Ports, Trade, Employment and Local Factor Prices:

Empirical Evidence based on Disaster-induced Rerouting of International Trade*

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Abstract

While impact studies of port infrastructure investments are common, the effects of changes in their utilization are much less understood. Leveraging the exogenous variation in shifting trade routes due to Hurricane Katrina, I estimate the port utilization effects on otherwise unaffected Florida port communities. The instrumental variable approach embedded in a system of theoretically motivated estimation equations provides sound identification of the urban economic impact of international cargo shipments and suggests a 10% increase in seaport services raises factor prices and employment by 0.46% to 0.69%. Aligning with the theory, the effects are driven by transportation and traded goods-producing sectors.

JEL codes: (F16, J30, Q54, R11, R41)

Key words: Hurricane Katrina; Employment; Transport; Instrumental variables, Spatial spillovers

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1 Introduction

Transport infrastructure investments are at the forefront of current policy debate. Quantifying the benefits from such investments has proven to be a challenging econometric task. Investment location is non-random and depends on regional economic conditions. Regional economic activity in turn responds to changes in transport infrastructure and its utilization. While investment effects have been studied in many contexts[1], the effects of changing utilization of these public goods is much less understood.

Within the context of transportation infrastructure, seaports play a critical role serving as gateways for domestic firms to international markets (Friedt and Wilson 2020). The tremendous growth of international trade over the past decades has put pressure on the U.S. port network and shaped economic development around port cities. The growing dependence on these infrastructures exposes local urban economies to the increasing uncertainties stemming from global power dynamics, national trade policy, and rising incidences of natural disasters, among other things. Anthropogenic climate change and the resulting environmental degradation, for example, have led to a rise in the frequency and destructive force of natural disasters around the globe (Emanuel 2005); and U.S. ports have experienced the detrimental and lasting effects of such events (Friedt 2021).

In this study, I investigate the impact of changes in port utilization on port-county economies. Theory shows that aggregate responses in employment, wages, and land values, for example, are shaped by a complex set of simultaneous interactions and industry-specific dynamics (Haughwout 1996; Friedt 2022); and to identify these systematic and endogenous port utilization effects on local port-county economies, I leverage natural disaster-induced diversion of international trade through unaffected seaports of entry/exit. Specifically, I develop a novel identification strategy that exploits the quasi-random variation in international shipments due to Hurricane Katrina via an instrumental variables (IV) approach embedded in a system of simultaneous equations.

The empirical analysis is grounded in a multi-sector urban equilibrium model developed by

[1]For an excellent review of the early literature see Gillen (1996). For more recent empirical applications see, for example, Chandra and Thompson (2000) or Duranton and Turner (2012).

Haughwout (1996, 2002) and extended by Friedt (2022). The extended theory produces aggregate and industry-specific predictions of the effects of an increase in public transport infrastructure services and highlights four, partially competing, mechanisms that drive the urban equilibrium response. I test the theoretical predictions and identify the factor price and employment effects of changing transport services via the quasi-random disaster-induced variation in port-level trade. The resulting elasticity estimates are theoretically consistent and policy relevant demonstrating that a rise in seaport services is productivity enhancing for manufacturing firms and increases demand for local transport services, which in aggregate outweigh the productivity-eroding effect on other service sectors. In aggregate a 10% increase in trade flowing through a U.S. seaport raises average annual port-county property values by 0.52% and average county-industry weekly wages by 0.46%. Further, I find that the underlying surge in productivity acts as a weak complement to labor that causes a 0.69% increase in employment.

Across industries, the empirical analysis produces robust evidence that the positive factor price and employment elasticities with respect to international cargo shipments are driven by the responses of goods-producing industries of traded products, as well as transport and transport-related service sectors. In contrast, industries of non-traded products exhibit no response to increases in local seaport services, while the labor markets of the leisure and hospitality sectors in Florida port counties exhibit the expected adverse effects from port-related congestion and other negative externalities (i.e. air and noise pollution).

The significance of estimating this local seaport service effect on urban economies is rooted in several recent developments. First, it is rooted in the tremendous growth of seaborne international trade[2] that has coincided with a significant rise in the frequency and severity of natural disasters (Emanuel 2005). Echoed by recent events, this positive correlation has led to a greater exposure of international trade to the disruptions caused by natural disasters and necessitates the contemporaneous adjustment in international shipments (Friedt 2021). Given the magnitude of annual cargo flows and the rise in natural disasters, it is important to understand how the facilitation of inter-

[2]In 2016, U.S. trade topped 3.5 trillion dollars requiring annual shipments of over 48 million containers according to The World Bank (2016).

national trade impacts local labor markets tied to these gateways (Acemoglu et al. 2005). To the best of my knowledge, my results are the first to shed light on how seemingly unaffected communities respond to the unexpected, yet significant rise in seaport services due to the disaster-induced diversion of trade. As such, my work contributes to the growing field of research evaluating the impact of natural disasters on local labor markets (see, for example, Belasen and Polachek (2008); Deryugina et al. (2018))

Second, my results offer new perspectives on the effects of trade and other related public policies. Much of the recent literature on trade studies the effects of import competition (see, for example, Autor et al. (2013); Kovak (2013)) or export opportunities (i.e. Michaels (2008); Feenstra et al. (2019)). As the literature shows these effects are not necessarily tied to transport infrastructure or confined to port cities. Unlike the adverse labor market effects of aggregate import penetration in any localities that compete with these imports, I find that trade diversion through localities that do not compete directly with those imports stimulates local port-city labor markets. By shedding light on the interdependence of the urban economy and port services tied to international trade, my findings inform the discussion on the effects of trade policy and offer guidance that is complementary to the literatures on import competition and export opportunities.

Third, the empirical literature on the economic impacts of infrastructure has struggled to capture the intensive margin effects of its efficient utilization (Baird 2005). Due to data limitations, the most convincing studies develop empirical strategies based on historical or planned public capital expenditures (see, for example, Chandra and Thompson 2000; Baum-Snow 2007; Duranton and Turner 2012; Donaldson 2018) to identify the extensive margin effects of infrastructure investments and are unable to disentangle the effects of these expenditures from increased infrastructure services. In some cases, the labor market effects of international cargo shipments have been considered, but are generally subject to significant endogeneity concerns (Ferrari et al. 2010; Bottasso et al. 2013). My research contributes to this vast literature on the economic impacts of transport infrastructure and addresses the persistent issues of endogeneity and quantification of intensive margin effects by identifying the labor market responses of increased seaport services through the

exogenous trade diversion in response to Hurricane Katrina. The results offer clear insights into the direction of causality and produce novel estimates of the intensive margin effects of increasing infrastructure utilization.

The paper proceeds as follows. In section 2, I derive the empirical model grounded in a the multi-sector urban equilibrium theory and discuss the identification strategy. I summarize the data in section 3. Section 4 presents the main empirical results, while section 5 concludes the paper.

2 Empirical Model

The empirical model is grounded in a multi-sector urban equilibrium theory developed by Friedt (2022) and based on the original work by Haughwout (1996, 2002). In short, the theory considers an economy with many jurisdictions across which households and firms can locate freely. Each jurisdiction offers distinct amenities and public goods consumed by households and firms. One may think of this as road or port infrastructures in a port city used by household and firms of different industries, including manufacturing, service, and transport sectors. Conditional on the local determinants and the agents' location decisions, industry-specific production, employment, land use, and factor prices are endogenously determined and create a spatial equilibrium captured by a set of simultaneous equations.

