STATE-LEVEL IMPORT PENETRATION

David Riker

ECONOMICS WORKING PAPER SERIES
Working Paper 2022–03–C

U.S. INTERNATIONAL TRADE COMMISSION
500 E Street SW
Washington, DC 20436

March 2022

The author thanks Tyler Daun, Peter Herman, Ross Jestrab, Chris Montgomery, William Powers, and Samantha Schreiber for very helpful comments. Office of Economics working papers are the result of ongoing professional research of USITC Staff and are solely meant to represent the opinions and professional research of individual authors. These papers are not meant to represent in any way the views of the U.S. International Trade Commission or any of its individual Commissioners.

State-Level Import Penetration
David Riker
Economics Working Paper 2022–03–C
March 2022

Abstract

I develop a structural econometric model of import penetration in different parts of the United States and then estimate the parameters of the model using data for the furniture industry, as well as several other U.S. manufacturing industries. The model is designed to address the limited availability of sub-national data. After estimating state-level import values and penetration rates, I simulate the effects of changes in tariff rates on consumer prices and domestic employment in different states. The model suggests that estimates of the local labor effects of imports can be improved by incorporating data on the location of import entry.

David Riker
Research Division, Office of Economics
U.S. International Trade Commission
david.riker@usitc.gov

1 Introduction

Official import statistics record the port districts where imports enter U.S. customs, but they do not reliably track the movement of these imports within the country or their final destination.[1] Knowing the destination of imports is critical for assessing the effects of changes in trade policy and other import price shocks on consumers and workers in different parts of the country. Data on domestic shipments from the Commodity Flow Survey indicate that U.S. product markets are geographically segmented by costs of shipping between states, so the location where an import enters the country can provide useful insight into where the import is likely to end up and where its economic impact is likely to be greatest.

The economic literature on the sub-national or local labor market effects of trade typically relies on data on nationwide import values that do not track where the imports enter the United States. For example, in the models of the local labor market effects of trade in Autor, Dorn and Hanson (2013) and Acemoglu, Autor, Dorn, Hanson and Price (2016), local labor market exposure to import competition is determined by applying local employment shares of industries prior to the import shock to nationwide import values for each industry. Another example is the models in Caliendo, Dvorkin and Parro (2019) and Caliendo and Parro (2021). These models include domestic shipping costs, but they calculate the share of imports destined for each state by allocating national total imports to individual states in proportion to the state's share of national total employment in the industry, again without regard to where the imports entered the United States. Since these studies do not incorporate

[1] The U.S. Census Bureau publishes a State of Destination import series that in principle provides information on where U.S. imports are consumed. The data set is based on importers' declarations about "the U.S. state, U.S. territory or U.S. possession where the merchandise is destined, as known at the time of entry summary filing." (`https://www.census.gov/foreign-trade/guide/sec2.html#state_SD`) However, as the Census Bureau acknowledges, the reported state of destination may be an intermediary, storage or distribution point rather than the location of the ultimate consumer or industrial user of the imports. The Census Bureau provides the following example: "a consolidated shipment of many automobiles may be shipped by the importing company to a distribution point in one state with the intent of later shipping the automobiles to numerous states for final sale."

information on the location of import entry, they treat a million dollars of imports that entered the United States in California the same as an equal amount of imports entering the United States in Maine, as if they had the same impact on local labor demands *within an industry*, and this seems unrealistic.

To this end, I develop a structural econometric model that estimates the value of U.S. imports destined for each state using readily available data on the location of import entry, domestic shipments, and distances between states. I apply the model to the U.S. furniture industry and find that domestic distance had a significant negative effect on shipments of furniture between states in 2017. I use the model to estimate import penetration rates by source country and state.

After calculating these import penetration rates, I simulate the effects of changes in tariff rates on consumer prices and domestic employment in each state. Import entry in the furniture industry was relatively concentrated in 2017, with over 40% of industry imports entering through West Coast ports and 32.4% entering the Los Angeles port district alone. A large share of these imports likely ended up in California, Oregon, and Washington due to shipping costs between states. The modeled state-level import penetration rates also reflect the location of domestic production in the industry, with lower penetration rates in major furniture-producing states, including Indiana, Michigan, and North Carolina.

The differences in import penetration rates across states imply differences in the consumer price effects of tariff changes and also differences in domestic employment effects, with the largest effects concentrated in California and other western states. Models of local labor market effects that do not incorporate information on the location of import entry will be able to capture the national average effect on domestic employment, but they will miss systematic differences in the magnitudes of employment effects across states. In states with concentrated import entry, they will under-estimate the employment effects, while in states with concentrated competing domestic production they will over-predict the employment effects of the tariff changes of the tariff changes.

The main contribution of this paper is the practicality of the econometric approach in light of the limited availability of U.S. sub-national industry-level data on consumption, prices, and the domestic shipiment of imports. The structural model and the resulting fixed effects specifications greatly reduce the data required to estimate state-level price and employment effects. The model demonstrates that district-level data on U.S. imports can provide information that is useful for understanding the geographic distribution of these economic effects.[2] After applying the model to imports and tariff changes in the furniture industry, I estimate state-level import penetration rates in several other U.S. manufacturing industries, including food, apparel, and chemicals. These additional applications of the model demonstrate the stability and broader applicability of the approach.

