U.S. Import and Export Elasticities: A Panel Data Approach

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Abstract

This paper describes the creation of a new dataset on sectoral-level import and export elasticities in the U.S. between the years 1978-2001. In particular, it proposes the use of Arellano and Bond panel data techniques as a means of estimating these elasticities while controlling for the endogeneous variables. In particular, it provides a dataset listing trade elasticities for a broad range of sectors at the NAICS 4-digit, and 6-digit, and the HS 6-digit, 8-digit 10-digit levels of industry aggregation. For import demand elasiticities, estimates are also provided at the ISIC 3-digit and the SIC 3-digit and 4-digit levels of industry aggregation. These results are compared to previous estimates in the literature, and we apply the new dataset to Gawande and Bandyopadhyay's empirical test of the "Protection for Sale" model. The resulting estimates can be used in a wide-range of applications in empirical studies of international trade policy, particularly in analyzing the welfare effects of international trade.

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1 Introduction

Import demand elasiticies are an important variable for any researcher who wishes to do empirical work in international trade policy. Even the most basic models of international trade tell us that the extent to which changes in import prices (be they from trade barriers or changes in supply and demand on world markets) affect the welfare of the importing country are dependent on the extent to which those changes in prices affect quanitities of imports. Other things being equal, a country that imposes a tariff on a good for which the demand for imports is highly elastic will suffer a greater welfare loss than if it imposed a similar tariff on a good with a less elastic demand. Not surprisingly, then, import demand elasticities have appeared as a variable in many recent empirical studies of the domestic political economy of trade policy. (See, for example, Goldberg and Maggi (1999), Gawande and Bandyopadhyay (2000), Eicher and Osang (2002) and Hauk (2007) for examples.)

However, despite the importance of trade elasticity estimates to empirical research in international trade policy, the availability of this data at the sectoral level has been scarce until relatively recently. All of the papers cited above use as their measure of import demand elasiticities estimates derived by Shiells, Stern and Deardorff (1986, henceforth SSD).[1] Despite this paper's wide use in the literature, its continued use as a source for data on import elasticities suffers from three obstacles. The first is the relative age of the data used to compute the elasticity estimates. SSD's data come from the period 1962-1978, which was a good time span for researchers who wished to make predictions about the U.S. economy in the 1980s, but is inappropriate for work done in the 1990s and 2000s. Secondly, SSD use a relatively high level of industry aggregation for their estimates – the 3-digit U.S. Standard Industrial Classification (SIC) system. While this system is useful for comparing to domestic data, its applicability to trade policy is hampered on two counts. First the SIC system is not the industry classification method that the U.S. uses for imports of goods and services produced abroad.[2] Prior to 1989, imports into the U.S. were classified according to the Tariff Schedule of the United States Annotated (TSUSA) system, and since 1989, they have been classified according to the Harmonised Tariff Schedule (HS) system. Secondly, under the TSUSA system, tariff and non-tariff barriers were applied at the 7-digit industry aggregation level and are applied at the 10-digit level under the current HS system. Hence, in order to know the economic effect of particular trade barriers, we would want elasticity estimates at these levels of disaggregation. Finally, as will be discussed later in the paper, SSD's estimation method does not provide us with a way of estimating the "pass-through" value of tariffs, which are also important for knowing the economic impact of a trade barrier.

Kee, Nicita and Olarreaga (2004, henceforth KNO) have provided an important improvement on the

[1] A recent search on scholar.google.com yielded 106 other citations of this paper.

[2] Since the 1997 Economic Census, the SIC system is no longer even used for domestic economic statistics, as it was replaced by the North American Industry Classification System (NAICS) in order to harmonize economic records with Canada and Mexico.

SSD estimates on two dimensions. First, they estimate import demand elasiticities for 117 countries at the HS 6-digit level. Secondly, they do so using data from the years 1988-2002. Nicita and Olarreaga (2006) also estimate import demand elasiticities for 3-digit International Standard Industrial Classification (ISIC) sectors for several countries spanning the time period 1976-2004. Their precise estimation technique makes use of a GDP function first proposed by Kohli (1991) where demand for imports is a function of the prices of all goods and of aggregate endowments. The GDP function methodology translates directly into a means of analyzing the actual welfare effects of trade distortions. However, it also requires using several assumptions about homogeneity of and invariance of production and demand functions. The accuracy of the elasticity estimates will depend to some degree on the validity of the theoretical assumptions made.

This paper differs from these more recent works by KNO in three different respects. First, it will provide estimates for trade elasticities at the HS 6, 8 and 10 digit levels, the NAICS 4 and 6 digit levels and the SIC 3 and 4 digit levels, giving us flexibility that we can use to analyze the effects of government policies at different levels of industry aggregation. It will also allow us to compare our results with several other previous estimates of import demand elasticities. It will also attempt to estimate tariff pass-through values along with the trade elasticity estimates.

Most importantly, the paper also proposes a new panel-data estimation technique. Starting with the assumption that imported goods from different countries of origin may be imperfect substitutes for each other and for domestically-produced goods within the same sector, we break our data down into observations by both economic sector and country of origin. This step allows us to use an Arellano and Bond (1991) style GMM panel data estimator, which allows us to utilize the great amount of country-level import data that we have and provides us with an instrumental variables technique that will solve the considerable endogeneity problems that arise when estimating elasticity regressions.

Import demand elasticities are only one side of a country's trade relations. We also add to the existing literature in also estimating the U.S.'s export supply elasticities. As in our work with import demand elasticities, we use a panel data set with U.S. exports arranged by destination country from the years 1978-2001. We use these data to calculate export supply elasticities at the HS 6, 8 and 10 digit levels and the NAICS 4 and 6 digit levels.

In addition to describing the methodology used to obtain these elasticity estimates, this paper also compares our estimates to estimates from previous work. It also evaluates the impact of our estimates on a well-known empirical study that uses import demand elasticities – the empirical test of the Grossman and Helpman (1994) "Protection for Sale" Model done by Gawande and Bandyopadhyay (2001).

2 Estimation Method For Import Demand Elasticities

2.1 Basic Equations

The main relationship that we want to know is the percentage change in imports of a particular product into the U.S. as a function of the percentage change in prices of that imported product. Econometrically, we would like to estimate the following equation:

$$\log q^M_{i,j,t} = a_{i,0} + a_{i,1} \log p^M_{i,j,t} + A_i' X_{i,j,t} + \varepsilon_{a,i,j,t}$$

where $q^M_{i,j,t}$ is the quantity of good i imported into the U.S. from country j at time t, $p^M_{i,j,t}$ is the price of the imported good, $\varepsilon_{a,i,j,t}$ is an error term, and $a_{i,1}$ can be interpreted as the own-price elasticity of demand for imports of the good in question.[3] We also include a vector of covariates $X_{i,j,t}$ and their associated coefficients A_i. Our regressions include the following variables as covariates in the demand equation: the price of the competing domestic good, the average price of imported goods from other countries in the same sector, the GDP deflator in the U.S., real GDP in the U.S., and, to account for possible rigidities in responses to market changes, a lagged value of the quantity of the good imported.