From this set of equations one can evaluate the effects of changes in infrastructure utilization, such as changes in the volume of port throughput, on the urban equilibrium. While the aggregate factor price responses to an increase in seaport services are theoretically indeterminate, the model produces three industry-specific testable hypotheses that align with the previous literature. These include: 1) the productivity-enhancing supply shock on manufacturing industries resulting from the reduction in international transport cost, greater accessibility and the enhanced market potential (Fujita et al. 2001); 2) the positive demand shock for local transport and transport-related service sectors (Chandra and Thompson 2000); and 3) the adverse supply shocks on non-tradable goods and service industries arising from the increases in domestic transport costs and congestion

(Fernald 1999).

As shown by Friedt (2022), the structural equilibrium conditions give rise to a set of four estimation equations that capture the prevailing wage rate, land values, and local transport costs, as well as jurisdictional employment. These equations can be represented as follows:

$$R = R(W, G, A, r, \tau, C) \tag{1}$$

$$W = W(R, G, A, r, \tau, H) \tag{2}$$

$$N = N(R, W, G, A, \tau, r, \lambda) \tag{3}$$

$$\tau = \tau(R, W, G, A, r, Z), \tag{4}$$

where I assume that local transport conditions are, in part, driven by jurisdictional port-level trade flows (τ) and factor prices are given by assessed property values (R) as well as average weekly wages (W). Local employment (N) is captured by industry-specific county-level employment disaggregated at the three-digit NAICS code. Following the theory, equation (1) describes property values as a function of the prevailing local wages, fiscal policy and provision of public goods (G), local amenities (A), international cargo shipments handled by the local seaport of entry or exit (τ), the national price of private capital (r) and local housing market and home characteristics (C). Simultaneously, wages are determined as a function of the prevailing local property values, fiscal policy and amenity controls, seaport infrastructure utilization, the price of private capital, and exogenous jurisdictional household characteristics (H). In line with Haughwout (1996), these exogenous housing market and household characteristics are required to identify the wage and land value equations and must serve as instruments for these endogenously adjusting factor prices.

Employment is modeled as a function of local wages and property values, along with fiscal policy and amenity controls, local shipments of international cargo, the price of private capital and labor market conditions (λ). These labor market characteristics, such as industrial composition and population density, proxy for the relative county-industry dependence on internationally-sourced intermediates and control for the size of the jurisdictional market. Lastly, I augment the empirical

model with Equation 4 expressing local transport services of international cargo shipments as a function of the prevailing factor prices, fiscal policy and amenity controls, the national economic conditions and an instrumental variable (Z) that identifies an exogenous change in local transport.

Imposing a log-linear form yields the primary empirical specification:

$$ln(R_{it}) = a_0 + a_1 ln(W_{ikt}) + a_2 G_{it} + a_3 A_{it} + a_4 ln(\tau_{it}) + a_5 C_{it} + a_6 t + \delta_i + \nu_{1it} \tag{5}$$

$$ln(W_{ikt}) = b_0 + b_1 ln(R_{it}) + b_2 G_{it} + b_3 A_{it} + b_4 ln(\tau_{it}) + b_5 H_{it} + b_5 t + \delta_i + \delta_k + \nu_{2ikt} \tag{6}$$

$$ln(N_{ikt}) = c_0 + c_1 ln(R_{it}) + c_2 ln(W_{ikt}) + c_3 G_{it} + c_4 A_{it} + c_5 ln(\tau_{it}) + c_6 \lambda_{it} + c_7 t + \delta_i + \delta_k + \nu_{3ikt} \tag{7}$$

$$ln(\tau_{it}) = d_0 + d_1 ln(R_{it}) + d_2 ln(W_{ikt}) + d_3 G_{it} + d_4 A_{it} + d_5 Z_{it} + d_6 t + \delta_i + \nu_{4it}, \tag{8}$$

where each of the socioeconomic characteristics, fiscal policy, amenity, and output measures (C, H, A, G) represent a vector of logged control variables discussed in the following section. Moreover, each equation is augmented with a set of county (i) and industry (k) fixed effects (δ_i and δ_k) as well as a time trend (t) to control for any unobservable time-invariant differences across counties and industries and common economic trends over time, such as the business cycle or national price of private capital. a_4, b_4 and c_5 mark the coefficient estimates of interest and represent the elasticities of factor prices and employment with respect to international cargo shipments utilizing local transport infrastructures.

It is important to note that this simultaneously estimated system of equations is only identified if there are as many instruments as dependent variables. In what follows, I provide a detailed discussion of the validity of the disaster-based instrument (Z_{it}), which identifies the seaport service equation (8). For the remaining factor price and employment equations (5)-(7), I rely on household, housing, and labor market characteristics that are commonly used in the previous literature.

2.1 Instrumental Variable

Given the obvious simultaneity of local trade flows, employment and factor prices, traditional Ordinary Least Squares (OLS) and Fixed Effects (FE) estimations of these elasticities would suffer from an endogeneity bias. To address the endogeneity concern, I instrument for local trade flows

exploiting the quasi-random variation provided by the diversion of international shipments through Florida seaports of entry and exit in response to Hurricane Katrina. Intuitively, the natural disaster shifts international trade across the existing infrastructure network, from devastated seaports to nearby harbors spared from the calamity. Given this increase in port calls by international carriers, local manufacturing firms arguably experience an exogenous decline in international freight rates, while local transport firms experience a positive demand shock. Both shocks may impact port-city employment and factor prices across industries and are uncorrelated to the contemporaneous local employment and prevailing factor prices.

The specific instrumental variable, Z, is a dummy variable indicating the sample period after the second landfall of Hurricane Katrina in August, 2005, for all Florida port counties and is interacted with the inverse of nautical shipping distance from the respective seaports to Hurricane Katrina's epicenter in Waveland, MS. As such, the instrument varies over the time and cross-sectional dimensions of the sample.

2.1.1 Relevance Condition

The merit of this identification strategy depends on the validity of the traditional relevance and exclusion restrictions. In this study, the relevance condition prescribes that Hurricane Katrina caused a significant alteration in international trade handled by Florida ports and that these port-specific changes in trade decayed with distance from Katrina's epicenter.

The short-run diversion of U.S. trade in response to Hurricane Katrina across the largest Gulf Coast and Lower Atlantic ports is illustrated in Figure 1. The map depicts the evolution of Hurricane Katrina[3] and the resulting port-level changes in trade between July, 2005 and September, 2005, one month before and after Hurricane Katrina's landfall. Figure 1 clearly shows the tremendous disruptions occurring at the ports closest to the disaster epicenter. The ports of New Orleans

[3]Hurricane Katrina was first reported as a tropical storm in the Bahamas. On August 25, 2005, it made its initial landfall in Florida as a category 1 hurricane before crossing over in the Gulf of Mexico, where it developed into a category 5 hurricane. Its second landfall occurred in the states of Mississippi and Louisiana on August 29, 2005, with sustained winds of 125 mph. Upon this second landfall, the havoc caused by Hurricane Katrina was felt along the majority of the U.S. Gulf Coast with the most severe effects along the coastal regions of Louisiana and Mississippi.

