From Coast to Coast: An Estimation of Import Exposure at the Subnational Level

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Abstract

Calculations of subnational import exposure can provide great insights into consumption patterns across the United States, but due to data limitations previous studies of the subject have either estimated import exposure at the state level or else used variations in local employment as a substitute for variations in local imports. I exploit features of the Freight Analysis Framework shipment dataset to generate import exposure measurements for 132 U.S. subnational regions. In so doing, I find that the average region has an import penetration rate of ten percent, with rates ranging from below five percent to twenty–three percent. Interior regions of the United States tend to have low exposure to imports and high exposure to locally produced goods, but metropolitan areas often have lower import exposure and higher local exposure than the non–metropolitan counties that surround them. Regression analysis reveals a small but statistically significant positive relationship between import exposure and population density, suggesting that, in general, urban areas will be more exposed to imports than less urbanized areas.

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1 Introduction

I define import exposure, or import penetration, as the fraction of consumer expenditure spent on imported goods. The estimation of this quantity at the U.S. subnational level has been a challenge for international trade economists due to the paucity of available data. Data on imports and exports exists only at the state level, which both obscures sub–state heterogeneity and could produce biased results because it only records the processing of imports in a given state and not whether said imports were consumed there. While a challenging task for researchers to compute, subnational import data is also of great interest since it may help inform economists' understanding of regional consumption patterns and by extension provide insight into the heterogenous regional effects of national trade policies. Papers that examine subnational import exposure try to circumvent data limitations either by combining national import data with county–level employment data, available through the Census Bureau's County Business Patterns, or else by conducting their analysis at the broader levels of states or Census regions, where data is more reliable than data on metropolitan areas or counties.

The relationship between import penetration and urbanity is of particular interest because it does not have a clear intuitive answer. More urban areas have access to a greater variety of imports, since due to fixed costs foreign producers only ship to certain sufficiently large markets, but urbanized regions could have greater access to local goods as well; in a rural region, residents might have to consume an imported good if the local alternative isn't available. An understanding of how urban characteristics impact import exposure could have implications for trade policy, as it gives policymakers an idea for how trade policies affect different areas based on their demographic status. The lack of data on subnational import penetration made such a relationship difficult to estimate.

In this paper, I provide a novel method of calculating import exposure based on 2022 data from the Freight Analysis Framework (FAF). I compute a region's exposure to foreign imports by exploiting a feature of the FAF data that allows me to separate shipments that originate in a foreign country from shipments that do not, and I further find the fraction of shipments within each region that originated in that same region rather than being shipped in from another area of the country. I then estimate the relationship between population density, a proxy for how urban or rural a region is, and exposure to foreign imports or local production. In doing so, I also obtain estimates for how the presence of a coastline or border with Canada or Mexico affects import exposure.

The construction of import penetration rates across the United States reveals that rural states at the geographic center of the country have some of the lowest import exposure rates. On the other hand, many major metropolitan areas within the country exhibit lower import exposure rates and higher local exposure rates than the more sparsely populated regions that surround them. Regression analysis reveals a small but statistically significant positive correlation between population density and import exposure and a small but statistically significant negative correlation between population density and local exposure, indicating that on average foreign imports will penetrate urban areas more than rural ones.

Section 2 discusses the existing literature on subnational import penetration. Section 3 discusses features of the FAF data, and presents my findings on how import exposure rates vary across the country. Section 4 presents regression results, and Section 5 concludes.

2 Literature Review

Papers that estimate subnational import exposure often do so in order to evaluate the regional effects of a national trade policy, combining import data at the national level with county–level data on employment. Hakobyan and McLaren (2016); Acemoglu, Autor, Dorn, Hanson, and Price (2016); and Autor, Dorn and Hanson (2013) are regression–based models that use this approach, and the structural analyses in Caliendo and Parro (2021) and Caliendo, Dvorkin and Parro (2019) do so as well. Testa, Klier, and Zelenov (2003) compute import exposure rates at the metropolitan area level using 1999 data on national import penetration rates and metropolitan area–level data on employment. However, regional variation in employment may not be the same as regional variation in imports, and so such an approach produces potentially misleading estimates of regional trade.

