Working Paper

The Local Impact of Containerization

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The Local Impact of Containerization

We investigate how containerization impacts local economic activity. Containerization is premised on a simple insight: packaging goods for waterborne trade into a standardized container makes them cheaper to move. We use a novel cost-shifter instrument—port depth pre-containerization—to contend with the non-random adoption of containerization by ports. Container ships sit much deeper in the water than their predecessors, making initially deep ports cheaper to containerize. We find that counties near containerized ports grew twice as rapidly as other coastal port counties between 1950 and 2010 because of containerization. Gains are concentrated in areas with initially low land values.

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Underlying the second wave of globalization following World War II is a vast improvement in the ability to transport goods. New York City's Herald Square Macy's now finds it cheaper to source a dress from Malaysia than from the city's own rapidly disappearing garment district (Levinson, 2008, p. 3). This decline in the importance of physical distance owes much to the development and rise of containerization (Bernhofen et al., 2016). Containerization, which took off in the early 1960s, is premised on a simple insight: packaging goods for waterborne trade into a standardized container makes them cheaper to move. Containerization simplifies and speeds packing, transit, pricing, and the transfer from ship to train to truck. It also limits previously routine and lucrative pilferage. The adoption of container technology, however, came at a substantial cost. In the years of peak outlays from 1968 to 1973, the U.S. spent about $2015 8 billion of public and private funds on the required port infrastructure (Kendall, 1986).[1]

In this paper, we use novel data and a new identification strategy to understand how a drastic decline in transportation cost such as the one brought by containerization impacts local economic activity. We focus on coastal counties in the United States near a port before the advent of containerization. We address the non-random adoption of container technology by ports with a novel cost-shifter instrument: port depth pre-containerization. This variable isolates exogenous cost-driven port containerization from adoption due to local demand. Because container ships sit much deeper in the water than their predecessors, they require deeper ports in which to dock. Dredging a harbor to increase depth is possible, but it is extremely costly.

To understand containerization's impact on local economic activity, we combine multiple data sources for the period 1910 to 2010. We use county-level information on population and demographics from the Decennial Census (1910 to 2010) and information on employment and payroll by industry from the County Business Patterns (1956 and 1971 to 2011). We supplement these data with information on the location of ports in 1953 and 2015, containerization adoption by ports, and port-level foreign trade in the pre-containerization era.

We find that, between 1950 and 2010, population in counties near containerized ports grew about twice as rapidly as in other coastal port counties because of containerization. This is a large effect: it is roughly equal to the amount by which coastal counties' population growth exceeds non-coastal county growth over the same period. We estimate

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[1] This is about $2015 1.6 billion per year, or one quarter of the annualized cost of the Interstate Highway System from 1956 through 1991 (source: `https://www.fhwa.dot.gov/interstate/faq.cfm`, assessed on 08/21/2017).

a slightly larger impact of containerization on employment. Examining local prices, we find that containerization caused land values to grow by an additional five percentage point annually, but had little impact on nominal wages.

We interpret the results through the lens of a standard spatial equilibrium model in the Roback tradition (Roback, 1982). We allow containerization to impact local consumer amenities, local productive amenities, and access to international markets through domestic and international transportation costs. The model does not predict a specific direction for containerization's impact on the three equilibrium outcomes: population, wages, and land prices. Using this framework, our empirical results suggest that containerization increased consumer and producer valuations of containerized counties by between one and two percent annually.

Finally, we find that containerization-induced population gains are concentrated in areas with initially low land values. This is consistent with the physical demands of container technology. The shift of port activity from water-based finger piers to giant cranes and vast marshalling yards requires large tracts of land.

Our paper adds to several literatures. First, our findings contribute to the debate on the impact of globalization on economic activity. Following Romer and Frankel (1999), a large literature has emerged to understand how improved access to international markets affects country level outcomes such as GDP (e.g., Pascali, 2017; Feyrer, 2019).[2] Our paper contributes to this literature by looking at how the reduction in trade costs brought by containerization affects the spatial distribution of economic activity within countries. In doing so, our results shed light on the potential uneven impacts of globalization.[3]

Second, our paper contributes to a growing literature investigating the consequences

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[2] Most papers in this literature find that improved access to international markets has large positive effects on GDP, with the exception of Pascali (2017) who documents mainly negative effects. Pascali (2017) is particularly related to our paper in that he exploits a major improvement in the shipping technology—the advent of the steamship—to examine how a decline in international transportation costs impacts economic activity.

[3] Our paper is related to Storeygard (2016), Campante and Yanagizawa-Drott (2017), and Maurer and Rauch (2019) who also estimate the effects of a common shock to transportation costs across regions more or less affected by this shock. In particular, Storeygard (2016) finds that when transportation costs decrease due to variation in oil prices, African cities near international ports grow faster than those further away. Like these three papers, we find large positive effects of access to international markets on local economic activity. Our paper also complements a growing literature in international trade that looks at the impact of trade shocks on local labor markets (e.g., Topalova, 2010; Autor et al., 2013; Kovak, 2013). These papers compare locations within a country that have similar access to international markets but that, because of initial differences in industry composition, are differentially affected by changes in a trading partner's economic activity (e.g., China). In contrast, we control for initial differences in industry composition and compare locations that experience differential gains in access to international markets.

of improvements in transportation infrastructure on local economic activity (e.g., Baum-Snow, 2007; Michaels, 2008; Duranton and Turner, 2012; Donaldson and Hornbeck, 2016; Donaldson, 2018; Baum-Snow et al., 2018; Alder, 2019; Balboni, 2019). These studies examine how investments in highways and railways have shaped the spatial distribution of economic activity within countries. Our paper is the first to study how large investments in maritime transportation infrastructure, specifically new container terminals, affect the economic conditions of target areas. Methodologically, our paper contributes a new instrumental variable strategy to address the non-random allocation of transportation infrastructure. Specifically, we introduce a cost-shifter instrument as a source of quasi-random variation in observed infrastructure (see Redding and Turner (2015) for a recent survey of the literature).[4]

Third, our work enhances the growing literature on containerization by expanding its focus beyond the shipping and trade industries. In this burgeoning literature, Rua (2014) investigates the global adoption of containerization and Bernhofen et al. (2016) estimate its impact on world trade.[5] Hummels (2007), Bridgman (2018), and Coşar and Demir (2018) analyze containerization's impact on shipping costs. Our work is particularly related to Ducruet et al. (2020), whose study of containerization builds on our use of porth depth as an exogenous cost-shifter instrument. While Ducruet et al. (2020) use world data on bilateral shipping flows and a quantitative economic geography model to understand the aggregate consequences of containerization, we focus on the local effects of containerization on population and economic activity in the United States. Our focus on the United States allows us to directly measure a number of key economic variables, including employment and wages by industry and land values.

Finally, our work relates to a broad economic geography literature in which the spatial distribution of economic activity within a country depends on differences in locational fundamentals such as productivity, amenities, land supply, and trade costs (e.g., Roback, 1982; Redding and Sturm, 2008; Allen and Arkolakis, 2014; Ahlfeldt et al., 2015; Redding, 2016; Coşar and Fajgelbaum, 2016; Fajgelbaum and Redding, 2018).[6] In this literature, our work is particularly related to Coşar and Fajgelbaum (2016) and Fajgelbaum and Redding (2018); they specify Ricardian trade models with a role for internal geography in which trade with the rest of the world occurs only through specific port

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[4] In a similar vein, Jonkeren et al. (2011) use river water level in Kaub, Germany as a key exogenous cost measure for European inland water transport.

[5] The classic book on this topic is Levinson (2008).

[6] See Redding (2020) for a review of this literature.

locations.

The remainder of this paper is organized as follows. The next section provides background on containerization, Section 3 outlines the theoretical model, and Section 4 discusses the data. We present empirical methods in Section 5 and results in Section 6. Section 7 concludes.

2 Containerization

Before goods were moved inside containers, shipping was expensive and slow. Vessels spent weeks at ports while gangs of dockworkers handled cargo piece by piece. Such port costs accounted for a sizeable share of the total cost of the movement of goods. The American Association of Port Authorities estimated that in-port costs, primarily labor, accounted for half the cost of moving a truckload of medicine from Chicago to Nancy, France in 1960 (Levinson, 2008, p. 9).

In response to these high costs, producers searched for alternatives. Trucker and entrepreneur Malcolm McLean is generally credited with being the first to match vision with reality when he moved 58 truck trailers on a ship from Newark to Houston in 1956 on the maiden container voyage.

Container shipping relies on two key innovations. The first is the mechanization of container movement. Rather than workers with carts or forklifts, specialized container cranes lift the boxes in and out of ships, around the port, and onto rail cars and trucks. This mechanization substantially decreased per unit labor costs, cut time at port and made ever-larger ships viable. Today's Post-Panamax ship is more than 17 times larger than the first ship that carried container goods in 1956 (see ship sizes in Appendix Figure 1).

The second key innovation of containerization is the development of common standards for container size, stacking techniques, and grip mechanisms. These standards allow a container to be used across modes of transportation—ships, trucks, rail—within and across countries. The U.S. standard for containers was adopted in the early 1960s, and the international standard followed in the late 1960s.

To achieve economies of scale, containerization requires physical changes to ports. In breakbulk ports, as cargo ports were known before the rise of containerization, ships pulled into finger piers and workers on- and off-loaded items by hand and cart. Ports were centrally located within cities and used a large amount of labor and a moderate amount of land for warehousing and storage. In contrast, containerized ports require substantially less labor per unit of weight and a much larger amount of land. Land is used both for the large cranes that move containers and for the marshalling of containers and trucks.

Converting a traditional port into a container port required substantial investments. However, despite its high cost, containerization diffused extremely rapidly across the United States. The bulk of domestic containerization adoption occurred in the 1960s, as shown in Figure 1, which reports the total number of US containerized ports by year. In the early 1960s, the benefits of containerization were perceived as primarily domestic, "a trend far more advanced in domestic waterhauls than in foreign trade" (Chinitz, 1960, p. 85). Containerization adoption in the United States continued at a slower pace throughout the 1970s and 1980s and plateaued thereafter. Adoption of containerization in the rest of the world followed a similar pattern, roughly one decade delayed (Rua, 2014).

Post-containerization, the distribution of dominant ports has shifted. Of the ten largest ports before containerization (in 1955, measured in terms of value of waterborne trade), two never containerized: New York (Manhattan), NY and Newport News, VA. In fact, the Port of Manhattan, the largest in the world in 1956, no longer exists as a freight port. Of today's 25 largest ports, four did not rank in the pre-containerization top 25. Only two of today's ten largest ports were in the pre-containerization top ten: Norfolk, VA and Los Angeles, CA.[7]

Containerized trade is now central to the global economy. Bernhofen et al. (2016) estimate that containerization caused international trade to grow by more than 20% percent between 1962 and 1990, an effect larger than that of regional trade agreements and contemporaneous tariff cuts. In 2017, containerized trade accounted for about 75 percent of non-bulk dry cargo shipments worldwide (United Nations Conference on Trade and Development, 2018).[8]

The literature credits containerization with substantially decreasing the cost of waterborne trade. While Hummels (2007) and Bridgman (2018) note only a small decline in shipping rates, Coşar and Demir (2018) find that containerization decreases variable shipping costs by 16 to 22 percent (using 2013 export transaction data for Turkey).[9]

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[7] See Kuby and Reid (1992) on port concentration.

[8] While containers are appropriate for carrying many goods, as diverse as toys and frozen meat, some goods are not yet containerizable. Both "non-dry cargo" and "dry-bulk commodities" such as oil, fertilizers, ore, and grain cannot be shipped inside "the box."

[9] Asturias (2020) examines how container shipping rates are determined, Ganapati et al. (2020) estimate

Traditional measures of shipping costs understate the true cost advantage yielded by containerization, particularly because containerization cuts the time ships spend at port and thus the total time in transit. Hummels and Schaur (2013) estimate that each day in transit is worth between 0.6 to 2.1 percent of a good's value, highlighting the time benefits of containerized shipping. In addition, containers ease logistics costs by protecting goods from unintentional damage and allowing different kinds of goods, with different destinations, to be shipped together (Holmes and Singer, 2018).

3 Theoretical Framework

Using this institutional knowledge, we now assess the long run local impact of containerization through the lens of a spatial equilibrium model in the Roback tradition (Roback, 1982).[10] To capture key features of containerization, we add domestic and international transportation costs to the standard framework. We then use the framework to generate predictions about the local impact of containerization on population and other economic outcomes.

3.1 Model

We model U.S. counties as small open economies that take goods prices as given. Counties differ from one another in land supply, local productive amenities, local consumer amenities, and geographic location. The economy has two factors of production: land and labor. As is standard in spatial equilibrium models, we assume that workers are perfectly mobile across counties; this free mobility implies equal utility across space in equilibrium.

To understand the geographically disparate impacts of containerization, we add internal geography as in Coşar and Fajgelbaum (2016). Specifically, we assume that there are port counties and non-port counties. We index counties by $x \in X$ and assume that only port counties have direct assess to international markets. Without loss of generality, we index all port counties by $x = 0$. For non-port counties, x is the distance between the county and its nearest port.

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trade costs on each containerized shipping leg, and Wong (2020) examines the asymmetry in container shipping rates.

[10] See Glaeser and Gottlieb (2009) and Moretti (2011) for recent overviews.

