Regional Import Data and the

Net Gains from Trade Liberalization

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ABSTRACT

Geographically disaggregated U.S. import data can contribute significantly to studies of international trade liberalization. I illustrate this point using a model of the demand for imports in many distinct regions within the United States. I estimate the parameters of the model using a fixed effects methodology and import data at the level of customs districts. Then I simulate the impact of bilateral trade liberalization on consumer prices and tariff revenues. The model predicts asymmetries in the pattern of trade diversion and in the distribution of the gains from trade liberalization that would be missed by models that rely on more aggregated trade data.

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1. INTRODUCTION

While there is a clear case for the economic benefits of global free trade, the welfare implications of preferential trade agreements are mixed. Preferential trade liberalization reduces prices to consumers, but distortions from trade diversion and the decline in tariff revenues may exceed the value of these benefits. There is an extensive literature that analyzes the welfare implications of preferential trade agreements. Panagariya (2000) provides an excellent survey of the theoretical literature, starting with the seminal contributions of Viner (1950) and Meade (1955). Clausing (2001), Ghosh and Yamarik (2004), and Magee (2008) provide econometric analysis of the diversion of imports that results from bilateral trade liberalization.

In most empirical models of international trade, the United States is represented as an integrated product market without geographic distinction, and the literature on preferential trade agreements is no exception. Yet the country covers a large and diverse area, and there is regional segmentation of consumers due to transportation costs within the United States. For example, consumers on the Pacific Coast face different consumption choices than consumers on the Atlantic Coast, either in terms of the absolute availability of products or at least in terms of delivered prices. The regional segmentation of consumers shapes the welfare implications of preferential trade agreements: conflicting gains and losses at the national level are even more pronounced at the regional level.

Consider, for example, a hypothetical reduction in tariffs on U.S. imports from China. As long as there is geographic segmentation of consumers, the resulting reduction in consumer prices will be unevenly distributed across the United States, because imports from China are relatively concentrated on the Pacific Coast. The tariff reduction will disproportionately displace imports from other Asian countries, because they are also concentrated on the Pacific Coast. On the other hand, the reductions in income due to the loss of tariff revenues are likely to be more evenly distributed. In this paper, I construct a dataset and model that formalize this example and quantify these economic adjustments. The model contributes to the empirical literature on trade diversion by taking into account more geographically disaggregated trade data.

The import statistics of the United States are reported by customs district, which is a set of neighboring ports. The district-level data are informative about the economic consequences of trade liberalization in different regions within the country. Despite its accessibility, information on the regional distribution of U.S. imports is rarely used in econometric modeling of international trade flows. Hummels (1999) and Blonigen and Wilson (2008) are important exceptions. Hummels (1999) uses port-level U.S. import data to relate international shipping costs to distance, weight, and other factors. Blonigen and Wilson (2008) model the determinants of port-specific shipping costs, including port efficiency and other observable factors like international distances.

In this paper, I use the district-level disaggregation of the trade data to estimate the parameters of an import demand model using a fixed effects methodology. With district-level import data, it is feasible to include country and district fixed effects for each industry to control for variables that are relevant but difficult to measure, including regional price indices, regional income levels, and the producer prices of imports. There are many similarities between the estimation methodology in this paper and the fixed effects methodology in Hummels (1999) and Hertel, Hummels, Ivanic, and Keeney (2007), but there are also important differences. Hummels (1999), and Hertel, Hummels, Ivanic, and Keeney (2007) control for country fixed effects. Their datasets include many importer-exporter pairs, and their econometric specifications include importer and exporter country effects. This is similar to the use of country fixed effects in Anderson and van Wincoop (2003) and Santos Sliva and Tenreyro (2006). In contrast, the econometric model in this paper focuses exclusively on U.S. imports, and therefore the country fixed effects absorb all importer-exporter variation. Instead, I use a measure of international trade costs that varies by industry, country of origin, and customs district to identify the demand elasticities. I estimate the model's parameters using a negative binomial PML estimator that generalizes the Poisson PML estimator recommended in Santos Silva and Tenreyro (2006).

Then I use the econometric estimates to simulate the effect of trade liberalization on import values, prices, and tariff revenues in sub-national regions within the United States. Specifically, I model the hypothetical elimination of U.S. duties on imports of electrical equipment from China. I examine whether the trade liberalization would be welfare reducing or improving in each region. The model predicts many asymmetries in the pattern of trade diversion and in the distribution of the gains from the trade liberalization that would be missed by models that rely on more aggregated trade data.

The paper is organized into the following five parts. Section 2 identifies the data sources and summarizes the geographic variation in import values and international trade costs. Section 3 derives the specification that I use to estimate the parameters of the import demand model. Section 4 discusses the econometric methodology and reports the parameter estimates. Section 5 reports the simulation analysis, and Section 6 provides concluding remarks.

2. DISTRICT-LEVEL VARIATION IN U.S. IMPORTS

The U.S. International Trade Commission reports the value of U.S. imports at the level of customs districts. A district is a set of neighboring ports. For example, the Los Angeles district includes the Port of Los Angeles, the Port of Long Beach, Los Angeles International Airport, the Port of Hueneme, and a few smaller ports. Imports that enter a district may be consumed locally or may be transshipped to other regions within the United States. The district of an import identifies a point along its path.

The basic principles of economic geography predict that the import shares of the different districts will depend on transportation costs within the United States and the costs of shipping between countries. Shipping costs from a foreign country to the United States vary by port, because the ports are different distances from the foreign country. When international shipping costs are large relative to transportation costs within the United States, I expect a high concentration of imports in the district that is closest to each foreign country. On the other hand, when transport costs within the United States are relatively large, I expect a more even distribution of imports across the districts.

