ESTIMATING TRADE DIVERSION AT MONTHLY AND ANNUAL FREQUENCY

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Abstract

We estimate the elasticity of substitution between U.S. imports of citrus fruit from different countries and the extent of trade diversion, using monthly trade data disaggregated by customs district of entry. The estimates based on these high frequency import data are more precise and informative than estimates based on annual data. We extend the analysis to include U.S. imports of other seasonal fruit.

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1 Introduction

Methods for estimating the elasticity of substitution between imports from different countries and the extent of potential trade diversion usually rely on annual import data at the country level. However, this is not ideal, especially for studying trade in products with seasonal fluctuations in supply. Analysis of annual country-level data misses important heterogeneity in the timing and location of import entries. The overlap of imports from different sources is a critical determinant of the extent of potential trade division.

In this paper, we develop a method for estimating the elasticity of substitution for U.S. imports of citrus fruit using the trade cost method in Riker (2020), Schreiber (2022), and Schrammel and Schreiber (2023) and district-level U.S. import data at a monthly frequency.[1] We find that estimates of the elasticity of substitution based on monthly data are more precisely estimated and informative than estimates based on annual data. We also find that the extent of overlap between imports from different source countries determines the extent of potential trade diversion between the countries.

For example, there is little potential for trade diversion between imports of citrus fruit from Australia and Israel, because these imports rarely overlap in the same districts in the same months. Imports from Australia mostly enter the West Coast in the Los Angeles, CA district (76.0 percent of total), between January and May, while imports from Israel mostly enter the East Coast New York, NY district (55.5 percent of total) and Philadelphia, PA district (42.9 percent of total), between July and October. The second largest import district for Australian citrus is Philadelphia, PA (9.3 percent of total), but there are only two months of overlap with imports from Israel during the five-year period due to seasonal differences between the two countries.

On the other hand, there appears to be substantial potential for trade diversion between

[1] A district is a group of ports where imports clear customs and enter the United States.

imports from Chile and Peru. Import from both countries are concentrated in Houston, Los Angeles, and Miami and arrive between May and November each year. In districts and months when they overlap, we estimate that a 10% increase in the tariff factor or other trade costs on imports from Peru results in a 46.09% increase in the import penetration ratio from Chile relative to the import penetration ratio from Peru. Just as annual data can lead to imprecise estimates of the elasticity of substitution, they can also provide a misleading indication of overlap.[2]

The rest of the short paper is presented in six parts. Section 2 introduces the economic framework. Section 3 describes the data that we analyze. Section 4 reports our econometric estimates of the elasticity of substitution between U.S. imports of citrus fruit from different countries. Section 5 reports our estimates of the extent of trade diversion between pairs of countries. Section 6 extends the analysis to imports of other seasonal fruits. Section 7 concludes.

2 Economic Framework

The concept of trade diversion has been studied in an extensive literature that started with Viner (1950) and has continued for decades, including recent contributions from Cheong, Kwak and Tang (2015), Cigna, Meinen, Schulte and Steinhoff (2022), and Mattoo and Ruta (2022). Trade diversion occurs when a tariff on imports from a one country reduces imports from that country and increases imports from a second country. The extent of trade diversion is often compared to the extent of trade creation in order to assess the net economic benefits of changes in trade policies or other barriers to trade. Cigna et al. (2022) finds little evidence of trade diversion in the short-term in response to the 2018 U.S. tariffs on China, though one of the reasons they provide for this finding is that there may be domestic substitution. Cheong

[2]They generally overstate overlap, though there are special scenarios where annual data under estimates the overlap of imports from two different source countries. We address this in detail in Section 5.

et al. (2015) finds that the magnitude of trade divergence is larger than previously though and comparable to the magnitude of trade creation. An important difference between our paper and the previously mentioned papers is that we measure trade diversion and competition using district level subnational data.

The conventional – though often implicit – assumption in estimates of the substitution between imports from different countries is that all of a country's imports from these countries that arrive in the same year compete with each other in a common national market, and they are interchangeable with each other regardless of where and when they enter the United States that year. However, this simplifying assumption is not close to realistic for seasonal fruit sold in the United States, a large country with product markets that are geographically segmented by significant domestic shipping costs. To understand trade diversion in the United States, it is critical to consider not only the elasticity of substitution but also the overlap of the timing and location of import entry. If imports from two sources do not overlap in the same part of the country in the same month, there is little potential for trade diversion.