The rest of the paper is organized into six parts. Section 2 presents the modeling framework. Section 3 discusses the econometric specification and reports estimates of parameter values for the U.S. furniture industry. Section 4 reports estimated state-level import values and penetration rates in the industry. Section 5 reports estimated price and employment effects of the tariff changes. Section 6 applies the model to other U.S. manufacturing industries. Section 7 concludes.

2 Modeling Framework

The model utilizes detailed U.S. import and export data. M_{ijd} represents the value of U.S. imports in industry i from foreign country j that arrive in port district d in a specific year.[3] This import value is observable in official trade statistics. The model uses measures of

[2]This is also demonstrated in Riker (2020), which uses an econometric model to estimate domestic shipping costs and import penetration at the level of BEA regions. The model in Riker (2020) does not use data from the Commodity Flow Survey, and it is only applied to the U.S. electrical equipment industry.

[3]A district is a grouping of neighboring U.S. ports in official import statistics. The model does not include a subscript for time to simplify the notation.

M_{ijd} to estimate the value of these imports delivered to each state s (M_{ijds}), and it sums over the districts to estimate the total value of imports by industry, country, and state ($M_{ijs} = \sum_d M_{ijds}$). X_{isd} represents the value of U.S. exports in industry i from state s that depart from district d. This export value is also observable in official trade statistics.

Within industry i, producers from different countries have different production, shipping, and distribution costs, but their products are perfect substitutes in the eyes of consumers, following the Ricardian models in Dornbusch, Fischer and Samuelson (1977) and Eaton and Kortum (2002). The delivered price of industry i imports from country j shipped to state s through district d is equal to $p_{ij} \cdot \tau_{ij} \cdot f_{ijd} \cdot z_{ijd} \cdot c_{ids}$. The first term, p_{ij}, is the producer price of imports from country j in industry i. τ_{ij} is the tariff factor, equal to one plus the tariff rate. f_{ijd} is an ad valorem international trade cost from country j to district d. It includes freight and insurance costs. c_{ids} is an ad valorem domestic shipping cost from district d to state s. z_{ih} is a supply cost factor that applies to shipments from supply source ih.[4] It reflects a combination of monetary and convenience costs of different distribution paths. z_{ih} has the Fréchet (type II extreme value) cumulative density function in equation (1), similar to the idiosyncratic productivity factors in Eaton and Kortum (2002), Caliendo and Parro (2015), Caliendo et al. (2019), and related trade models.

$$F\left(z_{ih}\right) = e^{-A_{ih}\ \left(z_{ih}\right)^{-\theta_i}} \tag{1}$$

A_{ih} is a technology parameter that reflects the absolute advantage of supply source h in industry i, and θ_i is the dispersion parameter of the Fréchet distribution.

Consumers choose the least costly path for shipping imports from country j to their state. Equation (2) is the value of expenditure on industry i imports from source country j that arrive at district d and are shipped domestically to state s for consumption.

[4] For example, h is jd for imports from country j entering district s and s for domestic production in state s.

$$M_{ijds} = \left(\frac{\Omega_{is}}{\Phi_{is}}\right) \ (A_{ijd})^{\theta_i} \ (p_{ij} \ \tau_{ij} \ f_{ijd} \ c_{ids})^{-\ \theta_i} \tag{2}$$

Ω_{is} is total expenditures on the products of industry i in state s. It includes expenditures on domestic products from state s, domestic products from other states that are shipped to state s, and imports that are shipped to state s. Φ_{is} reflects the choice set and delivered prices that consumers face in state s.

$$\Phi_{is} = \sum_{s'} \ (A_{is'})^{\theta_i} \ (p_{is'} \ c_{is's})^{-\ \theta_i} \ + \ \sum_{j}\sum_{d} \ (A_{ijd})^{\theta_i} \ (p_{ij} \ \tau_{ij} \ f_{ijd} \ c_{ids})^{-\ \theta_i} \tag{3}$$

The first term on the right-hand side of equation (3) is a sum over domestic producers from states indexed by s', and the second term in a sum over import sources indexed by country j and district d. The specific functional forms in equations (2) and (3) reflect the assumption that z_{ih} has the Fréchet distribution in equation (1). Equation (4) is the value of expenditure on industry i domestic shipments from original production state s' to consumers in state s.[5]

$$V_{is's} = \left(\frac{\Omega_{is}}{\Phi_{is}}\right) \ (A_{is'})^{\theta_i} \ (p_{is'} \ c_{is's})^{-\ \theta_i} \tag{4}$$

Turning back to imports, equation (5) is the total value of imports from country j that arrive at district d each year, M_{ijd}. It sums over the values destined for each of the states indexed by s.

$$M_{ijd} = \sum_{s} \ M_{ijds} = \sum_{s} \ \left(\frac{\Omega_{is}}{\Phi_{is}}\right) \ (A_{ijd})^{\theta_i} \ (p_{ij} \ \tau_{ij} \ f_{ijd} \ c_{ids})^{-\ \theta_i} \tag{5}$$

M_{ijd} is directly observable in import statistics. The value of imports destined for state s, M_{ijds}, is not directly observable, but it can be modeled. It is the product of the observable industry-country-district value M_{ijd} and a function of state expenditure and price levels,

[5] This value does not include imports shipping through state s. It only includes the domestic shipments of the domestic producers in state s.

domestic shipping costs, and θ_i:

$$M_{ijds} = M_{ijd} \left(\frac{\left(\frac{\Omega_{is}}{\Phi_{is}}\right) \ (c_{ids})^{-\theta_i}}{\sum_{s'} \left(\frac{\Omega_{is'}}{\Phi_{is'}}\right) \ (c_{ids'})^{-\theta_i}} \right) \tag{6}$$

Equation (6) is derived from equations (2) and (5).[6] If domestic shipments were costless, so that $\theta_i = 0$, then Φ_{is} would be the same in all states and equation (6) would collapse to a simple distribution of the imports across the states in proportion to each state's market size Ω_{is}.