Another strand of the economics literature does not assume that regional variations in employment will translate to regional variations in trade, but as a result of data limitations performs its analysis at the state or Census region level (Northeast, South, Midwest, West) rather than any more disaggregated subnational areas. Riker (2022) and Feenstra and Hong (2023, working paper) use subnational trade data to determine how changes in trade policy will affect different states, while Riker (2019) performs a similar analysis for U.S. census regions. Riker (2022) uses subnational shipment data from the Commodity Flow Survey, while Feenstra and Hong use the FAF. Analysis done at the state or regional level may potentially obscure large regional differences between states. For example, the assumption that import exposure in California's Central Valley is the same as import exposure in the San Francisco metropolitan area, or that import exposure is similar across all states in the Southern Census region, may not be realistic.

Borusyak and Jaravel (2021) estimate how import exposure rates vary across the U.S. income distribution, finding that import shares do not vary much by income. This paper complements Borusyak and Jaravel's findings by performing a similar task but for geography. An analysis of whether wealthier FAF regions have larger import exposures than poorer ones lies neatly at the intersection of the two papers.

In this paper, I build on the available literature by using data on subnational shipments to construct import penetration ratios at the subnational level. Doing so does not require me to assume that subnational variations in employment will translate to variations in imports. Furthermore, I will perform my analysis at the level of 132 sub–state regions, providing an additional level of granularity compared with state–level or Census region–level analysis.

3 Data

3.1 Data Description

The Freight Analysis Framework (FAF) provides data on shipment flows between 132 subnational regions. The regions represent both metropolitan areas and non–metropolitan areas, although the dataset does not represent all U.S. metropolitan areas. The FAF either represents each state in its entirety, as is the case with less–populated states such as Alaska and Idaho, or divides states into one or more metropolitan areas and the 'rest of the state', which includes all counties not represented by any of the aforementioned metropolitan areas. For example, the FAF divides Georgia into Atlanta, Savannah, and 'Rest of Georgia.'

One important feature of FAF data is that it notes whether a shipment between two subnational regions of the United States originated abroad or did not originate abroad.[1] Given data on trade between two regions, I can therefore distinguish between shipments whose initial origin was outside the United States and shipments originating within the United States, and in so doing determine the fraction of shipments arriving in a region that were imported. The FAF also notes whether a subnational shipment was exported abroad, and I exclude these observations from the dataset because this paper focuses on consumption within the

[1] The FAF includes eight foreign zones: Canada, Mexico, Rest of Americas, Europe, Africa, Southwest and Central Asia, Eastern Asia, and Southeast Asia and Oceania.

United States. Since the FAF records shipments that start and end within the same region, I can also break down domestic shipments into goods produced locally and goods produced elsewhere within the country.

An issue with FAF data, however, is that it does not record whether the domestic destination of a shipment is that shipment's final destination within the United States. In other words, the transfer of a shipment from Region A to Region B might only be for purposes of storage or warehousing, and the FAF does not note whether the same shipment is then sent on to Region C for eventual consumption. To resolve this issue, I bring in data from the 2017 Commodity Flow Survey (CFS), which is similar to the FAF but also records the North American Industry Classification System (NAICS) industry of the shipper. I calculate the fraction of shipments between each pair of regions that belong to the transportation and warehousing industry (NAICS 49), then subtract this fraction away from all domestic shipments recorded in the FAF.[2]

The formula representing import exposure is as follows:

$$\text{ImportExposure}_j = \frac{\sum\limits_{i,c \neq USA} \text{IMP}_{cij} * (1 - \frac{\text{IMP}_{cij,NAICS=49}}{\text{IMP}_{cij}})}{\sum\limits_{c,i} \text{IMP}_{c,ij}(1 - \frac{\text{IMP}_{cij,NAICS=49}}{\text{IMP}_{cij}})}$$

where c records a shipment's country of origin and i and j are respectively the domestic origin and destination of the shipment. The FAF also divides shipments by commodity, foreign export destination (if any), and mode of transportation; I aggregate shipments across these categories.