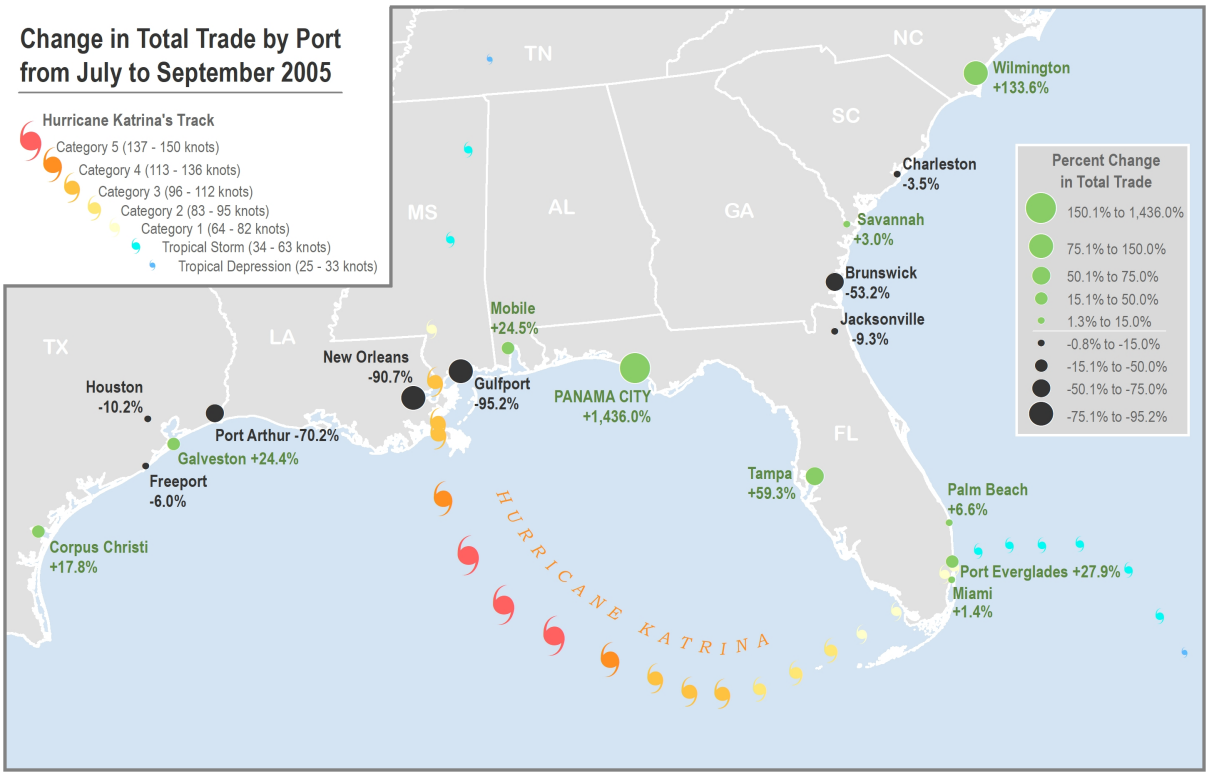
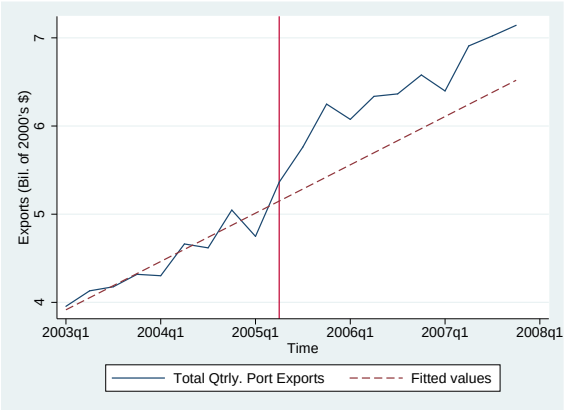


Figure 1: U.S. trade diversion in response to Hurricane Katrina

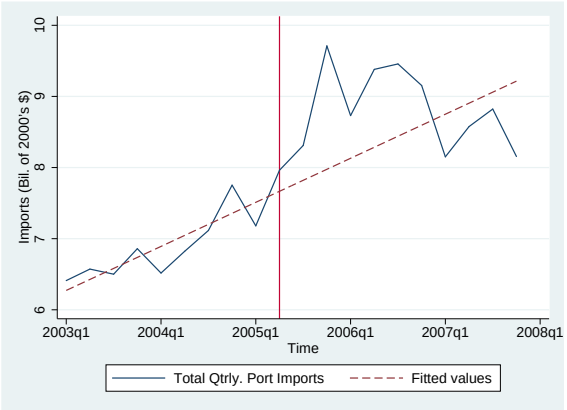
and Gulfport, for example, experience around 90% to 95% reductions in trade, whereas the port of Panama City, FL, roughly 400 kilometers east of Katrina's epicenter, reports a sensational increase of over 1,400% in total trade value.[4] Furthermore, Figure 1 shows that this relative effect sharply decreases over distance, as the port of Tampa, FL, about 730 kilometers east of ground zero, experiences a 59% increase in trade, whereas other Florida ports at greater distances seem to experience smaller short-run percentage changes in trade.

In the long run, these diversions, particularly through the port of Panama City, are rather persistent. Figures 2.1 through 3.2 plot actual trade flows before and after Hurricane Katrina and predicted exports and imports, but for the disaster, for all of Florida as well as the port of Panama City. With the exception of total Florida port imports, which suffer from the onset of the 'Great

[4] According to the local port authority, this incredible surge in seaport services can be traced back to rerouted container shipments by a single international carrier, named Linea Peninsular. This carrier permanently switched shipping routes and established biweekly port calls at the port of Panama City directly connecting Bay County to several ports in Mexico and beyond.

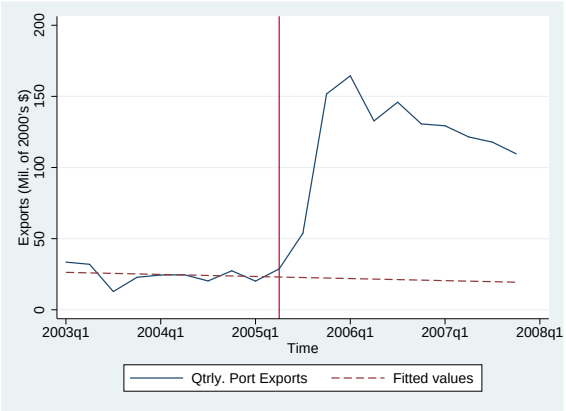


2.1: Quarterly exports

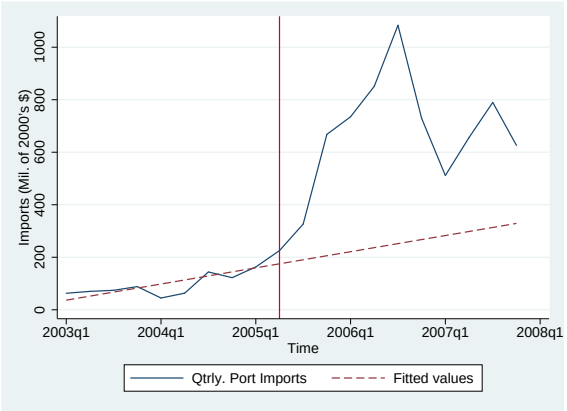


2.2: Quarterly imports

Figure 2: Total quarterly Florida port trade flows (Bil. of 2000's $)