In this paper, we build a partial equilibrium model based on a specific demand function. Equation (1) relates the value of imports of product j from country c into district d in period t (v_{jcdt}) to product-district-period aggregate expenditure and an industry price index (E_{jdt} and P_{jdt}), the elasticity of substitution (σ_j), the producer price of exports of product j from country a in time period t (p_{jct}), and a trade cost factor (f_{jcdt}). This constant elasticity of substitution (CES) demand function is the basis for the trade cost method in Riker (2020).

$$v_{jcdt} = E_{jdt} \ (P_{jdt})^{\sigma_j \ - \ 1} \ (p_{jcdt} \ f_{jcdt})^{1 \ - \ \sigma_j} \tag{1}$$

To simplify the model, we assume that each district supplies a distinct and separate pool of U.S. consumers, due to significant domestic shipments. This assumption is implicit in district-indexed E_{jdt} and P_{jdt} in equation (1).[3]

Equation (2) restates equation (1) in terms of product-country-period and product-district-period fixed effects (α_{jct} and γ_{jdt}), a trade cost elasticity (β_j), and the trade cost factor (f_{jcdt}).

$$v_{jcdt} = e^{\,\alpha_{jct} \, + \, \gamma_{jdt}} \, \left(f_{jcdt}\right)^{\,\beta_j} \tag{2}$$

Equation (1) implies that $\gamma_{jdt} = \ln E_{jdt} \, + \, (\sigma_j \, - \, 1) \, \ln P_{jdt}$, $\alpha_{jct} = (\sigma_j \, - \, 1) \, \ln p_{jct}$, and $\beta_j = 1 \, - \, \sigma_j$. Equation (2) is the basis for the econometric specification in Section 4.

3 Data Sources and Definitions

Our analysis relies on data on U.S. imports for consumption, both landed duty-paid value and customs value, from the U.S. International Trade Commission's Dataweb.[4] These data are disaggregated by source country, four-digit Harmonized Tariff Schedule (HTS) code within Chapter 8 (edible fruit and nuts), and customs district where the imports entered the United States. We use the landed duty-paid value of imports for v_{jcdt} and the ratio of the landed duty-paid value of the imports divided by their customs value for the trade cost factor f_{jcdt}. The landed duty-paid value includes tariffs as well as international freight costs and insurance.

Our simplifying assumption that each district supplies a distinct and separate pool of U.S. consumers is less likely for imports from Canada and Mexico, because the large volume of land crossings in districts like Laredo, Texas are probably not closely tied to local consumer markets in Texas. To avoid this problem, we limit the estimation sample to imports from

[3]With this assumption, it is not necessary to measure the size or scope of the consumer market served by imports into district d in the econometric analysis in Section 4.

[4]These data are all publicly available on the U.S. International Trade Commission's Dataweb at `https://dataweb.usitc.gov`.

countries outside of North America.

4 Econometric Estimates

Equation (3) is the econometric specification based on equation (2). It includes a multiplicative error term η_{jcdt}. We estimate β_j, and therefore the elasticity of substitution $\sigma_j = 1 - \beta_j$, using the Poisson Pseudo-Maximum Likelihood (PPML) estimator, following the trade models in Santos Silva and Tenreyro (2006) and Yotov, Piermartini, Monterio and Larch (2016).

$$v_{jcdt} = e^{\beta_j \; ln \; f_{jcdt} + \alpha_{jct} + \gamma_{jdt}} \times \eta_{jcdt} \tag{3}$$

We assume that the variation in f_{jcdt} is independent of the error term. We use a large set of fixed effects to control for unobserved aggregate expenditure, industry price indices, and producer prices of imports.

Table 1 reports the point estimates of σ_j for U.S. imports of citrus fruit (HTS code 0508) using monthly and annual data, along with 95% confidence intervals in parentheses.

Table 1: Econometric Estimates for Imports of Citrus Fruit

	Using Monthly Data	Using Annual Data
σ_j	4.609	4.306
	(2.975 - 6.242)	(1.670 - 6.943)
Number of Observations	2,069	450
Pseudo R-Squared	0.9259	0.9335

The point estimate based on monthly import data is more precise than the estimate based on annual import data. The magnitudes of the estimates are similar, though the estimate using monthly import data is larger. We use this estimate, $\sigma_j = 4.609$, in the calculations of trade diversion in the next section.