I also estimate the fraction of regional consumption produced locally, represented by domestic shipments that list i as an origin and a destination. I refer to this measure as 'local exposure.' Due to its location within the country or other geographic factors, a region might have a low exposure to foreign imports but still need to consume goods produced elsewhere rather than in that region itself. I represent this fraction by the formula

$$\text{LocalExposure}_j = \frac{\text{IMP}_{c=USA,jj} * (1 - \frac{\text{IMP}_{c=USA,jj,NAICS=49}}{\text{IMP}_{c=USA,jj}})}{\sum\limits_{c,i} \text{IMP}_{c,ij}(1 - \frac{\text{IMP}_{cij,NAICS=49}}{\text{IMP}_{cij}})}$$

I measure shipments both in values and in tons of quantity.

[2] I could not use the CFS for the entirety of the analysis because the CFS only records countries of export destination, not countries of import origin. Furthermore, the FAF has been updated annually in recent years, while the most recent CFS data is from 2017.

3.2 Descriptive Statistics

	Imports	Imports	Local	Local
Shipment measurement	Value	Tons	Value	Tons
Minimum	2.46%	.507%	7.86%	18.9%
Median	11.0%	4.27%	28.7%	49.9%
Mean	11.7%	5.25%	30.0%	50.8%
Maximum	23.6%	27.0%	54.7%	89.1%

Table 1: Summary statistics for import exposure and local exposure

On average, a little more than ten percent of shipments into a given region belong to imported goods, while around thirty percent of shipments are shipped from within that same region. Results display very little skew, but do show heterogeneity, especially within the fraction of shipments produced locally. Local production may account for as low as eight percent of local consumption or over fifty percent.

The calculation of exposure rates using quantities rather than values produces import penetration rates that are substantially lower and local exposure rates that are substantially higher. The average local penetration rate calculated using shipments in quantities is about the same as the *maximum* local penetration rate calculated using shipments in values. One explanation is that goods sent abroad tend to be higher in value per ton than goods sent domestically, as exporters must ship higher–valued items to recoup the additional tariffs and transportation costs that they incur.

Import exposure rates in Table 1 are similar or slightly lower than those produced by Testa, Klier, and Zelenov (2003), who estimate import penetration rates between ten and twenty percent for most metropolitan areas within the United States. They are significantly lower than the exposure rates in Riker (2022), which determines the average state–level import penetration rate to be 38.64%, and Riker (2019), which determines the nationwide import penetration rate to be almost fifty percent. The use of data that does not distinguish between shipments that arrive in an area and shipments destined for that area would bias import penetration rates upward, especially in states or regions with a coast or border. However, the FAF survey only records shipments that arrive in an area, not what eventual consumption looks like, and the arrival of goods may not reflect constituents' consumption patterns in a locality, even if the locality is the goods' final destination.

Figure 1 shows import penetration rates for the 132 FAF regions. I color–code regions according to the level of import exposure that they have, with regions in black being the least exposed to imports and regions