Workers

Workers in county x derive utility from an internationally traded composite consumption good, $c(x)$, land, $q(x)$, and local consumer amenities, $\theta(x)$. They supply one unit of labor inelastically in their county of residence. Workers choose consumption levels to maximize utility subject to their budget constraint. Workers' labor income is equal to spending on the consumption good and land, so that $w(x) = p_c(x)c(x) + r(x)q(x)$, where $w(x)$ denotes labor income, $p_c(x)$ is the local consumer price of the internationally traded composite consumption good, and $r(x)$ is the price of land. We assume that utility is Cobb-Douglas over the traded good and land, with a local consumer amenity multiplier $\theta(x)$. Indirect utility from living in x is given by

$$V(x) = \frac{\theta(x)w(x)}{p_c(x)^{\beta}r(x)^{1-\beta}} \,. \tag{1}$$

This indirect utility increases in local amenities and income and decreases in local prices. Free mobility ensures that workers achieve the same level of utility, $\bar{U}$, in all counties.

Firms

Firms produce in a perfectly competitive environment with constant returns to scale. We assume a Cobb-Douglas production technology with total factor productivity parameter, $A(x)$:

$$Y(x) = A(x)N(x)^{\alpha}L(x)^{1-\alpha} \,. \tag{2}$$

Here, $Y(x)$ denotes output, $N(x)$ is labor, and $L(x)$ is land. Firms choose inputs to minimize total cost subject to a production constraint. In spatial equilibrium, firms set price equal to marginal cost and earn zero profits everywhere:

$$\frac{w(x)^{\alpha}r(x)^{1-\alpha}}{\delta A(x)} = p_y(x) \,. \tag{3}$$

Here $p_y(x)$ denotes the price that firms in county x receive for their output and $\delta = \alpha^{\alpha}(1-\alpha)^{(1-\alpha)}$.

Internal Geography

Workers do not directly consume the output of local firms. For simplicity, we assume that firms produce intermediate goods that they sell on international markets at price $\bar{p}_y$. Workers consume a composite consumption good that is produced internationally using those intermediate goods and traded on international markets at price $\bar{p}_c$. The presence of international transportation costs, τ_0, and domestic transportation costs, τ_1, means that consumers in county x can buy one unit of the composite consumption good for $p_c(x) = (\tau_0 + \tau_1 x)\bar{p}_c$. Firms in county x receive $p_y(x) = (\tau_0 + \tau_1 x)^{-1}\bar{p}_y$ for each unit of output that they sell. Without loss of generality, we normalize the ratio of prices on international markets to one, or $\bar{p}_y/\bar{p}_c = 1$.

Equilibrium

We combine the worker and firm sides of the market to understand the factors that determine county population in equilibrium. We start with the equilibrium condition for land prices, which results from the spatial equalization of utility guaranteed by free mobility and the competitively driven absence of profits:

$$r(x) = \left(\theta(x)A(x)^{\frac{1}{\alpha}}p_y(x)^{\frac{1}{\alpha}}p_c(x)^{-\beta}\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}\bar{U}^{-1}\right)^{\frac{\alpha}{1-\alpha\beta}} . \tag{4}$$

This equation relates land prices to local productive amenities, local consumer amenities, and local prices. Transportation costs impact local land values through local consumption and firm output prices.

With this condition in hand, we characterize equilibrium population by combining the land and labor market clearing conditions with the firm and worker optimization conditions. Let $\bar{L}(x)$ denote the total amount of land available in county x. Land markets clear when all land is either allocated to firms, $L(x)^*$, or to workers, $q(x)^*N(x)$:

$$L(x)^* + q(x)^*N(x) = \bar{L}(x) . \tag{5}$$

Rewriting $q(x)^*$ and $L(x)^*$ using the worker and firm optimization conditions, we obtain an equation for equilibrium population that depends on location fundamentals and parameters of the model:

$$N(x) = \frac{\alpha}{1-\alpha\beta}\bar{L}(x)\theta(x)p_c(x)^{-\beta}r(x)^{\beta}\bar{U}^{-1} . \tag{6}$$

Taking logs and substituting for land prices using Equation (4), we obtain the following equation for population in county x:

$$\ln N(x) = \lambda_\theta^N \ln \theta(x) + \lambda_A^N \ln A(x) - \lambda_p^N \ln(\tau_0 + \tau_1 x) + \ln(\bar{L}(x)) + \kappa_N \ , \tag{7}$$

where

$$\lambda_\theta^N = \frac{1}{1-\alpha\beta}; \quad \lambda_A^N = \frac{\beta}{1-\alpha\beta}; \quad \text{and} \quad \lambda_p^N = \frac{2\beta}{1-\alpha\beta} \ .$$

Equation (7) tells us that population in county x depends on the magnitude of four fundamental location-specific attributes relative to all other counties: (1) local consumer amenities, $\theta(x)$, (2) local productive amenities, $A(x)$, (3) access to international markets, $\tau_0 + \tau_1 x$, and (4) land supply, $\bar{L}(x)$.[11]

Similarly, we derive equilibrium expressions for land prices and wages. Taking logs of Equation (4) yields land prices in county x as a function of fundamental location-specific attributes

$$\ln r(x) = \lambda_\theta^r \ln \theta(x) + \lambda_A^r \ln A(x) - \lambda_p^r \ln(\tau_0 + \tau_1 x) + \kappa_r \ , \tag{8}$$

where

$$\lambda_\theta^r = \frac{\alpha}{1-\alpha\beta}; \quad \lambda_A^r = \frac{1}{1-\alpha\beta}; \quad \text{and} \quad \lambda_p^r = \frac{1+\alpha\beta}{1-\alpha\beta} \ .$$

In turn, equilibrium wages in county x are given by

$$\ln w(x) = \lambda_\theta^w \ln \theta(x) + \lambda_A^w \ln A(x) - \lambda_p^w \ln(\tau_0 + \tau_1 x) + \kappa_w \ , \tag{9}$$

where

$$\lambda_\theta^w = \frac{\alpha - 1}{1-\alpha\beta}; \quad \lambda_A^w = \frac{1-\beta}{1-\alpha\beta}; \quad \text{and} \quad \lambda_p^w = \frac{1+\alpha\beta-2\beta}{1-\alpha\beta} \ .$$

Like land rents, equilibrium wages are driven by fundamental location specific-attributes.[12]

3.2 How Containerization Impacts Local Population

Our main interest is the impact of containerization on local population. To parallel our empirical specification, we express Equation (7) in first differences and take the

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[11] The final term in Equation (7), κ_N, is a constant that is a function of model parameters.

[12] The terms κ_r and κ_w are constants.

derivative with respect to an indicator for containerization, $C(x)$. This yields

$$\frac{\partial \Delta \ln N(x)}{\partial C(x)} = \lambda_\theta^N \frac{\partial \Delta \ln \theta(x)}{\partial C(x)} + \lambda_A^N \frac{\partial \Delta \ln A(x)}{\partial C(x)} - \lambda_p^N \frac{\partial \Delta \ln(\tau_0 + \tau_1 x)}{\partial C(x)} . \tag{10}$$

Equation (10) states that containerization impacts population through three factors: local consumer amenities, local productive amenities, and access to international markets. The fourth factor from Equation (7), land supply, drops in the first difference. Conceptually, containerization could have an impact on all three remaining factors. We now consider the likely direction of each of the three pathways.

First, containerization seems likely to decrease consumer amenities in counties near container ports. Container ports and their surroundings are not beloved residential locations. Ports cause pollution and the associated trucking activity generates noise, traffic congestion, and additional pollution. Therefore, containerization's impact on local consumer amenities likely decreases local population.

Second, containerization seems likely to increase total factor productivity in counties near container ports. This is especially true for industries such as transportation services, trucking, and warehousing. For example, the greater volume of containerized trade, coupled with the standardization of containers, likely increased economies of scale in trucking. Manufacturing firms located near containerized ports might also enjoy cheaper and faster delivery of local services and local intermediate goods. Therefore, containerization's impact on local productive amenities likely increases population.

Third, containerization impacts both domestic and international trade costs, both of which influence population. Containerization surely decreases international shipping costs. It also likely decreases domestic shipping costs. As we discuss in Section 2, containerization's reductions in domestic and international shipping costs are due, in large part, to two key innovations: the mechanization of container movement which cut time at port and the development of common standards which facilitates freight movement, both within and across countries.

As mechanization and standardization both decrease domestic and international transportation costs, their net impact on population is an empirical question. All else equal, a decline in domestic transportation costs flattens the transportation cost gradient and causes greater population growth in inland counties relative to port counties. In contrast, a decline in international transportation costs increases the geographic advantage of port counties and causes them to grow faster than inland counties. Given these two opposing forces, our theory makes no clear prediction about the impact of containerization-induced decreases in transportation costs on population growth near container ports.

Taking all these factors into account, the net impact of containerization on a county's population remains an empirical question, one that we answer below. Similarly, we also investigate empirically the effects of containerization on local land prices and wages. The land price and wage analogues of Equation (10) are

$$\frac{\partial \Delta \ln w(x)}{\partial C(x)} = \lambda_\theta^w \frac{\partial \Delta \ln \theta(x)}{\partial C(x)} + \lambda_A^w \frac{\partial \Delta \ln A(x)}{\partial C(x)} - \lambda_p^w \frac{\partial \Delta \ln(\tau_0 + \tau_1 x)}{\partial C(x)} \text{, and} \tag{11}$$

$$\frac{\partial \Delta \ln r(x)}{\partial C(x)} = \lambda_\theta^r \frac{\partial \Delta \ln \theta(x)}{\partial C(x)} + \lambda_A^r \frac{\partial \Delta \ln A(x)}{\partial C(x)} - \lambda_p^r \frac{\partial \Delta \ln(\tau_0 + \tau_1 x)}{\partial C(x)}. \tag{12}$$

These equations report that the direction of containerization's impact on land prices and wages is also ambiguous.

3.3 Containerization and Initial County Characteristics

In our empirical work, we also consider whether certain pre-containerization county characteristics can modify the impact of containerization on population. We are particularly interested in the role of pre-containerization land values.

While containerized ports require substantially less labor per unit of weight, they require a large amount of land. Land is used both for the giant cranes that move containers and for the marshalling of containers and trucks. In contrast, breakbulk ports operated at smaller scales and largely from water-based finger piers.

If large tracts of inexpensive land are indeed critical for successful containerization, container ports may have larger impacts in locations with initially low land values and more available land. Low initial land values could drive containerization because of the direct cost of large tracts of land in port development. In addition, low land values make proxy for the availability of land. Land availability could be either the total amount of land available for development, or the size of available land, since larger pieces of land allow developers to avoid the costly frictions inherent in land assembly (Brooks and Lutz, 2016; Hornbeck and Keniston, 2017). Land availability also allows for an easier transformation of the built environment to suit the need of businesses and households. We take this prediction to the data below.

4 Data

To study the impact of containerization on local economic activity, we construct a county-level panel dataset that includes population, employment, and wage information, as well as proximity to ports and port characteristics. This section gives an overview of the data and our estimation sample; the data appendix adds full details.

Our sample frame is the Decennial Census, for the years 1910 to 2010.[13] We assemble a time invariant panel of counties by aggregating 1950 counties to their 2010 counterparts and by dropping a few counties with large land area changes. We observe population from 1910 to 2010 and demographic characteristics from 1950 to 2010. We also observe total employment, total payroll, and employment and payroll by industry from the County Business Patterns in 1956 and then annually from 1971 to 2011.[14] We include variables that characterize the state of the transportation network at the advent of containerization (c. 1957 for rail and c. 1960 for highway). We measure total rail kilometers and highway kilometers in each county, per square kilometer of each county's area. We calculate 1920 county market access using Donaldson and Hornbeck (2016)'s transportation cost matrix. We omit Alaska and Hawaii. This yields 2,843 counties with complete data.[15]

To this sample frame, we add port attribute data. Our universe of ports is all ports that existed in either 1953 or 2015, as defined by the 1953 and 2015 *World Port Index*. For each port, we observe its location (latitude and longitude), size (in four discrete categories), and depth (in eight discrete categories). We observe the year of containerization from the *Containerisation International Yearbook*, volumes 1968 and 1970 to 2010.[16] We also observe 1948 and 1955 international trade in dollars by port from the Census Bureau's *Foreign Trade Statistics*.

We restrict our primary sample to 265 coastal port counties on the Pacific and Atlantic coasts. Our goal is to focus on a set of comparable counties that are active in maritime

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[13] For the 2010 sample, we use the Decennial Census for population figures and the American Community Survey (years 2008–2012) for other demographic covariates.

[14] We are very appreciative of digitized 1956 County Business Patterns from Matt Turner and Gilles Duranton. See the data appendix for more information about these data.

[15] Estimations using County Business Patterns data use a slightly smaller sample because the provider suppresses data for counties under certain conditions; see data appendix for complete details.

[16] For the purposes of this paper, and consistent with the industry definition, we call a port "containerized" when it has special infrastructure and equipment to handle containers. Specifically, the port has invested in equipment to handle shipping containers which enables their movement in and out of ship and onto a train or a truck.

trade before the advent of containerization. We make two key decisions to create our estimation sample. First, we focus on coastal ports by limiting the port sample to those within 100 km from the ocean. This excludes inland river and Great Lakes ports, whose surrounding areas may have different underlying population growth trends. Second, we define a "coastal port county" as one whose border is within 30 km of a 1953 coastal port. We measure a county's port depth as the maximal depth of any coastal port within 30 km of the county boundary and measure waterborne international trade as the sum of the value of all waterborne international trade at coastal ports within 30 km of the county boundary. We call a county "containerized" if any coastal port within 30 km of the county boundary containerized between 1950 and 2010.

The first panels of Figure 2 (West Coast) and Figure 3 (East Coast) show our primary estimation sample. These figures highlight that all treated and comparison observations are coastal port counties and that we limit our comparison group to fast-growing coastal regions (Rappaport and Sachs, 2003), rather than comparing coastal and non-coastal areas. As discussed in Section 6, our results are robust to using different distance cutoffs and alternative sample definitions.