5 Overlap and the Extent of Trade Diversion

The elasticity of substitution is, by definition, the percent change in relative demands with respect to relative prices. We use the estimate of σ_j in Table 1 to simulate the change in relative expenditure on imports from each pair of countries, or equivalently the change in their relative import penetration rates. Equation (4) is expenditure on imports from country a relative to expenditure on imports from country b in the market for product j in time period t entering district d.

$$\frac{v_{jadt}}{v_{jbdt}} = \left(\frac{p_{jat}\ f_{jadt}}{p_{jbt}\ f_{jbdt}}\right)^{1\ -\ \sigma_j} \tag{4}$$

Equation (5) converts equation (4) into percent changes after log linearizing.

$$\hat{R}_{jabdt} = (1\ -\ \sigma_j)\left(\hat{p}_{jat}\ +\ \hat{f}_{jadt}\ -\ \hat{p}_{jbt}\ -\ \hat{f}_{jbdt}\right) \tag{5}$$

R_{jabdt} represents the ratio $\frac{v_{jadt}}{v_{jbdt}}$.

We use equation (5) to simulate the effect of a hypothetical 10% increase in trade costs on imports from country b. This could be an increase in tariffs or international freight costs. $\hat{f}_{jbdt} = 0.10$, while $\hat{f}_{jadt} = 0$. In this simulation we adopt the simplifying partial equilibrium assumption that $\hat{p}_{jat} = \hat{p}_{jbt} = 0$. This will be the case, for example, whenever these producer prices are pinned down by factor prices set on economy-wide factor markets.

We define I_{jadt} and I_{jbdt} as binary variables that indicate whether there are imports of product j into district d in period t from country a or country b, respectively. There is no trade diversion from country b to imports from country a in the market for product j in district d in time period t if $I_{jadt}\ I_{jbdt} = 0$ (if imports from countries a and b do not overlap in market jdt). Equation (6) is the magnitude of trade diversion from the 10% increase in f_{jbdt} if $I_{jadt}\ I_{jbdt} > 0$ (if imports from countries a and b overlap in market jdt).

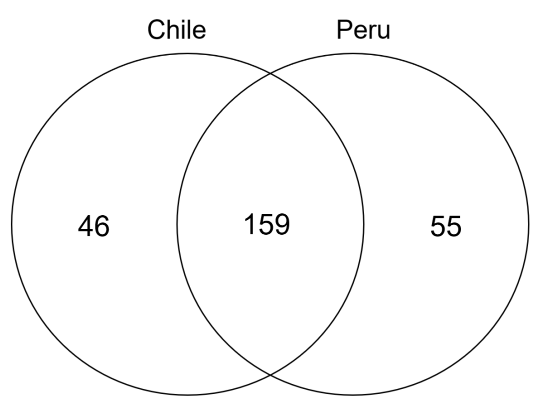
$$\hat{R}_{jabdt} = I_{jadt}\ I_{jbdt}\ (\sigma_j\ -\ 1)\ (0.10) \tag{6}$$

To summarize whether there is frequently a potential for trade diversion from product j imports from country a to imports from country b, equation (7) provides a statistic for their overlap, Ω_{jab}. It is the ratio of the number of district-months with imports from both countries to the number of district-months with imports from at least one of the countries.

$$\Omega_{jab} = \frac{\sum_d \sum_t I_{jadt}\ I_{jbdt}}{\sum_d \sum_t (I_{jadt}\ +\ I_{jbdt}\ -\ I_{jadt}\ I_{jbdt})} \tag{7}$$

We illustrate this overlap ratio using imports of citrus fruit from Chile and Peru as an example.