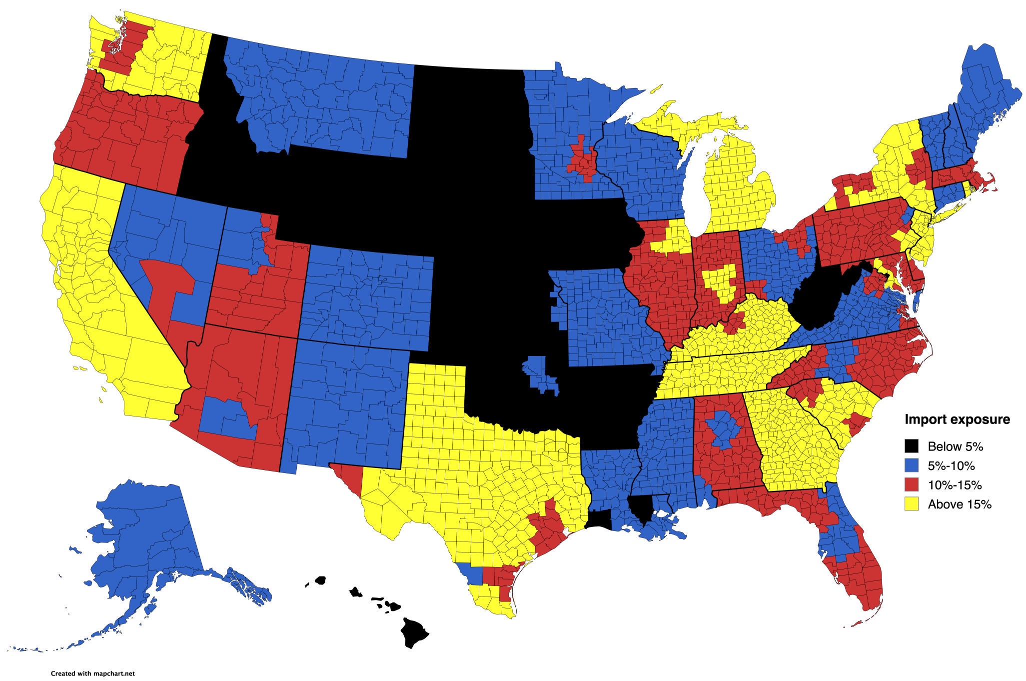

Figure 1: Geographical distribution of subnational import exposure

in yellow being the most exposed. I calculate exposure rates in Figure 1 and Figure 2 using shipment values, but the ordinality of rates among regions does not change very much if I calculate the rates using quantities.

Larger states with a coastline and/or border are often highly exposed to imports. States fitting this description that are at least partially yellow or red include Washington, California, Arizona, Texas, Georgia, North Carolina, Michigan, New Jersey, and New York. Moreover, rural states and states in the interior of the country tend to have lower import penetration rates, as these regions have less access to shipments from abroad. However, substantial heterogeneity also exists at the sub–state level; metropolitan areas in border/coastal states such as Phoenix, Houston, Jacksonville, and Seattle have lower import exposure rates than the rest of their states, while in Kansas, Oklahoma, Illinois, and Indiana constituent metro areas have higher import exposure rates than the rest of their states. I suggest that in states with a coastline or border the availability of local substitutes in metro areas lowers the fraction of total shipments that are imported, while in states with a low penetration of imports the slightly higher concentration of people in metro areas increases the accessibility of foreign–made goods.

Comparing the wealthiness of different areas with their import exposure rates, there does not seem to be a clear pattern. Wealthy areas, which include the San Francisco Bay Area, the D.C. suburbs, and the Gold Coast in Connecticut, do not show consistently low or high import penetration measures. Poorer regions, such as West Virginia, Kentucky, and New Mexico, also differ widely in the import shares they display. This observation complements the finding in Borusyak and Jaravel (2021) that import penetration shares do not vary much by income.