5 Empirical Methods

We now turn to our empirical strategy for estimating the causal effect of containerization on local economic activity in the long run. We first present a difference-in-differences framework and illustrate its strengths. We then discuss remaining concerns with causality, followed by our instrumental variable strategy.

5.1 Difference-in-Differences

Our goal is to understand how local economic activity responds to the advent of containerization. Specifically, we assess the relationship between containerization and population growth. We also investigate whether initial land values modifies a county's response to containerization. Our empirical specification asks whether proximity to a containerized port is associated with changes in key economic outcomes, conditional on a host of covariates. We estimate

$$\Delta \ln(y_{i,t}) = \beta_0 + \beta_1 \Delta C_{i,t} + \beta_2 X_i + \Delta\epsilon_{i,t} \ , \tag{13}$$

where $i \in I$ indexes counties and $t \in T$ indexes years. Our primary dependent variable, $y_{i,t}$, is population. As suggested by our theoretical framework, we also consider employment, wages, and land values as dependent variables. The operator Δ denotes long run differences divided by the number of years, so that $\Delta \ln(y_{i,t}) = \left(\ln(y_{i,t}) - \ln(y_{i,1950})\right) / (t - 1950)$.[17] This is a first-order approximation of the annual growth rate.

Our key explanatory variable is an indicator for proximity to a containerized port at time t, $\Delta C_{i,t}$, which is equivalent to $C_{i,t}$, as no containerized ports existed in 1950 ($C_{i,1950} = 0 \; \forall i \in I$). Specifically, $C_{i,t}$ is equal to one if there is a containerized port within 30 km of county i's boundary at time t and zero otherwise.

To establish the causal effect of containerization on local economic activity, we must contend with the non-random assignment of containerized ports to coastal port counties. The difference-in-differences specification in Equation (13) goes some way to this end by netting out all time-invariant county-specific characteristics correlated with the location of containerized ports. Such characteristics include geography, proximity to population centers, climate, and historical antecedents for the location of particular industries. This method also nets out any national changes that impact all coastal port counties equally between 1950 and 2010.

In the event that containerization is also a function of time-varying county attributes, we also include a vector of baseline covariates, X_i. Including initial covariates in the difference-in-differences model allows for differential trends in the dependent variable by the initial covariates. We list these in greater detail in Section 6, but X_i includes regional fixed effects, measures of pre-containerization maritime importance and international trade volume, historical population levels and growth, initial manufacturing intensity, and climate. We cluster standard errors throughout at the 2010 commuting zone to account for spatial dependence in the errors. A commuting zone is a grouping of counties that approximate a local labor market. In our sample, the average commuting zone includes 3.5 counties.

This empirical strategy yields a causal estimate of the effect of containerization on local economic activity when containerization is uncorrelated with the error term. This is equivalent to saying that β_1 is a causal estimate when containerized ports are randomly assigned to coastal port counties, conditional on time-invariant county-level factors and the included pre-containerization covariates. Because we include a host of initial period covariates, these estimates cannot be driven by, for example, pre-existing trends in

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[17] When we use County Business Patterns data, the initial year is 1956.

population or employment.

To evaluate whether gains vary by initial conditions such as land values, we introduce an interaction term that allows β_1 to vary depending on whether a given county is below the median for a specific attribute. Call this attribute h_i and let $H_i = 1$ when $h_i < \text{median}(h_i)$ and 0 otherwise. We therefore modify Equation (13):

$$\Delta \ln(y_{i,t}) = \gamma_0 + \gamma_1 \Delta C_{i,t} + \gamma_2 \Delta C_{i,t} * H_i + \gamma_3 X_i + \gamma_4 H_i + \Delta \epsilon_{i,t} \ . \tag{14}$$

Now γ_1 reports the average impact of proximity to a container port on population growth, and γ_2 reports whether there is any differential population growth in counties with h_i below the median. We expect containerization induced population growth to be larger in locations with low initial land values. We therefore anticipate $\gamma_2 > 0$ when h_i is a measure of initial land values.

While both equations (13) and (14) net out county-specific time-invariant factors as well as trends by initial conditions, it may still be the case that an element in the error term $\Delta\epsilon_{i,t}$ remains correlated with both containerization and the outcome variable of interest. For example, a change in demand due to a county-specific technological shock could drive both adoption of containerization and local population growth.

5.2 Instrumental Variables

To address any remaining non-randomness in the assignment of containerized ports to coastal port counties, we use port depth in 1953, Z_i, as an instrument for whether a county has a containerized port, $\Delta C_{i,t}$. Specifically, we instrument county containerization with 1953 port depth as

$$\Delta C_{i,t} = \alpha_0 + \alpha_1 Z_i + \alpha_2 X_i + \Delta \eta_{i,t} \ . \tag{15}$$

For the interaction specification in Equation (14), we use both 1953 port depth, Z_i, and the interaction between port depth and being below the median of a given covariate, $Z_i * H_i$, as instruments.

There are two requirements for the instrument to yield a causal estimate of containerization on local economic activity. The first is a strong relationship between containerization and port depth in 1953. The second requirement is that, conditional on covariates, port depth in 1953 is uncorrelated with unobserved determinants of changes in local economic activity from 1950 to period t. In other words, 1953 port depth impacts changes in local economic activity only through the creation of a containerized port and the follow-on effects of that decision; mathematically, this is $\text{cov}(z_i, \Delta\epsilon_{i,t}) = 0$. We discuss each of these requirements in turn.

First, we anticipate that containerization should be strongly related to port depth in 1953 because container ships require deeper ports than their predecessors. As Appendix Figure 1 illustrates, today's container ships carry over 17 times more volume than their predecessors. Larger ships sit deeper in the water and thus require greater depth to navigate and dock.

It is possible, but quite expensive, to drill, blast or dredge an initially shallow port sufficiently deep to accept container ships. Given enough money and sufficiently lax environmental regulation, a harbor can arguably be made arbitrarily deep. However, port depth is only malleable at great cost. Therefore, initially deep ports have a competitive advantage when technology changes to favor deeper ports. This inability of ports to adjust equally is confirmed by Broeze, who notes that while "ship designers [keep] turning out larger and larger vessels," and "the engineering limits of port construction and channel deepening have by no means been reached[, t]his, however, may not be said of the capacity of all port authorities to carry the cost of such ventures" (Broeze, 2002, pp. 175–177). Thus, initial port depth is a key component of the cost of converting a breakbulk port into a containerized port.

Our instrument is therefore analogous to a cost shifter instrument often used in the industrial organization literature (Hausman, 1996; Nevo, 2001). Port depth should affect the supply of ports after the advent of containerization, but have no effect on the demand for ports.

This cost-based argument that 1953 port depth is a key driver of later containerization is consistent with containerization's pattern of adoption. Figure 4a shows the likelihood that a county is containerized, specifically that the county's boundary is within 30 km of a containerized port, over time. We show this relationship by 1953 port depth, measured as the maximum depth of any port within 30 km of the county's boundary in 1953. It is immediately clear that counties near deeper 1953 ports are more likely to containerize at time t. Among counties within 30 km of a 1953 port of more than 40 feet in depth, roughly three-quarters are containerized by 2010. Furthermore, these counties are the fastest to adopt container technology. More than half of counties near 1953 ports that are 35 to 40 feet deep are containerized by 2010. The relationship between the likelihood of containerization and port depth is nearly monotonic. Counties near initially shallow ports—those less than 20 feet deep—never adopt container technology.

An alternative way to view the strength of our instrument is to compare the geographic distribution of port depth in 1953 and containerization, as we do in the top and bottom panels of Figure 2 for the West Coast and Figure 3 for the East Coast. In Figure 2, the top panel shows the estimation sample – counties within 30 km of a 1953 port – in blue and red (we include grey counties for reference). Red counties are treated: they are within 30 km of a containerized port in 2010. Control counties, those never within 30 km of a containerized port, are shown in blue.

The bottom panel of Figure 2 shows 1953 port depth (depth of the deepest port within 30 km of the county boundary in 1953). The darkest color indicates counties with ports that are 40 or more feet deep and lighter colors successively less deep ports. Figure 3 repeats this pairing for the East Coast.

Visually, the relationship between containerization and port depth is strong. Statistically, the correlation coefficient for these two variables is 0.54. In a simple cross-sectional regression of containerization on depth, depth explains 30 percent of the variance in containerization. Appendix Table 1 shows first stage estimates. In our most complete specification, an additional foot of depth increases the likelihood of containerization by almost two percentage points. To put this in values that are relevant in our data, counties near the deepest 1953 ports, roughly 40 feet, are 40 percentage points more likely to containerize than counties near middle-depth ports of 20 feet, all else equal.

Port depth in 1953 is an important predictor of containerization, even conditional on the many covariates we use. The lowest F statistic on the instrument in any specification is 20; the highest is 23. Encouragingly, we find that the coefficient on the instrument and its significance is little changed by the inclusion of covariates, suggesting that the instrument is not correlated with the observables we include.[18]

Given this evidence of a strong relationship between the endogenous variable and the instrument, we now turn to the second condition for instrument validity—that proximity to a deep port in 1953 affects local economic activity only through its impact on containerization and containerization's subsequent economic effects.

A key concern with the instrument is that proximity to deeper ports may explain changes in county economic activity even before containerization. Our framework as-

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[18] Throughout, we report the Kleinberg-Paap F statistic, which summarizes the overall strength of the first-stage, as suggested by Sanderson and Windmeijer (2016).

serts that port depth should matter for economic activity only after the advent of containerization. To test this claim, we assess whether decadal population changes respond to port depth. Specifically, we regress the change in log population from year $t - 10$ to year t on port depth in 1953 and controls.[19]

We report results in Figure 4b. Each dot in this figure is from a separate regression and reports the coefficient on 1953 port depth in year t. For example, the 1930 estimate is from a regression of log population change from 1920 to 1930 on 1953 port depth and covariates. Each coefficient's 95 percent confidence interval is in grey whiskers. Only after 1960 – when containerization truly became a world technology – do we see a significant relationship between port depth and decadal changes in population. As container technology matures and its adoption plateaus, the relationship between 1953 port depth and population growth levels off. This evidence that port depth in 1953 affects population growth only after the advent of containerization supports the validity of the instrument.

Our instrument would also fail to satisfy the requisite criteria if port depth were correlated with factors associated with the demand for ports. For example, if ports anticipated demand for containerized traffic in the late 1940s and created deeper harbors in anticipation of this demand, the instrument would be invalid. We deal with this concern in various ways. First, we look to see whether growth in international port traffic from 1948 to 1955 is correlated with port depth. It is not; in fact, ports with greater growth in international trade in the immediate post war period (1948-1955) have lower than average depth. In addition, we control directly for anticipated demand, as measured by pre-containerization population levels, market access, and population growth in all our specifications. This addresses, among other things, that places that were growing faster between 1920 and 1940 anticipated further population growth between 1950-2010 and dredged deeper ports to accommodate this anticipated subsequent growth. As discussed below in more detail, our results are robust to controlling directly for other variables that could be correlated with anticipated demand for port traffic such as the change in the share of non-agricultural employment 1940-1950, the 1948 to 1955 growth in the value of international trade at ports within 30 km of the county boundary, and

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[19] Controls, which capture differential trends by covariate, include regional fixed effects, the number of 1953 ports within 30 km of the county boundary and that number squared, the log 1910 population and that number squared, 1920 log market access and that number squared, share of manufacturing employment in 1956, average rain and that number squared, average minimum winter temperature and that number squared, average maximium summer temperature and that number squared.

that value squared.

6 Results

With this empirical framework in hand, we now turn to estimation. In the first subsection, we discuss our main results using population as the dependent variable. The following subsection shows that our results are robust to alternative samples and specifications. The final subsection investigates other outcomes and explores the mechanisms behind the overall results.

6.1 Main Results: Impact of Containerization on Population Growth

We start with containerization's impact on population and report below summary statistics, difference-in-differences results, and instrumental variable results.

6.1.1 Summary Statistics and OLS Results

We illustrate the characteristics of containerized and non-containerized counties with summary statistics in Table 1. Column (1) shows means for coastal port counties within 30 km of a containerized port, our treatment group, and Column (2) reports means for coastal port counties never within 30 km of a containerized port. Column (3) shows means for our full estimation sample: counties with a coastal port within 30 km of the county boundary in 1953. The final column of Table 1 reports estimates for all other counties in continental US.

The figures on log population in the first rows of this table clearly show that coastal port counties near containerized ports were larger pre-containerization than other coastal port counties, and that coastal port counties in general were more populous than other US counties. From 1910 to 1950—the pre-containerization years—log population in coastal port counties near future containerized ports increased at a faster rate than in non-containerized coastal port counties and other US counties. These pre-treatment differences between counties generate a possible bias that we address in both the difference-in-differences and instrumental variable strategies.

Looking at employment, wages and land values, we see that containerized coastal port counties are more similar to non-containerized port coastal counties than all other US counties. For example, in 1956, the average containerized coastal port county had a log employment of 9.91; the figure for non-containerized coastal port counties was 8.58, while all other US counties averaged 7.73. This pattern holds for payroll per employee and land values as well.

Comparing the log population statistics in 1950 to those in 2010, these summary statistics also illustrate our main finding: coastal port counties near containerized ports grow at a faster pace after the advent of containerization than the average untreated coastal port county. The first row of Table 1 shows that coastal port counties near containerized ports grew 0.2 percentage points faster annually 1950-2010, or 1.7 percent vs 1.5 percent per year.