Figure 1: Example of Overlap Ratio for Chile and Peru



The number of districts with imports of citrus fruit from Chile in a given year and month but no imports from Peru is 46. The number of districts with imports of citrus fruit from Peru in a given year and month but no imports from Chile is 55. The number of districts with imports of citrus fruit from both Peru and Chile in the same year and month is 159. Ω_{jab} is the ratio of the intersection to the union. For citrus imports from Chile and Peru, the ratio is calculated as follows:

$$\Omega_{Citrus,\ Chile,\ Peru} = \frac{159}{46 + 159 + 55} = \frac{159}{260} = 0.612 \tag{8}$$

In this case, Chile and Peru tend to import citrus into the same districts (Houston-Galveston, TX, Los Angeles, CA, Miami, FL, Philadelphia, PA, Savannah, GA) between the months of May and November. These imports account for 145 of the 159 occurrences of overlap in the five year period from 2018–2022. Chile imports into more districts than Peru which explains 21 of 46 occurrences where imports from Chile do not compete with imports from Peru. While the peak months for citrus imports from Peru and Chile are May through November, Peru imports more than Chile in December through April. Peru imports in December through April account for 50 out of the 55 occurrences where they do not compete with imports from Chile. This illustrates the importance of using monthly data, especially when looking at goods where import competition is dependent on seasonality.

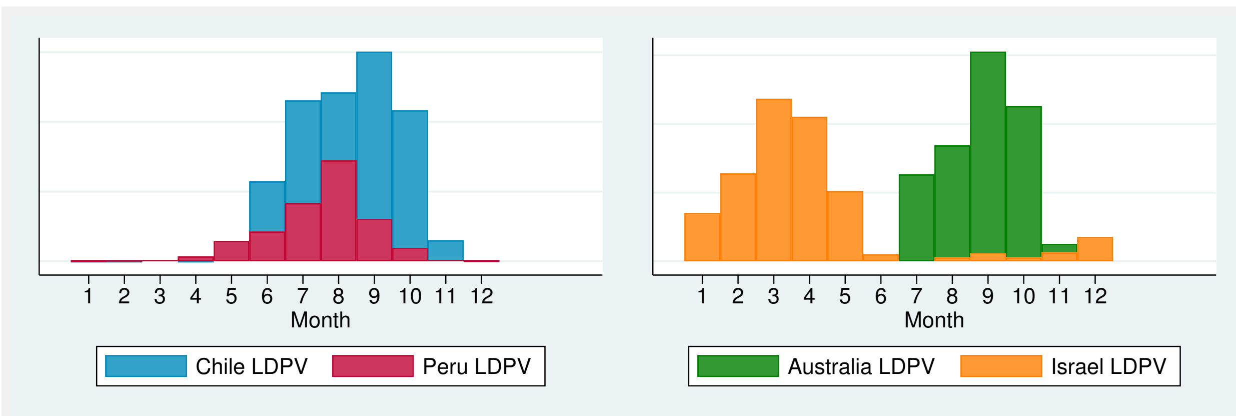
Table 2 reports the overlap ratio Ω_{jab} for imports of citrus fruit from the top ten import sources for citrus fruit. The values for Ω_{jab} range from zero to one. They are symmetric around the diagonal, so the table focuses on the upper triangle of the matrix.

Table 2: Overlap Ratio for Top Ten Importers of Citrus at Monthly Frequency

	Argentina	Australia	Chile	Colombia	Israel	Mexico	Morocco	Peru	South Africa	Uruguay
Argentina	1.000	0.214	0.330	0.247	0.052	0.024	0.205	0.311	0.314	0.352
Australia		1.000	0.311	0.084	0.012	0.002	0.096	0.249	0.180	0.240
Chile			1.000	0.254	0.058	0.059	0.171	0.612	0.276	0.188
Colombia				1.000	0.263	0.089	0.358	0.411	0.190	0.193
Israel					1.000	0.019	0.475	0.159	0.176	0.095
Mexico						1.000	0.011	0.066	0.014	0.005
Morocco							1.000	0.262	0.306	0.250
Peru								1.000	0.260	0.191
South Africa									1.000	0.348
Uruguay										1.000

The values for Ω_{jab} range from 0.012 (Israel and Australia) to 0.612 (Chile and Peru) with an average of 0.241 and median of 0.248.[5] Country pairs with similar climates and geographic locations relative to the import districts tend to have a higher percentage of overlap: Columbia and Peru, Peru and Chile, Israel and Morocco. While country pairs with differentiated climates and geographic locations tend to have a lower percentage of overlap: Israel and Australia, Morocco and Australia, Israel and Chile. Outside of Mexico the small overlap ratios for country pairs are largely due to seasonal differences in citrus imports (Figure 2).