One major concern that we need to address is the problem of endogeneity. While it is likely that there is a causal effect of the price of an import on the amount of the good that is imported, it is equally possible that the price of an import will depend on the quantity of the good imported. SSD address this issue by estimating not only an import demand equation, but a system of five simultaneous equations including an import demand equation, an import supply equation, a domestic good demand equation, a domestic good supply equation and an expenditure equation. By performing a 3SLS estimation on the system, SSD are able to resolve potential endogeneity problems, albeit at the cost of having to collect data for many more variables than appear in the equation of primary interest and thereby losing some degrees of freedom in a small-sample estimation. KNO address the endogeneity problem by estimating a structural equation based on GDP maximization function. They are able to identify the structural parameters from their model and use these to estimate import demand elasticities. While the method addresses the endogeneity problem, it also makes their estimates a function of the model that they use and the restrictions that they need to impose to identify their parameters.

[3] To see this, note that including the constant term $a_{i,0}$ in the regression effectively differences the both the left-hand side and right-hand side variables from their respective means. A total derivative of both sides of the equation yields

$$\begin{aligned}
\frac{\partial \log q^M_{i,j,t}}{\partial q^M_{i,j,t}} dq^M_{i,t} &= a_{i,1} \frac{\partial \log p^M_{i,j,t}}{\partial p^M_{i,j,t}} dp^M_{i,j,t} \\
\frac{1}{q^M_{i,j,t}} dq^M_{i,j,t} &= a_{i,1} \frac{1}{p^M_{i,j,t}} dp^M_{i,j,t} \\
\frac{dq^M_{i,j,t}/q^M_{i,j,t}}{dp^M_{i,j,t}/p^M_{i,j,t}} &= a_{i,1}
\end{aligned}$$

which is the elasticity of demand for the product.

We take a different approach to the endogeneity question. Using the data described below from the Center for International Data, we collect a panel of data that includes not only imports by sector and year into the U.S., but also by country of origin. Creating a panel data set allows us to use the Arellano and Bond (1991) GMM panel-data estimator where potentially endogenous first-differenced variables are instrumented for by lagged levels of those variables. Using country-level observations also gives us more data points in our elasiticity regressions and enables us to consider the possibility that the prices of imports may be the result of country-specific shocks abroad. We may also consider the possibility that imports classified within the same economic sector but from different countries of origin may be imperfect substitutes for each other.

While the instruments included with the Arellano and Bond estimator eliminate the need for a system of simultaneous equations, we will estimate two separate equations. For the purposes of this paper, an import demand equation that measures the responsiveness to quantities of imports with respect to import prices and other relevant variables will be our primary regression of interest. However, we are also interested the determinants of the price of imports, and an import supply equation will also be added to our estimates. Hence our two regression equations will be:

$$\begin{aligned}
\log q^M_{i,j,t} &= a_{i,0} + a_{i,1}\log p^M_{i,,j,t} + a_{i,2}\log p^D_{i,t} + a_{i,3}\log p^M_{i,\tilde{},j,t} + a_{i,4}\log P_t + a_{i,5}\log Y_t \qquad (1)\\
&\quad + a_{i,6}\log q^M_{i,j,t-1} + \varepsilon_{a,i,j,t}\\
\log p^M_{i,,j,t} &= b_{i,0} + b_{i,1}\log q^M_{i,j,t} + b_{i,2}\log p^D_{i,t} + b_{i,3}\log p^M_{i,\tilde{},j,t} + b_{i,4}\log(1+t)_{i,j,t} + b_{i,5}\log(1+t)_{i,\tilde{}j,t} \qquad (2)\\
&\quad + b_{i,6}\log(1+r)_{j,t} + b_{i,7}\log P_{j,t} + b_{i,8}\log e_{j,t} + b_{i,9}\log p^M_{i,,j,t-1} + \varepsilon_{b,i,j,t}
\end{aligned}$$

where $p^D_{i,t}$ is the price of the domestically-produced good from sector i in time t,[4] $p^M_{i,\tilde{},j,t}$ is the price of imported goods from countries other than country j, P_t is the U.S. GDP deflator, Y_t is the U.S. real GDP, $q^M_{i,j,t-1}$ is the one-year lagged quantity of imports, $(1+t)_{i,j,t}$ is the ad-valorem tariff rate on imports from country j, $(1+t)_{i,\tilde{}j,t}$ is the ad-valorem tariff rate on imports from countries other than j, $(1+r)_{j,t}$ is the real interest rate in country j, $P_{j,t}$ is the GDP deflator for country j, $e_{j,t}$ is the nominal U.S. dollar exchange rate for country j's currency, and $p^M_{i,,j,t-1}$ is the one-year lagged import price.

2.2 Data

The data used in this paper come from two major sources. The first source is data collected by Feenstra, Romalis and Schott (2002) at the Center for International Data at the University of California at Davis (henceforth, CID). This source provides us with data on the value, quantity and tariff duties collected on imports into the U.S. by country of origin at the HS 10-digit sector from 1989-2001 and by TSUSA 7-digit sector from 1978-1988. We can use these data to calculate the quantity and price of imports by sector and

[4] Because the U.S. government keeps statistics on the domestic prices of goods by NAICS sectors rather than HS sectors, we use the F.A.S. price of U.S. exports by HS 6-digit sectors as a proxy for the domestic price.

tariff rates by sector. It also gives us information on U.S. exports by sector, which we use to proxy for the price of domestic production by HS sector.

The other source of data is the World Development Indicators database provided by the World Bank. From here we get data on GDP deflators, real GDP, interest rates and exchange rates for nearly all of the countries in our sample. Some country-years, however, do not have the necessary data, and will therefore be dropped from our sample.[5]

One minor problem with using this data set comes from the fact that, as technology and innovation progress in the global economy, new codes are added to the HS system and old codes are discontinued on a regular basis. Also, due to changing trade patterns, there may be certain countries that export goods in a certain sector to the U.S. in a given year, only to stop exporting in that sector the next year. As a result, we will have an unbalanced panel dataset and certain country-sectors will have more yearly observations than others. We address this potential issue by dropping sectors from our dataset that have fewer than 25 observations or fewer than 3 countries from which the good is imported.[6]

In order to aggregate data from 10-digit HS levels and 7-digit TSUSA levels into larger sectors, we calculate value-weighted prices using the following formula:

$$p_{I,j,t} = \frac{\sum_{i \in I} p_{i,j,t} V_{i,j,t}}{\sum_{i \in I} V_{i,j,t}}$$

where $p_{i,j,t}$ is the price of imports from country j in small sector i, $p_{I,j,t}$ is the calculated price of imports in aggregated sector I, and $V_{i,j,t}$ is the total value (c.i.f. plus import duties) of imports in small sector i. Similarly, we calculate the quantity of imports in the larger sector as

$$q_{I,j,t} = \frac{\sum_{i \in I} V_{i,j,t}}{p_{I,j,t}}$$

Other sector-specific values are aggregated in a similar manner. While aggregating 10-digit HS sectors into 8 and 6-digit HS sectors is a straightforward process, aggregating the HS data into NAICS, SIC and ISIC sectors and the pre-1989 TSUSA data requires concordance tables. The CID data come with tables needed to convert from TSUSA to HS sectors,[7] from HS to NAICS sectors, and from TSUSA to SIC sectors. In order to convert HS sectors to ISIC sectors, we use concordance tables provided online by Haveman (2008).

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[5] A country's volume of trade with the U.S. is a good positive indicator of the availability of a country's economic statistics to researchers. The countries dropped will disproportionately be ones with which the U.S. has a relatively small trade volume.

[6] When using an Arellano-Bond estimator, the first two years of a country-sector are used to create the differenced variable and the lagged dependent variable. Therefore, a country-sector for which we have N consecutive years of data will only have $N-2$ observations.