Moving to a regression framework, columns 1 to 4 of Table 2 show difference-in-differences results, assessing the relationship between proximity to a containerized port and population growth after the advent of containerization. The dependent variable in these and all subsequent regressions is the annual change in log population over the period 1950 to 2010. Column 1 presents estimates of β_1 from Equation (13) conditional on location and initial maritime importance, as measured by regional fixed effects, the number of ports in 1953 within 30 kilometers of the county's boundary and its square, and the total dollar value of waterborne international trade in 1955 at ports with 30 kilometers of the county's boundary and its square. These results show a half percentage point increase in the annual population growth rate for coastal port counties near containerized ports relative to coastal port counties not near containerized ports. In other words, population growth in containerized counties is about 30% faster over the entire period than in the control group (an annual growth rate of 2 percent relative to non-containerized mean of 1.5 percent).[20]

Columns 2 through 4 add additional covariates. As shown in Table 1's summary statistics, containerized and non-containerized counties have different pre-containerization population levels and likely different initial access to domestic markets. To address these pre-treatment differences, we control, in Column 2, for log population in 1910 and its square, as well as log 1920 market access and its square. Market access captures proximity to other population centers.[21] This specification allows for differential trends in

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[20] In this and all estimates in this paper, we cluster standard errors by the 2010 commuting zone to account for spatial dependence across counties.

[21] County market access is calculated using the 1920 county-to-county transportation cost matrix from Donaldson and Hornbeck (2016)'s replication archive. 1920 market access for county i is defined as $MA_i = \sum_{j \neq i} \tau_{i,j}^{-\theta} \text{1920 Population}_j$. We take Donaldson and Hornbeck (2016)'s value of the trade elasticity parameter $\theta = 8.22$ to calculate county market access. Regression results using an alternative definition of market access constructed using a trade elasticity parameter $\theta = 1$, also known as a measure of "market

population by initial size and market connectedness. Including quadratics in these variables allows for potentially non-linear impacts of prior population and market access on population growth. Column 2 shows only a small change in the coefficient of interest when we add these additional covariates, suggesting that they add little explanatory power to the basic specification in Column 1.

We also know that pre-containerized population growth varies by treatment. Table 1 reports that the annual growth rate 1910-1950 in treated counties was about 1.98 percent compared to 1.25 percent in control counties. To address the concern that our results are driven by differential pre-containerization population growth, Column 3 presents results conditional on the change in log population from 1920 to 1940. This specification therefore allows for differential trends in population 1950-2010 based on pre-existing trends. Again, results are little changed, with an increase in the annual population growth rate of about half a percentage point for containerized counties (0.006).

Containerized counties may have been differentially exposed to other forces that drove population over our period of analysis. A large literature (Rappaport and Sachs, 2003; Glaeser, 2005; Glaeser and Gyourko, 2005) has documented the movement of US population to warmer climates over the second half of the twentieth century. In addition, industrial activity was far from evenly distributed in the mid-1950s, and much industrial activity was located near ports. To ensure that neither of these factors is driving our results, the specification in Column 4 adds the share of manufacturing employment in 1956 and a vector of weather measures: average rainfall and its square, average minimum winter temperature and its square, and average maximum summer temperature and its square. Our main coefficient estimate is barely changed, suggesting that neither changing climate amenities nor population trends based on initial manufacturing strength drive our results.

6.1.2 Instrumental Variables

Although the difference-in-differences specification addresses many confounding factors potentially correlated with both proximity to a containerized port and population growth, it is possible that some part of the error term remains correlated with the adoption of container technology. To address this, we now turn to our instrumental variable (IV) estimation.

The right panel of Table 2 shows our IV estimates. The four columns repeat the

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potential", are virtually identical.

pattern of covariates from the OLS portion of the table on the left. The IV coefficient estimates are uniformly larger than the OLS estimates, and, similar to the OLS results, they vary little as we add covariates.[22]

The most complete specification, in Column 8, shows that containerization caused a 1.2 percentage point increase in the annual population growth rate over the 60 years from 1950 to 2010. That is, due to containerization, coastal counties near containerized ports grew 80 percent faster than non-containerized coastal port counties. The effect of containerization on population growth is sizeable, roughly similar to the overall difference in annual population growth between coastal port counties and all other continental US counties in the 1950 to 2010 period.[23] Furthermore, the estimated increase in annual population growth due to containerization implies that, over the full 60-year period, containerized counties grew twice as much as otherwise comparable coastal port counties.[24]

To further interpret the magnitude of these results, we compare our results with Duranton and Turner (2012). These authors find that a 100 percent increase in a city's initial stock of highways yields a 13 percent increase in population over a 20 year period. This translates to an annualized increase of about 0.6 percentage points. Our effects are larger. We find that containerization's impact is about twice as large as doubling a city's initial stock of highways.

6.2 Results Robust to Additional Considerations

We now turn to threats to identification and extensions of these main results. We start by showing that our results are robust to changes in sample definitions. We then show that our results hold in other plausible specifications. Finally, we conclude by assessing

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[22] We expect containerization to have a larger impact on population growth in initially less populous smaller counties. When we use the instrument to correct for endogeneity in the proximity to a containerized port, we likely give more weight to initially smaller counties where depth is the main driver of the containerization decision. This causes the IV coefficients to increase relative to OLS.

[23] Column 3 in Table 1 reports an average annual growth rate in coastal port counties of 1.6 percent vs 0.5 percent for all other counties in continental US.

[24] Our estimation does not discriminate between growth and reallocation. We look to results on demographics to shed some light on this issue. Appendix Table 2 presents results for demographic outcomes. Using our IV estimation with the full set of covariates from Table 2 Column 8, we find that containerization has no effect on the share of population over 65 and the share foreign born (Column 3 and Column 4). We take this as suggestive evidence that containerization had no impact on births and deaths as reflected in the age distribution and no impact on international migration. Our results on population are therefore likely to operate through internal migration (reallocation). The results also show that containerization causes the share of people with a college degree to increase significantly by about 9 percentage points and the share African American to decrease by about 9 percentage points.

whether our estimated impact of containerization could be driven by alternative infrastructure investments, including naval bases and oil ports.

6.2.1 Alternative Samples

Our results in the previous section derive from a specific sample definition, and one might be concerned that our results are contingent on this definition. In the main results, we study 265 coastal port counties, defined as those within 30 km of a 1953 port, and call a county treated if it is within 30 km of a containerized port. Changing this distance cut-off—which changes both the sample definition and the treatment definition—has little impact on the qualitative result. Results A, B and C in Table 3 use samples that use 20, 25 and 40 km cut-offs. The estimated coefficient is largest at the 20 km cut-off, and declines as the size of the cut-off increases. This is due in part to new counties joining the comparison group, and in part to some previous comparison counties moving into the treated group. Regardless of how we define "coastal port counties" and the treatment, we find that containerization is associated with additional population growth.

In our main specification, we focus on coastal port counties so as to limit the analysis to counties that are influenced by maritime trade before containerization and mitigate issues of different underlying trends. To better understand our results relative to the influential work of Rappaport and Sachs (2003), who show that coastal counties grew faster than the national average between 1950 and 2000, we re-estimate our main specification adding counties that are "coastal" according to their definition. Specifically, Result D includes all counties with centroids within 80 km of the ocean to the estimation sample and reports that our findings are virtually unchanged when we include these additional coastal counties to our primary estimation sample. This slightly broader sample includes dark grey counties in Figure 2 and Figure 3.

One potential concern with the sample restrictions from results A through D is that they yield mostly urban treated areas and rural untreated areas. To address this, we use a sample of all counties in coastal states, which includes several urban areas in the control group. Using this sample, Result E shows a 2.2 percentage point increase in annual population growth, larger than our main estimate of 1.2 percentage points. An even broader expansion of the sample, to the entire continental United States further addresses this concern. The result from this estimation (Result F) is roughly comparable to that when using all counties in coastal states. Therefore, our main results are driven neither by the omission of non-coastal counties nor other non-coastal urban areas. There is a trade-off between sample size and having a valid control group. As we expand the estimation sample, we degrade our research design because we include counties that are further inland and not necessarily comparable to port counties before the advent of containerization. The upside is that we have a broader sample and include in our control group other urban areas.

6.2.2 Alternative Specifications

We now turn to testing the robustness of our results to changes in the specification. To better understand the temporal pattern of containerization's influence, and to understand whether it is independent of the more recent China shock and other large changes to the global trading landscape, we investigate at what point in time containerization's impact is visible in population growth. Rather than using the annual change in population growth from 1950 to 2010 as the dependent variable, we use annual growth from 1950 to 1980, 1990 or 2000. Result G shows that by 1980, containerization-induced annual population growth is about three-quarters of what we estimate over the full 1950 to 2010 period. By 1990, containerization's impact on annual population growth is 1.2 percentage points (Result H), and by 2000, it is 1.3 percentage points (Result I). The effect of annual population growth through 2000 is actually higher than that through 2010 (our main specification), suggesting a possible plateauing in containerization's impact after 2000.[25]

Issues of timing aside, our main estimates depend on a log approximation of growth, using annual changes in log population as dependent variable, or $(\ln y_{i,2010} - \ln y_{i,1950})/60$. To test whether this log approximation distorts our results, we calculate actual annual growth rate as $(y_{i,2010}/y_{i,1950})^{1/60} - 1$ and use this as the dependent variable. Result J, with this dependent variable, is the same as the main result to the third decimal point. Thus, for our estimates, the annual change in logs is a very good approximation for the annual growth rate.

We also consider the role of possible confounders. A large strand of literature in

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[25] Appendix Figure 2 shows the cumulative impact of containerization over time by reporting the cumulative impact of containerization in 10-year intervals, starting in 1960. Here we show long-run changes so the dependent variable is the change in log population from 1950 to year t, with $t = 1960, 1970, 1980, 1990, 2000, \text{and } 2010$. The point estimate for 2010 in Appendix Figure 2 is simply our coefficient in Table 2 Column 8 multiplied by 60. Starting with 1960, this figure illustrates containerization's growing impact on population growth, likely as a result of the dramatic growth in the domestic and international container network that occurred in this period (Figure 1 and Rua, 2014), as well as the slowdown in containerization's impact in the 2000s.

urban economics suggests that population and economic growth is associated with an area's education and demographic characteristics (Moretti, 2004). This may bias our estimates inasmuch as these attributes are correlated with our instrument. To address this, we add a vector of pre-containerization human capital measures: the share of population with a college degree or more, the Black share of population, the share foreign born, and the share of population age 65 and older. To address the concern that 1953 port depth may be correlated with future anticipated demand for port services, we add additional covariates: the change in the share of non-agricultural employment from 1940 to 1950, the total value of waterborne international trade in 1948 within 30 km of the county's boundary and its square, and growth in the value of waterborne international trade at ports within 30 km of the county boundary from 1948 to 1955 and its square. We report results of this specification in Result K. The inclusion of all these covariates causes the coefficient of interest to change by 0.1 percentage point (0.013 versus 0.012), and the coefficient remains precisely estimated. This suggests that if instrumented containerization remains correlated with an omitted variable, the correlation is unlikely to be driven by pre-existing human capital or anticipated growth in trade.

Our final alternative specification explores whether containerization's impact is larger in initially less populous counties. To assess this, we estimate our basic specification weighted by 1950 county population. The weighted result—Result L—is slightly smaller than the unweighted one, suggesting that containerization's impact on population growth is larger in initially less populous locations. This is consistent with our exploration of the role of land value in Section 6.3 below.

6.2.3 Other Considerations: Naval Bases and Oil Ports

We conclude this discussion of robustness by considering other infrastructure investments plausibly correlated with port depth: naval bases and oil ports. We start with naval bases. In the US, these large military installations are likely to promote local economic activity. If growth-yielding federal investments were concentrated near very deep ports, this could bias our main coefficient estimate upward. To address this concern, we re-estimate Equation (13) using instrumental variables and omitting counties within 50 km of any naval base. The coefficient of interest is virtually identical to our main estimate.[26]

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[26] As of the 1950s, the US had four domestic naval bases, at least 10 naval stations, and over 250 total facilities, which includes hospitals, test stations, air stations, and a large variety of other installations (U.S.

Similarly, if very deep ports were crucial for oil imports, and oil imports caused population growth, our main coefficient estimate would be biased upward. A number of factors argue against this interpretation. First, as of 1948, 90 percent of US oil was produced domestically and the US accounted for 62 percent of the world oil market (Mendershausen, 1950, p. 4). It was not until the 1970s, almost two decades after the advent of containerization, that the US was no longer able to fulfill oil demand with domestic oil and started relying on oil imports more heavily.

Furthermore, port depth is not a key determinant in the suitability of a port for oil trade, allaying concerns about the validity of the instrument. During the period of domestic oil hegemony, most oil moved by pipeline, rather than by ship. Even when oil imports increased, port depth was not as crucial, because oil ships connected to offload via a pipeline that can be quite long. Therefore, ships need not dock directly at the harbor to offload oil; they can anchor where waters are deeper. Moreover, before the Suez Canal was dredged in the mid-1960s, it was a major limiting factor for using larger ships, as vessels with a draft deeper than 37 feet were not allowed to pass (Horn et al., 2010, p. 43). [27]

6.3 Mechanisms

Having explored containerization's impact on population, and the robustness of our findings, we now turn to the mechanisms that may underly these findings. We start by examining containerization's impact on employment, wages, and land values, and then use our model to back out containerization's impact of consumer and producer valuations of containerized locations. We conclude by analyzing whether the impact of

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Department of the Navy, 1952, 1959). Naval bases were Pearl Harbor, HI; San Diego, CA; Norfolk, VA and New London, CT. New London was actually taken out of "base" status between 1952 and 1959, but we include it for completeness. Relative to naval bases, naval stations are smaller, serve more limited purposes, and receive less investment (Coletta, 1985). Naval stations are so numerous that they are indistinguishable from our coastal port locations.