3 Econometric Estimation

Next, I apply the model to the U.S. furniture manufacturing industry (NAICS code 337) as an illustrative example. The model includes 39 U.S. import districts, 50 states, and the District of Columbia.

I assume a specific, but conventional, functional form for the ad valorem domestic shipping cost factor c_{ids}. It is equal to $\max[1,\ (miles_{ds})^{\lambda_i}]$. The variable $miles_{ds}$ is the distance from d to s, and the parameter $\lambda_i > 0$. I assume that the same function with parameter λ_i also applies to domestic shipments from state s' to state s. For imports, m_{ds} is calculated as the orthodromic distance from the largest port in district d to the largest city in state s. For domestic shipments, $m_{s's}$ is calculated as the orthodromic or great circle distance from the largest city in state s' to the largest city in state s.

Equation (7) is the log-linear econometric specification for the value of domestic shipments in industry i from state s' to state s, $V_{is's}$. It is derived from equation (4).

$$\ln V_{is's} = -\lambda_i \ \theta_i \ \max[0,\ \ln miles_{s's}] \ + \ \alpha_{is'} \ + \gamma_{is} \ + \ \epsilon_{is's} \tag{7}$$

[6]This calculation does not require a measure of A_{ijd}, since this parameter cancels from the numerator and denominator of the ratio.

$\alpha_{is'}$ and γ_{is} are industry-state fixed effects. The error term, $\epsilon_{is's}$, captures measurement error in $\ln V_{is's}$. Equations (8) and (9) relate the coefficients in the econometric specification in equation (7) to the structural parameters in equation (4).

$$\alpha_{is'} = -\ \theta_i\ \ln\ (p_{is'})\ +\ \theta_i\ \ln A_{is'} \tag{8}$$

$$\gamma_{is} = \ln\ \left(\frac{\Omega_{is}}{\Phi_{is}}\right) \tag{9}$$

Table 1 reports weighted least squares estimates of the parameters in equation (7).[7] The estimation sample includes 2,099 state-to-state furniture shipment values calculated from individual shipments in the public use file for the 2017 Commodity Flow Survey that I aggregated to the state level. The point estimate of $-\lambda\ \theta$ for the furniture industry is -0.4135, with a robust standard error of 0.0120. The R^2 statistic for the regression is 0.8460. The estimates of γ_{is} range from a low for domestic shipments to the District of Columbia to a high for shipments to California. The estimates of $\alpha_{is'}$ range from a low for domestic shipments from Montana to a high for shipments from North Carolina. The table reports a subset of the many estimated γ_{is} and $\alpha_{is'}$ fixed effects.[8]

In addition to providing specific parameter values for the model simulations, the econometric model provides a test of the geographic segmentation of U.S. product markets: the estimate of $-\lambda_i\ \theta_i$ indicates that distance had a significant negative effect on domestic shipments between states.

Moving to the second econometric model, equation (10) is the log-linear specification for the value of imports, M_{ijd}. It is derived from equation (5).

[7]The weights in the regression are the shipment weights included in the public use file of the 2017 Commodity Flow Survey.

[8]The fixed effects for California, γ_{CA} and α_{CA}, are omitted from the specification, so the reported values are relative to the values for California.

Table 1: Econometric Model of U.S. Domestic Shipments of Furniture

Model Parameters	**Point Estimates**	**Standard Errors**	**Model Parameters**	**Point Estimates**	**Standard Errors**
$-\lambda\ \theta$	-0.4135	(0.0120)			
γ_{AZ}	-1.1649	(0.2189)	α_{AZ}	-1.6578	(0.2938)
γ_{IL}	-0.8377	(0.1721)	α_{IL}	-0.7596	(0.1591)
γ_{MA}	-1.3616	(0.2041)	α_{MA}	-1.8470	(0.2420)
γ_{MO}	-1.3427	(0.1977)	α_{MO}	-1.5610	(0.1515)
γ_{NC}	-1.2518	(0.1911)	α_{NC}	0.1694	(0.1202)
γ_{NY}	-0.5499	(0.1447)	α_{NY}	-1.1374	(0.1449)
γ_{PA}	-0.8945	(0.1979)	α_{PA}	-0.5054	(0.1882)
γ_{TX}	-0.0846	(0.1979)	α_{TX}	-0.6494	(0.1624)
γ_{WA}	-1.0290	(0.2321)	α_{WA}	-1.2060	(0.2272)
Observations	2,099				
R^2	0.8460				

$$\ln M_{ijd} = \delta_{ij} \ - \theta_i \ \ln f_{ijd} \ + \ \psi_{id} \ + \ \zeta_{ijd} \tag{10}$$

f_{ijd} is the international freight cost factor. It is calculated as the ratio of the cost-in-freight value of the imports to their customs value. δ_{ij} and ψ_{id} are industry-country and industry-district fixed effects. The error term, ζ_{ijd}, captures measurement error in $\ln M_{ijd}$ and also the $\theta_i \ \ln A_{ijd}$ term. Equations (11) and (12) relate the coefficients in the econometric specification in equation (10) to the structural parameters in equation (5).