[7] The TSUSA to HS conversion only allows us to convert from TSUSA 7-digit sectors to HS 8-digit sectors. We will therefore have to drop pre-1989 observations from our HS 10-digit estimates.

3 Import Results

3.1 General Results

In order to see whether or not our data produce results that are in line with what we expect, we estimate both equations (1) and (2) using all of our data by running a simple fixed-effects estimator on all of our data at each of the industry aggregation levels. The more than 1,000,000 data points available make an AB estimator using all of our data computationally infeasible. These results will be biased due to the endogeneity issue mentioned above. However, they will provide a useful reality check before proceeding further.

Our predicted coefficients from these regressions are:

- $a_{i,1} < 0$ – a higher import price should result in a lower quantity of imports
- $a_{i,2} > 0$ – higher domestic prices on the good in question should result in more imports
- $a_{i,3} > 0$ – higher import prices on goods from other countries should result in more imports from the country in question
- $a_{i,4} > 0$ – higher domestic prices in general should result in more imports
- $a_{i,5} > 0$ – higher real GDP will result in more imports for most goods[8]
- $b_{i,1} < 0$ – fewer imports of a good will result in higher import prices
- $b_{i,2} > 0$ – higher prices for domestic goods will allow importers to charge higher prices for imports
- $b_{i,3} > 0$ – higher prices on other imports will allow importers to charge higher prices
- $b_{i,4} > 0$ – a higher tariff rate on imports will raise the final price of the imports
- $b_{i,5} < 0$ – a higher tariff rate on other imports will lower the world price of the good
- $b_{i,6} > 0$ – a higher real interest rate in the country of origin will increase the cost of the good
- $b_{i,7} > 0$ – a higher GDP deflator in the country of origin will increase the cost of the good
- $b_{i,8} < 0$ – a stronger U.S. dollar will lower the price of the imported good

The results of our estimate can be found in Table 1. We see that for the demand equation, all of the coefficients are of the expected sign. In particular, the coefficient on $\log p^M_{i,j,t}$ is negative and significant at the 1% level for all levels of sector aggregation, which is particularly important as it is the primary coefficient

[8] Certain types of imports might be considered inferior goods, and the coefficient for these particular goods would be negative. However, we suspect that these goods are in the minority of total imports.

that we are interested in. The coefficients on $\log p^D_{i,t}$, $\log p^M_{i,\tilde{},j,t}$ and $\log Y_t$ are also positive as expected and significant at the 1% level for all levels of aggregation. The coefficient on $\log P_t$ is positive and significant at the 1% level for all levels of aggregation with the exception of the HS10 estimate, for which it is negative. Thus, for the demand equation, all of our variables are of the expected sign, and nearly all are statistically significant.

In the supply regression in Table 2, we see that the coefficients on all variables are of the expected sign save $\log(1+r)_{j,t}$, which is never significant and in some instances, of the incorrect sign. The coefficients on all of the other variables are significant as well, except for the coefficient on $\log(1+t)_{i,j,t}$ when that variable is aggregated to the SIC 4-digit level. Hence, our simple analysis of this data set indicates that the data are largely consistent with our predicted relations.

3.2 Sectoral-Level Results

Our goal, however, is not to analyze the data as a whole, but rather to estimate import elasticities at the sectoral level. We therefore break down our data by 10-digit, 8-digit and 6-digit HS sectors, by 6-digit and 4-digit NAICS sectors, by 4-digit and 3-digit SIC (1972 revision) sectors, and by 3-digit ISIC (revision 2) sectors. Within each sectoral regression, an aggregate measure of imports from the relevant sector from a particular country in a particular year constitute an observation. In terms our data panel, a 10-digit product from a particular country is the cross-sectional variable whereas the year is the time variable.

The point estimates and standard errors for each of the several thousand sectors for which we have data can be found on the author's website. Our primary goal is to find estimates of the import demand elasticities (coefficient $a_{i,1}$ in our regression equations) and Table 3 provides a summary of our findings. The SSD elasticity data looked at sectoral level data aggregated across countries at the 3-digit SIC level from the years 1962-1978, and used a 3SLS estimation technique that included a system of supply and demand equations for both imports and domestically-produced goods. Consequently, for each sector, they had 17 observations and many coefficients to estimate. Of their 74 elasticity estimates, only 63 (85.14%) had the correct sign and 36 (48.65%) had estimates that were negative and significant at the 5% level. Our estimates improve on these numbers in both an absolute and a relative sense. For our 3-digit SIC estimates, we found 153 sectoral import elasticities (100% of our available sectoral data) that had the correct sign, and 152 of these estimates (99.35%) were significant at the 5% level. As we move down through the table using finer sectoral divisions, we see that while the percentage of "correct" estimates falls somewhat (though even 71.93% of our 10-digit HS estimates have the correct sign and are significant at 5%) the absolute number of number of sectors for which we have data increases considerably. Figures 1-5 provide us with diagrams showing the distribution of the sectoral-level estimates. We see here that the vast majority are negative numbers, and in most cases, seem to be centered around the value of -1.[9]

[9] In order to eliminate the distorting impact of a few extreme observations on these figures, the upper and lower 2.5% of

Table 3 provides us with average estimates of the remaining coefficients in the demand equation. From the first column, it is clear that we have consistently found import demand elasticities that average from slightly greater than -1 for higher levels of industry aggregation to slightly less than -1 for lower levels of industry aggregation. With regards to the other variables, the average values are generally of the correct sign, though there is some amount of variation in these averages depending on the the sectoral level used.

3.3 Interpreting the Results

The demand equation provides us with very useful numerical results. In particular, the panel data fomulation of our empirical work allows us to distinguish between price shocks that affect only one trading partner and price shocks that affect all trading partners. For example, should real interest rates increase in Country J, the predicted effect on imports from Country J in sector I will be:

$$\Delta \log q^M_{I,J,t} = a_{I,1} b_{I,6} \left[\Delta \log(1+r)_{J,t}\right]$$

where $a_{I,1}$ and $b_{I,6}$ are the estimated coefficients from equations (1) and (2). The change in the interest rate in Country J has an impact on import prices, and the change in import prices has an impact on the quantity of imports. We can also use these values to estimate the loss in total surplus in the importing country as a result of this change. The approximate change in the price of imports will be

$$\Delta p^M_{I,J,t} = p^M_{I,J,t-1} b_{I,6} \left[\Delta \log\left(1+r\right)_{J,t}\right]$$

which implies an approximate change in quantity of

$$\Delta q^M_{I,J,t} = q^M_{I,J,t-1} a_{I,1} b_{I,6} \left[\Delta \log\left(1+r\right)_{J,t}\right]$$

Using these changes, we can compute the loss in total surplus to the importing country as

$$\begin{aligned} & \frac{1}{2}\left[q^M_{I,J,t-1} + q^M_{I,J,t}\right] \Delta p^M_{I,J,t} \\ = \; & q^M_{I,J,t-1} p^M_{I,J,t-1} b_{I,6} \left[\Delta \log\left(1+r\right)_{J,t}\right] \left[1 + \frac{1}{2} a_{I,1} b_{I,6} \left[\Delta \log\left(1+r\right)_{J,t}\right]\right] \end{aligned}$$