[27] Two other investments geographically proximate to ports also bear consideration: Foreign Trade Zones and cruise shipping. In 1934, the US established Foreign Trade Zones, which allowed tax-free imports of intermediate inputs for final products to be exported from the zone. As of 1953, there were five foreign trade zones in the US (United States, Foreign Trade Zones Board, 1954). We find no differential population growth in containerized counties with foreign trade zones in 1953 (all foreign trade zones are in containerized counties; results available upon request).

The cruise industry also rose to prominence in the post-war period, though its major growth post-dates the large investments in containerization. We examine whether population growth differs in containerized counties proximate to cruise ports and find that these counties experience slightly slower population growth over the period (results available upon request).

containerization varies by initial conditions, with an emphasis on land values.

6.3.1 Containerization's Impact on Employment, Wages, Land Values

Employment. As population and employment are interchangeable in our theoretical framework, we anticipate increases in employment in containerized counties after containerization. Table 4 reports results using annual changes in log Census employment 1950-2010 and annual changes in log CBP employment 1956-2011 as outcome variables. Using our IV estimation with the full set of covariates from Table 2 Column 8, the second row of Table 4 shows that containerization caused an additional 1.5 percentage-point growth annually in Census employment from 1956 to 2011 (the first row displays the impact on population for comparison). This effect is about three-quarters the average annual employment growth over the period in our sample (2 percentage points per year; second column). It is also about 25 percent larger than containerization's impact on annual population growth from 1950 to 2010. This finding holds regardless of whether we measure employment using the worker's residential location (Census employment, second row) or workplace location (CBP employment, third row).

To understand the difference in population and employment results, Panel B reports containerization's impact on the employment-to-population ratio using the change over the entire period between 1950 and 2010 (non-annualized) as the dependent variable.[28] We estimate that containerization raised this ratio by 7.4 percentage points, an increase that is roughly three-quarters of the average growth over the period in the employment-to-population ratio for all counties in our sample.

While the employment data in the Census measure the number of employed people who reside in a county, the CBP employment data capture the number of workers at establishments physically present in the county (regardless of the county of residence of the employee). We exploit differences between these two measures to shed light on whether the increases in employment come from residents or commuters. We find no statistically different effects on both measures of employment (Panel B, second row), which suggests that containerization does not drive commuting from nearby counties.

Wages and Land Values. Our theoretical framework also suggests impacts on nominal wages and land values, though as with population, the signs of these impacts remain an empirical question. We find that containerization caused land values to increase by an

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[28] This variable uses Census employment.

additional 5 percentage points annually between 1956 and 1991.[29] In contrast, containerization had no significant impact on nominal wages between 1956 and 2011, as measured by CBP first quarter payroll per employee.

Employment and Wages by Industry. Because containerization lowers transportation costs, and because the value of these lowered costs are not equal across industries, containerization's impact on employment and wages could vary by industry. We explore whether there are notable patterns by industry using CBP data. We create time-consistent industries and analyze employment and wages by industry and industry employment shares. We find little differentiation across industries (see Appendix Table 4).[30] This could be because impacts are spread equally across all sectors, or because our sample is small and the sector-specific data are measured with more noise than the overall measures.

6.3.2 Using the Theory to Unpack the Determinants of Local Population Increase

We now use our theoretical framework to further unpack the different channels through which containerization affects population and employment. We combine our theoretical framework with our empirical estimates for the impact of containerization on nominal wages and land values to back out changes in consumer and firm amenities due to containerization.

Specifically, we use the expressions for wages and land values in Equations (11) and (12) to infer the effect of containerization via two main channels: local consumer amenities inclusive of non-housing consumption prices ($\frac{\theta(x)}{(\tau_0+\tau_1 x)^\beta}$), which we call local consumer valuations; and local productive amenities inclusive of firm output prices ($\frac{A(x)}{(\tau_0+\tau_1 x)}$), which we call local firm valuations. Rearranging each of the two equations yields

$$\frac{\partial \Delta \ln w(x)}{\partial C(x)} = \lambda_\theta^w \frac{\partial \Delta \ln \frac{\theta(x)}{(\tau_0+\tau_1 x)^\beta}}{\partial C(x)} + \lambda_A^w \frac{\partial \Delta \ln \frac{A(x)}{(\tau_0+\tau_1 x)}}{\partial C(x)} \text{ and} \tag{16}$$

$$\frac{\partial \Delta \ln r(x)}{\partial C(x)} = \lambda_\theta^r \frac{\partial \Delta \ln \frac{\theta(x)}{(\tau_0+\tau_1 x)^\beta}}{\partial C(x)} + \lambda_A^r \frac{\partial \Delta \ln \frac{A(x)}{(\tau_0+\tau_1 x)}}{\partial C(x)}. \tag{17}$$

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[29] We use county-level data on land assessments from the Census of Governments. See appendix for full details.

[30] Furthermore, our main employment result is unchanged when we exclude employment in transportation services.

The λ parameters are functions of α and β only.[31]

With these equations, assumptions about α and β, and our Table 4 estimates for containerization's impact on wages ($\hat{\delta}_w = \frac{\partial \Delta \ln w(x)}{\partial C(x)}$) and land prices ($\hat{\delta}_r = \frac{\partial \Delta \ln r(x)}{\partial C(x)}$), we now have a system of two linear equations and two unknowns. As in Glaeser and Gottlieb (2009), we use linear combinations of our coefficients to estimate local consumer and firm valuations of containerized locations. These valuations include the effects of containerization on both amenities and transportation costs; we cannot separately identify containerization's impact on transportation costs because the model has only two linearly independent equations, one for each market.

Solving the system of equations, we find that

$$\frac{\partial \Delta \ln \frac{\theta(x)}{(\tau_0+\tau_1 x)^{\beta}}}{\partial C(x)} = (1-\beta)\hat{\delta}_r - \hat{\delta}_w \tag{18}$$

and

$$\frac{\partial \Delta \ln \frac{A(x)}{(\tau_0+\tau_1 x)}}{\partial C(x)} = \alpha\hat{\delta}_w + (1-\alpha)\hat{\delta}_r \ . \tag{19}$$

These equations have clear interpretations. Assuming utility is constant across space in equilibrium, the model interprets a decrease in real wages as an increase in consumer amenities due to containerization. Similarly, assuming profits are equal across space, an increase in total costs (the weighted sum of wages and land prices) corresponds to an increase in local productive amenities.

Assuming standard values for the share of labor in production and the share of housing in consumption ($\alpha = .65$ and $1-\beta = 0.30$), we find that containerization increases consumers' valuation of containerized locations by 1.3 percent annually and firms' valuation of containerized locations by 1.9 percent annually.[32] If we assume that containerization negatively impacts local consumer amenities $\theta(x)$ because of noise and pollution, then the containerization-induced decline in transportation costs must have been large enough to yield a non-housing consumption price decrease that more than offsets the deterioration in consumer amenities.

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[31] These parameters are defined in (8) and (9) above. As a reminder, we have $\lambda_\theta^w = \frac{\alpha-1}{1-\alpha\beta}$, $\lambda_A^w = \frac{1-\beta}{1-\alpha\beta}$, $\lambda_\theta^r = \frac{\alpha}{1-\alpha\beta}$, and $\lambda_A^r = \frac{1}{1-\alpha\beta}$.

[32] These results are robust to alternative parameter assumptions: Values of α and β between 0.6 and 0.75 yield estimates between 1.1 and 2.2 percent.

6.3.3 Where Gains to Containerization Are Largest

Turning from the mechanisms by which containerization impacts economic outcomes, we now consider whether certain pre-containerization county characteristics can modify the impact of containerization on population. We are particularly interested in the role of pre-containerization land values.

We use two proxies for land values circa 1956: county population density as of 1950, and the assessed value of land from the 1956 Census of Governments. While this last measure is the closest to a direct measure of the variable of interest, assessed values are notoriously different from market values. Particularly in this period, it was not unusual for assessment practices to vary substantially – and systematically – across jurisdictions (Anderson and Pape, 2010). The intensity of land use should be tightly correlated with the value of land, making population density a useful alternative proxy for land value.

Table 5 reports coefficients from Equation (14), where the dependent variable is the annual change in log population, 1950 to 2010. The first row reports estimates of γ_2, a measure of any additional population change from 1950 to 2010 in containerized counties with a value of variable h_i below the median. The second row reports estimates of γ_1, or the average relationship between containerization and population growth. The third row reports estimates of γ_4, which is the association between counties with a value of h_i below the median and population growth. The first column, in which h_i is land value, shows that population growth associated with containerization is concentrated in containerized counties in the bottom half of the distribution of 1956 land value per square kilometer. These counties account for virtually all of the population growth associated with containerization.

The relationship with 1950 population density is similar but weaker, as shown in the second column of Table 5. Containerized counties in the bottom half of the 1950 population density distribution account for about half of annual population growth in coastal counties from 1950 to 2010. This result is less precise than that from column 1 and marginally significant.

Interestingly, the population gains associated with lower land value or population density occur in counties that – all else equal – are losing population over the 1950 to 2010 period. The third coefficient in the table reports that, on average, counties in the bottom half of the population density or land value distribution have negative population growth from 1950 to 2010. Thus, containerization converts these low land value or low population density locations from locations of net population loss (final coefficient in the table) to net population gain.

In addition to low land value, containerization might also plausibly be more successful in places with initially strong connections to the transportation network or in places with a larger stock of transportation infrastructure. We explore interactions with 1920 log market access (column 3), 1957 railroad kilometers per county square kilometer (column 4), and 1960 highway kilometers per county square kilometer (column 5). Containerization-induced population change is not significantly stronger in locations with initially strong connections to the transportation network or in locations with more transportation infrastructure. This surprising finding may be driven in part by containerization's primary requirement for cheap land, which is, if not orthogonal to 1950s era transit access, at least not closely related.

Overall, these results paint a picture of containerization exerting the greatest influence not in dominant agglomerations—large, wealthy urban areas—but in second-tier agglomerations where land was cheap.

7 Conclusion

Containerized shipping is a fundamental engine of the global economy. Containerization simplifies and speeds packing, transit, pricing, and every transfer from ship to train to truck. It eliminates previously profitable pilferage and makes shipping more reliable. Since the advent of containerization in 1956, the cost of moving containerizable goods has plummeted.

We analyze how local economic activity responds to the dramatic decline in trade costs brought by containerization, framing our work in terms of a Roback model with both domestic and international transit costs. We use a novel cost-shifter instrument based on initial port depth to show that containerization caused substantial population and employment growth in counties near containerized ports. Consistent with containerization's need for substantial land for large cranes and vast marshalling yards, we find that population increases are predominantly in counties with initially low population density and low land values.

Containerized shipping – along with the rise of the motor vehicle and air travel – is one of the great transport innovations of the twentieth century. We show that containerization's outsized influence on international trade works through local impacts. Understanding these local impacts is central to shedding light on the potential uneven impacts of globalization.

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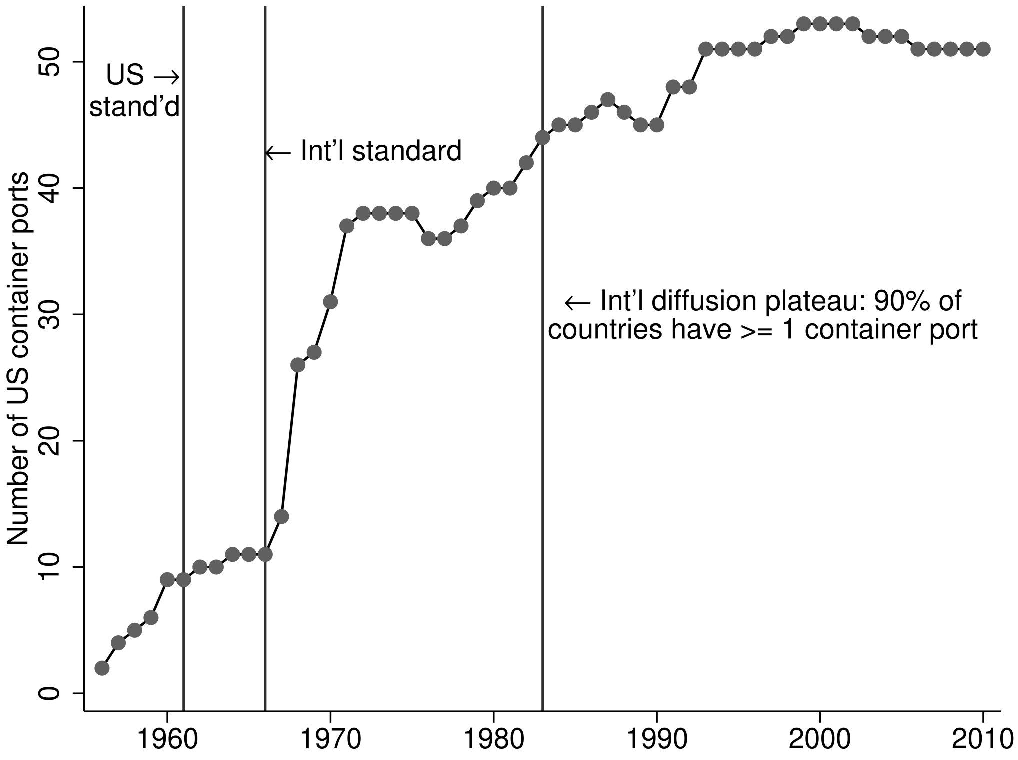
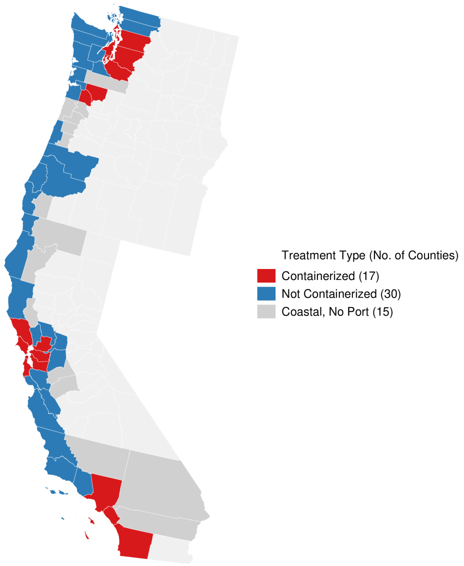
Figure 1: Adoption of Containerization: 1956–2010



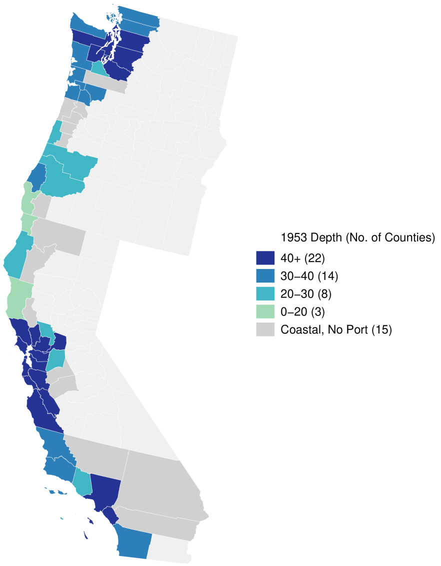
Note: This figure shows the diffusion of containerization across US ports. Source: *Containerisation International Yearbook*, volumes 1968 and 1970–2010.