$$\delta_{ij} = - \ \theta_i \ \ln \ (p_{ij} \ \tau_{ij}) \tag{11}$$

$$\psi_{id} = \ln \left(\sum_{s'} \left(\frac{\Omega_{is'}}{\Phi_{is'}} \right) \ (c_{ds'})^{-\theta_i} \right) \tag{12}$$

I estimate θ_i using weighted least squares and 2,399 country-district observations for U.S. furniture imports in 2017. The R^2 statistic for the regression is 0.9799. The estimated value of θ_i for the furniture industry is 3.1463, with a robust standard error of 0.3675. This estimate, along with the estimate that $-\lambda_i\,\theta_i = -0.4135$ in Table 1, implies that $\lambda_i = 0.1314$ for the furniture industry.

Using the estimates of domestic shipping costs, γ_{is}, and θ_i and the district-level import value M_{ijd}, I calculate the value of industry imports destined for state s according to equation (13).

$$M_{ijds} = M_{ijd}\,\left(\frac{e^{\gamma_{is}}\,\left(c_{ids}\right)^{-\theta_i}}{\sum_{s'}\,e^{\gamma_{is'}}\,\left(c_{ids'}\right)^{-\theta_i}}\right) \tag{13}$$

This calculation does not require measures of p_{ij}, $p_{is'}$, f_{ijd}, $A_{is'}$, A_{ijd}, τ_{ij}, Ω_{is}, or Φ_{is}, even though these factors all affect the value of imports, because they are collectively captured in the econometric estimates of the fixed effects γ_{is} and the observed value of M_{ijd}. c_{ids} is calculated using the econometric estimate of λ_i and the measure of miles described above.

Table 2 illustrates the economic significance of domestic distances. The table reports the estimated share of shipments from Californian manufacturers that stayed in California and then the shares destined for thirteen other states. The share of these domestic shipments to each state reflects geographic proximity, but it also reflects the size of the consumer market in the destination state and the extent of competition from nearby domestic producers and nearby import entry.[9] As a benchmark to gauge the importance of domestic shipping costs, the second column of numbers reports each state's share of nationwide expenditures on furniture. This would be the distribution of imports across states *if there were no domestic shipment costs* and trade between states were frictionless.

[9]Specifically, the modeled share of domestic shipments from state s' to state s is equal to $\frac{e^{\gamma_{is}}\,\left(c_{is's}\right)^{-\theta_i}}{\sum_k\,e^{\gamma_{ik}}\,\left(c_{is'k}\right)^{-\theta_i}}$.

Table 2: Domestic Shipment Shares from California

Destination State	**State's Share of Shipments from California (%)**	**State's Share of National Expenditure on Furniture (%)**
California	65.05	14.22
Texas	3.02	7.45
Florida	2.22	5.75
Arizona	1.79	1.85
Colorado	1.36	2.04
Washington	1.36	2.50
Illinois	1.29	4.26
Pennsylvania	1.07	3.66
Michigan	0.98	4.11
Missouri	0.86	1.79
Indiana	0.84	2.92
North Carolina	0.78	3.14
Massachusetts	0.65	1.69
Maine	0.13	0.30

4 State-Level Import Penetration Rates

Table 3 reports the value of furniture imports from China that arrived in each of the districts in 2017. This measure, represented in the model by M_{ijd}, is directly observable in official import statistics. The table indicates that import entry from China was relatively concentrated on the West Coast, especially Los Angeles, as we would expect.

Table 4 reports the model estimates of the value of U.S. imports destined for each state for a sample of the states. For the remaining states the values are combined together in an "All Other" category to simplify the table.[10] While this modeled pattern of import destinations is more geographically dispersed than the observed pattern of import entry, it is still clearly concentrated in California.

[10] However, they are not aggregated in the underlying model.

Table 3: Furniture Imports from China by District

Entry District	Value ($ Million)	District's Share (%)
Anchorage, AK	6.0	0.0
Baltimore, MD	548.1	2.1
Boston, MA	186.5	0.7
Buffalo, NY	100.1	0.4
Charleston, SC	623.5	2.4
Charlotte, NC	154.9	0.6
Chicago, IL	1,725.2	6.7
Cleveland, OH	657.9	2.5
Columbia-Snake, OR	58.5	0.2
Dallas, TX	1.4	0.0
Detroit, MI	245.3	0.9
District of Columbia	729.5	2.8
Duluth, MN	202.7	0.8
El Paso, TX	13.9	0.1
Great Falls, MT	298.7	1.2
Honolulu, HI	52.3	0.2
Houston, TX	850.7	3.3
Laredo, TX	7.2	0.0
Los Angeles, CA	8,393.5	32.4
Miami, FL	406.7	1.6
Milwaukee, WI	7.3	0.0
Minneapolis, MN	300.2	1.2
Mobile, AL	135.6	0.5
New Orleans, LA	796.5	3.1
New York, NY	2,622.8	10.1
Nogales, AZ	6.6	0.0
Norfolk, VA	1,355.2	5.2
Ogdensburg, NY	53.9	0.2
Pembina, ND	3.9	0.0
Philadelphia, PA	67.8	0.3
Portland, ME	0.4	0.0
Providence, RI	0.2	0.0
San Diego, CA	9.4	0.0
San Francisco, CA	1,084.5	4.2
Savannah, GA	2,279.3	8.8
Seattle, WA	1,170.0	4.5
St. Albans, VT	10.7	0.0
St. Louis, MO	299.6	1.2
Tampa, FL	433.3	1.7
Total	25,899.6	100.0