To examine the geography of U.S. imports, I analyze the annual landed duty-paid value of U.S. imports for consumption through each of the 38 districts in the 48 contiguous states and the District of Columbia. I do not include the districts in Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands because they are less integrated with the rest of the United States. The district-level data combine imports that are delivered by air, sea, and land.

Table 1 reports descriptive statistics for imports from thirty of the largest U.S. trade partners in 2009. The table identifies the customs district that had the largest share of imports from each country. Generally, the district with the largest share is Los Angeles or New York. Imports from East Asia are relatively concentrated in Los Angeles, and imports from Europe are relatively concentrated in New York, reflecting international distance. However, the largest district share is almost always less than fifty percent. The moderately concentrated district shares suggest that transportation costs within the United States are also a significant determinant of the regional distribution of U.S. imports.

Table 2 provides a second view of these import data. It reports the shares of imports from each of the source countries through each of the 38 districts in 2009. To abbreviate the table, I aggregate the countries into six groups: Europe, East Asia/Australia, Canada, Mexico, Central/South America, and the rest of the world. The share of imports from Asia and Australia is relatively high in California, Oregon, and Washington but also in the Midwest districts of Chicago, Cleveland, Dallas, and St. Louis. The share from Central and South America is relatively high in Florida and Texas, and the shares from Mexico and from Canada are highest along their borders with the United States. Overall, there are substantial differences in the country shares across the 38 districts.

To examine the relationship between international trade costs and the district-level import shares, I construct a measure of international trade costs based on the ratio of the landed duty-paid value of the imports to their customs value. The difference between the landed duty-paid values and the custom values represents the combined cost of freight, insurance, charges, and duties. Table 3 reports the mean and standard deviation of the ad valorem rate implied by this trade cost ratio for eight industries in 2009. There is considerable variation within each industry across the countries and districts. The standard deviation of the rate is larger than its mean in all but one of the industries. The average rate is highest for NAICS industry 337, which includes furniture, and lowest for NAICS industry 334, which includes computers. The final column of Table 3 reports the share of the within-industry variation in the trade cost ratio that is explained by the county of origin, based on a regression of the log of the trade cost ratio on a set of country dummy variables. At least 80% of the variation within each industry reflects the customs district of the imports and is not explained by the country of origin alone.

3. MODEL SPECIFICATION

In this section, I introduce a structural model of import demands with regional segmentation of consumers within the United States. The model utilizes the district-level variation in the import data, and it is the basis of the trade policy simulations in Section 5.

In the model, the products within each industry are differentiated by country of origin, and consumer preferences have a constant elasticity of substitution (CES) form. In this way, the model is similar to the demand structure in Anderson (1979), Anderson and van Wincoop (2003), Hertel, Hummels, Ivanic, and Keeney (2007), Helpman, Melitz, and Rubinstein (2008), and many other contributors to the empirical trade literature. The imports from each country enter the United States through multiple districts. They are not limited to the district that is closest to the country of origin. One explanation for this diversity is that consumers have only a limited ability to arbitrage between imports that enter the different districts.[1] A second explanation is that imports are differentiated according to the location of entry into the United States. The data may reflect both of these factors. I incorporate both into the model by assuming that imports in the same industry from the same country are differentiated to some extent by

[1] For example, Hillberry and Hummels (2008) conclude that the pattern of U.S. domestic shipments of manufactured goods is extremely localized, based on a detailed analysis of micro-data from the 1997 Commodity Flow Survey.

district (representing a preference for supply diversification and possibly physical differences in the products) and consumers are geographically segmented.

Specifically, the consumers' CES preferences are nested in three tiers. The upper tier combines composites of products from different industries, with an elasticity of substitution across the industries of one and a constant expenditure share for each industry. The second tier (within each industry) combines domestic products and a composite of imports, with an elasticity of substitution equal to ω. The third tier combines imports from different countries and different districts, with an elasticity of substitution equal to σ.

Individual consumers reside in different regions within the United States. I assume that each region is an integrated product market without significant costs of transporting the imports within the region. I also assume that there are prohibitive costs of transporting the imports between regions, and these costs segment the national product market. (Although this assumption is restrictive, the empirical analysis examines how the results vary when the boundaries of these regions are drawn differently, and I develop tests of coefficient restrictions implied by alternative region boundaries.) Each customs district is located in one of the regions. National import demands are an aggregation of the demands of individual consumers who reside in the different regions. The transportation costs differentiate consumption bundles by region. In contrast, the implicit assumption in a trade model with a fully integrated national market is that there are not significant transportation costs throughout the United States.

The variable V_{jd} in equation (1) represents the landed duty-paid value of an industry's imports from country j to district d in a specific year.[2]

$$V_{jd} = \mu\, Y_d\, Z_d \left(P_j\ T_{jd} \right)^{1-\sigma} \tag{1}$$

The parameter μ is the expenditure share of the industry. Y_d represents aggregate expenditure in the region that includes district d. Specifically, it is the sum of the incomes of the all of the individual consumers in the region. As long as consumers have identical CES preferences and face the same set of prices, their expenditures can be aggregated by region, as in equation (1). The number of consumers and the distribution of income among the consumers is not relevant to import demand, given the region's aggregate expenditure level Y_d. Z_d is a function of the CES price indices for the industry's products in the region that includes district d.[3] P_j is the producer price of the industry's products from country j, prior to the addition of international trade costs. T_{jd} is the international trade costs, which vary by industry, country, and district. The assumption that international trade costs are ad valorem is a common simplification in theoretical and empirical models of international trade flows. For example, Hummels (1999) and Hertel, Hummels, Ivanic, and Keeney (2007) assume that transport costs between countries are ad valorem. In Anderson and van Wincoop (2003), transportation costs between states and countries are ad valorem.