Figure 2: Geographic Variation in Treatment and Instrument: West Coast

(a) Treatment: County Boundary is within 30km of a Container Port in 2010



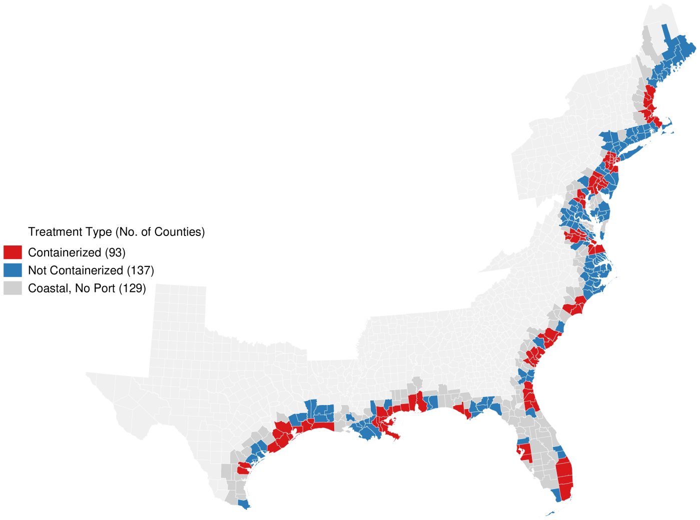
(b) Instrument: Depth of the Deepest Port within 30 km of County Boundary in 1953



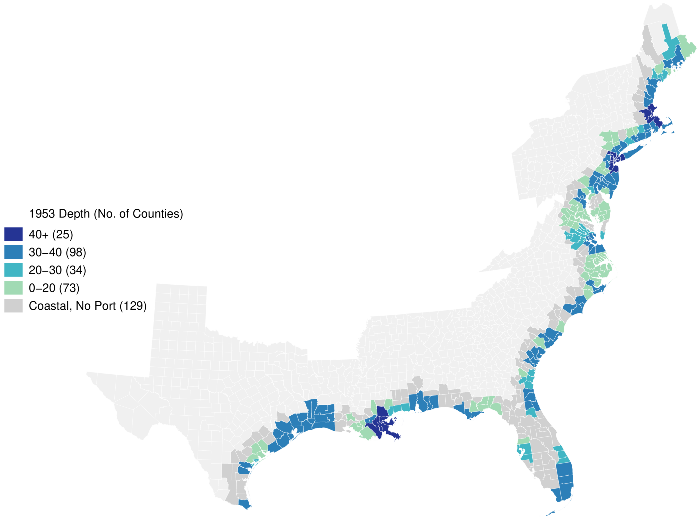
Notes: The upper panel uses red and blue to show counties we classify as "coastal port counties," which are those with a port in 1953 within 30 km of the county boundary. Among these coastal port counties, "containerized" counties are in red and are those with a container port in 2010 within 30 km of the county boundary. The remainder of coastal port counties – those that are not within 30 km of a container port by the end of the study period – are in blue. Grey counties are not within 30 km of a port in 1953 and therefore are excluded from our primary sample. We include them in the estimation sample in a robustness check and in this figure for reference. Dark grey counties have centroids within 80 km of the ocean coast and are classified as "coastal" in Rappaport and Sachs (2003). We include them in the estimation sample in a robustness check and in this figure for reference. The bottom panel shows the same set of "coastal port counties," now shaded by the depth of the deepest port within 30 km of the county boundary in 1953.

Figure 3: Geographic Variation in Treatment and Instrument: East Coast

(a) Treatment: County Boundary is within 30km of a Container Port in 2010



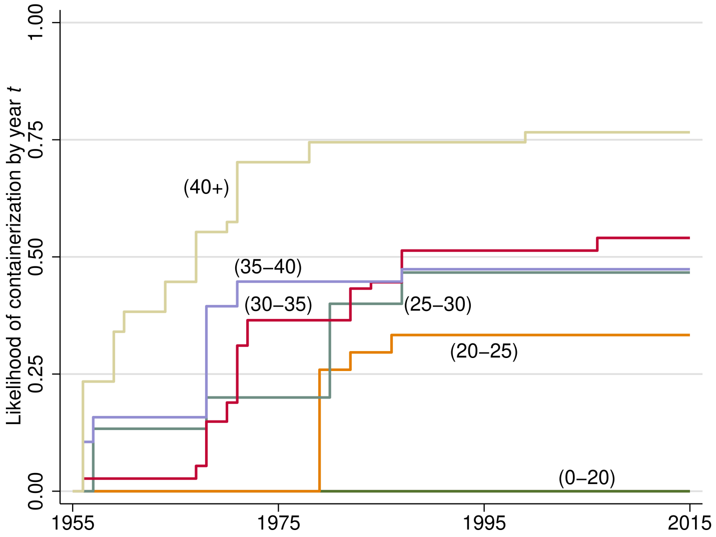
(b) Instrument: Depth of the Deepest Port within 30 km of County Boundary in 1953



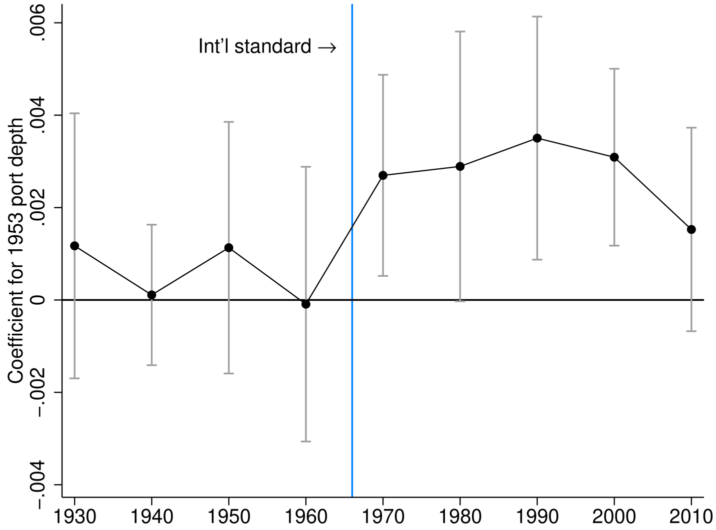
Notes: The upper panel uses red and blue to show counties we classify as "coastal port counties," which are those with a port in 1953 within 30 km of the county boundary. Among these coastal port counties, "containerized" counties are in red and are those with a container port in 2010 within 30 km of the county boundary. The remainder of coastal port counties – those that are not within 30 km of a container port by the end of the study period – are in blue. Grey counties are not within 30 km of a port in 1953 and therefore are excluded from our primary sample. We include them in the estimation sample in a robustness check and in this figure for reference. Dark grey counties have centroids within 80 km of the ocean coast and are classified as "coastal" in Rappaport and Sachs (2003). We include them in the estimation sample in a robustness check and in this figure for reference. The bottom panel shows the same set of "coastal port counties," now shaded by the depth of the deepest port within 30 km of the county boundary in 1953. We exclude Great Lakes port counties from the analysis.

Figure 4: Graphical Intuition

(a) First Stage: Depth and Likelihood of Containerization



(b) Reduced Form: Depth and Population Changes



Notes: The top panel shows the likelihood a county's boundary is within 30 km of a container port by year *t* as a function of the depth of the deepest port within 30 km of the county boundary in 1953. Counties near deeper ports are both more likely to be near a container port and more likely to containerize early. Figure 4b plots the reduced form estimate of 1953 port depth on decadal population changes. For example, the 1930 value is the coefficient on depth from a regression where the dependent variable is the change in log population from 1920 to 1930; 95 percent confidence intervals are in grey. These estimates include the full set of covariates from Table 2 with the exception of the change in log population between 1920 and 1940. We exclude this variable, since we do not want to control for future events and the time period is after the first three coefficients. To make the estimates comparable, we drop the covariate in all specifications in this figure. We see no significant impact of port depth on decadal population changes until after the widespread adoption of container technology.

Table 1: County Characteristics by Distance to Nearest Container Port

	Estimation sample: Counties within 30 km of 1953 port			
	Also within 30 km of container port in 2010?			
	Yes	No	Both	All other counties
	(1)	(2)	(3)	(4)
Log Population				
Annual Change, 1950 to 2010	0.017	0.015	0.016	0.005
	[0.012]	[0.011]	[0.011]	[0.012]
2010	12.52	11.3	11.78	10.19
	[1.43]	[1.41]	[1.54]	[1.35]
1950	11.48	10.41	10.83	9.87
	[1.63]	[1.24]	[1.50]	[1.04]
1910	10.69	9.95	10.24	9.69
	[1.49]	[1.06]	[1.29]	[0.97]
Log Employment				
Annual Change, 1956 to 2011	0.027	0.026	0.026	0.022
	[0.017]	[0.013]	[0.015]	[0.013]
2011	11.38	9.99	10.54	8.94
	[1.66]	[1.59]	[1.75]	[1.40]
1956	9.91	8.58	9.1	7.73
	[2.05]	[1.59]	[1.89]	[1.42]
Log First Quarter Payroll per Employee, $1000s				
Annual Change, 1956 to 2011	0.047	0.044	0.045	0.042
	[0.006]	[0.006]	[0.006]	[0.008]
2011	2.36	2.03	2.16	1.79
	[0.34]	[0.44]	[0.43]	[0.51]
1956	-0.21	-0.39	-0.32	-0.54
	[0.34]	[0.39]	[0.38]	[0.50]
Log of Land Value				
Annual Change, 1956 to 1991	0.11	0.116	0.114	0.084
	[0.037]	[0.028]	[0.032]	[0.036]
1991	15.42	14.54	14.88	12.54
	[1.74]	[1.57]	[1.69]	[1.62]
1956	11.59	10.47	10.91	9.59
	[2.17]	[1.64]	[1.94]	[1.32]
Observations	104	161	265	2578

Note: This table reports means, with standard deviations below in parentheses. Our main estimation sample, Column (3), is the set of counties with a 1953 port within 30 km of the county boundary. Column (1) contains estimates for our those who have a container port in 2010 within 30 km of the county boundary and Column (2) contains estimates for those who do not have a container port in 2010 within 30 km of the county boundary. The final column presents estimates for all other continental US counties for which we have complete data.

Table 2: Containerization Associated with Increased Population Near the Port

	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1{Containerized}	0.005***	0.007***	0.006***	0.005***	0.015***	0.015***	0.014***	0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.004)	(0.005)	(0.004)
Covariates								
Region fixed effects	x	x	x	x	x	x	x	x
Number of 1953 ports	x	x	x	x	x	x	x	x
Value of waterborne trade, 1955	x	x	x	x	x	x	x	x
Log population, 1910		x	x	x		x	x	x
Market access, 1920		x	x	x		x	x	x
Change in log pop., 1920-1940			x	x			x	x
Weather				x				x
Share manufacturing emp., 1956				x				x
Adjusted R-squared	0.11	0.23	0.27	0.31				
F Stat, Excluded instrument					22.26	22.98	20.59	22.46

Notes: Stars denote significance levels: * 0.10, ** 0.05, and *** 0.01. All regressions use the 265 observations from the sample of coastal port counties within 30 km of a port in 1953. We cluster standard errors at the 2010 commuting zone. The dependent variable is the annual change in log population, 1950-2010, and its mean is 0.016. We report the Kleinberg-Papp F statistic, as discussed in Sanderson and Windmeijer (2016). Region fixed effects are indicators for census regions. "Number of 1953 ports" is the number of 1953 ports within 30 km of the county's boundary, and that number squared. "Value of waterborne international trade, 1955" is the total dollar value of international trade in 1955 within 30 km of the county's boundary and that number squared. "Log population, 1910" is the log of 1910 county population, and that number squared. "Market Access, 1920" is the log 1920 market access, calculated using the transportation cost matrix from Donaldson and Hornbeck (2016), and that number squared. "Weather" is a vector of the average rainfall in that county and that amount squared, the average minimum temperature in the winter and that number squared, and the average maximum temperature in the summer and that number squared. See data appendix for complete details on years and sources.