However, in many cases, a shock to a commodities import prices are unlikely to be confined to one country of origin. If an event in the world economy causes the price of imports of good I from all countries to increase, then we have to take into account the feedback effect on prices that occurs when a decrease in prices of imports from other countries enables the imports from a given country to fall in price.as well. For example, assume that the value of the U.S. dollar falls in general against the currencies of its trading partners. This event causes the price of import I from Country J to rise, but it will also cause the import

observations in each aggregation level were eliminated from the figures.

price of good I to rise across all countries of origin. If this effect is symmetric across all countries (i.e. $\Delta \log e_{J,t} = \Delta \log e_{\sim J,t}$ and $\Delta \log p^M_{I,J,t} = \Delta \log p^M_{I,\sim J,t}$), then the relevant change in the price of import I will be

$$\begin{aligned} \Delta \log p^M_{I,J,t} &= b_{I,3} \Delta \log p^M_{I,\sim J,t} + b_{I,8} \Delta \log e_{J,t} \\ (1 - b_{I,3}) \Delta \log p^M_{I,J,t} &= b_{I,8} \Delta \log e_{J,t} \\ \Delta \log p^M_{I,J,t} &= \frac{b_{I,8}}{1 - b_{I,3}} \Delta \log e_{J,t} \end{aligned}$$

Similarly, the effect on quantity imported of good I from Country J will be

$$\begin{aligned} \Delta \log q^M_{I,J,t} &= a_{I,1} \Delta \log p^M_{I,J,t} + a_{I,3} \Delta \log p^M_{I,\sim J,t} \\ \Delta \log q^M_{I,J,t} &= (a_{I,1} + a_{I,3}) \Delta \log p^M_{I,J,t} \\ \Delta \log q^M_{I,J,t} &= (a_{I,1} + a_{I,3}) \left(\frac{b_{I,8}}{1 - b_{I,3}} \right) \Delta \log e_{J,t} \end{aligned}$$

Just as before, we can approximate the change in consumer surplus from this shock as

$$q^M_{I,J,t-1} p^M_{I,J,t-1} \left(\frac{b_{I,8}}{1 - b_{I,3}} \right) \Delta \log e_{J,t} \left[1 + \frac{1}{2} (a_{I,1} + a_{I,3}) \right] \left(\frac{b_{I,8}}{1 - b_{I,3}} \right) \Delta \log e_{J,t}$$

4 Estimation Method for Export Supply Elasticities

4.1 Basic Equations

Our estimation strategy for export elasticities is, in some ways, a mirror image of our strategy for estimating import elasticities. We want to find out how the quantity of U.S. exports to a particular country respond to the price of those exports. Our regression equation is

$$\log q^X_{i,j,t} = c_{i,0} + c_{i,1} \log p^X_{i,j,t} + C_i' Z_{i,j,t} + \varepsilon_{c,i,j,t}$$

where $q^X_{i,j,t}$ is the quantity of exports in sector i to country j at time t, $p^X_{i,j,t}$ is the price of those exports, $Z_{i,j,t}$ is a vector of other covariates, and $c_{i,1}$ can be interpreted as the elasticity of export supply for good i. Our other covariates are: the average price of U.S. exports in sector i to other countries, the average price of imports of goods in sector i into the U.S.,[10] the GDP deflator in country j, the real GDP in country j, the exchange rate between the dollar and country j's currency, and the one-year lagged value of the export quantity. As with our import equations, we treat the three price variables as endogenous and instrument for them using the Arellano-Bond technique.

While we treat the export price as an endogenous variable, we would also like to know its determinants. Therefore, as with the import estimates, we estimate a second equation using the export price as a dependent

[10] This variable is a proxy for the "world price" of goods in sector i on the international market.

variable. The two equations that we estimate are

$$\log q^X_{i,j,t} = c_{i,0} + c_{i,1}\log p^X_{i,j,t} + c_{i,2}\log p^X_{i,\tilde{}j,t} + c_{i,3}\log p^D_{i,t} + c_{i,4}\log P_{j,t} + c_{i,5}Y_{j,t} + c_{i,6}\log e_{j,t} + c_{i,7}\log q^X_{i,j,t-1} + \varepsilon_{c,i,j,t} \quad (3)$$

$$\log p^X_{i,j,t} = d_{i,0} + d_{i,1}\log q^X_{i,j,t} + d_{i,2}\log p^X_{i,\tilde{}j,t} + d_{i,3}\log p^D_{i,t} + d_{i,4}\log(1+r)_{US,t} + d_{i,5}\log w_{US,t} + d_{i,6}\log P_{US,t} + d_{i,7}\log\log p^X_{i,j,t-1} + \varepsilon_{d,i,j,t} \quad (4)$$

where $P_{j,t}$ is the GDP deflator of country j, $Y_{j,t}$ is the real GDP (in constant year 2000 US dollars) of country j, $e_{j,t}$ is the exchange rate in dollar terms for country j, $\log(1+r)_{US,t}$ is the real interest rate in the U.S., $w_{US,t}$ is the wage rate in the U.S., and $P_{US,t}$ is the GDP deflator of the U.S.. The data used in these regressions come from the same sources as in the import demand regressions with one exception. The data on U.S. wage rates come from the IMF International Financial Statistics CD-ROM.

As with the import demand elasticities, we test the relationships among the variables in the broader dataset before moving on to an analysis of specific sectors. In this case our predicted coefficients are:

- $c_{i,1} < 0$ – if export prices are lower, then exports should be greater to country j
- $c_{i,2}$, $c_{i,3} > 0$ – if world prices of the good are higher, then country j should demand more exports
- $c_{i,4} > 0$ – if prices of goods are high in country j, it should import more
- $c_{i,5} > 0$ – if country j's GDP is higher, then it should import more
- $c_{i,6} < 0$ – as country j's currency becomes weaker, it should import less
- $c_{i,7} > 0$ – if country j imported a lot last year, it should import a lot this year
- $d_{i,1} < 0$ – more exports should mean lower prices for those exports
- $d_{i,2} > 0$ – higher prices on other exports should mean higher prices for exports to country j
- $d_{i,3} > 0$ – higher world prices will mean that the price of exports will be higher
- $d_{i,4} > 0$ – higher U.S. interest rates make production more expensive and raise prices
- $d_{i,5} > 0$ – higher U.S. wage rates make production more expensive and raise prices
- $d_{i,6} > 0$ – a higher U.S. GDP deflator raises the prices of intermediate goods

Table 4 shows us the result of this analysis. In the foreign demand equation, we see that the results conform to our expectations. All of the coefficients are of the expected sign and are significant at the 1% level. Table 5 shows the results for the U.S. export supply equation. All of the coefficients are of the expected sign with the exception of the U.S. GDP deflator, which is negative for all aggregation levels except for HS 10.

5 Comparison of Estimates to Previous Literature

Because of the new method that we use to estimate our import demand elasticities, we should not expect them to match up precisely to existing estimates. But in order to check that they are not producing radically different values, we compare our own estimates to previous work done by KNO, Nicita and Olearraga and SSD.

We first compare our work to the estimates found by KNO, who estimated U.S. import demand elasticities at the HS 6-digit level. Our dataset has 3250 overlapping sectors with theirs. Using the standard errors from their estimates, we find that our estimates fall within a 90% confidence interval 1989 times, or 61.2% of the time. If the difference in our estimates were attributable solely to white noise error terms found in our regression, we would expect this number to be closer to 90%. Hence, we have some reason to believe that there is a structural difference in our approach to estimating import demand elasticities.