Table 4: Furniture Imports from China by State

State	Value ($ Million)	State's Share (%)
Arizona	435.2	1.7
California	6,367.5	24.6
Colorado	448.6	1.7
Delaware	129.0	0.5
Florida	1,326.5	5.1
Georgia	612.2	2.4
Illinois	1,188.3	4.6
Indiana	447.4	1.7
Iowa	168.9	0.7
Kansas	192.0	0.7
Maine	70.6	0.3
Massachusetts	406.4	1.6
Michigan	609.9	2.4
Missouri	368.0	1.4
New York	1,818.7	7.0
North Carolina	507.8	2.0
Oregon	286.1	1.1
Pennsylvania	720.2	2.8
Tennessee	291.3	1.1
Texas	1,691.3	6.5
Virginia	447.1	1.7
Washington	850.4	3.3
All Other	6,516.2	25.2
Nationwide Total	25,899.6	100.0

To calculate an import penetration rate for each state s, I also estimate the state's total expenditures on the products of the industry, $\Omega_{is} = \sum_{s'} V_{is's} + \sum_j \sum_d M_{ijds}$. Equation (14) is the penetration rate for imports from each country f in state s, combining imports across all of the districts indexed by d.

$$\mu_{ijs} = \sum_d \left(\frac{M_{ijds}}{\Omega_{is}} \right) \tag{14}$$

Table 5 reports estimates of μ_{ijs} for furniture imports from the top two source countries, China and Vietnam, and from an aggregate of the rest of the world, based on the modeled state-level import values. The penetration rates for imports from China range from 12.61% in Michigan to 38.00% in California, with a national average of 21.98%. The rates for imports from Vietnam range from 2.65% in Michigan to 6.97% in California, with a national average of 4.44%. The rates for imports from the rest of the world range from 8.37% in North Carolina to 16.19% in New York, with a national average of 12.22%.

The differences in import penetration rates clearly reflect proximity to the location of import entry and the extent of competition from nearby domestic producers and other imports that are shipped to the state. The penetration rates are lower in major furniture-producing states like Indiana, Michigan, and North Carolina. The differences in import penetration rates across states translate into differences in the price and employment effects of tariff changes, as I demonstrate in the next section.

Table 5: State-Level Import Penetration Rates by Country

	Imports from China (%)	**Imports from Vietnam (%)**	**Imports from Rest of World (%)**
Arizona	19.99	4.09	13.09
California	38.00	6.97	10.92
Colorado	18.64	3.93	12.23
Delaware	20.26	4.34	13.35
Florida	19.58	4.08	11.62
Illinois	23.67	3.68	12.92
Indiana	12.99	2.68	8.62
Iowa	16.56	3.54	10.86
Kansas	18.70	3.94	12.44
Maine	19.92	4.27	13.81
Massachusetts	20.36	4.27	13.10
Michigan	12.61	2.65	16.00
Missouri	17.46	3.68	11.48
North Carolina	13.74	2.77	8.37
Pennsylvania	16.69	3.55	11.85
Texas	19.26	4.13	12.53
Virginia	20.05	4.60	11.70
Washington	28.89	4.69	15.73
National Average	21.98	4.44	12.22

5 Simulated State-Level Effects of Tariff Changes

To simulate the impact of changes in trade policy on consumer prices and domestic employment in different states, I need several additional modeling assumptions. I assume that the industry is a small share of the overall economy, producer prices are equal to marginal costs of production due to competition in product markets, factor prices that the industry faces are set in economy-wide factor markets, and total expenditures on the products of the industry are a fixed share of aggregate expenditures in the state. Consequently, industry total expenditure levels (Ω_{is}) and domestic and foreign producer prices (p_{ij} and p_{is}) are not affected by changes in the industry's tariff rates and are treated as exogenous variables in the simulations. These conventional partial equilibrium assumptions reduce the data requirements of the model. It is possible to extend the model to undertake a general equilibrium analysis of the change in the tariff rate, but this would greatly expand data requirements.[11]

5.1 Effects on Consumer Prices in the Industry

Under the partial equilibrium assumptions and log-linearizing the model, the percent change in the industry price index for consumers in state s ($\hat{P}_{is}$) that results from a percent change in the tariff factor on imports from country j ($\hat{\tau}_{ij}$) depends only on the magnitude of the tariff change and the import penetration rate in state s.[12]

$$\hat{P}_{is} = \mu_{ijs} \ \hat{\tau}_{ij} \tag{15}$$

Table 6 reports model-based estimates of state-specific $\hat{P}_{is}$ resulting from a hypothetical 10% increase in the tariff factor on furniture imports from China, holding foreign and domestic

[11]The calculation of state-level import values based on equation (13) does not require these partial equilibrium assumptions, so these estimates could be incorporated into a general equilibrium model without modification.

[12]The tariff factor, also called the power of the tariff, is equal to one plus the tariff rate.

producer prices and international freight costs constant, and then from a 10% increase in the tariff factor on furniture imports from *all* countries.[13] The table also reports national average price effects, based on nationwide import penetration rates.