Equation (1) can be rewritten using a district effect α_d and a country effect γ_j.

$$V_{jd} = \mu\, e^{\alpha_d+\gamma_j} \left(T_{jd} \right)^{1-\sigma} \tag{2}$$

[2] To simplify the notation, I omit subscripts for industry and time from the equations that follow.

[3] Specifically, $Z_d = [(M_d)^{1-\omega} + (N_d)^{1-\omega}]^{-1}(M_d)^{\sigma-\omega}$, where M_d and N_d are CES price index for the composites of the industry's imports and domestic products in the region that includes district d.

Equation (3) defines the district effect based on equation (1).

$$\alpha_d = ln(Y_d) + ln(Z_d) \quad \textbf{(3)}$$

It includes all factors that are common across the countries of origin of the imports, for a given industry and district. These include the aggregate expenditure level and the consumer price index in the region. Anderson and van Wincoop (2003) emphasize the importance of controlling for the price index in the destination market. This is reflected in their multilateral resistance term. The district fixed effect in equation (2) serves this purpose. Equation (4) defines the country effect based on equation (1).

$$\gamma_j = (1 - \sigma)\ ln(P_j) \quad \textbf{(4)}$$

It includes all factors that are common across the districts for a given country and industry.

Equation (5) is a log-linear transformation of the industry-specific model in equation (2).

$$ln(V_{jd}) = \alpha_d + \gamma_j + (1 - \sigma)\ ln(T_{jd}) \quad \textbf{(5)}$$

In the import data, there are many district-country pairs with $V_{jd} = 0$. This may be explained by prohibitively high fixed costs of exporting to the district, following Helpman et al. (2008). For these district-country pairs, the log-linear transformation in equation (5) is not feasible.

4. ESTIMATION ISSUES AND ECONOMETRIC RESULTS

The econometric model is flexible with respect to the level of product aggregation. There is enough detail in the district-level U.S. import data to estimate the model parameters at the level of three-digit NAICS industries, at the level of six-digit NAICS industries, or even at the level of ten-digit HTSUS products. In this paper, I report separate parameter estimates for three-digit NAICS industries 331 through 339. I estimate a separate version of the model for each industry. The estimates pool across countries and the 38 districts. They focus on U.S. imports in 2009. I treat the district effects and country effects as fixed effects.

The fixed effects specification greatly reduces the information required to estimate the parameters of the model. I do not need to observe which consumers reside in each region, or even which districts are included in each region, to estimate the parameters in the model. The region's price index is absorbed in the district fixed effect, α_d, as are the region's aggregate expenditure levels. Likewise, the producer prices are absorbed in the country fixed effect, γ_j. Since the international trade costs vary by district and by country, they are not absorbed by the district fixed effects or the country fixed effects. They provide the variation that identifies σ. I assume that the international trade costs are not correlated with district and country specific shocks to import demand.

I estimate the parameters of equation (5) by adding a normally-distributed error term and applying Ordinary Least Squares (OLS). Following Santos Silva and Tenreyro (2006, 2009), I also estimate the non-linear fixed effects model in equation (2). The negative binomial regression is a generalization of the Poisson model in Santos Silva and Tenreyro (2006). It allows for overdispersion. χ^2 tests of the estimates indicate that the negative binomial regression model is more appropriate, because there is significant overdispersion every one of the eight industries that I analyze.

Many potential district-country pairs have no imports in one of the eight industries. In these cases, there is no direct measure of the trade cost ratio T_{jd}. Instead, I impute the value of

T_{jd} based on an average trade cost ratio from the other seven industries for the same district, country and year, weighted by the other industries' landed duty-paid import values. For the observations with imputed values of T_{jd}, the OLS estimation of the log-linearized model is still not feasible, since the value of V_{jd} is zero. However, these observations can be included in the negative binomial PML estimation.

Table 4 reports the point estimates and 95% confidence intervals for alternative estimates of σ. The OLS estimates for the eight industries range from 4.887 to 13.807. They are all significantly greater than one. For each industry, F-tests reject the hypothesis that the country effects are jointly equal to zero and the hypothesis that the district effects are jointly equal to zero. The estimates in the next column are based on the negative binomial PML estimator but do not include country-district pairs with zero imports. (Therefore, they do not rely on imputations.) For all of the industries, I reject the more-restricted Poisson PML estimator due to overdispersion. For most of the industries, the point estimates are smaller than their OLS counterparts. The largest differences are for industries NAICS 333 (Machinery) and 339 (Medical Instruments et al.). The third column of estimates is based on the negative binomial estimator with imputed values of T_{jd}. All of the point estimates in this column are smaller than their OLS counterparts. The largest differences are for industries NAICS 337 (Furniture) and 339 (Medical Instruments et al.)

An additional concern is that the estimates in Table 4 could be dominated by imports from Canada and Mexico, which account for a large share of total U.S. manufacturing imports and are highly concentrated in border districts. As a sensitivity analysis, I re-estimated σ for each industry excluding imports from Canada and Mexico from the sample. I report the alternative estimates in the final column in Table 4. The alternative estimates of σ are lower than their counterparts in Model 2, but the differences are small.

The simple average of the point estimates for the industries is approximately 7.59. This is close to the average industry-level elasticity of substitution of 7.55 in Hertel, Hummels, Ivanic, and Keeney (2007). To extend this comparison, I aggregate the three-digit manufacturing industries into the GTAP sectors analyzed in Hertel, Hummels, Ivanic, and Keeney (2007) and then estimate σ for these sectors. Table 5 reports a side-by-side comparison of the two sets of estimates.