3.1: Quarterly exports

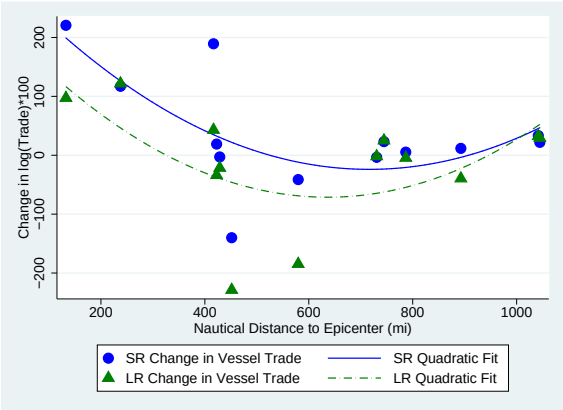


3.2: Quarterly imports

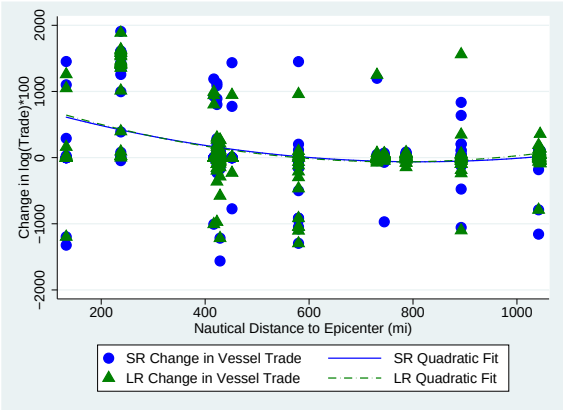
Figure 3: Quarterly trade flows, Port of Panama City (Mil. of 2000's $)

Trade Collapse' towards the end of 2007, these figures highlight the persistence of the disaster-induced rerouting effect.

While these observations provide strong evidence of the disaster-induced rerouting of trade towards major Florida ports, the relevance criterion of the instrumental variable additionally requires that this diversion is inversely related to the ports' distance to Hurricane Katrina's epicenter. Figures 4.1 and 4.2 depict average one-quarter to one-year Florida port-level percentage changes in the value of total and industry-specific seaborne trade. The fitted quadratic lines suggest that the changes in the value of seaborne trade handled by the set of Floridan ports are inversely related to the port's (or port county's) distance from Katrina's epicenter and approximate the assumed



4.1: Change in total vessel trade (%)



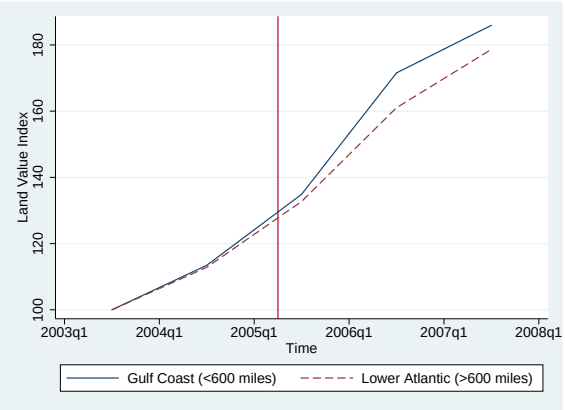
4.2: Change in industry-specific trade (%)

Figure 4: Total trade diversion over distance

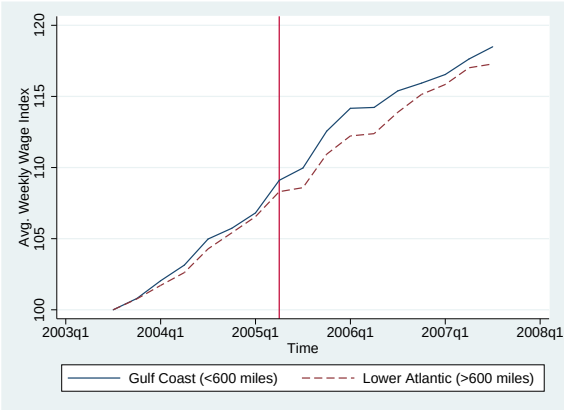
inverse distance decay.

Two potential concerns that could undermine the validity of the relevance assumption are: 1) pre-treatment trends in county-level factor prices, employment and trade could vary systematically with distance to Katrina's epicenter due to some other factor; and 2) that the affected Florida ports closest to Hurricane Katrina offer some extraordinary and endogenously adjusting infra- or superstructure characteristics that make them the only possible destinations for rerouted cargo. As to (1), I split the sample of port counties between those located less than 600 nautical miles from Katrina's epicenter (Gulf Coast) and those located at greater distance (Lower Atlantic) and graph the indexed four-quarter moving averages of land values, wages, and employment, as well as total trade (see Figures 5.1 through 5.4). The data provide clear evidence in support of the parallel pre-treatment trends assumption across port counties in close proximity and those at greater distances to Hurricane Katrina and offer some evidence of the treatment effect after its landfall. Both average land values and wages in Gulf Coast port counties in closer proximity to Hurricane Katrina exhibit a clear departure from the growth trajectory of average land values and wages in Lower Atlantic port counties, which coincides with a notable surge in Gulf Coast port-level trade.

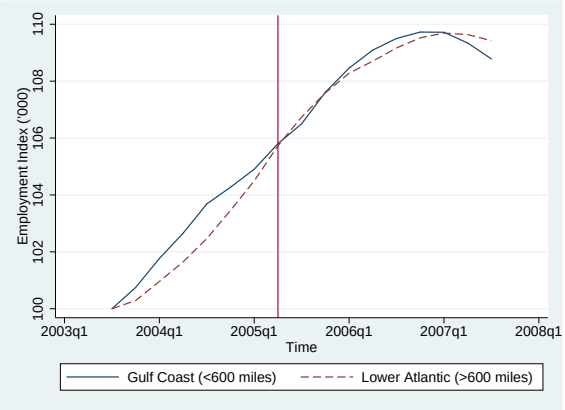
As to (2), data on port-specific infrastructure and superstructures show that ports in close proximity to Hurricane Katrina exhibit no particular advantage over those located at greater distances. A summary of these port characteristics is available upon request.



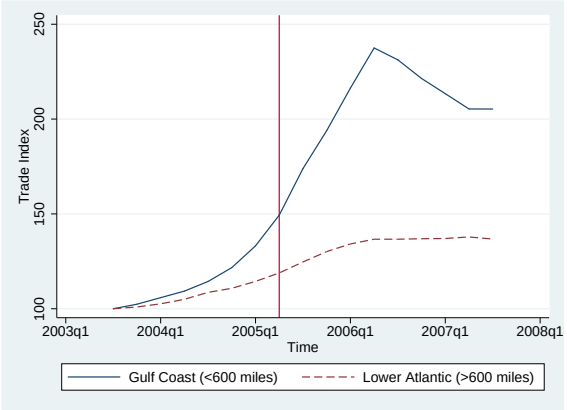
5.1: Land values



5.2: Weekly wages



5.3: Employment



5.4: Total Trade

Figure 5: Weighted moving average statistics by Florida coast

2.1.2 Exogeneity Condition

In terms of the exogeneity conditions underlying the proposed IV approach, there are two important assumptions: 1) Hurricane Katrina had no direct influence on Florida county employment and factor prices except through the observed diversion of international trade and 2) the diversion of international cargo was not driven by the contemporaneous employment and prevailing factor prices of Florida seaport counties. Considering the potential violation of criterion (1), the most likely channel through which Florida home and labor markets may have been directly affected by Hurricane Katrina, is the potential influx of evacuees from New Orleans and other devastated areas. Estimates regarding Hurricane Katrina evacuees indicate that Florida experienced a marginal inflow of about 15,000 refugees (or 0.084% of Florida's entire population) primarily relocating

to the major Metropolitan areas of Miami and Tampa-St. Petersburg (BBC News 2005). The average number of out-of-state migrants to Florida counties, however, fell over that same period and IRS data on total migration to Florida as well as migration of likely evacuees from affected states suggest that the change in annual out-of-state movers before and after Hurricane Katrina is uncorrelated with the nautical distance of a port county from the disaster's epicenter.