Table 3: Impact of Containerization Robust to Alternative Samples and Specifications

Alternative Sample	Coeff. (SD)	Mean [Obs.]	Alternative Specification	Coeff. (SD)	Mean [Obs.]
A. 20 km of 1953 port	0.018**	0.016	G. Final year is 1980	0.009*	0.020
	(0.007)	[229]		(0.005)	[265]
B. 25 km of 1953 port	0.012**	0.016	H. Final year is 1990	0.012**	0.018
	(0.005)	[248]		(0.005)	[265]
C. 40 km of 1953 port	0.008**	0.016	I. Final year is 2000	0.013***	0.017
	(0.004)	[293]		(0.005)	[265]
D. R & S coastal	0.013***	0.015	J. DV: annual growth	0.012***	0.016
	(0.005)	[388]		(0.005)	[265]
E. Coastal states	0.022***	0.009	K. Extra controls	0.013**	0.016
	(0.006)	[1,249]		(0.006)	[265]
F. All US counties	0.020***	0.006	L. 1950 Pop. weighted	0.010***	0.016
	(0.006)	[2,843]		(0.003)	[265]

Notes: Stars denote significance levels: * 0.10, ** 0.05, and *** 0.01. All specifications are IV regressions with clustered standard errors at the 2010 commuting zone and include the most complete set of covariates from Table 2. A., B., and C. limit the sample to counties with a coastal port within 20, 25, and 40 km of the county boundary in 1953. D. adds counties with a centroid within 80 km of the ocean coast to the main estimation sample, as in Rappaport and Sachs (2003). E. includes all counties in coastal states. F. includes all continental US counties for which we have complete data. G., H., and I. use 1980, 1990, and 2000 as the final year of the sample period. J. uses the exact annual population growth rate 1950-2010 as dependent variable. K. also controls for 1950 county demographics (share of people 25 and older with a college degree or more, share age 65 and older, share African American, and share foreign born), change in share of non-ag. employment 1940-1950, total value of international trade in 1948 within 30 km of the county's boundary and that number squared, and growth in trade at ports within 30 km 1948-1955 and that percentage squared. L. is our main specification weighted by 1950 county population.

Table 4: Employment and Local Prices Near Containerized Ports

	Coeff. (SD)	DV Mean [Obs.]
Panel A, Main Outcomes: DV is Annual Change in	(1)	(2)
Log Population, 1950 to 2010	0.012*** (0.004)	0.016 [265]
Log Census Employment, 1950 to 2010	0.015*** (0.005)	0.020 [265]
Log CBP Employment, 1956 to 2011	0.016*** (0.005)	0.026 [265]
Log Payroll per Employee, 1956 to 2011	0.002 (0.003)	0.045 [265]
Log Land Value, 1956 to 1991	0.051*** (0.014)	0.114 [265]
Panel B, Other Employment Measures: DV is		
Change in Census Employment-to-Population Ratio, 1950 to 2010	0.074*** (0.022)	0.104 [265]
Change in Log Census Employment / Change in Log CBP Employment	-0.326 (0.384)	0.767 [265]

Notes: Stars denote significance levels: * 0.10, ** 0.05, and *** 0.01. All regressions are instrumental variable estimates with standard errors clustered at the 2010 commuting zone. All estimations use the complete set of covariates as discussed in Table 2. See data appendix for complete details on years and sources.

Table 5: Larger Gains in Counties with Initially Low Land Values

	Interaction Variable is				
	Log Assessed Value Per Sq ft, 1956	Population Density, 1950	Market Access, 1920	1957 Railway length, km/County km sq.	1960 Highway length, km/County km sq.
	(1)	(2)	(3)	(4)	(5)
1{Containerized} * 1{County $\leq$ median(variable)}	0.012***	0.007*	0.005	0.007	0.006
	(0.004)	(0.004)	(0.004)	(0.009)	(0.004)
1{Containerized}	0.001	0.006	0.009*	0.006	0.007
	(0.005)	(0.004)	(0.005)	(0.009)	(0.005)
1{County $\leq$ median(variable)}	-0.006**	-0.002	-0.003	-0.003	-0.005*
	(0.002)	(0.002)	(0.002)	(0.005)	(0.003)
Share of observations $\leq$ median	0.65	0.68	0.55	0.67	0.72

Note: Stars denote significance levels: * 0.10, ** 0.05, and *** 0.01. All specifications are instrumental variable estimates of Equation (14) with the annual change in log population from 1950 to 2010 as the dependent variable. All regressions have 265 observations and cluster standard errors at the 2010 commuting zone. The coefficients in each column reports any additional annual population growth for containerized counties that are below the median of the variable listed in the column header. The second coefficient reports the average impact of containerization on annual population growth, and the third row reports the average impact of being below the median of the variable listed in the column header on annual population growth. We use the median of the variable in the treated population only.

FOR ONLINE PUBLICATION

A Data Appendix

A.1 Data Sources

We use data from a variety of sources. This appendix provides source information.

1. County Business Patterns
   These data include total employment, total number of establishments (with some variation in this definition over time), and total payroll.

   - 1956: Courtesy of Gilles Duranton and Matthew Turner. See Duranton et al. (2014) for source details. We collected a small number of additional counties that were missing from the Duranton and Turner data.
     - In these data, payroll is defined as the "amount of taxable wages paid for covered employment [covered by OASI, or almost all "nonfarm industrial and commercial wage and salary employment" (page VII)[33]] during the quarter. Under the law in effect in 1956, taxable wages for covered employment were all payments up to the first $4,200 paid to any one employee by any one employer during the year, including the cash value of payments in kind. In general, all payments for covered employment in the first quarter were taxable unless the employee was paid at the rate of more than $16,800 per year. For the first quarter of 1956, it is estimated that 97.0 percent of total non-agricultural wages and salaries in covered employment was taxable. The taxable proportion of total wages becomes smaller in the later quarter of the year. Data are presented for the first quarter because wages for this quarter are least affected by the provisions of the law limiting taxable wages to $4,200 per year." (page VI, Section III, Definitions in 1956 County Business Patterns report.)
   - 1967 to 1985: U.S. National Archives, identifier 313576.
   - 1986 to 2011: U.S. Census Bureau. Downloaded from `https://www.census.gov/econ/cbp/download/`
     - For comparability, we also use total first quarter payroll from these data.

2. Decennial Census: Population and demographics data by county

   - 1910: ICPSR 02896, Historical, Demographic, Economic and Social Data: The United States, 1790-2002, Dataset 38: 1950 Census I (County and State)

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[33] Data also exclude railroad employment.

- 1920: ICPSR 02896, Historical, Demographic, Economic and Social Data: The United States, 1790-2002, Dataset 38: 1950 Census I (County and State)
- 1930: ICPSR 02896, Historical, Demographic, Economic and Social Data: The United States, 1790-2002, Dataset 38: 1950 Census I (County and State)
- 1940: ICPSR 02896, Historical, Demographic, Economic and Social Data: The United States, 1790-2002, Dataset 38: 1950 Census I (County and State)
- 1950
  - ICPSR 02896, Historical, Demographic, Economic and Social Data: The United States, 1790-2002, Dataset 38: 1950 Census I (County and State)
  - Census of Population, 1950 Volume II, Part I, Table 32.
- 1960: ICPSR 02896, Historical, Demographic, Economic and Social Data: The United States, 1790-2002, Dataset 38: 1960 Census I (County and State)
- 1970: ICPSR 8107, Census of Population and Housing, 1970: Summary Statistic File 4C – Population [Fourth Count]
- 1980: ICPSR 8071, Census of Population and Housing, 1980: Summary Tape File 3A
- 1990: ICPSR 9782, Census of Population and Housing, 1990: Summary Tape File 3A
- 2000: ICPSR 13342, Census of Population and Housing, 2000: Summary File 3
- 2010: U.S. Census Bureau, 2010 Decennial Census Summary File 1, Downloaded from `http://www2.census.gov/census_2010/04-Summary_File_1/`
- 2010 (2008-2012): U.S. Census Bureau, American Community Survey, 5-Year Summary File, downloaded from `http://www2.census.gov/acs2012_5yr/summaryfile/2008-2012_ACSSF_All_In_2_Giant_Files%28Experienced-Users-Only%29/`

3. Port Universe and Depth

   - We use these documents to establish the population of ports in any given year.
     - 1953: *World Port Index*, National Geospatial-Intelligence Agency (1953)
     - 2015: *World Port Index*, National Geospatial-Intelligence Agency (2015)
   - The *World Port Index* measures port depth at three locations: wharf, anchorage, and channel. There are three counties associated with a 1953 port with a measured channel or anchorage depth, but no reported wharf depth. For these three occurrences, we measure wharf depth as the maximum of the channel or anchorage depth, so as to avoid the problem of having a county that is near a port but has no measured port depth.

4. Port Containerization Adoption Year

   - 1956–2010: *Containerisation International Yearbook* for 1968 and 1970–2010

5. Port Volume: Total imports and exports by port

    - 1948: United States Foreign Trade, January-December 1949: Water-borne Trade by United States Port, 1949, Washington, D.C.: U.S. Department of Commerce, Bureau of the Census. FT 972.
    - 1955: United States Waterborne Foreign Trade, 1955, Washington, D.C. : U.S. Dept. of Commerce, Bureau of the Census. FT 985.
    - 2008: *Containerisation International* yearbook 2010, pp. 8–11.

6. Highways

    - 2014: 2014 National Transportation Atlas, Office of the Assistant Secretary for Research and Technology, Bureau of Transportation Statistics, United States Department of Transportation. `http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_atlas_database/2014/index.html`.
    - c. 1960: Office of Planning, Bureau of Public Roads, US Department of Commerce, "The National System of Interstate and Defense Highways." Library of Congress Call number G3701.P21 1960.U5. Map reports improvement status as of December 31, 1960.

7. Railways

    - 2014: 2014 National Transportation Atlas, Office of the Assistant Secretary for Research and Technology, Bureau of Transportation Statistics, United States Department of Transportation. `http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_atlas_database/2014/index.html`.
    - c. 1957: Army Map Service, Corps of Engineers, US Army, "Railroad Map of the United States," prepared 1935, revised April 1947 by AMS. 8204 Edition 5-AMS. Library of Congress call number G3701.P3 1957.U48.

8. Market access

    - County market access is calculated using the 1920 county-to-county transportation cost matrix from Donaldson and Hornbeck (2016). 1920 market access for county i is defined as $MA_i = \sum_{j \neq i} \tau_{i,j}^{-\theta} 1920\ \text{Population}_j$. We take Donaldson and Hornbeck (2016)'s value of the trade elasticity parameter $\theta = 8.22$. Regression results using an alternative definition of market access with a trade elasticity parameter $\theta = 1$ (a measure of "market potential") are virtually identical.

9. Property value data

- 1956: 1957 Census of Governments: Volume 5, *Taxable Property Values in the United States*
- 1991: 1992 Census of Governments, Volume 2 *Taxable Property Values*, Number 1 *Assessed Valuations for Local General Property Taxation*
- In both 1957 and 1992, the Census reports a total figure for the New York City, which consists of five separate counties (equivalent to the boroughs). We attribute the total assessed value from the census of governments to each county (borough) by using each borough's share of total assessed value. For 1956, we rely upon the *Annual Report of the Tax Commission and the Tax Department to the Mayor of the City of New York* as of June 30, 1956, page 23 which reports "Assessed Value of All Real Estate in New York City for 1956-1957." For 1991, we rely upon *Department of Finance Annual Report, 1991-1992*, pages 19-24.
- The District of Columbia is missing an assessed value for 1956 in the Census of Government publication listed above. However, the amount is available in *Trends in Assessed Valuations and Sales Ratios, 1956-1966*, US Department of Commerce, Bureau of the Census, March 1970. We use this value.
- For 2010 value, we use the sum of the value of aggregate owner occupied stock (American Community Survey) and the aggregate value of the rental occupied stock. As the Census only reports aggregate gross rent, we convert aggregate gross rent to aggregate value of the rental stock by multiplying the aggregate value of the rental stock (by 12 to generate a monthly figure) by the average rent-price ratio for years 2008-2012 (corresponding with the ACS years) from Lincoln Institute Rent-price ratio data[34].

10. Temperature and Rainfall
    - Temperature: North America Land Data Assimilation System (NLDAS) Daily Air Temperatures and Heat Index, years 1979-2011 on CDC WONDER Online
    - Rainfall
      - Anthony Arguez, Imke Durre, Scott Applequist, Mike Squires, Russell Vose, Xungang Yin, and Rocky Bilotta (2010). NOAA's U.S. Climate Normals
      - Not all counties have weather stations that measure rain, and not all weather stations have valid measurements. For the roughly 170 counties without rainfall data, we impute rainfall from nearby counties (those within 50 kilometers).

A.2 Data Choices

1. U.S. County Sample

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[34] `http://datatoolkits.lincolninst.edu/subcenters/land-values/rent-price-ratio.asp`

Our unit of analysis is a consistent-border county from 1950 to 2010. We generate these counties by aggregating 1950 counties. Please see the final Appendix Table for the specific details of aggregation.[35]

The 1956 County Business Patterns allowed for reporting of only 100 jurisdictions per state, leading to the reporting of aggregate values for agglomerations of counties in states with many counties. See Duranton et al. (2014) for the initial collection of these data, and additional details. To resolve the problem of making these 1956 units consistent with the 1950 census units, we disaggregate the 1956 CBP data in the agglomerated reporting into individual counties, attributing economic activity by population weights.

Alaska and Hawaii were not states in 1950. We omit Alaska from our sample, because in 1950 it has only judicial districts, which do not correspond to modern counties. To limit to the continental US, we also drop Hawaii. We keep Washington, DC, in all years.

We also make a few additional deletions

- Two counties that only appear in the data (1910-1930) before our major period of analysis: Campbell, GA (13/041) and Milton, GA (13/203).
- Two problematic counties. Menominee, WI (55/078) created in 1959 out of an Indian reservation; it has very few people. Broomfield, CO (08/014), created in 2001 from parts of four other counties.
- Two counties where land area changes are greater than 40 percent. These are Denver County, CO (08/031) and Teton County, WY (56/039).