Figure 2: Seasonal Competition of Imports



We find that the overlap ratios for imports of citrus by country pairs calculated using data collected at annual frequency (reported in table 3) are on average 2.25 times larger than the ratios calculated using data at the monthly frequency. There are two main reasons that the annual overlap ratios are larger: a country imports into a district for a large number of months in a given year without competition from the paired country, or a country imports into a district for a large number of months and only competes with the paired country in a small number of those months. South Africa and Colombia is a country pair where both reasons are true.

[5]Mexico was included in the table since they are one of the largest importers of citrus into the U.S., but not included in the econometric estimation, because almost all of their imports come into the Laredo, TX customs district. All consumption of Mexican imports of citrus is not occurring in or close to this district.

In 2020, Colombia imports citrus into Miami, FL and Nogales, AZ in 12 months and one month of the year, respectively, absent any competition from citrus imports from South Africa. In the calculation of Ω_{jab} at the monthly frequency, we would add 12 to the denominator for imports into Miami, FL and one into the denominator for imports into Nogales, AZ. In the Ω_{jab} calculation using annual frequency, imports into Miami, FL and Nogales, AZ in 2020 are considered at the same weight of one.

Additionally, in 2018, South Africa imported citrus into Philadelphia, PA in seven months of the year and only competed with imports from Colombia in one of those months. In 2020, South Africa imported citrus into Philadelphia, PA in seven months of the year and competed with imports from Colombia in all seven months. At the monthly frequency we would add one to the numerator for 2018 and seven for 2020 imports into Philadelphia, PA, where the two countries compete, when calculating Ω_{jab}. At the annual frequency the competing imports into Philadelphia, PA in 2018 and 2020 are given the same weight of one in the calculation of Ω_{jab}.

Table 3: Overlap Ratio for Top Ten Importers of Citrus at Annual Frequency

	Argentina	Australia	Chile	Colombia	Israel	Mexico	Morocco	Peru	South Africa	Uruguay
Argentina	1.000	0.257	0.450	0.500	0.478	0.111	0.310	0.594	0.423	0.333
Australia		1.000	0.476	0.167	0.118	0.049	0.273	0.375	0.206	0.280
Chile			1.000	0.465	0.333	0.200	0.333	0.769	0.375	0.179
Colombia				1.000	0.560	0.204	0.387	0.600	0.556	0.222
Israel					1.000	0.149	0.391	0.452	0.550	0.294
Mexico						1.000	0.074	0.164	0.075	0.043
Morocco							1.000	0.441	0.522	0.444
Peru								1.000	0.500	0.258
South Africa									1.000	0.316
Uruguay										1.000

There are special scenarios where the overlap ratios calculated from the annual data are smaller than the ratios calculated from the monthly data. This tends to occur when one country in a country pair imports into many districts and the other imports into few districts.

Those few districts account for a large number of the months that they compete and a large amount of the total months each country imports into the U.S. Furthermore, there has to be little year-over-year variation in the number of months that the citrus imports from each country compete in the given district. The country pair of Argentina and Uruguay is an example of this scenario.

Argentina imports citrus into seven different districts during the time period from 2018–2022, with imports into Philadelphia, PA occurring in the largest number of months each year. All of the citrus imports from Argentina face competition from Uruguay in each month they are imported into Philadelphia, PA. In the monthly calculation, the six other districts that Argentina import into are discounted in the denominator of the Ω_{jab} since they account for a small portion of the total number of months they import citrus into a given district. In the annual calculation they are given equal weight. The numerator in this case is weighted fairly accurately by the annual data since most of the competition is occurring in Philadelphia, PA and the year-over-year variation in the number of months each country's citrus imports compete in the customs district is small. They compete in Philadelphia, PA in five months of the year in 2018 and 2020 and six months of the year in 2019, 2021, and 2022. The over weighted denominator and similarly weighted numerator results in the overlap ratio calculated at the annual frequency to be smaller than the ratio calculated at the monthly frequency.

The annual estimates of the overlap ratio tend to have a positive bias except in special scenarios where the bias is negative. The direction of the bias is not the most important finding, but rather the existence of bias in general. The monthly data provides a better estimate of import competition than the annual data.

6 Extending the Analysis to Imports of Other Fruits

It is straightforward to extend the analysis to other imported products, since the model has minimal data requirements, by design, and all of the data are publicly available. In this section, we reproduce the analysis for several other seasonal fruits. Table 4 reports estimates of the elasticity of substitution for imports of bananas, dates, and melons.