The second exogeneity assumption postulates that the decision of carriers to reroute international cargo shipments was driven by factors unrelated to local employment and the prevailing county-level factor prices. If, however, carriers decided to reroute international cargo through ports located in counties with larger than average employment growth, for example, the elasticity estimates with respect to international cargo shipments would be biased upward and overstate the positive influence of international transport services on local employment. Reassuringly, interviews with port authorities revealed that international carriers forced to switch ports of entry or exit were primarily driven by the consideration of added shipping distance. Local labor market and factor price conditions were not mentioned as the primary determinants in the rerouting decision.

3 Data

To examine the factor price and labor market effects arising from the disaster-induced increase in transport services, I have constructed a novel dataset combining information from a variety of national and local sources. The primary data include quarterly county-industry-level wage and employment statistics drawn from the Quarterly Census of Employment and Wages (QCEW). Land values are given by annual county-level taxable property values obtained from the Florida Department of Revenue. In addition, I have obtained data on various socioeconomic, amenity, and policy control variables. Annual county-level population and federal expenditure statistics, for example, are drawn from the U.S. Census Bureau, whereas annual local property taxation rates are available through the Florida Department of Revenue. Quarterly trade data quantifying the shift in transport services were obtained from the U.S. Census Bureau, USA Trade Online database and are avail-

able at the port-industry level.[5] Column (4) of Table 1 provides an exhaustive list of the sources I have drawn from in this analysis.

The final sample runs from Q1 2003 to Q4 2007 and includes 67 Florida counties, 14 of which are home to a U.S. seaport of entry and/or exit for internationally traded products. For each county, I observe employment and wage statistics for up to 93 unique three-digit industries, 59 of which are classified as service sectors and 34 of which are goods producing. Of the latter industry group, 28 sectors produce tradable goods and are matched with the US Census trade data by port. Lastly, among all industries there are seven relevant transport and transport-supporting industries including, for example, air, truck, rail, and water transport as well as warehousing and storage.

In Table 1, I present the mean statistics for each variable and break this information down across three subsamples and pre and post Hurricane Katrina time periods (*Panel A & B*). I isolate Bay County from other Florida counties in this summary, because the port of Panama City, experiencing the largest relative fluctuations in trade (see Figure 1), is located in this specific county. The dependent variables of interest are summarized in *Panels A & B* of Table 1. The pre-treatment averages for these data (2003q1-2005q2) reveal that Bay County wages are slightly larger than the average Florida non-port county (column (1) vs. (3)) and significantly smaller than the average of the remaining Florida port counties (column (1) vs. (2)). In contrast, average industry employment and property values in Bay County are slightly smaller than those observed in non-port counties and significantly smaller than those in other port counties. Similarly, U.S. trade entering or exiting through the port of Panama City is much smaller than the average quarterly U.S. trade flows handled by the remaining port counties.[6]

Panel B summarizes post Hurricane Katrina data (2005q3-2007q4) and indicates considerable disaster-induced variation in sample averages. Whereas changes in wages are similar across all counties (around 3% to 4%), total property values and average industry employment grew nearly

[5]These trade data are classified under the Harmonized Commodity Description and Coding System (HS). To match the six-digit HS observations for traded products with three-digit NAICS labor market statistics, I employ the annual U.S. Census NAICS-HS concordances for imports and exports.

[6]It is important to note that U.S. port-level trade flows exhibit a large degree of heterogeneity. Indeed, there are sample ports smaller than Panama City, such as the ports of Fort Pierce, Key West, or Manatee, FL, and some larger, including the ports of Tampa, Everglades, Jacksonville, or Miami.

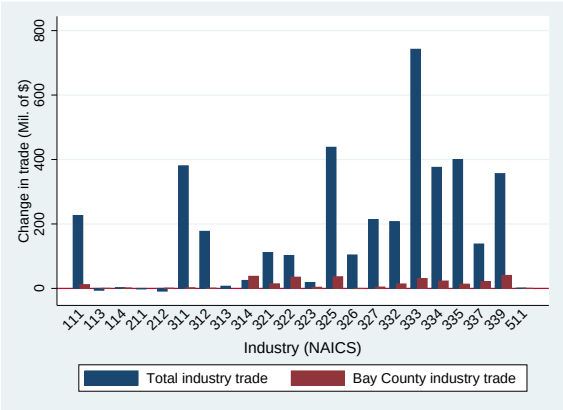
Table 1: Summary statistics for various county groups

	Bay County (1)	Other Port Counties (2)	Non-Port Counties (3)	Source (4)
Panel A: Mean values (2003q1-2005q2)				
Avg. Industry Weekly Wage ($)	519.84	623.53	500.30	QCEW
Taxable Property Value (B$)	8.46	50.99	11.50	FL-DOR
Industry Employment ('000)	2.31	11.85	2.78	QCEW
Vessel Trade (M$)	130.78	985.65		CENSUS-TRADE
Vessel Trade ('000 metric tons)	212.82	934.15		CENSUS-TRADE
# of Observations	652	9,611	22,616	
Panel B: Mean values (2005q3-2007q4)				
Avg. Industry Weekly Wage	534.21	647.08	517.32	QCEW
Taxable Property Value	14.23	69.09	15.81	FL-DOR
Industry Employment ('000)	2.69	12.53	3.00	QCEW
Vessel Trade (M$)	822.22	1,254.31		CENSUS-TRADE
Vessel Trade ('000 metric tons)	317.31	1,054.62		CENSUS-TRADE
# of Observations	620	9,668	23,287	
Panel C: Socioeconomic Controls (2003q1-2007q4)				
Pvt. Housing Building Permits ('000)	3.46	8.26	3.03	CENSUS-CONST
ln(Value per Private Housing Permit)	4.70	4.95	4.87	CENSUS-CONST
Residents under Age 18 ('000)	37.36	200.20	44.59	CENSUS-POP
Residents Age 25 to 45 ('000)	44.27	243.94	52.20	CENSUS-POP
Retirees ('000)	18.38	105.13	29.00	SSA
Population, African American (%)	11.36	15.41	13.05	CENSUS-POP
Residents per 1000 sq. Meter	0.08	0.37	0.10	CENSUS-POP
Location Quotient (LQ), Manufacturing	0.46	0.52	0.55	QCEW
# of Observations	1,272	19,279	45,903	
Panel D: Amenity & Policy Control Variables				
Banks & Savings Institutions	51.88	244.33	60.92	FDIC
Federal Govn't Direct Loans (M$)	7.95	30.14	15.85	CENSUS-GOVTS
Department of Defense Expenditure (M$)	667.07	722.94	201.10	CENSUS-GOVTS
Actual Millage (1/10 of %)	5.01	6.13	6.73	FL-DOR
# of Observations	1,272	19,279	45903	

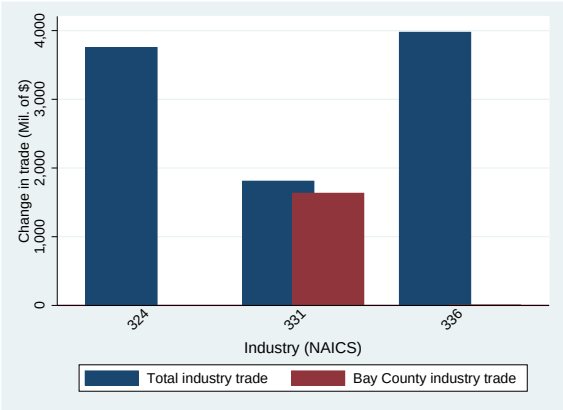
Notation: B$ = Billions of U.S. dollars, M$ = Millions of U.S. dollars, TH$ = Thousands of dollars, (000s) = Thousands. All monetary values are measured in 2000 dollars.