The econometric model does not impose specific assumptions about the boundaries of the consumer regions. The United States could be one integrated region, or each district is part of a separate region. However, the econometric estimates can be restricted to test whether two or more of the districts are integrated in the same region. If districts d and d' are in the same region, then they have common price indices and aggregate expenditure levels, and therefore $\alpha_d = \alpha_{d'}$ in equation (2). Therefore, I analyzed the boundaries of the regions for each industry using a series of tests of coefficient restrictions on α_d. I tested whether the districts within the same BEA regions have the same value of α_d.[4] I also tested whether *all* of the districts have the same value of α_d. The χ^2 tests of the coefficient restrictions strongly reject the null hypotheses. The tests indicate that the most disaggregated case – the 38 region scenario – is appropriate for all eight industries.

[4] The U.S. Burea of Economic Analysis groups states into the following eight regions: New England, Mideast, Great Lakes, Plains, Southeast, Southwest, Rocky Mountain, and Far West.

5. SIMULATIONS OF BILATERAL TRADE LIBERALIZATION

The economic model, with its estimated parameter values, provides a tool for approximating the effect of a bilateral trade liberalization on import values, consumer prices, and tariff revenues in different regions within the United States. As an illustration, I simulate the effect of eliminating the duties on U.S. imports of electrical equipment from China. The hypothetical tariff reduction is preferential (i.e., bilateral) in the sense that it only applies to tariffs on the industry's imports from a single country, though it applies to all imports from China regardless of where they enter the United States.

The purpose of the simulation is to use the disaggregated trade data while simplifying other aspects of the model. Specifically, I assume that producer prices are not changed by the industry-specific, bilateral trade liberalization.[5] The trade liberalization is not analyzed in a global general equilibrium context like Hertel, Hummels, Ivanic, and Keeney (2007). Since I am modeling sub-national product markets, the data requirements for a global general equilibrium analysis would likely be formidable.

For most of the simulations, I assume that $\omega = 1$. In this Cobb-Douglas case, the cross-price elasticity of demand between imports and domestic shipments is zero. Several econometric studies that provide industry-level estimates of this elasticity of substitution, including Blonigen and Wilson (1999) and Galloway, McDaniel, and Rivera (2003), indicate that the elasticity of substitution between domestic products and an aggregate of imports is generally close to one. In Blonigen and Wilson (1999), for example, the estimated elasticity for 93 of the 146 industries is

[5] This simplifying assumption is consistent with the models in Helpman, Melitz, and Yeaple (2004) and Chaney (2008), for example. In their models, producer prices are a fixed mark-up over factor prices and factor prices are determined by international arbitrage in homogeneous goods.

between 0.5 and 1.5. Galloway, McDaniel, and Rivera (2003) estimate an elasticity of substitution for 309 four-digit SIC manufacturing industries for the period 1989-1995. The average short-run elasticity estimate for these 309 industries is 0.95. Adopting this specific value for ω significantly reduces the data requirements of the simulations, since they do not require information about the regional distribution of the domestic shipments of U.S. producers in each industry. As a sensitivity analysis, I also calculated the simulations assuming that $\omega = \sigma > 1$.

Measuring the Extent of Trade Diversion

Following Clausing (2001), Ghosh and Yamarik (2004), and Magee (2008), I calculate the diversion of imports that would result from the bilateral trade liberalization. As the industry's imports from China increase, the industry's imports from other countries decline. The extent of trade diversion depends on differences in the country shares of each region's imports. To illustrate this point, consider a simple example. Suppose that there are substitutable products from two different countries that are imported into two sub-national regions, labeled East and West. Assume that one country's product is only imported into East, one country's product is only imported into West, and it is prohibitively costly to ship the products between the East and West regions. The products are substitutes in the preferences of consumers, but the two types of imports are not in the choice sets of the same consumers. Because there is no geographic overlap of imports in this simple example, there is no trade diversion.

To measure the extent of trade diversion, I need to define which districts are located in the same consumer region. However, I do not need to know how many consumers reside in each region. I calculate the extent of trade diversion under alternative region scenarios. The first scenario, which is supported by the tests of coefficient restrictions, is that each of the 38 districts is in a distinct region. In this case, consumers in each of the 38 regions only purchase imports from the region's single district. The second scenario is that the 48 contiguous states and the District of Columbia are fully integrated in a single consumer region. With a nationwide region, U.S. consumers substitute among imports that enter all 38 districts. This is the case implicitly assumed in most models with consumer choices represented as aggregated (national) demands.

I use the industry-level model in equation (2) to calculate the change in a region's imports from the other countries. $\hat{V}_{jd}$ in equation (6) represents the percentage change in the industry's imports from country j to district d that results from eliminating tariffs on the industry's imports from China, assuming that $\omega = 1$ and that aggregate expenditure levels are unchanged by the trade liberalization. (China is indicated by the subscript c).

$$\hat{V}_{jd} = (1 - \sigma)(V_{cd}/V_d)\,\hat{T}_{cd} \qquad \text{for } j \neq c \qquad \textbf{(6)}$$

I derive equation (6) by log-differentiating the demand for the industry's imports from country j to district d with respect to the trade cost T_{dc}, holding fixed aggregate expenditure levels and producer prices. V_{cd} is the value of the industry's imports from China in district d, and V_d is the value of all of the industry's imports into district d. σ is the parameter estimate from the second column in Table 4. At the district level, the percentage reduction in imports from other countries depends on factors that are district-specific (the share of the district's imports that are from China and the percentage change in trade costs) and factors that are not district-specific (the elasticity of substitution σ).