On the other hand, when we compare our estimates to Nicita and Olearraga, who use essentially the same methodology as KNO, the match between our datasets is much stronger. Our dataset has 27 overlapping estimates for ISIC 3-digit sectors. Of these 22 (or 81.5% fall within the 90% confidence interval of the estimates for the other dataset. Whatever structural differences there are between our method and the GDP function approach seem to be attenuated at higher levels of sectoral aggregation.

When compared to SSD's ISIC 3-digit observations, a large fraction of our estimates are also within a 90% confidence interval. Our dataset has 26 overlapping observations with SSD's ISIC 3-digit estimates. Of these, 23 (or 88.5%) of our elasticity estimates are within a 90% confidence interval around their estimates. The percentage falls somewhat when we compare our estimates to their 3-digit SIC elasticity estimates. For that level of aggregation, our datasets overlap on 117 observations. Of these, 84 (or 71.8%) fall within the 90% confidence interval.

That our estimates do not completely conform to the numbers found in previous work is not surprising. In the case of the SSD data, we were using a completely separate time period for our estimates. In the case of KNO, while our time periods overlapped, the length of our panel took in observations from earlier years. In both cases, we were attempting a new method of estimating import demand elasticities. We now look at whether or not our new estimates have a considerable impact when used in an empirical application.

6 Application to "Protection for Sale" Estimates

Trade elasticity estimates are particularly important when trying to determine the welfare effects of trade barriers. The Ramsey Rule from the public finance literature shows that indirect taxes generally cause greater economic distortions when either the demand for or the supply of a product is highly elastic. This carries over into the field of international trade. A trade barrier will cause a greater welfare loss if imposed on an import that has a higher import demand elasticity.

One empirical application of this insight has centered around the tests of the Grossman and Helpman "Protection for Sale" (1994) model. The major result of this model was their prediction that trade protection in a country would follow a pattern determined by the following equation

$$\frac{t_i}{1+t_i} = \frac{I_i - a_L}{a_L + \alpha}\frac{z_i}{e_i}$$

where t_i is the ad-valorem tariff for sector i, I_i is an indicator variable that takes on the value of 1 if a lobby group lobbies the government on behalf of the sector, a_L is the total fraction of the economy represented by a lobby group, α is a variable representing the weight that the government puts on national welfare as opposed to contributions from lobby groups, z_i is the inverse of the import penetration ratio in sector i, and e_i is the import demand elasticity for sector i. This equation implies that, holding other variables constant, the politically optimal tariff on an economic sector will be decreasing in the import demand elasticity of that sector.

Goldberg and Maggi (1999), Gawande and Bandyopadhyay (2000) and Eicher and Osang (2002) have all developed empirical tests of the Grossman and Helpman model. We focus on the second of these two tests, as Gawande and Bandypadhyay test a wide number of sectors using Shiells, Stern and Deardorff as their elasticity estimates. The specific functional form that they estimate is

$$\frac{NTB_i}{1+NTB_i} = \alpha_0 + \alpha_1\frac{z_i}{e_i} + \alpha_2 I_i\frac{z_i}{e_i} + \alpha_3 INTERMTAR_i + \alpha_4 INTERMNTB_i + \varepsilon_i$$

where NTB_i is the non-tariff barrier coverage ratio for sector i,[11] $INTERMTAR_i$ is the tariff rate on intermediate goods used in sector i, and $INTERMNTB_i$ is the NTB coverage ratio on intermediate goods used in sector i. Because z_i is likely to be affected by the NTB coverage ratio, Gawande and Bandyopadhyay instrument for these terms using a combination of capital-labor ratios for the sectors, and own-price and cross-price elasticities of demand.

The estimated coefficients in their original work can be found in Table 7. Of the 242 SIC 4-digit sectors appearing in the Gawande and Bandyopadhyay dataset, we have significant import demand elasticity estimates for 213 of them. Hence, we estimate three regressions – one using Gawande and Bandyopadhyay's original data set, one using a restricted sample. In order to conform to the predictions of the Grossman and Helpman model, coefficient α_1 must be negative, α_2 must be positive and $\alpha_1 + \alpha_2$ must be positive. While the values of coefficients α_3 and α_4 are not explicitly predicted by the Grossman and Helpman model, we would expect both of these to be positive. Indeed, in our estimates, α_1 α_2 and α_4 are all of the expected sign and are significant in all three regressions. Coefficient α_3 is also of the expected sign, but is not signficant in some specifications. The biggest departure from the predictions made by the Grossman and Helpman models is that coefficients α_1 and α_2 do not sum to a positive number.

[11] Most of this literature uses NTB ratios as the dependent variable instead of tariff rates. It is believed that these variables are the form of trade protection most directly affected by domestic politics.

The most important result from our table is that the substitution of new elasticities from our own work does not substantially affect the results of the regressions. This fact provides us with assurance that we can use estimates from this and other levels of aggregation in a wide variety of empirical applications.

7 Conclusions

We have demonstrated that it is possible to use panel data estimation techniques to create a dataset of import demand and export supply elasticities. Our paper looks at a broad panel of data on U.S. imports and exports during the years 1978-2001 and applies an Arellano and Bond style GMM estimator to find the import and export elasticities for a wide variety of economic sectors. We are thus able to solve the endogeneity problems inherent in import and export elasticity regressions without having to create a large structural equation model or having to ground our regressions in a restrictive theory.

Our work has created a dataset with estimates of U.S. import demand elasticities at the 6, 8 and 10-digit HS levels of industry aggregation, the 4 and 6-digit NAICS levels of industry aggregation, the 3 and 4-digit levels of SIC industry aggregation and the 3-digit ISIC level of industry aggregation. We have also estimate U.S. export supply elasticities at the 6, 8 and 10-digit HS levels of industry aggregation and the 4 and 6-digit NAICS levels of industry aggregation. In doing so we have provided a dataset that will be flexible enough to meet the needs of researchers who need to match trade elasticity estimates with U.S. economic data.

Finally, we have created a dataset that matches up to a large degree with previous estimates of import demand elasticities. While our different methodology obviously produces results that are not identical, it does produce results that are not completely out of line with previous work. In our particular application to the empirical tests of the "Protection for Sale" literature, the substitution of our estimates for the SSD estimates do not significantly affect regression results of Gawande and Bandyopadyay. Having run our new estimates through this battery of tests we are confident in offering this dataset for people doing empirical work with U.S. imports and exports.