Sources: QCEW = Quarterly Census fo Employment and Wages - Bureau of Labor Statistics, FL-DOR = Florida Department of Revenue - Property Tax Oversight, CENSUS-TRADE = U.S. Census Bureau - USA Trade Online, CENSUS-CONST = U.S. Census Bureau - Construction Division, CENSUS-POP = U.S. Census Bureau - Population Estimates, SSA = Social Security Administration, CENSUS-GOVTS = U.S. Census Bureau - Governments Division, FDIC = Federal Deposit Insurance Corporation.

Notes: Averages and the number of observations are based on the respective statistics available for non-missing county-industry employment and wage data. In total there are 93 industries, 14 port counties and 53 non-port counties.



6.1: Small to moderate changes



6.2: Large changes

Figure 6: Industry-specific changes in trade flows

twice as fast (68% and 16% respectively) in Bay County relative to the averages of the remaining port and non-port counties in the aftermath of Hurricane Katrina. A likely explanation is the spectacular rise in seaport services. Columns (1) and (2) of Table 1 show that the average value of quarterly trade increases more than five fold in Bay County and 27% in all other port counties over the two year period after Hurricane Katrina. This aggregate rise is driven by increases in trade values across many different manufacturing industries, and in particular *Petroleum and Coal Product Manufacturing* (NAICS 324), *Primary Metal Manufacturing* (NAICS 331) and *Transportation Equipment Manufacturing* (NAICS 336). See Figure 6.1 and 6.2.

Following the literature (Duffy-Deno and Dalenberg 1993; Haughwout 2002)), I include a host of local amenity control variables and socioeconomic instruments. The vector of instrumental housing market characteristics (C) that identify the land rent equation, includes supply-side determinants in the form of new private housing building permits and the average value per permit as well as demand-side characteristics, such as the number of residents under the age of 18. In contrast, the vector of instrumental household traits (H) that identify the wage equation is comprised of plausibly exogenous demographic characteristics, such as the county's number of retired workers and population of age 25 to 45. A common demographic control for both the land rent and wage equation is the county's population share of African Americans. To identify the employment equation, I integrate labor market characteristics (λ) that capture the county-level industry compo-

sition via the manufacturing location quotient and market size via the population density expressed in 1,000 residents per square meter.

Amenity and fiscal policy control variables (A and G) include annual statistics on the total number of financial institutions, as well as the county-level property tax rate given by the actual millage rate. Data on federal government direct loans and Department of Defense (DoD) expenditure are included to control for county-level public capital spending and the provision of infrastructure.

4 Results

The estimation results I present in this section are comprised of two parts. First, I estimate the aggregate county-level effects. Second, I explore the heterogeneity in seaport service effects across multiple goods and services sectors.

4.1 Aggregate County Effects

In Table 2, I present the primary average county-level effects of seaport services on the urban economy. Each panel of Table 2 corresponds to one of the factor price or employment equations and the relevant coefficients of interest. For the sake of brevity, coefficient estimates for all other control variables are available upon request. To illustrate the importance of controlling for the previously highlighted endogeneity issues, I build this analysis from a naive OLS regression (including fixed effects) to the more appropriate 2SLS and preferred 3SLS estimations.

As expected, the OLS regression analysis, reported in columns (1) and (2) of Table 2, produces coefficient estimates that generally carry the expected sign and some statistical significance. However, these coefficient estimates are notably smaller in comparison to the 2SLS and 3SLS analyses (columns (3) through (5)) and suggest a significant attenuation bias stemming from the simultaneity of factor prices, employment and seaport services.

Instrumenting for seaport services via the 2SLS technique alleviates some of this bias. The first-stage coefficient estimates and test statistics of the 2SLS estimations, reported in columns (3) and

(4) of Table 2, provide evidence in support of the strength of our instrumental variable. The first-stage tests, for example, resoundingly reject the null hypotheses of a weak instrument and under identification of the seaport service equation. The coefficient estimates on the instrumental variable indicate that Florida seaports in closer proximity to Hurricane Katrina experienced economically and statistically significant increases in trade flows after the disaster.

The second-stage estimates of the seaport service effects on local factor prices and employment (see columns (3) and (4) of Table 2) are considerably larger than the OLS coefficients and statistically significant for the land value and employment equations. I find that a 10% rise in international trade flows facilitated through the local seaport raises land values and employment by around 0.3% to 0.4%.

Finally, I turn towards the preferred 3SLS estimation. In general, I find that the estimated coefficients tend to be highly significant and carry the expected sign. In Florida port counties, a 1% increase in average weekly wages results in a 1.1% reduction of taxable property values and 1.3% reduction in total employment. Likewise, firms compensate for a 1% rise in taxable property values with a 1.0% reduction in average weekly wages. As a complement to land, I find that labor demand responds negatively to an increase in property values. A 1% rise in average annual property values reduces quarterly industry-specific employment by around 1.2% for the average Florida port county.

In terms of international cargo shipments facilitated through the local seaport, I find that the coefficient on the instrumental variable is statistically significant at the 1% level and carries the expected sign. The rerouting of international trade in response to Hurricane Katrina causes a significant rise in cargo shipments handled by Florida ports and the effect is decreasing over nautical shipping distance from the disaster's epicenter.[7]

The elasticity estimates of interest are given by the seaport trade effects on factor prices and employment and are highly significant at the 1% level. Similar to the 2SLS estimates, the results

[7] Although the 3SLS routine estimates the seaport service equation simultaneously with the factor price and employment equations, I present the corresponding coefficient estimate as the first-stage IV coefficient for the sake of conformity with the 2SLS estimator and table format.

Table 2: Land values, wages, and employment - Full Sample

	(1) OLS	(2) OLS	(3) IV 2-SLS	(4) IV 2-SLS	(5) IV 3-SLS
Panel A: Taxable Property Value (R)					
ln(W)	-0.024***		-0.0335***		-1.056***
	(-6.75)		(-5.74)		(-24.18)
ln(τ_{it})	0.0005***	0.0004***	0.0418***	0.044***	0.052***
	(2.95)	(2.68)	(12.70)	(13.36)	(20.30)
First-Stage Coefficient: IV			164.94***	236.35***	91.006***
Anderson-Rubin F-stat			91.47***	215.55***	
Panel B: Avg. Weekly Wages (W)					
ln(R)	-0.174***		-0.177***		-0.994***
	(-6.01)		(-5.96)		(-35.83)
ln(τ_{it})	0.0008	0.0007	0.009	0.0005	0.046***
	(1.55)	(1.45)	(1.04)	(0.07)	(13.32)
First-Stage Coefficient: IV			164.21***	227.14***	91.006***
Anderson-Rubin F-stat			1.065	0.006	
Panel C: Quarterly Employment (N)					
ln(R)	0.102**		0.089*		-1.180***
	(2.09)		(1.68)		(-6.06)
ln(W)	0.037		0.0301		-1.312***
	(0.91)		(0.70)		(-3.49)
ln(τ_{it})	0.001**	0.002**	0.037*	0.0275**	0.069***
	(2.03)	(2.45)	(1.74)	(2.04)	(4.59)
First-Stage Coefficient: IV			166.39***	227.14***	91.006***
Anderson-Rubin F-stat			3.113*	4.22**	
A, G controls	Y	Y	Y	Y	Y
C, H, λ controls	N	Y	N	Y	Y
County & Ind. FE	Y	Y	Y	Y	Y
Weak Instrument (KP Wald F stat)			132.21	255.33	
Under Identification (KP LM stat)			145.77***	107.46***	