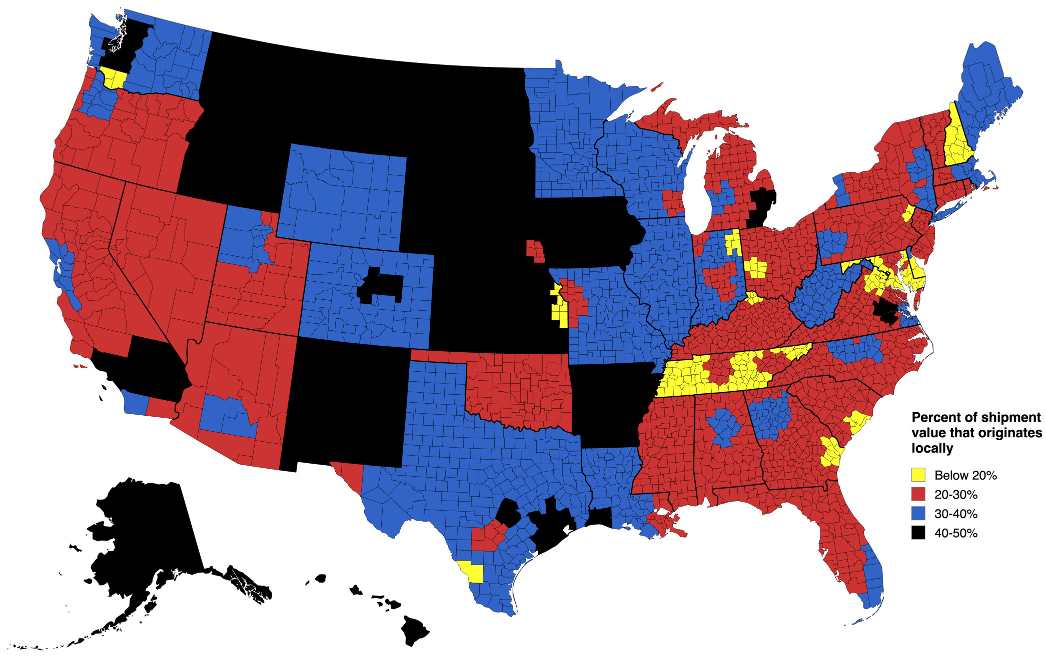

Figure 2: Geographical distribution of subnational local exposure

Figure 2 shows how local exposure varies in FAF regions across the country. In general, areas with a low level of penetration from foreign imports have a higher level of exposure to local production. Exceptions to this pattern include Laredo, TX, Oklahoma and New Hampshire, which have both a low import penetration and relatively low local penetration. Other areas such as Austin, Atlanta, and Richmond, VA have relatively high import penetration rates as well as high local exposure. Due to factors including geography and population density, some areas may be tempting both for foreign trade and local enterprise, while other areas do not have much of either and so rely on subnational imports from other parts of the United States.

In many states, major metropolitan areas have a higher exposure to locally produced goods than regions of the state outside those metropolitan areas. For example, Austin and Houston (in black) have a higher local exposure rate than the rest of Texas (in blue), and this pattern also holds for Los Angeles, San Francisco, Denver, Seattle, Phoenix, Atlanta, Boston, and New York City. However, smaller metropolitan areas such as Kansas City, Charleston, SC, Indianapolis, and Milwaukee all have smaller local exposure rates than their surroundings, while some of the highest observed local penetration rates are in rural areas including North Dakota, South Dakota, Iowa, New Mexico, and Rest of Nebraska. These results suggest that the lowest level of local penetration occurs in areas urban enough to be easily accessible via shipping routes, while not urban enough to offer a variety of locally produced goods for consumption.

Exposure to imports from a specific area of the world depends heavily on distance from that origin region. Areas in California, Arizona, Texas, Utah, and New Mexico have some of the highest penetration rates of imports from Mexico, while Kansas, Washington State, and rural northern states have some of the lowest. Regions with a high exposure to imports from Canada all border Canada (with the exception of Ohio, which is connected to Canada via Lake Erie), and regions with the lowest exposure to Canadian imports are all in the South. Regions with a high exposure to imports from Eastern Asia are in California, Nevada, Oregon, and Washington, as well as major metropolitan areas such as New York City and Chicago.

4 Regression Results

After using the FAF data to obtain measures of import exposure for substate U.S. regions, I use these measures to determine the relationship between urbanization, represented by population density, and import exposure. The expected result for this relationship is ambiguous, and its empirical findings may contribute to our understanding of how trade policies may impact regions differently across the country. I construct measures of 2022 population density in people per square mile for each FAF region by downloading population and area data for each county in the United States. I then match each FAF region to its constituent counties and calculate population density for FAF regions by dividing the total population, summed across counties, by the total area.

I include as controls in the regression a dummy variable for whether the region has a coastline, a dummy variable for whether the region borders Canada or Mexico, and dummies representing the broader Census areas to which the regions belong, with Midwest as the omitted category. Since large quantities of shipping pass through the Great Lakes, I also consider a region to have a coastline if it borders a Great Lake.[3] 44.7% of FAF regions border the ocean or a Great Lake, while 16.7% border Canada or Mexico. The South represents the largest number of FAF regions at 40.9% of the total, with the Northeast, Midwest and West comprising respectively 15.9%, 20.5%, and 22.7%.

Table 2 gives summary statistics for the population density variable. The median FAF region has 229 people

	Minimum	Median	Mean	Maximum
2022 population density	1.34	229	442	11740
1970 population density	.471	139	326	13219

Table 2: Population density summary statistics

per square mile, with the most densely populated region (District of Columbia) having 11740 per square mile and the least densely populated region (Alaska) having 1.34 people per square mile. FAF regions represent combined statistical areas (CSAs), which include more counties than metropolitan statistical areas (MSAs) and are thus less concentrated. FAF regions generally have lower population densities than metropolitan areas or cities. However, Washington, D.C. has a particularly high population density because the FAF splits CSAs by state lines, and so it only includes the District of Columbia itself without the Maryland and Virginia suburbs.

