	-0.094	-0.118*
	(0.240)	(0.760)	(0.706)	(0.699)	(0.733)	(0.382)	(0.129)	(0.065)
Unemployment	-1.371***	0.085	-0.200	0.353*	-0.070	-0.042	-0.039	-0.003
	(0.140)	(0.282)	(0.348)	(0.187)	(0.237)	(0.150)	(0.052)	(0.031)
Share cons. services						-1.037***		
						(0.191)		
Share railroad							-0.936***	
							(0.086)	
Share trucking								-1.144***
								(0.120)
R-squared	0.878	0.906	0.957	0.880	0.861	0.857	0.839	0.752
N	165	165	165	165	165	165	165	165

Notes: This table reports the results from a series of regressions based on equation (1). All models include time and CZ dummies. Robust standard errors in parentheses are clustered on CZ. Dependent variables are changes in the following variables: (1) share of unemployed workers; (2) workforce size (in logs); (3) share of non-college-educated workers; (4) share of workers employed in the manufacturing sector; (5) share of workers employed in the services sector; (6) share of workers employed in the consumer services sector; (7) share of workers employed in the railroads industry; (8) share of workers employed in the trucking industry. * (**) (***) indicates significance at the 10 (5) (1) percent level.

4.2 Unemployment

How did containerization affected overall unemployment? Containerization may affect unemployment through several channels. Given the results in the previous section, containerization destroyed the jobs of longshoremen and contributed positively to the unemployment rate. On the other hand, containerization also may bring benefits. There are a number of different channels through which other industries can benefit from containerization. First, new technologies that increased the speed and decreased the cost of transportation may induce manufacturing industries to locate closer to ports in order to gain access to foreign markets. As mentioned earlier, this channel is related to market-potential function of Harris (1954), according to which the demand for goods produced in a location is the sum of purchasing power in other locations, weighted by transport costs.[7] These transportation costs are lowest in locations with efficient ports. Manufacturing industries that depend on intermediate goods produced in foreign countries or in distant US regions may also benefit from being close to ports. Some services industries that provide complementary services to the shipping industry may also generate new jobs.

The first column of table 4 presents the results of the specification that estimates the effect of containerization on the change of the unemployment rate. As can be seen, the initial share of longshore workers had negative effect on the unemployment rate. This means that despite the large negative effect of containerization on workers in a specific occupation, its implications for the entire labor market was the opposite, it reduced the unemployment rate. One may argue that this is due to the fact that those workers who lost their jobs moved to other locations. To verify the validity of this argument, in the second column I estimate the effect of containerization on the change in the size of CZs (measured as total workforce in logs). The results show that such concerns are not justified. Actually, the effect is positive but not significant. This means that containerization created more jobs in areas that relied more heavily on port activities but the effect was not strong enough to make CZs to expand by increasing their total workforce.

4.3 Educational Composition

The third column of table 4 investigates the effect of containerization on changes in the share of non-college-educated workers. This regression is important because containerization substituted out tasks performed by low-skilled workers in a specific industry, so it is possible that its effects may have changed the educational compo-

[7]For an empirical analysis of this concept see Head and Mayer (2006).

sition of the entire workforce in CZs. The coefficient on the interaction between the initial share of longshoremen with the containerization dummy has a negative sign, which means that the share of non-college-educated workers has decreased but it is far from being statistically significant. In the robustness section I consider an alternative specification, according to which containerization had negative effect on the share of non-college-educated workers but the evidence is weak.

4.4 Sectors

After documenting the negative effect of containerization in CZs with relatively larger share of workers employed as longshoremen on unemployment, I investigate more specifically which sectors benefited from improvements in the water transportation industry. To this end, I estimate equation (1) where the dependent variables are changes in the share of employment in the manufacturing and services sectors.

The result of these specifications are presented in table 4. As can be seen from the fourth column, the initial share of longshoremen had a positive effect on the share of manufacturing jobs during the containerization period. This finding supports the argument that the decrease in transportation costs enticed manufacturing firms to create more jobs. One may also argue that containerization had a positive effect on the share of manufacturing jobs because it destroyed the jobs of longshoremen and increased unemployment, which put downward pressure on wages and made such locations more attractive for manufacturing firms. However, this argument is not unlikely to be correct because as it was documented above, containerization had a negative effect on the level of unemployment. Given the expansion of the relative share of manufacturing jobs, it is natural that containerization should have had negative effect on the relative share of the services sector. The fifth column of table 4 confirms this expectation.[8]