Equation (7) aggregates the district-level model to calculate a nationwide measure of trade diversion. The percentage change in nationwide imports of the industry's products from country j, $\hat{V}_j$, is a share-weighted average of the percentage change in the imports in each district.

$$\hat{V}_j = \sum_d \left(V_{jd}/V_j\right) \hat{V}_{jd} \qquad \textbf{(7)}$$

Equations (6) and (7) imply equation (8).

$$\hat{V}_j = (1-\sigma) \sum_d \left[\left(V_{jd}/V_j\right) (V_{cd}/V_d) \hat{T}_{cd} \right] \quad \text{for } j \neq c \qquad \textbf{(8)}$$

This nationwide measure of trade diversion depends on the degree to which imports from China and from country j enter the United States through districts that serve the same set of consumers. Equation (9) is the counterpart to equation (8) for the single region scenario.

$$\hat{V}_j = (1-\sigma) \sum_d \left[(V_{cd}/V) \hat{T}_{cd} \right] \qquad \text{for } j \neq c \qquad \textbf{(9)}$$

V represents the industry's total imports from all of the countries through all of the districts.

Table 6 applies this calculation to imports in the electrical equipment industry (NAICS 335). The table reports the percentage change in the annual landed duty-paid value of imports from each country in response to a hypothetical elimination of tariffs on the industry's imports from China, based on equations (8) and (9).[6] The percentage change in the value of imports is the same for all countries if there is a single region: in this case, the tariff reduction leads to proportional diversion of imports from all of the other countries. However, in the scenarios where there is regional segmentation of U.S. consumers, there are substantial differences in the diversion of imports from each of the countries. The percentage changes in imports from other countries in East Asia and from Australia are higher than the percentage changes in imports from

[6] The 95% confidence intervals reported in the table reflect the uncertainty in the econometric estimates of σ.

Europe, India, and Brazil and are much higher than the percentage changes in imports from Canada and Mexico. These differences reflect the geographic overlap of imports from these countries. A model of trade diversion that ignores the regional segmentation of U.S. consumers will miss these asymmetries.

Table 7 reproduces this analysis for the electrical equipment industry assuming that $\omega = \sigma > 1$. I adjust V_d in equation (8) and V in equation (9) to also include the value of domestic shipments. The data on domestic shipments are based on the total value of shipments of each industry and state in the 2007 Economic Census, minus the FAS value of the exports from the industry and state. I use 2007 trade and shipment data and aggregate the 38 districts into 28 regions in order to match the 2007 Economic Census data. When I set $\omega = \sigma > 1$, the cross-price elasticity of non-Chinese imports is lower for all of the countries. However, the pattern of relative magnitudes remains the same: the percentage changes in imports from other countries in East Asia and from Australia are higher than the percentage changes in imports from Europe, India, and Brazil and are much higher than the percentage changes in imports from Canada and Mexico.

Measuring the Changes in Real Income in Each Region

The estimates of trade diversion are a useful first step, but they fall short of an analysis of the welfare implications of the bilateral trade liberalization.[7] To approximate the welfare implications in each region, I calculate the change in the price index of consumers in each region and the reduction in tariff revenue. The percentage change in real income in each region is the

[7] Panagariya (2000) emphasizes this point with numerous theoretical examples.

difference between the percentage change in income in the region (due to the reduction in tariff revenue) and the percentage change in the region's consumer price index.

The consumer benefits from lower prices are not evenly distributed throughout the country. They are concentrated in the districts where the imports from China are concentrated. The price changes vary across the districts with the industry's share of imports from China. Table 8 reports the percentage decline in the industry-specific import price index for the single region scenario and the minimum and maximum percentage declines in the 38 region scenario. The import price declines in the single region scenario are always bounded by the range of the region-specific price declines in the 38 region scenario, since the former is a weighted average of the latter.

If $\omega = 1$ and each district is a separate product market, then equation (10) represents the percentage change in the consumer price index in district d from eliminating the tariffs on the industry's imports from China.

$$\widehat{CPI}_d = (V/Y)(V_{cd}/V_d)\,\hat{T}_{cd} \qquad \textbf{(10)}$$

V is the industry's total imports from all of the countries into all of the districts, and Y is the country's aggregate expenditure level. The change in the consumer price index depends on the expenditure share of China in the industry's total district d imports and on the magnitude of the tariff reduction. Equation (11) is the counterpart to equation (10) for the single region scenario.

$$\widehat{CPI} = (V/Y)\sum_d[(V_{cd}/V)\,\hat{T}_{cd}] \qquad \textbf{(11)}$$

The reduction in tariff revenues reduces the consumers' income as long as there are offsetting increases in taxes or reductions in revenue transfers to consumers. I assume that the decline in tariff revenues would be offset by an increase in taxes (or a decline in transfers) that would maintain revenue neutrality. To incorporate the change in tariff revenues into the simulation, I need to specify the regional incidence of the taxes or transfers. I assume that the additional revenue is collected in proportion to the incomes of consumers in each region. This would be the case, for example, if the revenue were collected by an income tax with the same rate in each region. The variable $\hat{Y}$ in equation (12) is the percentage change in disposible income in each district that results from the decline in tariff revenues, assuming that the decline in tariff revenue is the only change in the consumers' income.

$$\hat{Y} = -(Y_d/Y)(R_{cd}/Y_d) + \sum_{j \neq c} \sum_k (Y_d/Y)\big(R_{jk}/Y_d\big)\, \hat{V}_{jk} \qquad \textbf{(12)}$$

Y represents national income, and Y_d is income in district d. The variable j is an index of countries, and the variable k is an index of all districts in the United States. R_{cd} is the tariff revenue from the industry's imports from China to district d, and R_{jk} is the tariff revenue from the industry's imports from country j to district k. $\hat{V}_{jk}$ is defined in equation (6) for $\omega = 1$. $\hat{Y}$ is the same for all of the districts, since the Y_d terms cancel from the right-hand side of equation (12). The first term on the right-hand side of the equation is the direct effect of the elimination of the tariff revenue on imports from China. The second term is the reduction in tariff revenue on imports from other countries due to trade diversion. Both are expressed as a share of total income.