Table 6: Estimated State-Level Effects on Consumer Prices

	Percent Increase in State's Price Index Only Imports from China (%)	**Percent Increase in State's Price Index** All Imports (%)
Arizona	2.00	3.72
California	3.80	5.59
Colorado	1.86	3.48
Delaware	2.03	3.80
Florida	1.96	3.53
Georgia	1.67	3.04
Illinois	2.37	4.03
Indiana	1.30	2.43
Iowa	1.66	3.10
Kansas	1.87	3.51
Maine	1.99	3.80
Massachusetts	2.04	3.77
Michigan	1.26	3.13
Missouri	1.75	3.26
New York	2.65	4.91
North Carolina	1.37	2.49
Oregon	2.05	3.67
Pennsylvania	1.67	3.21
Tennessee	1.59	2.93
Texas	1.93	3.59
Virginia	2.01	3.64
Washington	2.89	4.93
National Average	2.20	3.86

One way to summarize the variation in the price effects of the tariff increase is to calculate the ratio of the range of state-level price effects to the national average price effect. For the

[13]The percent change in the aggregate Consumer Price Index in state s is an expenditure share-weighted average of the estimated $\hat{P}_{is}$ for each industry in the state. The model could also be used to estimate the effects of changes in international freight costs or foreign producer prices, but the simulations reported in Table 6 hold these variables constant in order to isolate the effect of the tariff change.

simulation with a tariff increase only on imports from China, the state-level price effects range from 1.30% in Indiana to 3.80% in California. This range is 1.14 times the 2.20% national average effect. For the simulation that increases the tariff rate on imports from all source countries, the state-level and national average effects are all larger, the role of California is relatively muted, and there is also less variation in the price effects across the states, with the range of state-level effects only 0.82 times the national average price effect.[14]

This comparison indicates that taking into account sub-national differences in the location of import entry and import penetration rates is important for assessing the effects of trade policy changes whenever import entry is geographically concentrated, and this is typically the case when the trade policy changes apply narrowly to imports from a single country rather than broadly to imports from all countries.

5.2 Effects on Domestic Employment in the Industry

While the consumer price effects in state s are a simple calculation based on the import penetration rate in state s, calculating domestic employment effects within the industry is based on a weighted average of import penetration rates across all of the states, using the states' shares of domestic shipments from state s as weights.[15] Equation (16) is the percent change in domestic employment in the industry in state s ($\hat{L}_{is}$) that results from percent changes in the tariff factor on imports from country j ($\hat{\tau}_{ij}$) when I adopt the partial equilibrium assumptions, log-linearize the model, and hold foreign and domestic producer prices and international freight costs constant.

$$\hat{L}_{is} = \sum_{s'} \left(\frac{e^{\gamma_{s'}} \ (c_{ss'})^{-\theta_i}}{\sum_{s''} e^{\gamma_{s''}} \ (c_{ss''})^{-\theta_i}} \right) \mu_{ijs'} \ (1 \ - \ \eta_{is}) \ \theta_i \ \hat{\tau}_{ij} \tag{16}$$

η_{is} represents the export share of domestic production in state s.

[14]This is the ratio of the range, 5.59% - 2.43%, to the average national price effect, 3.86%.

[15]I estimate each state's shipment shares using equation (4).

$$\eta_{is} = \frac{\sum_d X_{isd}}{\sum_{s'} V_{iss'} + \sum_d X_{isd}} \tag{17}$$

Table 7 reports estimates of state-specific $\hat{L}_{is}$ for the same hypothetical 10% increase in the tariff factor on furniture imports from imports from China, and then on furniture imports from all countries. Although the same tariff rates apply nationwide, the effects of the increase in the tariff rates vary across the states based on their estimated import penetration rates. Among the states listed in Table 7, the percent changes range from a low of 5.56% in Michigan to a high of 9.62% in California.

Table 7: Percent Increase in Industry Employment

	Tariff Increase for China Imports Only	**Tariff Increase for All Imports**
Arizona	6.19	11.06
California	9.62	14.92
Colorado	6.22	11.25
Delaware	5.82	10.65
Florida	6.13	11.05
Georgia	5.79	11.50
Illinois	6.36	11.27
Indiana	5.59	10.18
Iowa	5.98	10.83
Kansas	6.07	11.00
Maine	6.21	11.31
Massachusetts	6.02	11.00
Michigan	5.56	10.80
Missouri	5.74	10.41
New York	6.96	12.78
North Carolina	5.68	10.28
Oregon	6.65	11.79
Pennsylvania	6.03	11.14
Tennessee	5.93	10.76
Texas	6.17	11.31
Virginia	6.24	11.32
Washington	7.41	12.94
National Average	6.30	11.24

The magnitude of the employment effects are larger in the second column of Table 7, but the range in the employment effects across states is smaller relative to the national average employment effect when the tariff increase applies to imports from a broader set of countries. Again, this comparison indicates that taking into account sub-national differences in the location of import entry is important for assessing the effects of changes in trade policy when the changes apply narrowly to imports from a single country.

The change in the number of workers employed in industry i is the product of $\hat{L}_{is}$ and the initial level of industry employment in state s. Table 8 reports estimates of state-specific ΔL_{is} corresponding to the estimates of $\hat{L}_{is}$ in Table 9. While larger initial domestic employment in a state results in a smaller import penetration rate in the state, it generally results in a larger change in the number of workers employed in the state. For example, Michigan has the third largest even though it had the smallest percent change in Table 7, because Michigan has a relatively large initial level of employment in the furniture industry.