Since water transportation industry itself is part of the services sector, one may also argue that the negative effect on the relative share of services jobs is the direct consequence of containerization. Automation in the cargo handling may also affect some other services industries. To make sure that the results presented in the fifth column are robust to such arguments, I estimate the effect of containerization on the consumer services sector (in column 6), which has little relationship with the water transportation industry. Distinguishing consumer services sectors form business services is not straightforward. Many industries such as, banking, insurance, construction and many others provide services both to consumers and business. For this reason I choose only

[8]It should be noted that both sectors do not add up to one because the services sector excludes public administration and other non-market activities, also there is the agricultural sector, although its share is very small in most CZs.

those that predominantly cater to consumers only such as, beauty shops, barber shops, shoe repair shops, etc.[9] In addition to the full set of control variables, this specification also includes the initial share if employment in the consumer services industry. The results show that, in CZs with larger share of longshoremen, containerization had negative effect on the employment in the consumer services sector as well.[10]

4.5 Land Transportation

Next I turn to more specific services industries that are related to the maritime shipping industry. Two industries that could have been affected by containerization are trucking and railroads. However, the direction of the effect is not obvious. On the one hand the effect may be positive, because port cities may serve as hubs and connect inland territories to other markets. This will increase demand for inland transportation and crete new jobs. On the other hand, containerization may also negatively affect these industries. To understand the negative effect, one needs to recall the initial motivations that lead to the introduction of the first containership. *Ideal-X*, the fist containership, was introduced by Malcom McLean, a trucking entrepreneur, who was concerned about increased US highway congestion. From this point of view containerization also competed with trucking, so its effect could be negative. The last two columns of table 4 report the results of the estimation, where the dependent variables are the share of workers employed in the railroads and trucking industries respectively. In addition to the full set of control variables, I introduce the initial share of employment in the corresponding industry. The coefficient of interest is not significant for both specifications. These findings reflect unequivocal effects of containerization on these industries. In addition to those countervailing forces described above, containerization also had negative effect on the employment in the railroads industry because, similar to longshore workers, there were material movers employed at railway stations, whose jobs also disappeared. Another factor that needs to be taken into account is that significant share of demand for services provided by both industries does not depend on the developments in the water transportation industry. In particular the railroads provide passenger services and trucks deliver goods to stores that are produced in the same city.

Findings documented in this paper have some important implications regarding the assumption made in Moretti (2010). In that study the author assumes that those sectors that have experienced nationwide decline in employment have been hit by a

[9]The full list of these industries is available from the author upon request.

[10]I do not conduct a similar exercise for business services sectors because there are very few industries that provide services exceptionally to businesses. Given that business outsourcing was not very common in 1950, in some CZs there no people employed in those few sectors.

negative shock and should have negative spillovers on other industries. However, as the results of this paper show, declines in the share of employment in a specific sector may be the consequence of a positive productivity shock and this shock may have positive effect on the employment growth of some industries and decrease the level of unemployment.

4.6 Robustness

In this subsection I reestimate specifications discussed above but replace the share of longshoreman variable with the log of their number. The main idea is that containerization is a capital intensive business with increasing returns to scale technology, and larger ports were more likely to be affected by it. Running ahead it should be mentioned, that here is a strong correlation between the two measures, so there are no big differences in the results.

The first column of table 5 reports the results for the specification that estimates the effect of containerization on the share of workers employed as longshoreman. As can be seen containerization had large negative effect on the share of longshoremen even when an alternative measure of dependance on port activity is used. The following seven columns reestimate the same regressions in table 4 in the same order. The key difference that can be noticed in table 5 is that containerization did not have statistically significant effect on the relative shares of manufacturing and services sectors. As mentioned earlier this is due to the fact that the share variable better captures the dependance of a given CZ on its port, and the developments in the water transportation industry have more pronounced effect on regional economic structure in those CZs that are more dependent on their ports. Another interesting difference is that, in CZs with relatively more longshoremen, containerization had a negative effect on the share of non-college-educated workers, but the coefficient is barely significant at 10 percent level. This result provides weak evidence that containerization was a skill-biassed technological change and its negative effect on low-skilled workers was reflected at the level of the entire CZ not just within a specific industry.