Table 9 reports the changes in the consumer price index and the tariff revenue distributions of each district in response to the hypothetical elimination of tariffs on electrical equipment imports from China. The simulated changes in the price indices and tariff revenues are small, measured in fractions of a percentage point. This is because the tariffs on electrical equipment imports from China are modest and these imports from China account for a relatively small share of the total expenditures of U.S. consumers.

In the single region scenario, the decline in tariff revenue is approximately equal to the decline in the consumer price index. On the other hand, the relative magnitudes of the price and tariff revenue effects, and therefore the net effects on real income, are mixed when the calculations recognize the geographic segmentation in the 38 region scenario. The percentage decline in the consumer price index exceeds the percentage decline in income for the Providence, St. Louis, Dallas, Los Angeles, Seattle, Portland (Oregon), Minneapolis, New Orleans, Savannah, Duluth, San Francisco, Norfolk, Chicago, Charlotte, New York, Philadelphia, and Cleveland districts, but not for the other 21 districts.

6. CONCLUSIONS

Regional analysis of U.S. import data can help to refine the modeling of the economic consequences of international trade liberalization. I illustrate this with a model of the demand for imports in many distinct regions within the United States. I estimate the model parameters for eight manufacturing industries using district-level U.S. import data, variation in international trade costs to different customs districts, and several fixed effects estimators. The model provides an estimate of the extent of trade diversion and the changes in real incomes in each region.

The functional form assumptions and other restrictions of the model provide a tractable framework for utilizing the geographically disaggregated import data. The baseline model only requires readily available data on the customs and duty-paid values of U.S. manufacturing imports. However, the restrictions are also limitations. The sub-national model does not address potential general equilibrium effects of preferential trade agreements, including changes in the country's terms of trade and changes in the efficiency of domestic production. These are important areas for future research.

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TABLE 1: District Concentration of U.S. Imports by Country of Origin in 2009

Country of Origin	U.S. District with the Largest Share of Imports from the Country	District's Share As a Percentage
Australia	New York, NY	28.23
Belgium	New York, NY	51.08
Brazil	New York, NY	13.36
Canada	Detroit, MI	49.96
China	Los Angeles, CA	33.10
France	New York, NY	15.42
Germany	New York, NY	13.48
Hong Kong	Los Angeles, CA	25.16
India	New York, NY	41.22
Indonesia	Los Angeles, CA	31.93
Ireland	New Orleans, LA	29.76
Israel	New York, NY	52.61
Italy	New York, NY	22.70
Japan	Los Angeles, CA	21.25
Korea	Chicago, IL	21.56
Malaysia	Los Angeles, CA	26.05
Mexico	Laredo, TX	48.14
Netherlands	New York, NY	16.72
Philippines	Los Angeles, CA	29.22
Russia	New York, NY	20.93
Saudi Arabia	Baltimore, MD	37.89
Singapore	Los Angeles, CA	20.94
Spain	New York, NY	16.00
Sweden	New York, NY	21.27
Switzerland	New York, NY	35.37
Taiwan	Los Angeles, CA	22.04
Thailand	Los Angeles, CA	31.21
United Kingdom	New York, NY	18.58
Venezuela	Mobile, AL	29.06

Note: The table includes U.S. imports in NAICS 331-339.

TABLE 2: Shares of Imports by District and Country of Origin in 2009, as a Percentage

District	Europe	East Asia and Australia	Canada	Mexico	Central and South America
Baltimore, MD	53.95	20.29	1.15	2.44	5.61
Boston, MA	54.83	14.28	4.98	7.19	0.69
Buffalo, NY	4.85	2.79	85.02	0.42	0.06
Charleston, SC	56.48	14.76	0.04	0.30	5.70
Charlotte, NC	35.61	20.13	0.34	0.51	0.88
Chicago, IL	16.24	37.71	0.25	0.16	0.46
Cleveland, OH	23.34	31.71	6.72	4.15	1.04
Columbia-Snake, OR	13.34	72.52	0.86	0.38	0.17
Dallas, TX	12.39	35.44	0.89	0.44	0.23
Detroit, MI	5.62	4.94	85.01	0.28	0.24
Duluth, MN	0.34	13.36	48.87	0.00	0.00
El Paso, TX	0.65	2.27	0.06	90.25	0.12
Great Falls, MT	18.05	7.97	33.89	10.45	10.45
Houston, TX	38.92	19.29	0.21	1.00	12.43
Laredo, TX	0.61	3.40	0.30	91.83	0.20
Los Angeles, CA	6.48	34.83	0.13	0.19	0.19
Miami, FL	20.66	12.44	0.65	10.13	33.24
Milwaukee, WI	73.62	10.23	4.68	0.90	0.36
Minneapolis, MN	36.75	20.82	0.59	0.29	0.39
Mobile, AL	40.01	37.28	1.40	0.34	7.50
New Orleans, LA	29.52	24.66	5.06	6.49	4.64
New York, NY	34.34	23.22	1.71	0.14	1.75
Nogales, AZ	5.87	3.65	1.46	83.36	0.14
Norfolk, VA	32.22	23.22	0.03	0.02	5.29
Ogdensburg, NY	3.29	2.21	90.53	0.15	0.04
Pembina, ND	4.13	2.26	91.18	0.57	0.10
Philadelphia, PA	60.52	13.14	0.94	0.19	5.01
Port Arthur, TX	53.82	34.54	0.00	8.44	0.49
Portland, ME	78.14	1.70	15.02	0.02	3.67
Providence, RI	56.36	12.58	0.04	21.07	0.06
St. Albans, VT	5.19	1.01	92.51	0.04	0.00
St. Louis, MO	15.00	46.51	2.64	0.47	0.69
San Diego, CA	4.54	13.61	0.03	79.27	0.04
San Francisco, CA	7.66	56.85	0.27	1.36	0.22
Savannah, GA	28.94	27.98	0.24	1.18	0.63
Seattle, WA	9.99	35.16	8.87	0.07	0.11
Tampa, FL	19.88	48.79	1.14	2.05	4.76
Washington, DC	78.10	11.06	4.20	0.19	0.41