Notes: The dependent variables encompass the log of annual county property prices (R), the logs of quarterly county-industry avg. weekly wages (W) and employment (N). Coefficients reported in columns (1) and (2) are based on the simple OLS estimator. Results reported in columns (3) through (5) use the instrumental variables approach via the 2SLS and 3SLS estimators. Standard errors for OLS and 2-SLS estimates are clustered at the county-industry level. Estimates in columns (1) and (3) are based on regressions that directly include factor prices, while those in columns (2) and (4) are based on regressions that proxy for these factor prices via demographic, housing and labor market characteristics. The strength of the instrument is evaluated via the first-stage coefficient, as well as the weak instrument and underidentification test statistics (Kleinbergen and Paap (KP) χ^2-distributed LM rank test statistic; KP Wald F statistics). T-statistics (columns (1)-(4)) and Z-ratios (column (5)) are reported in parentheses and statistical significance at the conventional levels is indicated by *** p<0.01, ** p<0.05, * p<0.1.

suggest that the increase in average county seaport services, as well as the associated reduction in international transport costs and improved access to foreign markets for local firms dominates the potential adverse productivity and dis-amenity effects arising from higher local transport costs and greater local congestion. Resolving the theoretical ambiguity concerning the average jurisdictional effects, I find that a 10% increase in seaport services leads to a 0.52% rise in annual property values and 0.46% increase in the prevailing average weekly wage rate. Moreover, the implied surge in firm productivity results in an increase in the demand for labor. A 10% rise in international cargo shipments through the local port of entry or exit raises average quarterly county-industry level employment by 0.69%.

Port utilization matters to the local economy. Changes in trade handled by a given port, such as those triggered by a natural disaster, can have significant economic impacts on otherwise unaffected urban economies. Based on the preferred estimates shown in column (5) of Table 2, increases in international trade flows seem to act as a catalyst for the local economy.

4.2 Industry-specific County Effects

Next, I test the industry-specific hypotheses distinguishing between (1) the productivity-enhancing effect of reducing in international transport costs, (2) the positive demand shock on the local transport sector due to the rise in seaport services, and (3) the productivity-eroding effects of higher domestic transport costs and negative externalities, i.e. congestion, air and noise pollution, among others. To this end, I reestimate the model and restrict the estimation sample by industry classification. I focus the industry-specific analysis on the preferred 3SLS estimates. As expected, the industry-specific labor market effects presented in *Panels B & C* of Table 3 display a high degree of variability.

Somewhat surprisingly, the seaport trade effect on local industry-specific wages and employment is notably larger for the average service sector (column (4)) relative to the average goods sector (column (1)). The service sector estimates, in fact, mirror the average county results in terms of magnitude and statistical significance, whereas the average trade effects on goods-producing

industry wages and employment are indistinguishable from zero.

To further investigate this initial finding, I differentiate the industries across those that produce commodities facilitated through the local seaport of entry or exit and those that do not. For traded industries, point estimates reflect the industry-specific wage and employment elasticity with respect to the industry-specific local seaport of entry or exit trade flows (τ_{ikt}). For commodities that are produced in a port county but not facilitated through the local port of entry/exit, the point estimates provide the elasticity of industry-specific wages and employment with respect to total local seaport trade of other traded commodities (τ_{it}). As such, I can differentiate between the potential productivity-enhancing effect on locally facilitated industries, and the potential productivity-eroding congestion and domestic transport cost effects on industries of non-traded commodities that are exposed to the increase in local traffic flows of other goods.

The estimation yields the expected results and aligns the theoretical considerations with the empirical findings. Local industries that do not take advantage of the local seaport are unaffected by a rise in seaport services, while the sectors producing goods facilitated through the local infrastructure experience statistically and economically significant responses in average weekly wages and employment. Specifically, the point estimates suggest that the productivity enhancement through a 10% increase in industry-specific seaport services raises average weekly wages and quarterly employment in these industries by 0.3% and 1.6%, respectively.

Analyses of local service sectors produce similarly convincing evidence of the urban equilibrium effects of seaport trade flows. For local transport industries and related service sectors, I find considerably larger labor market responses to changes in local seaport trade flows. As expected, the positive demand shock of a 10% increase of international trade facilitated through the local seaport causes a 0.73% increase in average weekly wages and 1.38% rise in quarterly employment averaged across these local transport industries (Table 3, column (5)).

In contrast, the average labor market effects on non-transport service sectors are more moderate, yet economically as well as statistically significant. Similar to the non-traded goods-producing industries, the results presented in column (6) of Table 3 indicate the absence of an adverse con-

Table 3: Land values, wages, and employment - Industry-specific Effects, 3 SLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Goods			**Services**		
	All	Traded	Non-traded	All	Transport	Non-transport	Hospitality
Panel A: **Taxable Property Value (R)**							
ln(W)	-1.504***	-2.004***	-1.029***	-0.781***	-0.248***	-0.848***	-0.441***
	(-18.76)	(-17.50)	(-13.00)	(-16.67)	(-3.66)	(-17.11)	(-4.02)
ln(τ_{it})	0.0273***		0.0116*	0.0456***	0.0328***	0.0451***	0.00539
	(3.51)		(1.93)	(21.44)	(7.53)	(18.95)	(0.91)
ln(τ_{ikt})		0.0673***					
		(8.63)					
Panel B: **Avg. Weekly Wages (W)**							
ln(R)	-0.643***	-0.501***	-0.749***	-1.245***	-2.216***	-1.150***	-1.536***
	(-13.77)	(-24.50)	(-5.94)	(-33.03)	(-8.86)	(-31.14)	(-7.06)
ln(τ_{it})	0.00961		-0.00826	0.0486***	0.0729***	0.0422***	-0.0610***
	(1.35)		(-0.95)	(12.63)	(4.11)	(10.70)	(-3.94)
ln(τ_{ikt})		0.0340***					
		(8.69)					
Panel C: **Quarterly Employment (N)**							
ln(R)	-1.354***	-2.433***	-0.492	-0.854***	-1.587**	-0.693***	-0.967
	(-3.08)	(-3.92)	(-0.84)	(-4.64)	(-2.13)	(-3.93)	(-1.49)
ln(W)	-1.692***	-5.134***	-0.575	-0.920**	-0.931	-0.838**	-1.107
	(-2.71)	(-3.13)	(-1.27)	(-2.32)	(-1.57)	(-2.02)	(-0.95)
ln(τ_{it})	0.0318		0.0376	0.0493***	0.138**	0.0339**	-0.105***
	(1.03)		(1.43)	(3.29)	(2.42)	(2.37)	(-2.65)
ln(τ_{ikt})		0.159***					
		(5.06)					
Observations	6218	4308	2023	12851	1091	11760	1175
R^2	0.832	0.674	0.926	0.957	0.987	0.955	0.982
$A, G, C, H,$ λ controls	Y	Y	Y	Y	Y	Y	Y
County & Ind. FE	Y	Y	Y	Y	Y	Y	Y
Included Industries (NAICS)	111-339, 999	111-114, 211-212, 311-339, 511	111-238, 311-316, 323, 325-331, 334-339, 999	400-814	481-484, 486, 488, 493	400-480, 485, 487, 489-492, 494-814	711-713, 721-722

Notes: Z-ratios are reported in parentheses. The dependent variables encompass the log of annual county-level property prices (R), the logs of quarterly county-industry-specific avg. weekly wages (W) and employment (N). The number of observation varies because the underlying estimation samples are restricted to the relevant goods- and service-producing industries in port counties. The overlap in industries that are traded and non-traded (columns (2) through (3)) stems from the location dependent definition of these types of sectors. A traded sector is one that is produced in a given port county and facilitated by the local seaport of entry/exit. A non-traded sector is one that is produced in a given port county but not facilitated by the local infrastructure. Statistical significance at the conventional levels is indicated by *** p<0.01, ** p<0.05, * p<0.1.

gestion effect. Instead, the coefficients suggest that a 10% increase in seaport transportation raises average weekly wages and quarterly employment by 0.42% and 0.34% for non-transport service sectors, respectively. Consistent evidence of these positive service sector effects has been documented by Chandra and Thompson (2000), for example, and can be interpreted as the 'indirect' or 'induced' industry effect due to the enhanced local transportation activities (Friedt and Wilson 2020).