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Table 1 -- Import Demand Test Equation

	NAICS 4	NAICS 6	HS 6	HS 8	HS 10	SIC 3	SIC 4
Own Price	-0.583***	-0.985***	-1.024***	-1.068***	-1.067***	-0.530***	-0.640***
	(0.00488)	(0.00253)	(0.00136)	(0.00121)	(0.00128)	(0.00402)	(0.00305)
Domestic Price	0.0150***	0.0347***	0.0104***	0.0378***	0.0205***	0.0182***	0.0422***
	(0.00448)	(0.00249)	(0.00181)	(0.00184)	(0.00304)	(0.00442)	(0.00351)
Other Imports Price	0.0716***	0.176***	0.185***	0.151***	0.0741***	0.0517***	0.103***
	(0.00602)	(0.00327)	(0.00200)	(0.00198)	(0.00264)	(0.00536)	(0.00419)
US Deflator	1.458***	2.540***	2.204***	1.858***	-0.595***	1.626***	1.473***
	(0.108)	(0.0586)	(0.0309)	(0.0272)	(0.0810)	(0.111)	(0.0825)
US Real GDP	1.422***	0.965***	0.444***	0.527***	1.585***	0.184**	0.328***
	(0.0887)	(0.0477)	(0.0252)	(0.0220)	(0.0451)	(0.0877)	(0.0644)
Lagged Quantity	0.409***	0.354***	0.358***	0.304***	0.195***	0.443***	0.421***
	(0.00248)	(0.00129)	(0.000683)	(0.000620)	(0.000721)	(0.00233)	(0.00174)
TSUSA Indicator Variable	0.689***	0.905***	0.917***	0.845***		-0.369***	-0.333***
	(0.0203)	(0.0109)	(0.00573)	(0.00548)		(0.0198)	(0.0146)
Constant	-33.74***	-19.04***	-4.402***	-6.485***	-37.00***	2.616	-1.683
	(2.644)	(1.424)	(0.752)	(0.656)	(1.347)	(2.615)	(1.920)
Observations	104834	271658	1145479	1539664	1331735	117090	203276
Number of Countries	9114	25575	137570	238960	270173	10735	19871
R-squared	0.416	0.611	0.571	0.532	0.439	0.463	0.483

*** p<0.01, ** p<0.05, * p<0.1

Standard errors in parentheses

Table 2 -- Import Supply Test Equation

	NAICS 4	NAICS 6	HS 6	HS 8	HS 10	SIC 3	SIC 4
Quantity	-0.183***	-0.318***	-0.299***	-0.314***	-0.355***	-0.216***	-0.251***
	(0.00161)	(0.000882)	(0.000416)	(0.000367)	(0.000434)	(0.00172)	(0.00125)
Domestic Price	0.0875***	0.0690***	0.0278***	0.0463***	0.0378***	0.115***	0.107***
	(0.00275)	(0.00159)	(0.00106)	(0.00106)	(0.00180)	(0.00309)	(0.00239)
Other Imports Price	0.644***	0.473***	0.362***	0.302***	0.139***	0.610***	0.568***
	(0.00310)	(0.00189)	(0.00114)	(0.00113)	(0.00156)	(0.00330)	(0.00257)
Tariff Rate	0.820***	0.0678	0.138***	-0.104***	0.0666**	0.615***	0.147
	(0.139)	(0.0694)	(0.0316)	(0.0264)	(0.0258)	(0.127)	(0.0989)
Other Imports Tariff Rate	-1.680***	-1.337***	-0.820***	-1.016***	-0.546***	-0.952***	-0.720***
	(0.153)	(0.0763)	(0.0371)	(0.0322)	(0.0346)	(0.140)	(0.110)
Foreign Real Interest Rate	-0.0168	-0.0310*	-0.0155	0.00491	0.0117	-0.0371	-0.0315
	(0.0233)	(0.0166)	(0.0116)	(0.0107)	(0.0130)	(0.0298)	(0.0248)
Foreign GDP Deflator	0.0771***	0.106***	0.108***	0.113***	0.204***	0.0779***	0.0808***
	(0.00588)	(0.00336)	(0.00187)	(0.00178)	(0.00331)	(0.00676)	(0.00497)
Foreign Exchange Rate	-0.0451***	-0.0414***	-0.0254***	-0.0218***	-0.0102***	-0.0399***	-0.0349***
	(0.00454)	(0.00231)	(0.000980)	(0.000818)	(0.000695)	(0.00488)	(0.00325)
Lagged Price	0.106***	0.100***	0.136***	0.108***	0.0381***	0.118***	0.127***
	(0.00219)	(0.00132)	(0.000754)	(0.000674)	(0.000750)	(0.00224)	(0.00173)
TSUSA Indicator Variable	-0.166***	-0.154***	-0.0932***	-0.124***		-0.539***	-0.506***
	(0.00844)	(0.00477)	(0.00246)	(0.00249)		(0.00961)	(0.00690)
Constant	2.922***	4.563***	4.121***	4.311***	4.853***	3.286***	3.543***
	(0.0301)	(0.0174)	(0.00968)	(0.00927)	(0.0173)	(0.0349)	(0.0258)
Observations	104834	271658	1145479	1539664	1331735	117090	203276
Number of sectorcountry	9114	25575	137570	238960	270173	10735	19871
R-squared	0.607	0.645	0.546	0.500	0.398	0.545	0.538

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 1: NAICS 4-digit Import Elasticity Estimates Distribution