Reverse causality is an issue with this regression setup, as the presence of a port or availability of cheap imported goods could induce urbanization in a region. To address this causality issue, I run a two–stage least squares regression using the relevant county's population density in 1970, fifty years prior, as an instrument.[4] While historical population density has a strong influence on current population density, it cannot possibly influence present–day import exposure except through present–day population density. Table 2 exhibits summary statistics for 1970 population density; with the exception of parts of Pennsylvania, New York, and Ohio, 1970 population densities are lower than their 2022 counterparts. [5]

A regression of logged 2022 population density on logged 1970 population density reveals that an increase of one percent in a region's 1970 population density predicts a nearly one percent increase in that region's 2022 population density. The F–statistic is 1230, indicating strong instrument relevance.

[3]The omission of this consideration does not measurably alter results. I also run the regressions while considering Great Lakes states to have a border with Canada, and this change in formulation did not change results either.

[4]As a robustness check, I also perform instrumental variable regressions with population density in each year from 1971 to 1979, without any change in results.

[5]Changes in population density would reflect changes in population, since the total area of FAF regions did not change between 1970 and 2022.

	Logged 2022 population density
Intercept	-.570** (.262)
Logged 1970 population density	.890*** (.0254)
Adjusted R-squared	.904
F–statistic	1230

Table 3: First–stage regression

Measurement	Value	Value	Value	Tons	Tons	Tons
Intercept	-.851*** (.303)	-.990*** (.318)	-1.02*** (.368)	-1.17*** (.447)	-1.31*** (.470)	-1.21*** (.472)
Population Density (logged)	.146*** (.0320)	.132*** (.0326)	.159*** (.0369)	.212*** (.0457)	.197*** (.0481)	.273*** (.0472)
Coast			.200** (.0840)			.526*** (.108)
Border			.173 (.125)			.468*** (.160)
Northeast			.200 (.141)			.397** (.180)
South			.206* (.107)			.278** (.137)
West			.326** (.125)			.721*** (.161)
Instrument	No	Yes	Yes	No	Yes	Yes
Adjusted R–squared	.140	.139	.216	.135	.135	.408
N	132	132	132	132	132	132

Table 4: Effects of population density on logged import exposure

Table 4 shows the results of regressing import exposure, with shipments measured both in values and in tons, on population density. A ten percent increase in population density would induce a 1.5 percent increase in import exposure measured by value and an increase of over two percent in import exposure measured by quantity. All population density coefficients are statistically significant at the one percent level, indicating a robust, if small in magnitude, positive relationship between urbanization and import exposure. All else equal, cities will spend a higher fraction of their expenditure on imported goods than people living outside cities, and the effect of greater access to trade outweighs the concurrent greater access to locally produced alternatives.

The inclusion of an instrumental variable does not markedly affect results, while the inclusion of controls causes a moderate increase in the effect of density on shipments measured by quantity. Regions with a coastline are predicted to have higher import penetrations than regions without one, and regions within the West of the country are predicted to have higher import penetrations than regions in the Midwest, perhaps due to its (relatively) close proximity with Canada, China, and Mexico. *Border* and *Northeast* display significant positive relationships with import exposure when shipments are measured by quantity but not when they are measured by value, implying that shipments arriving in these types of regions are predicted to have low values per quantity.

Measurement	Value	Value	Value	Tons	Tons	Tons
Intercept	-1.95*** (.215)	-1.89*** (.226)	-1.68*** (.392)	-1.40*** (.269)	-1.42*** (.227)	-1.33*** (.212)
Population Density (logged)	-.0708*** (.0220)	-.0651*** (.0231)	-.0465*** (.0269)	-.0657*** (.0221)	-.0676*** (.0232)	-.0588*** (.0213)
Coast			.111* (.0613)			.0465 (.0484)
Border			.00395 (.0909)			.0852 (.0718)
Northeast			-.139 (.102)			.0850 (.0718)
South			-.168*** (.0782)			-.0500 (.0618)
West			.0480 (.914)			.103 (.0722)
Instrument	No	Yes	Yes	No	Yes	Yes
Adjusted R–squared	.0668	.0663	.105	.0565	.0564	.152
N	132	132	132	132	132	132