The complete absence of the theorized negative externalities of increasing seaport services, however, is unlikely. In the case of Florida seaport counties, the leisure and hospitality service sectors might exhibit particular vulnerability. A sharp increase in port-related traffic, along with noise and air pollution from port operations, might diminish the desirability of a given port county as a travel destination and reduce the number of visiting tourists. Indeed, restricting the sample to leisure and hospitality service sectors yields estimates that point to significant reductions in average weekly wages and quarterly employment (Table 3, column (7)).

5 Discussion & Conclusion

The empirical results are largely consistent with the recent literature on the economic development effects of transport infrastructure investments (see, for example, Chandra and Thompson (2000); Duranton and Turner (2012) or related to the work by Donaldson (2018)) and offer several novel insights. The natural disaster based identification strategy is a new approach to the well known endogeneity problem. Moreover, while previous studies offer convincing evidence on the extensive margin effects of providing road, rail, air and seaport infrastructure, my estimates of the urban equilibrium responses to the utilization of existing transport infrastructure offer new insights into the intensive margin effects that are not yet well understood.

In general, the results show that international cargo shipments have a significant impact on housing and labor market outcomes. I find that seaport trade flows are positively correlated with the level of local factor prices and that the implied productivity enhancement acts as a complement

to labor that positively affects employment. The results further suggest that increased seaport services have a productivity-enhancing effect on industries of traded commodities and a positive demand effect on local transport and transport-related service sectors, but a negligible impact on goods-producing industries of non-traded commodities.

In light of these findings, this research has policy relevance. As natural disasters are not the only cause of international trade diversion, other policies, such as increasing trade protections or infrastructure investments, can shift the patterns of international cargo movements. While the effects of such policies are manifold, this study illuminates how the transportation of international trade impacts local employment and factor prices and offers guidance on how to support these communities in the case of drastically changing trade patterns. In the case of a natural disaster, for example, my work suggests that the resulting diversion of trade may intensify the economic hardship experienced by disaster-stricken communities. As such, my findings emphasize the importance of protective infrastructure, such as breakwaters, to minimize the port damages sustained during weather and climate extremes and limit the sudden rerouting of international cargo shipments.

My findings give rise to various areas of future inquiry including, for example, further delineation across alternative types of transport services and infrastructures. Does containerized trade have the same effect as trade in bulk commodities? How do the effects of airports differ from seaports? Further research is needed. Moreover, one might investigate whether the changes in port utilization affect non-port communities. Finally, my results are driven by the exogenous diversion of international trade caused by Hurricane Katrina. As such, an important question to consider is whether my findings can be generalized to less intensive hurricanes, other types of natural disasters or alternative sources of trade variation, such as trade liberalization or port investments.

References

Daron Acemoglu, Simon Johnson, and James Robinson. The rise of europe: Atlantic trade, institutional change, and economic growth. *American economic review*, 95(3):546–579, 2005.

David Autor, David Dorn, and Gordon Hanson. The china syndrome: The impact of import competition on us labor markets. *American Economic Review*, 103(6):2121–2168, 2013.

Brian Baird. Public infrastructure and economic productivity: a transportation-focused review. *Transportation Research Record: Journal of the Transportation Research Board*, (1932):54–60, 2005.

Nathaniel Baum-Snow. Did highways cause suburbanization? *The Quarterly Journal of Economics*, 122(2):775–805, 2007.

BBC News. Mapping the destruction. 2005. URL `http://news.bbc.co.uk/2/shared/spl/hi/americas/05/katrina/html/evacuation.stm`. Online; accessed 06/22/2018.

Ariel R Belasen and Solomon W Polachek. How hurricanes affect wages and employment in local labor markets. *American Economic Review*, 98(2):49–53, 2008.

Anna Bottasso, Maurizio Conti, Claudio Ferrari, Olaf Merk, and Alessio Tei. The impact of port throughput on local employment: Evidence from a panel of european regions. *Transport Policy*, 27:32–38, 2013.

Amitabh Chandra and Eric Thompson. Does public infrastructure affect economic activity?: Evidence from the rural interstate highway system. *Regional Science and Urban Economics*, 30(4): 457–490, 2000.

Tatyana Deryugina, Laura Kawano, and Steven Levitt. The economic impact of hurricane katrina on its victims: evidence from individual tax returns. *American Economic Journal: Applied Economics*, 10(2):202–33, 2018.

Dave Donaldson. Railroads of the raj: Estimating the impact of transportation infrastructure. *American Economic Review*, 108(4-5):899–934, 2018.

Kevin T Duffy-Deno and Douglas R Dalenberg. The municipal wage and employment effects of public infrastructure. *Urban Studies*, 30(9):1577–1589, 1993.

Gilles Duranton and Matthew A Turner. Urban growth and transportation. *Review of Economic Studies*, 79(4):1407–1440, 2012.

Kerry Emanuel. Increasing destructiveness of tropical cyclones over the past 30 years. *Nature*, 436 (7051):686, 2005.

Robert C Feenstra, Hong Ma, and Yuan Xu. Us exports and employment. *Journal of International Economics*, 120:46–58, 2019.

John G Fernald. Roads to prosperity? assessing the link between public capital and productivity. *American Economic Review*, 89(3):619–638, 1999.

Claudio Ferrari, Marco Percoco, and Andrea Tedeschi. Ports and local development: Evidence from italy. *International Journal of Transport Economics/Rivista internazionale di economia dei trasporti*, pages 9–30, 2010.

Felix Friedt. Natural disasters, aggregate trade resilience and local disruptions: Evidence from hurricane katrina. *Review of International Economics*, 2021.

Felix Friedt. Port infrastructure, trade, and local factor prices: An urban equilibrium theory. *mimeo*, 2022.

Felix L Friedt and Wesley W Wilson. The economic impact of seaport and other infrastructure investments and leakages: A literature review. *Journal of Transport Economics and Policy (JTEP)*, 54(4):219–243, 2020.

Masahisa Fujita, Paul R Krugman, and Anthony J Venables. *The spatial economy: Cities, regions, and international trade*. MIT press, 2001.

David W Gillen. Transportation infrastructure and economic development: a review of recent literature. *Logistics and Transportation Review*, 32(1):39, 1996.

Andrew F Haughwout. Infrastructure, wages and land prices. In *Infrastructure and the Complexity of Economic Development*, pages 75–95. Springer, 1996.

Andrew F Haughwout. Public infrastructure investments, productivity and welfare in fixed geographic areas. *Journal of public economics*, 83(3):405–428, 2002.

Brian K Kovak. Regional effects of trade reform: What is the correct measure of liberalization? *American Economic Review*, 103(5):1960–76, 2013.

Guy Michaels. The effect of trade on the demand for skill: Evidence from the interstate highway system. *The Review of Economics and Statistics*, 90(4):683–701, 2008.

The World Bank. *World Development Indicators 2016*. The World Bank, 2016. URL `https://data.worldbank.org/`.