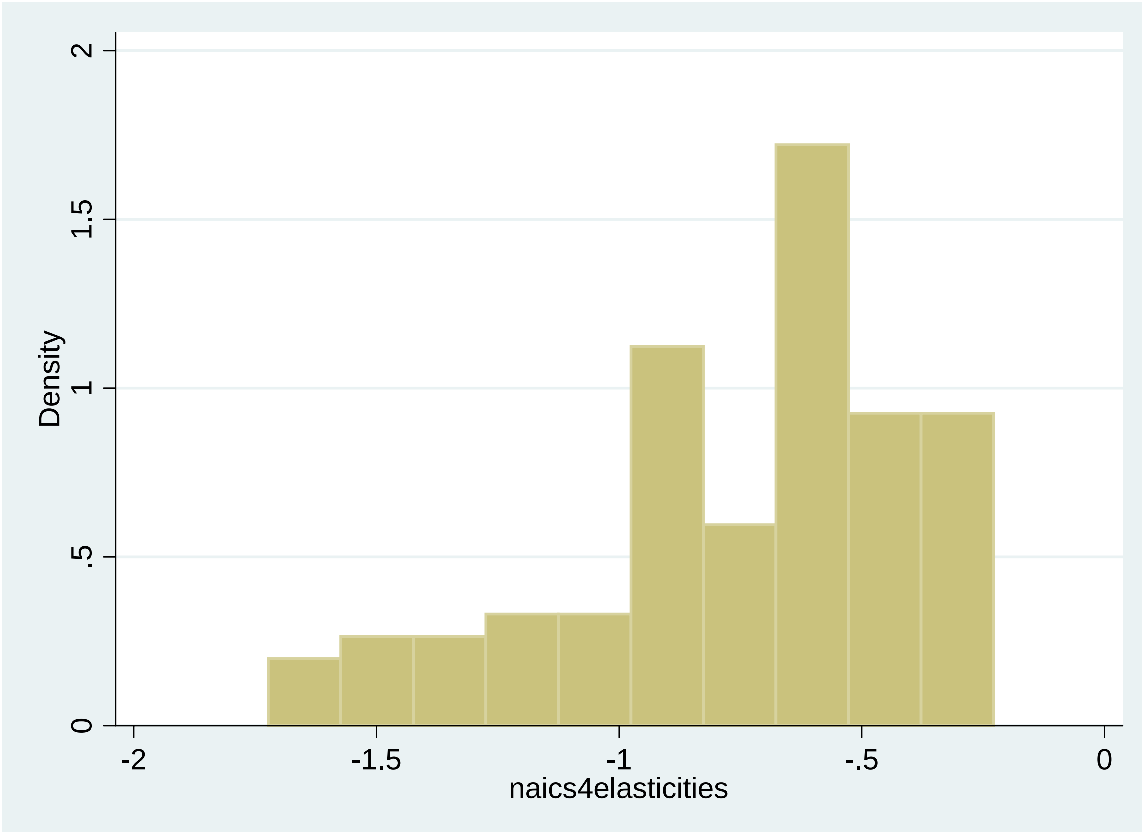

Figure 2: NAICS 6-digit Import Elasticity Estimates Distribution

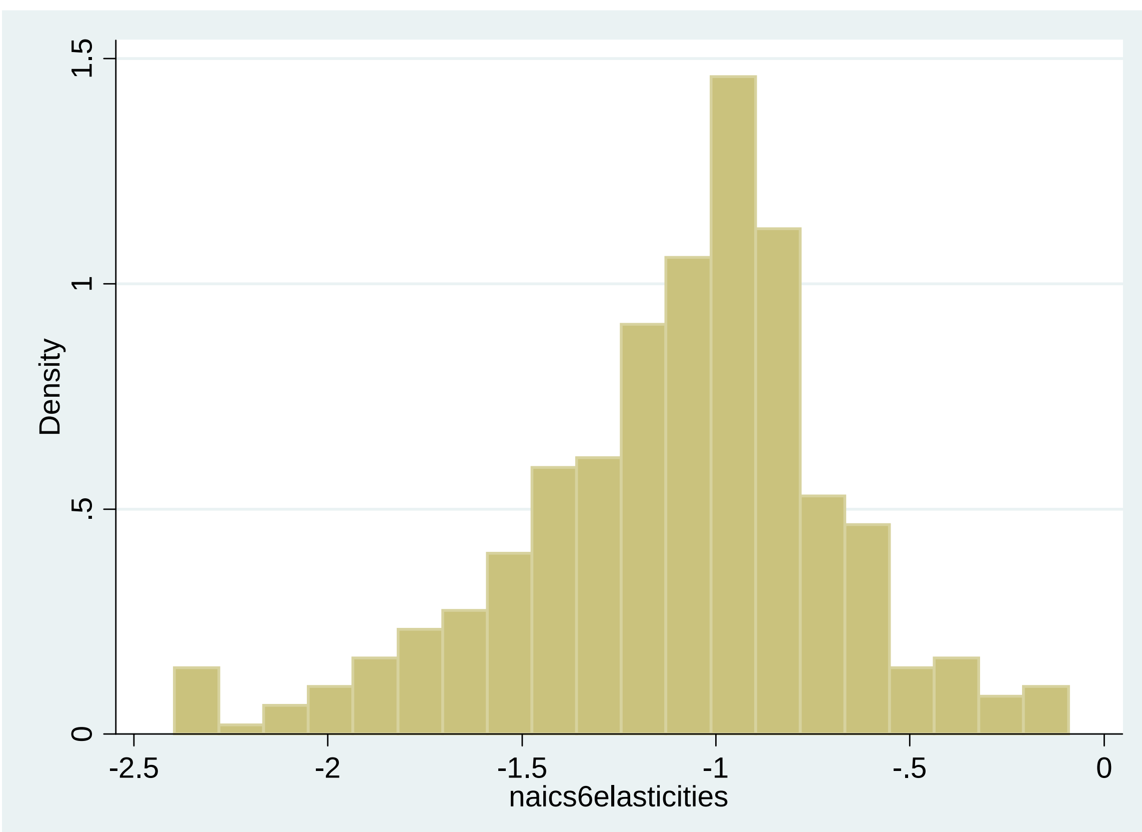

Figure 3: HS 6-digit Import Elasticity Estimates Distribution

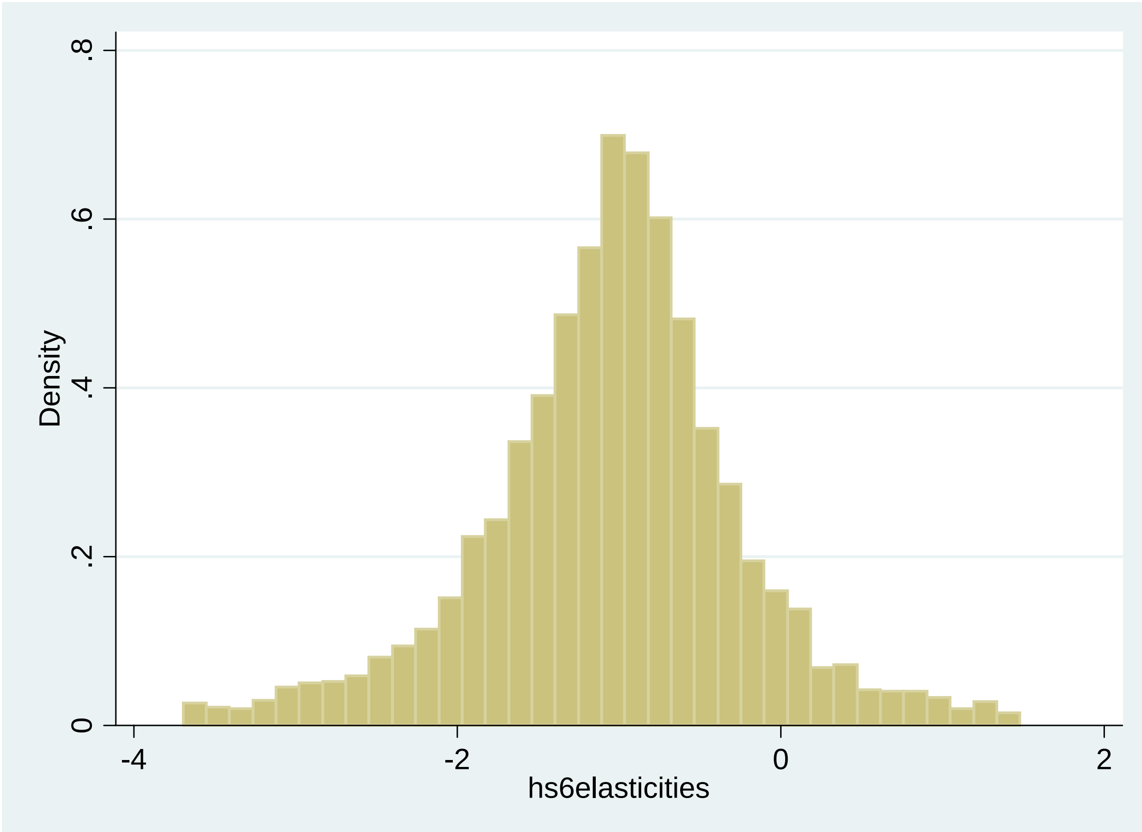

Figure 4: HS 8-digit Import Elasticity Estimates Distribution

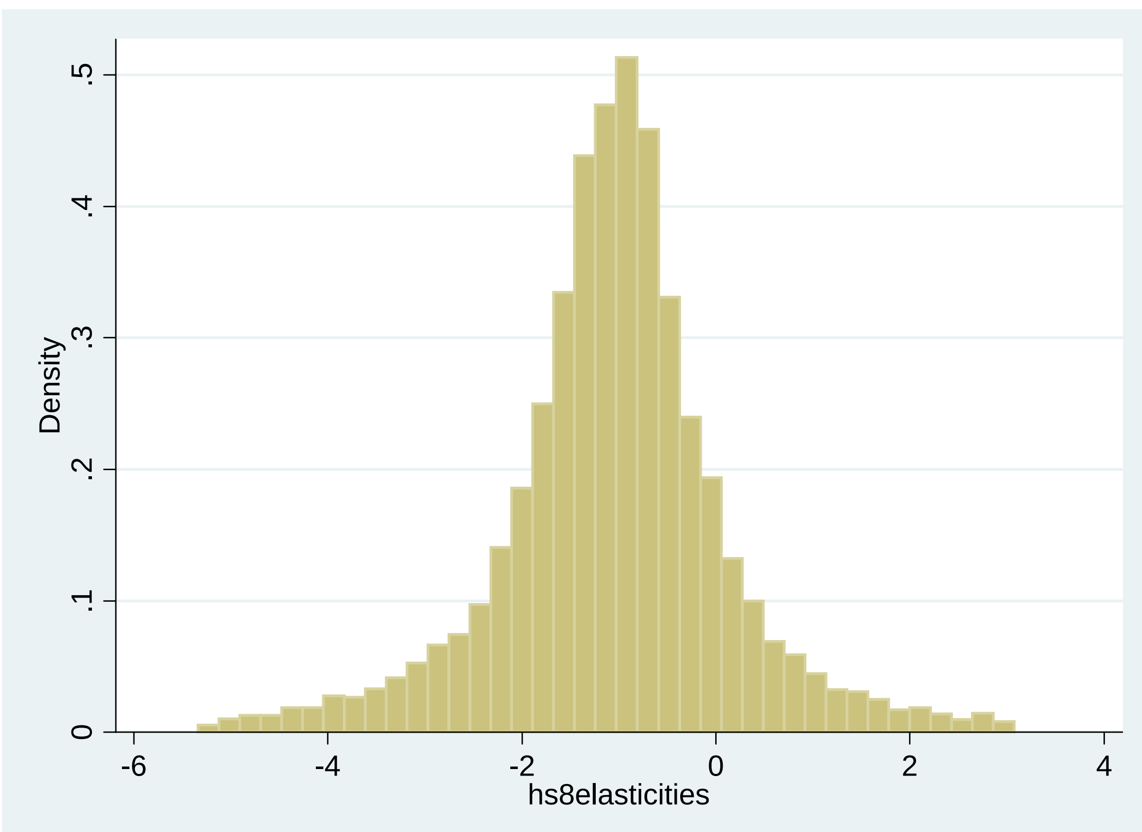

Figure 5: HS 10-digit Import Elasticity Estimates Distribution

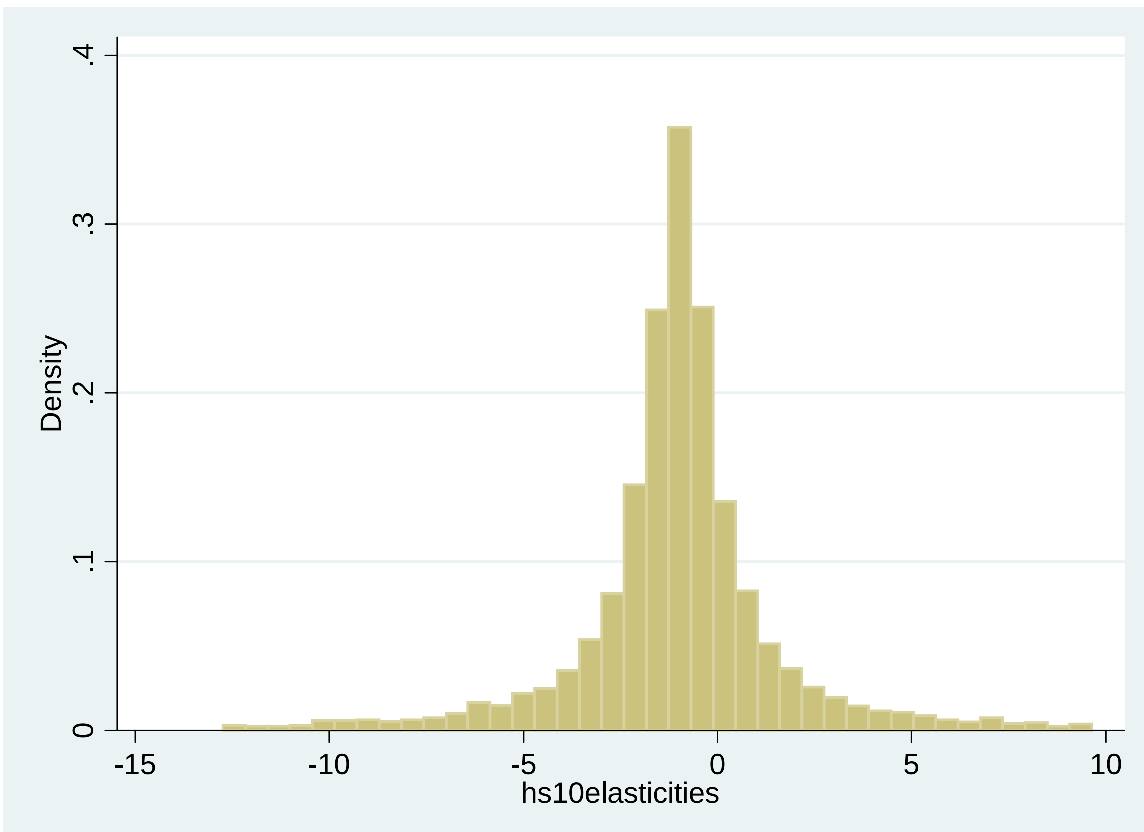

Table 3 -- Import Elasticity Significance Stats

	Correct Sign	Significant at 10%	Significant at 5%	Significant at 1%
NAICS 4	106 100.00%	104 98.11%	104 98.11%	104 98.11%
NAICS 6	428 99.30%	422 97.91%	422 97.91%	421 97.68%
HS 6	4194 96.55%	3838 88.35%	3,796 87.38%	3708 85.36%
HS 8	8146 94.55%	7142 82.89%	7,026 81.55%	6,790 78.81%
HS 10	7,969 90.12%	6,507 73.58%	6,361 71.93%	6,082 68.78%
SIC 3	153 100.00%	152 99.35%	152 99.35%	152 99.35%
SIC 4	361 99.18%	357 98.08%	356 97.80%	355 97.53%