Table 5: The effect of containerization on the development of regions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Longshoremen·d_t	-0.001**	-0.002*	-0.002	-0.004*	0.002	-0.000	-0.000	-0.001	-0.000
	(0.000)	(0.001)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)	(0.001)	(0.000)
Longshoremen	-0.000	0.001	0.005*	0.002	-0.002	0.001	0.000	0.001	0.000
	(0.000)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.000)	(0.000)
Size	0.000	-0.001	-0.123***	0.001	0.004	0.006	-0.001	0.001	0.000
	(0.001)	(0.002)	(0.005)	(0.006)	(0.006)	(0.007)	(0.004)	(0.001)	(0.000)
Share agriculture	0.003	-0.065**	0.019	-0.018	0.060	0.021	0.017	0.004	-0.005
	(0.004)	(0.026)	(0.037)	(0.038)	(0.053)	(0.065)	(0.034)	(0.008)	(0.005)
Share manufacturing	-0.010	-0.011	0.043	0.136	-1.043***	-0.171	-0.039	-0.015	-0.003
	(0.008)	(0.040)	(0.102)	(0.094)	(0.069)	(0.104)	(0.051)	(0.016)	(0.009)
Share services	-0.001	0.029	-0.280**	0.236**	0.088	-1.356***	-0.026	0.009	-0.033**
	(0.008)	(0.048)	(0.120)	(0.096)	(0.153)	(0.154)	(0.105)	(0.022)	(0.013)
Share non-college	0.001	0.087**	-0.236**	0.154	0.050	0.054	0.001	0.039**	0.021
	(0.007)	(0.037)	(0.105)	(0.093)	(0.123)	(0.102)	(0.071)	(0.017)	(0.014)
Share black	-0.005	0.143***	0.028	-0.133	-0.440***	0.076	0.017	0.014	-0.007
	(0.021)	(0.052)	(0.217)	(0.151)	(0.155)	(0.221)	(0.084)	(0.036)	(0.013)
Share foreign	-0.025	-0.010	-1.073	0.249	0.504	-0.031	0.313	-0.044	-0.118*
	(0.073)	(0.324)	(0.663)	(0.696)	(0.568)	(0.636)	(0.445)	(0.107)	(0.061)
Unemployment	-0.005	-1.342***	-0.027	-0.316	0.178	0.160	0.093	-0.053	-0.004
	(0.031)	(0.131)	(0.315)	(0.329)	(0.205)	(0.198)	(0.134)	(0.052)	(0.028)
Share cons. services							-1.097***		
							(0.208)		
Share railroad								-0.918***	
								(0.091)	
Share trucking									-1.149***
									(0.119)
R-squared	0.454	0.869	0.909	0.959	0.864	0.849	0.844	0.831	0.753
N	165	165	165	165	165	165	165	165	165

Notes: This table reports the results from a series of regressions based on equation (1). All models include time and CZ dummies. Robust standard errors in parentheses are clustered on CZ. Dependent variables are changes in the following variables: (1) share of workers employed as longshoremen; (2) share of unemployed workers; (3) workforce size (in logs); (4) share of non-college-educated workers; (5) share of workers employed in the manufacturing sector; (6) share of workers employed in the services sector; (7) share of workers employed in the consumer services sector; (8) share of workers employed in the railroads industry; (9) share of workers employed in the trucking industry. * (**) (***) indicates significance at the 10 (5) (1) percent level.

5 Conclusions

In this paper I studied the effect of containerization on the regional development of US CZs that host ports. The results showed that those areas that had relatively larger share of workers employed as longshoreman experienced larger job losses in this specific occupation. These job loses did not result in increased unemployment rate, actually the opposite happened. These results can be explained by the fact that lower transportation costs brought by containerization encouraged more manufacturing firms to move closer to ports which provided cheaper and faster access to large markets.

The containerization had profound effect on the industrial structure of port cities. As argued in the paper, areas more dependent on ports created more jobs in manufacturing industries. It is very likely that this had consequences that extend beyond the study period. On the one hand, it is possible that manufacturing jobs became a curse for cities that were more dependent on port activity, because after 1980's the competitiveness of US manufacturing industry declined and there were large job losses in this sector. On the other hand the long run effect could be positive, because lower transportation costs created incentives for manufacturing firms to move not only their production operation closer to ports but also their their headquarters. Headquarters bring talented and high-skilled workers. The results in this paper provide weak evidence that the share of high-skilled workers increased in larger ports. These factors could have contributed to future prosperity of such cities in later periods, when the economies of advanced countries switched to providing headquarter services instead of manufacturing goods. This is an interesting topic, which requires detailed quantitative investigation.

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