Table 8: Increase in Number of Employees

	Tariff Increase For China Imports Only	**Tariff Increase For All Imports**
Arizona	321	573
California	3,315	5,143
Colorado	258	466
Delaware	38	70
Florida	650	1,172
Georgia	608	70
Illinois	663	1,171
Indiana	1,265	2,305
Iowa	375	678
Kansas	170	308
Maine	76	138
Massachusetts	235	430
Michigan	1,420	2,757
Missouri	378	686
New York	889	1,634
North Carolina	1,986	3,596
Oregon	416	738
Pennsylvania	985	1,819
Tennessee	617	1,119
Texas	1,312	2,403
Virginia	552	1,002
Washington	469	820
Nationwide Total	23,416	41,763

These estimates of state-level labor market effects differ from the estimates of local labor market effects in Autor et al. (2013) in several ways. First,the estimates of employment effects in Tables 7 and 8 are industry-specific and at the level of states, instead of an aggregate across manufacturing industries at the level of local commuting zones. Second, the estimates in Tables 7 and 8 are based on a later time period, and they focus on different trade shocks. Still, the importance of taking into account the location of import entry – reflected in the difference between the estimated effects based on state-specific penetration rates and the effects based on the national penetration rates in Tables 7 and 8 – suggests that it could be helpful to also incorporate estimates of sub-national import penetration into the local labor effects models in Autor et al. (2013) and the extensive literature that followed it.

6 Application to Other Manufacturing Industries

Finally, I apply the model to several other U.S. manufacturing industries to demonstrate the stability and broader applicability of the approach and to illustrate interesting differences across the industries. Table 9 reports econometric estimates of the model parameters for the food products industry (NAICS code 311), the apparel industry (NAICS code 315), and the chemicals industry (NAICS code 325), as well as the furniture industry (NAICS code 337). Table 9 also reports the value of the domestic shipping cost parameter λ_i implied by the econometric estimates of $-\lambda_i\ \theta_i$ and θ_i. The implied values of λ_i indicate that distance had a much larger impact on the cost of domestic shipments in the furniture industry than in the other three manufacturing industries.

Table 9: Estimated Parameter Values for Different Industries

Parameter	**Furniture**	**Food**	**Apparel**	**Chemicals**
Model of Domestic Shipments				
$-\lambda_i \ \theta_i$	-0.4135	-0.4029	-0.3281	-0.3777
	(0.0120)	(0.0087)	(0.0137)	(0.0131)
Observations	2,099	2,240	1,898	2,431
R^2	0.8460	0.9122	0.9176	0.8872
Model of Imports				
θ_i	3.1463	5.1778	4.3579	5.6842
	(0.3675)	(0.6176)	(0.5736)	(0.6438)
Observations	2,399	2,519	2,761	2,683
R^2	0.9799	0.9825	0.9749	0.9810
Implied λ_i	0.1314	0.0778	0.0753	0.0664

Table 10 reports the 2017 distribution of import entry across districts for each of the four industries, aggregating the imports in each industry across all source countries. The shares in each column sum to 100.0%.[16] There were significant differences among the industries, reflecting differences in the source country composition of imports and the location of consumer demand and domestic production. The concentration of imports into the Los Angeles district that I noted for the furniture industry is also a feature of the apparel industry but not the food and chemicals industries. There is a relatively large concentration of imports into the New York district in the food and apparel industries. In terms of the geographic concentration of import entry, the furniture industry (with the top two districts accounting for 35.6% of industry imports) lies between the highly concentrated apparel industry (with the top two districts accounting for 53.7% of industry imports) and the much less concentrated food and chemicals industries (with 23.5% and 26.5% entering the top two districts).

[16]The very small share of imports that entered the Port Arthur, TX district are reported in the Houston, TX row in Table 10.

Table 10: District's Share of Value of Industry Imports (%)

Entry District	Furniture	Food	Apparel	Chemicals
Anchorage, AK	0.0	0.0	0.0	0.1
Baltimore, MD	2.1	2.8	0.2	1.1
Boston, MA	0.6	0.5	0.6	1.2
Buffalo, NY	2.0	4.7	0.2	1.8
Charleston, SC	2.4	0.8	1.9	3.5
Charlotte, NC	0.5	0.1	1.1	1.5
Chicago, IL	5.6	3.7	2.5	13.3
Cleveland, OH	2.2	0.5	5.9	8.1
Columbia-Snake, OR	0.2	0.1	0.5	0.2
Dallas, TX	0.0	0.1	0.0	1.9
Detroit, MI	3.9	7.7	0.2	7.2
District of Columbia	2.3	0.2	1.0	1.4
Duluth, MN	1.4	0.8	0.0	1.3
El Paso, TX	0.7	0.6	0.6	0.2
Great Falls, MT	1.2	3.3	0.2	0.9
Honolulu, HI	0.2	0.2	0.0	0.0
Houston, TX	3.3	2.7	0.9	4.9
Laredo, TX	3.0	8.3	2.1	2.0
Los Angeles, CA	25.1	9.2	35.1	5.9
Miami, FL	1.9	2.3	5.6	0.8
Milwaukee, WI	0.0	0.0	0.0	0.0
Minneapolis, MN	0.9	0.3	0.2	0.4
Mobile, AL	0.5	0.1	1.3	2.1
New Orleans, LA	2.4	1.8	1.5	4.0
New York, NY	10.5	17.3	18.6	10.5
Nogales, AZ	0.5	0.5	0.2	0.1
Norfolk, VA	4.9	1.4	1.8	2.5
Ogdensburg, NY	1.3	3.3	0.7	1.5
Pembina, ND	0.4	3.0	0.0	1.9
Philadelphia, PA	0.6	6.7	0.5	6.8
Portland, ME	0.0	0.8	0.2	0.7
Providence, RI	0.0	0.0	0.0	0.0
San Diego, CA	1.8	1.5	0.9	0.2
San Francisco, CA	3.7	4.9	2.2	1.4
Savannah, GA	7.1	3.5	7.9	7.5
Seattle, WA	4.1	3.5	3.6	1.1
St. Albans, VT	0.4	0.7	0.2	0.1
St. Louis, MO	0.7	0.8	0.4	1.4
Tampa, FL	1.6	1.4	0.9	0.6