Note: The table includes U.S. imports in NAICS 331-339.

TABLE 3: Variation in International Trade Costs across Industries and Districts in 2009

Three-Digit Manufacturing Industries	Mean of the Ad Valorem Rate	Standard Deviation of the Ad Valorem Rate	Share of Variation in the Rate Explained by Country Effects
Primary Metals NAICS 331	0.0645	0.0764	0.1315
Fabricated Metals NAICS 332	0.0662	0.0514	0.1335
Machinery NAICS 333	0.0450	0.0427	0.1348
Computers NAICS 334	0.0301	0.0489	0.1370
Electrical Equipment NAICS 335	0.0648	0.1204	0.0975
Transportation Equipment NAICS 336	0.0534	0.0546	0.1543
Furniture NAICS 337	0.0998	0.1013	0.1825
Medical Instruments et al. NAICS 339	0.0621	0.1024	0.0894

TABLE 4: Econometric Estimates of σ

The estimates are based on an industry-level specification with country and district fixed effects.

Point estimates with 95% confidence intervals in parentheses

Three-Digit Manufacturing Industries	Model 1: OLS	Model 2: NB PML without Imputation	Model 3: NB PML with Imputation	Model 2 without Canada or Mexico
Primary Metals NAICS 331	9.925 (6.408, 13.443)	8.652 (6.992, 10.312)	7.910 (6.197, 9.624)	8.155 (6.568, 9.742)
Fabricated Metals NAICS 332	8.110 (5.471, 10.749)	8.993 (6.705, 11.281)	7.293 (4.974, 9.612)	8.410 (6.154, 10.667)
Machinery NAICS 333	9.766 (6.299, 13.233)	7.530 (5.101, 9.958)	8.631 (6.165, 11.097)	7.225 (4.804, 9.645)
Computers NAICS 334	7.535 (4.285, 10.785)	6.447 (4.768, 8.125)	7.091 (5.399, 8.783)	6.464 (4.777, 8.152)
Electrical Equipment NAICS 335	4.887 (1.585, 8.190)	3.757 (2.751, 4.762)	3.852 (2.765, 4.939)	3.816 (2.821, 4.811)
Transportation Equipment NAICS 336	13.807 (10.953, 16.661)	13.916 (12.088, 15.744)	13.637 (11.751, 15.524)	13.805 (11.990, 15.621)
Furniture NAICS 337	5.418 (3.728, 7.108)	5.117 (3.418, 6.816)	2.022 (0.261, 3.784)	4.858 (3.241, 6.474)
Medical Instruments et al. NAICS 339	9.125 (5.676, 12.574)	6.297 (4.966, 7.628)	5.459 (4.256, 6.662)	5.940 (4.660, 7.220)

TABLE 5: Estimates for the GTAP Sectors and Comparison to the Estimates in Hertel et al. (2007)

Point estimates with 95% confidence intervals in parentheses

GTAP Sectors	NB PML without Imputation	Table 1 in Hertel et al. (2007)
Ferrous Metals	5.519 (3.860, 7.178)	5.9
Non-Ferrous Metals	10.814 (8.749, 12.879)	8.4
Fabricated Metals	8.410 (6.154, 10.667)	7.5
Machinery Equipment	6.312 (4.864, 7.760)	8.1
Electronic Equipment	6.464 (4.777, 8.152)	8.8
Motor Vehicles and Parts	7.209 (5.943, 8.476)	5.6
Other Transportation Equipment	12.809 (10.617, 15.001)	8.6
Other Manufacturing	5.940 (4.660, 7.220)	7.5

TABLE 6: Reductions in Electrical Equipment Imports from Other Countries

from Removing Tariffs on Electrical Equipment Imports from China

Point estimates with 95% confidence intervals in parentheses. Reduction in imports in percentage points.

Country	38 Regions $\omega = 1$	1 Region $\omega = 1$
Australia	-4.987 (-6.321, -3.652)	-3.687 (-4.673, -2.700)
Austria	-4.383 (-5.555, -3.209)	-3.687 (-4.673, -2.700)
Belgium	-4.220 (-5.349, -3.090)	-3.687 (-4.673, -2.700)
Brazil	-3.667 (-4.648, -2.685)	-3.687 (-4.673, -2.700)
Canada	-1.450 (-1.838, -1.062)	-3.687 (-4.673, -2.700)
Finland	-3.450 (-4.373, -2.527)	-3.687 (-4.673, -2.700)
France	-4.153 (-5.264, -3.041)	-3.687 (-4.673, -2.700)
Germany	-4.346 (-5.508, -3.182)	-3.687 (-4.673, -2.700)
India	-4.438 (-5.625, -3.250)	-3.687 (-4.673, -2.700)
Italy	-4.382 (-5.555, -3.209)	-3.687 (-4.673, -2.700)
Japan	-4.803 (-6.088, -3.517)	-3.687 (-4.673, -2.700)
Korea, South	-5.756 (-7.296, -4.215)	-3.687 (-4.673, -2.700)
Malaysia	-5.570 (-7.060, -4.079)	-3.687 (-4.673, -2.700)
Mexico	-0.432 (-0.548, -0.317)	-3.687 (-4.673, -2.700)
Netherlands	-4.272 (-5.415, -3.128)	-3.687 (-4.673, -2.700)
Singapore	-4.460 (-5.653, -3.266)	-3.687 (-4.673, -2.700)
Spain	-4.137 (-5.243, -3.029)	-3.687 (-4.673, -2.700)
Sweden	-4.307 (-5.458, -3.153)	-3.687 (-4.673, -2.700)
Taiwan	-4.941 (-6.262, -3.618)	-3.687 (-4.673, -2.700)
United Kingdom	-4.348 (-5.511, -3.184)	-3.687 (-4.673, -2.700)