Table 5: Effects of population density on logged local exposure

Table 5 shows the predicted effects of population density on the percentage of shipments arriving in a given region that originate locally. A higher population density predicts lower local exposure, a relationship that remains statistically significant and only slightly decreases in magnitude with the addition of controls. Even though residents of urban areas should have access to a greater array of locally produced goods than residents of more sparsely populated areas, this access does not translate to greater consumption of locally produced goods as a percentage of total consumption. Some goods, such as agricultural goods, may be more accessible at a local level to rural residents than urban residents, and so I posit that this greater access to local goods is inconsistent and does not outweigh the stronger, across–the–board access to international shipping.

Control variables have a less significant impact on local exposure than they do on import exposure; when we measure local exposure by quantity, none has a statistically significant coefficient. This difference may reflect the greater role that geographic considerations play in decisions to export compared with decisions to ship subnationally. For example, coastal regions are more attractive to foreign importers than non–coastal regions but not any more attractive to firms shipping within the United States, and indeed the *Coastline* estimate displays a far greater degree of significance in Table 4 than in Table 5. While Western regions are predicted to have higher import exposure than non–Western regions, in column 4 the South is predicted to consume a lower proportion of locally made goods than the Midwest. No other regional dummy variable shows any significance.

While informative, the regression results in Tables 4 and 5 mask the regional heterogeneity that one may observe in Figure 1 and Figure 2. Although more densely populated regions generally have higher proportional consumption of imports and lower proportional consumption of locally produced goods, Figure 2 shows that in several states the main metropolitan area has a higher local exposure rate than the rest of the state. Regression results represent overall trends in the data and should not be taken as absolute.

5 Conclusion

Since direct measurements of subnational imports do not exist, previous literature on the topic has either substituted granular variation in employment for granular variation in imports or else conducted its analysis at the level of states or broader Census regions, where data is more readily available. In this paper, I use FAF data on shipments below the state level to construct measurements of each FAF region's exposure to imports and to goods produced locally.

I find that import exposure rates for shipments measured by value are around ten percent on average, while local exposure rates average about twenty–eight percent and can go as high as fifty–four percent. Regression analysis reveals a robust positive relationship between population density and import exposure as well as a robust negative relationship between population density and local exposure. However, these relationships, while statistically significant, are small and mask heterogeneity in import and local exposure when measured across the country; import exposure rates of the main metropolitan area in many states are smaller than those of the rest of the state, and local exposures in those metropolitan areas are higher. Taken together, results suggest that smaller metropolitan areas, such as Savannah, GA or Omaha, NE, are large enough to attract foreign imports but not large enough to produce a countervailing array of local shipments.

The results of this exercise imply that protectionist policies at the national level could affect densely populated areas most adversely, since those areas are generally more exposed to imports. However, smaller metropolitan areas could be more adversely affected than larger ones because larger metropolitan areas are more able to substitute local goods for the imported goods that become too expensive or unavailable. Comprehensive analysis of this topic is not possible without a structural model that evaluates how a change in trade policy generates spatial welfare effects across the country. One striking finding is that the import exposure rates presented in Section 3 are significantly lower than those estimated in the literature. I assume that if a shipment (outside the transportation and warehousing sector) ends up at a given destination it must be consumed there, but for myriad possible reasons shipments going into an area may not accurately reflect consumption in that area. Shipments, unlike consumer expenditure data, contain intermediate goods, which may be less likely to be imported than final goods and is not part of consumption. Another explanation is that doing estimates on a larger geographic scale, as in Riker (2022, 2019) can generate aggregation bias.

Future studies should break down import exposure analysis by sector or mode of transportation, which can generate insight into the variance of import penetration across different types of goods. For example, Riker (2022) finds that import penetration in the food sector is about eight percent on average and varies widely across states, while import penetration in the apparel sector is over ninety percent and has hardly any variation across states. The aggregation of sectors to produce import exposure rates could be another source of aggregation bias in the results.

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