Table 11 reports the estimated state-level import penetration rates by industry for many, as well as the national averages. Import penetration rates are very high in the apparel industry, but there is not much difference in these rates across states. The other three industries have significant differences in import penetration rates across states, and this implies significant differences in the consumer price and domestic employment effects of import price shocks.

Table 11: State-Level Import Penetration Rates by Industry (%)

State	**Furniture**	**Food**	**Apparel**	**Chemicals**
Arizona	37.18	7.98	92.25	26.71
California	55.89	8.18	91.17	20.74
Colorado	34.80	6.90	92.21	26.72
Delaware	37.95	9.90	92.11	30.29
Florida	35.28	7.45	91.97	26.74
Georgia	30.43	5.85	91.95	26.04
Illinois	40.27	6.88	93.58	37.70
Indiana	24.29	6.31	91.85	26.42
Iowa	30.96	4.95	92.01	24.47
Kansas	35.08	5.68	92.12	28.22
Maine	38.00	10.63	92.33	32.78
Massachusetts	37.73	9.36	91.57	30.70
Michigan	31.26	12.19	92.76	37.85
Missouri	32.62	5.69	90.98	26.03
New York	49.09	17.27	92.60	33.98
North Carolina	24.88	6.64	89.30	23.63
Oregon	36.71	7.57	92.08	28.26
Pennsylvania	32.09	10.76	91.22	32.97
Tennessee	29.34	6.14	90.73	25.23
Texas	35.92	6.75	90.89	16.00
Virginia	36.34	7.89	92.30	29.22
Washington	49.31	10.34	93.92	31.29
National Average	38.64	8.07	91.79	26.67

In terms of the variation in these rates across states, the ratio of the range in state-level import penetration rates to the national average rate for the furniture and chemical industries lie in the middle of the four industries, both with a ratio of 0.82. The ratio for the food industry is much larger at 1.53, and the ratio for the apparel industry is much smaller at 0.05.

7 Conclusions

Data on the location of U.S. import entry is useful for assessing where the imports are likely to end up and where their economic impact is likely to be greatest. Yet these data are rarely utilized in models of international trade – even in models that focus on the effects of imports on local labor markets within the United States.

This paper demonstrates a practical use for these data. The model is designed to address the limited availability of sub-national data at the industry level. The structural model infers the value of imports destined for each state from available district-level data on the location of import entry, without relying on importers' sometimes incomplete declarations about destination. The econometric estimates indicate that domestic shipping costs reduce trade between states and determine the pattern of state-level import penetration in each industry.

Model simulations demonstrate that differences in import penetration rates across states matter when estimating the consumer and employment effects of tariff changes. The effects of an increase in tariffs on furniture imports from China are concentrated in California where most imports enter the country, even though tariff changes apply nationwide. Models of local labor market effects that do not incorporate information on the location of import entry capture the national average effect on domestic employment, but they miss systematic differences in the magnitudes of employment effects across states. In states with significant import entry, they under-estimate the employment effects, while in states with significant domestic production they over-predict the employment effects of the tariff changes.

References

Acemoglu, D., Autor, D., Dorn, D., Hanson, G. and Price, B. (2016). Import Competition and the Great U.S. Employment Sage of the 2000s, *Journal of Labor Economics* **34**(S1, Part 2): S141–S198.

Autor, D., Dorn, D. and Hanson, G. (2013). The China Syndrome: Local Labor Market Effects of Import Competition in the United States, *American Economic Review* **103**(6): 2121–2168.

Caliendo, L., Dvorkin, M. and Parro, F. (2019). Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock, *Econometrica* **87**(3): 741–835.

Caliendo, L. and Parro, F. (2015). Estimates of the Trade and Welfare Effects of NAFTA, *Review of Economic Studies* **82**(1): 1–44.

Caliendo, L. and Parro, F. (2021). Trade Policy. NBER Working Paper 29051.

Dornbusch, R., Fischer, S. and Samuelson, P. (1977). Comparative Advantage, Trade, and Payments in a Ricardian Model with a Continuum of Goods, *American Economic Review* **67**(5): 823–839.

Eaton, J. and Kortum, S. (2002). Technology, Geography, and Trade, *Econometrica* **70**(5): 1741–1779.

Riker, D. (2020). Estimating U.S. Import Penetration in Sub-National Regions, *Journal of International Trade and Economic Development* **29**(7): 891–906.