2. County Business Patterns data

   - For some county/industry groupings, there is a disclosure risk in reporting either the total number of employees or the total payroll. In such cases, we convert the disclosure code ("D" in the years before 1974) to 0.
   - "Payroll" is first quarter payroll.
   - For 1956 and 2011, we impute missing employment data for industry-county observations where we observe number of establishments. Specifically, we estimate employment in a county-industry as a function of the number of establishments (reporting units in 1956), establishments squared, fixed effects for the one-digit industry to which the observation belongs, and an interaction between establishments and establishments squared with the one-digit industry fixed effects. We replace all predicted values below one with one. In 1956,

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[35] These groupings relied heavily on the very helpful work of the Applied Population Laboratory group at the University of Wisconsin. See their documentation at `http://www.netmigration.wisc.edu/datadictionary.pdf`.

we have 136,498 observations, 16,070 of which have missing employment; we impute values for 16,054 of these with a R^2 of 0.93. In 2011, we have 2,089,962 observations, 1,456,603 of which have missing employment; we impute values for all of these with a R^2 of 0.72.

Appendix Figure 1: Evolution of Ship Sizes

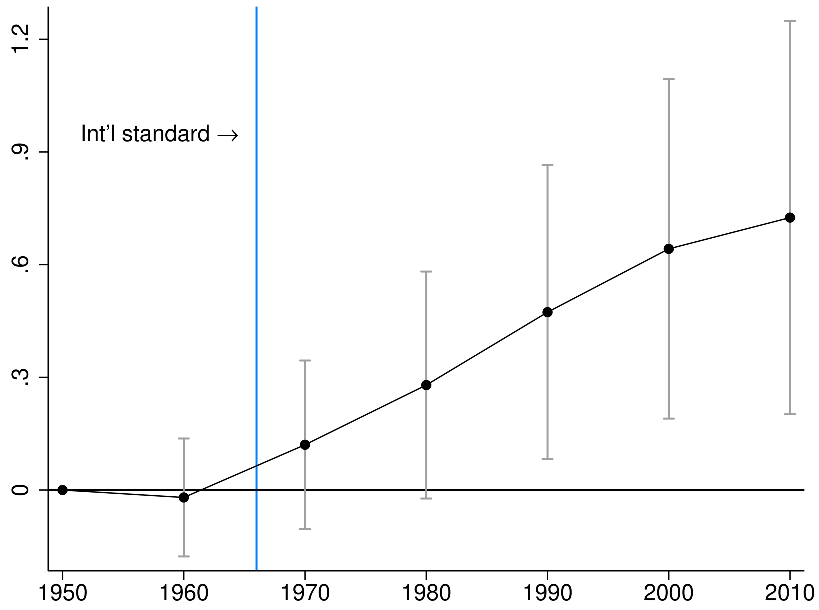
WWII technology

First container ships, 1956 to 1970s

Today, Post-Panamax

Source: WWII, authors; remaining ships, (Rodrigue, 2017). We are not allowed to use the first two panels of this figure in any published work.

Appendix Figure 2: Containerization Associated with Larger Impact Over Time



Notes: This figure reports IV estimates (black dots) and 95 percent confidence intervals (grey whiskers) with standard errors clustered at the 2010 commuting zone. All regressions use the complete set of covariates in Table 2. The dependent variable is the change in log population from 1950 to year t. The dependent variable for the final dot ($t = 2010$) is the same as the estimate in Column 8 of Table 2 multiplied by 60.

Appendix Table 1: First Stage and Reduced Form

	First Stage				Reduced Form			
	Dependent Variable is 1{Containerized}				Dependent Variable is Annual Change in Log Pop., 1950-2010			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Depth, deepest port w/i 30 km	0.0182^{***}	0.0185^{***}	0.0180^{***}	0.0183^{***}	0.0003^{***}	0.0003^{***}	0.0003^{***}	0.0002^{**}
	(0.0038)	(0.0038)	(0.0039)	(0.0037)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Covariates								
Region fixed effects	x	x	x	x	x	x	x	x
Number of 1953 ports	x	x	x	x	x	x	x	x
Value of waterborne trade, 1955	x	x	x	x	x	x	x	x
Log population, 1910		x	x	x		x	x	x
Market access, 1920		x	x	x		x	x	x
Change in log pop., 1920-1940			x	x			x	x
Share manufacturing emp., 1956				x				x
Weather				x				x
Adjusted R-squared	0.45	0.47	0.47	0.48	0.12	0.22	0.26	0.30
Mean dependent variable	0.39	0.39	0.39	0.39	0.02	0.02	0.02	0.02
F Stat, Excluded instrument	22.26	22.98	20.59	22.46				

Notes: See notes from Table 2.

Appendix Table 2: Demographic Outcomes

	Dependent Variable is Fraction			
	With College Degree or More	Black	Older Than 65	Foreign Born
	(1)	(2)	(3)	(4)
1{Containerized}	0.092***	-0.094***	-0.007	0.001
	(0.030)	(0.036)	(0.015)	(0.017)
Mean, dependent variable	0.21	-0.03	0.06	0.04

Notes: Stars denote significance levels: * 0.10, ** 0.05, and *** 0.01. All regressions are instrumental variable estimates with standard errors clustered at the 2010 commuting zone. The dependent variable is the change from 1950 to 2010 in the variable noted in the column header. All estimations use the most complete set of covariates as discussed in Table 2.

Appendix Table 3: Effect of Depth on Containerization Consistent Across Depth Types

	Depth is Measured at		
	Wharf	Channel	Anchorage
	(1)	(2)	(3)
Port Depth in 1953, in feet			
Less than 10	0.022	0.002	-0.003
	(0.031)	(0.028)	(0.028)
10 to 15	0.021	0.022	0.018
	(0.036)	(0.045)	(0.043)
15 to 20	0.014	0.034	0.246
	(0.055)	(0.036)	(0.169)
20 to 25	0.380**	-0.000	0.132
	(0.165)	(0.037)	(0.084)
25 to 30	0.426**	0.477***	0.401***
	(0.201)	(0.148)	(0.132)
30 to 35	0.504***	0.430***	0.388***
	(0.118)	(0.126)	(0.125)
35 to 40	0.278**	0.587***	0.739***
	(0.126)	(0.175)	(0.153)
40 and over	0.413**	0.278**	0.272*
	(0.183)	(0.126)	(0.145)
R-squared	0.69	0.70	0.68

Notes: All regressions use the sample from column 3 from Table 1. We cluster standard errors at the 2010 commuting zone. The dependent variable is an indicator variable for being within 30 km of a containerized port in 2010. All regressions include the most complete set of covariates from Table 2. The type of depth is as noted in the column header.

Appendix Table 4: Little Differentiation of Impact by Industry

	Relative Growth in Employment		Change in Employment Share		Relative Growth in Payroll per Emp.	
	Coeff. (SD)	Mean [Obs.]	Coeff. (SD)	Mean [Obs.]	Coeff. (SD)	Mean [Obs.]
	(1)	(2)	(3)	(4)	(5)	(6)
Industry						
Construction	0.351	0.840	-0.015	-0.024	-0.050	1.020
	(0.526)	[257]	(0.027)	[265]	(0.061)	[246]
Manufacturing	0.972	-0.001	-0.007	-0.301	0.088	1.064
	(1.519)	[260]	(0.027)	[265]	(0.150)	[225]
Transp. & Comm.	-1.648	0.748	-0.027	-0.027	0.174	0.911
	(1.590)	[262]	(0.020)	[265]	(0.139)	[236]
Wholesale Trade	-1.519	1.073	0.005	-0.017	0.207**	1.087
	(1.169)	[259]	(0.021)	[265]	(0.102)	[236]
Retail Trade	-0.834	0.869	-0.018	-0.072	-0.009	0.932
	(0.687)	[263]	(0.028)	[265]	(0.076)	[262]
Finance	-0.737	1.245	0.038	-0.005	-0.203*	1.110
	(0.979)	[263]	(0.030)	[265]	(0.114)	[242]
Services	-0.666	2.253	0.021	0.451	0.101	1.065
	(1.988)	[262]	(0.039)	[265]	(0.074)	[259]
Transportation	-0.163	0.724	0.003	0.003	0.190**	0.929
	(0.809)	[182]	(0.013)	[265]	(0.090)	[173]
Truck. & Ware.	-2.308	0.891	0.001	0.004	0.160*	0.920
	(2.274)	[173]	(0.008)	[265]	(0.084)	[163]

Notes: Stars denote significance levels: * 0.10, ** 0.05, and *** 0.01. All regressions are IV estimates with standard errors clustered at the 2010 commuting zone. The dep. var. in (1) is the change in log employment 1956-2011 in the industry at left divided by the change in log total employment over the same period. The dep. var. in (2) is the change in industry employment share 1956-2011. The dep. var. in (3) is the change in log payroll per employee 1956-2011 in the industry at left fdivided by the change in log payroll per employee in all industries over the same period. All estimations use the complete set of covariates from Table 2. See data appendix for complete details on years and sources. We measure transportation services as "services which support transportation;" this includes "air traffic control services, marine cargo handling, and motor vehicle towing". For 1956, we use SIC 47 for "services incidental to transportation," and for 2011 we use NAICS 488 for "support activities for transportation."

Appendix Table 5: County Groupings for Consistent Counties

			Initial Counties		
State	State FIPS	Grouped County FIPS	County Name	County FIPS	Notes
Arizona	04	027	La Paz County	012	Used to be part of Yuma County (04/027)
Florida	12	086	Miami Dade	025	Name change, from Dade County to Miami-Dade, yielded a numbering change.
Hawaii	15	010	Kalawao County	005	
Hawaii	15	010	Maui County	009	
Montana	30	067	Yellowstone County	113	Yellowstone County merged is to Park County (30/067)
Nevada	32	510	Ormsby County	025	Becomes Carson City (32/510)
New Mexico	35	061	Cibola County	006	Used to be part of Valencia County (35/061)
South Dakota	46	041	Armstrong County	001	Is merged into Dewey County (46/041)
South Dakota	46	071	Washabaugh County	131	Is merged into Jackson County (46/071)
Virginia	51	900	Albermarle County	003	
Virginia	51	901	Alleghany County	005	
Virginia	51	906	Arlington County	013	
Virginia	51	902	Augusta County	015	
Virginia	51	903	Bedford County	019	
Virginia	51	903	Campbell County	031	
Virginia	51	904	Carroll County	035	
Virginia	51	905	Chesterfield County	041	
Virginia	51	915	Dinwiddie County	053	
Virginia	51	924	Elizabeth City	055	

Virginia	51	906	Fairfax County	059	
Virginia	51	907	Frederick Couty	069	
Virginia	51	904	Grayson County	077	
Virginia	51	908	Greensville County	081	
Virginia	51	909	Halifax County	083	
Virginia	51	905	Henrico County	087	
Virginia	51	910	Henry County	089	
Virginia	51	911	James City County	095	
Virginia	51	912	Montgomery County	121	
Virginia	51	800	Nanasemond City	123	Is later folded into Suffolk County (51/800)
Virginia	51	913	Norfolk County	129	
Virginia	51	914	Pittsylvania County	143	
Virginia	51	915	Prince George County	149	
Virginia	51	913	Princess Anne	151	
Virginia	51	916	Prince William County	153	
Virginia	51	917	Roanoake County	161	
Virginia	51	918	Rockbridge County	163	
Virginia	51	919	Rockingham County	165	
Virginia	51	920	Southhampton County	175	
Virginia	51	921	Spotsylvania County	177	
Virginia	51	924	Warwick County	189	
Virginia	51	922	Washington County	191	
Virginia	51	923	Wise County	195	
Virginia	51	924	York County	199	
Virginia	51	906	Alexandria City	510	
Virginia	51	903	Bedford City	515	
Virginia	51	922	Bristol City	520	
Virginia	51	918	Buena Vista City	530	
Virginia	51	900	Charlottesville City	540	
Virginia	51	913	Chesapeake City	550	
Virginia	51	901	Clifton Forge City	560	
Virginia	51	905	Colonial Heights City	570	
Virginia	51	901	Covington City	580	

Virginia	51	914	Danville City	590	
Virginia	51	908	Emporia City	595	
Virginia	51	906	Fairfax City	600	
Virginia	51	906	Falls Church City	610	
Virginia	51	920	Franklin City	620	
Virginia	51	921	Fredricksburg City	630	
Virginia	51	904	Galax City	640	
Virginia	51	924	Hampton City	650	
Virginia	51	919	Harrisonburg City	660	
Virginia	51	915	Hopewell City	670	
Virginia	51	918	Lexington City	678	
Virginia	51	903	Lynchburg City	680	
Virginia	51	916	Manassas City	683	
Virginia	51	916	Manassas Park City	685	
Virginia	51	910	Martinsville City	690	
Virginia	51	800	Nanasemond County	695	Appears for a few years in County Business Patterns data as a county.
Virginia	51	924	Newport News City	700	
Virginia	51	913	Norfolk City	710	
Virginia	51	913	Portsmouth City	710	
Virginia	51	923	Norton City	720	
Virginia	51	915	Petersburg City	730	
Virginia	51	924	Poquoson City	735	
Virginia	51	912	Radford City	750	
Virginia	51	905	Richmond City	760	
Virginia	51	917	Roanoake City	770	
Virginia	51	917	Salem City	775	
Virginia	51	909	South Boston City	780	
Virginia	51	913	South Norfolk City	785	
Virginia	51	902	Staunton City	790	
Virginia	51	913	Virginia Beach City	810	
Virginia	51	902	Waynesboro City	820	
Virginia	51	911	Williamsburg City	830	

Virginia	51	907	Winchester City	840	
Wyoming	56	039	Yellowstone Park County	047	Is merged into Teton County (56/039)