Table 4: PPML Estimates for Additional Fruits

Four-Digit HTS Code	Using Monthly Data	Using Annual Data
Bananas	8.433	10.671
(HTS 0803)	(7.370 - 9.496)	(8.734 - 12.608)
Dates	4.627	4.130
(HTS 0804)	(4.014 - 5.240)	(2.481 - 5.780)
Melons	3.641	3.203
(HTS 0807)	(2.993 - 4.288)	(1.776 - 4.629)

Tables 5, 6, and 7 report the overlap ratio Ω_{jab} for imports of these additional fruits.

Table 5: Overlap Ratio for Top Ten Importers of Bananas

	Colombia	Costa Rica	Ecuador	Guatemala	Honduras	Mexico	Nicaragua	Panama	Peru	Thailand
Colombia	1.000	0.583	0.541	0.488	0.637	0.264	0.431	0.354	0.511	0.207
Costa Rica		1.000	0.735	0.627	0.492	0.378	0.384	0.322	0.662	0.204
Ecuador			1.000	0.594	0.423	0.358	0.323	0.273	0.558	0.279
Guatemala				1.000	0.428	0.438	0.323	0.275	0.492	0.189
Honduras					1.000	0.202	0.378	0.302	0.534	0.080
Mexico						1.000	0.265	0.244	0.289	0.199
Nicaragua							1.000	0.441	0.361	0.210
Panama								1.000	0.260	0.154
Peru									1.000	0.128
Thailand										1.000

Table 6: Overlap Ratio for Top Ten Importers of Dates

	Brazil	Chile	Costa Rica	Dominican Rep	Ecuador	Honduras	Mexico	Peru	Thailand	Turkey
Brazil	1.000	0.164	0.112	0.244	0.161	0.172	0.013	0.100	0.066	0.097
Chile		1.000	0.196	0.254	0.261	0.168	0.049	0.211	0.141	0.159
Costa Rica			1.000	0.271	0.378	0.419	0.236	0.483	0.255	0.260
Dominican Rep				1.000	0.349	0.291	0.010	0.294	0.196	0.217
Ecuador					1.000	0.189	0.135	0.353	0.207	0.237
Honduras						1.000	0.024	0.307	0.085	0.126
Mexico							1.000	0.164	0.153	0.078
Peru								1.000	0.251	0.312
Thailand									1.000	0.385
Turkey										1.000

Table 7: Overlap Ratio for Top Ten Importers of Melons

	Belize	Brazil	Canada	Costa Rica	Dominican Rep	Guatemala	Honduras	Jamaica	Mexico	Panama
Belize	1.000	0.310	0.000	0.061	0.653	0.230	0.166	0.300	0.012	0.657
Brazil		1.000	0.000	0.215	0.390	0.472	0.351	0.199	0.018	0.325
Canada			1.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000
Costa Rica				1.000	0.092	0.384	0.655	0.049	0.070	0.090
Dominican Rep					1.000	0.304	0.231	0.311	0.011	0.692
Guatemala						1.000	0.545	0.155	0.031	0.273
Honduras							1.000	0.114	0.040	0.235
Jamaica								1.000	0.008	0.280
Mexico									1.000	0.009
Panama										1.000

7 Conclusions

We estimate the elasticity of substitution between U.S. imports of citrus fruit from different countries and the extent of trade diversion between imports from specific pairs of countries using high frequency trade data disaggregated by district of entry. The estimates based on the monthly data are more precise and informative than comparable estimates based on annual data.

The analysis demonstrates the utility of high frequency, sub-national import data. The extent of potential trade diversion of seasonal imports depends on the geographic and temporal overlap of import entry. An analysis based on annual data will miss important heterogeneity and usually overstates the overlap between imports from different countries.

We show that our method is useful for estimating the elasticity of substitution and the extent of overlap and trade diversion, but it has limitations. In its current form, the method is not able to estimate the impact of a trade cost shock on domestic producers or on the average prices faced by domestic consumers. This would require additional data on domestic production and sales data at the same level of spatial and temporal disaggregation as the import data, or a method for estimating the import penetration rate using only the trade data, so this is a challenge for future research.

Another limitation is that the assumption that each district serves a distinct and separate sub-national market in the United States is too strong, and it is probably a source of imprecision in the estimates of the extent of trade diversion. Still, information on the district of import entry helps us to incorporate observable differences in overlap when assessing the potential for diversion.

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