TABLE 7: Reductions in Electrical Equipment Imports from Other Countries from Removing Tariffs on Electrical Equipment Imports from China

Point estimates with 95% confidence intervals in parentheses. Reduction in imports in percentage points.

Country	28 Regions $\omega = \sigma$	1 Region $\omega = \sigma$
Australia	-2.109 (-2.674, -1.544)	-1.483 (-1.880, -1.086)
Austria	-1.603 (-2.032, -1.174)	-1.483 (-1.880, -1.086)
Belgium	-1.401 (-1.776, -1.026)	-1.483 (-1.880, -1.086)
Brazil	-0.928 (-1.176, -0.679)	-1.483 (-1.880, -1.086)
Canada	-1.663 (-2.108, -1.218)	-1.483 (-1.880, -1.086)
Finland	-1.164 (-1.476, -0.853)	-1.483 (-1.880, -1.086)
France	-1.369 (-1.735, -1.002)	-1.483 (-1.880, -1.086)
Germany	-1.428 (-1.810, -1.046)	-1.483 (-1.880, -1.086)
India	-1.628 (-2.063, -1.192)	-1.483 (-1.880, -1.086)
Italy	-1.397 (-1.771, -1.023)	-1.483 (-1.880, -1.086)
Japan	-2.079 (-2.635, -1.522)	-1.483 (-1.880, -1.086)
Korea, South	-2.506 (-3.176, -1.835)	-1.483 (-1.880, -1.086)
Malaysia	-2.263 (-2.869, -1.657)	-1.483 (-1.880, -1.086)
Mexico	-0.159 (-0.202, -0.116)	-1.483 (-1.880, -1.086)
Netherlands	-1.540 (-1.952, -1.127)	-1.483 (-1.880, -1.086)
Singapore	-1.449 (-1.837, -1.061)	-1.483 (-1.880, -1.086)
Spain	-1.162 (-1.473, -0.851)	-1.483 (-1.880, -1.086)
Sweden	-1.419 (-1.798, -1.039)	-1.483 (-1.880, -1.086)
Taiwan	-1.870 (-2.371, -1.369)	-1.483 (-1.880, -1.086)
United Kingdom	-1.461 (-1.851, -1.069)	-1.483 (-1.880, -1.086)

TABLE 8: Percentage Decline in the Import Price Index in Each District in Each Region Resulting from Eliminating the Industry's Tariffs on Imports from China, 38 Region Scenario and One Region Scenario

Three-Digit Manufacturing Industries	38 Regions Minimum	One Region	38 Regions Maximum
Primary Metals NAICS 331	0.000	0.079	2.994
Fabricated Metals NAICS 332	0.001	0.836	1.828
Machinery NAICS 333	0.000	0.123	0.418
Computers NAICS 334	0.000	0.180	0.561
Electrical Equipment NAICS 335	0.000	0.981	2.682
Transportation Equipment NAICS 336	0.000	0.104	0.727
Furniture NAICS 337	0.000	0.121	0.402
Medical Instruments et al. NAICS 339	0.000	0.527	3.177

TABLE 9: Simulated Changes in Consumer Prices and Tariff Revenue for the 38-Region Scenario

Point estimates with 95% confidence intervals in parentheses. Changes reported in hundredths of a percent.

District	Decline in Consumer Price Index		Decline in Tariff Revenue Distributions	
	38 Regions	1 Region	38 Regions	1 Region
Baltimore, MD	0.23			
Boston, MA	0.38			
Buffalo, NY	0.13			
Charleston, SC	0.30			
Charlotte, NC	0.48			
Chicago, IL	0.50			
Cleveland, OH	0.43			
Columbia-Snake, OR	0.62			
Dallas, TX	0.72			
Detroit, MI	0.08			
Duluth, MN	0.60			
El Paso, TX	0.06			
Great Falls, MT	0.37			
Houston, TX	0.30			
Laredo, TX	0.01			
Los Angeles, CA	0.69			
Miami, FL	0.34			
Milwaukee, WI	0.28			
Minneapolis, MN	0.61	0.40	0.40	0.40
Mobile, AL	0.34			
New Orleans, LA	0.61			
New York, NY	0.47			
Nogales, AZ	0.24			
Norfolk, VA	0.52			
Ogdensburg, NY	0.03			
Pembina, ND	0.04			
Philadelphia, PA	0.47			
Port Arthur, TX	0.00			
Portland, ME	0.28			
Providence, RI	1.08			
St. Albans, VT	0.06			
St. Louis, MO	0.79			
San Diego, CA	0.04			
San Francisco, CA	0.55			
Savannah, GA	0.06			
Seattle, WA	0.66			
Tampa, FL	0.40			
Washington, DC	0.04			