Table 4 -- Export Demand Test Equation					
	NAICS 4	**NAICS 6**	**HS 6**	**HS 8**	**HS 10**
Own Price	-0.946***	-0.962***	-0.979***	-0.986***	-1.016***
	(0.00301)	(0.00196)	(0.000909)	(0.000858)	(0.000993)
Domestic Price	0.0291***	0.0355***	0.00468***	0.00419***	0.0320***
	(0.00206)	(0.00126)	(0.000554)	(0.000517)	(0.00220)
Other Exports Price	0.0920***	0.121***	0.109***	0.109***	0.0864***
	(0.00365)	(0.00250)	(0.00137)	(0.00134)	(0.00249)
Foreign GDP Deflator	0.0873***	0.0872***	0.0676***	0.0659***	0.0170***
	(0.00574)	(0.00380)	(0.00181)	(0.00174)	(0.00340)
Foreign Real GDP	1.198***	1.141***	0.995***	0.985***	0.794***
	(0.0169)	(0.0120)	(0.00580)	(0.00561)	(0.00863)
Foreign Exchange Rate	-0.0440***	-0.0434***	-0.0225***	-0.0203***	-0.00810***
	(0.00481)	(0.00305)	(0.00139)	(0.00132)	(0.00131)
TSUSA Indicator Variable	0.516***	0.540***	0.695***	0.685***	
	(0.00938)	(0.00653)	(0.00315)	(0.00302)	
Lagged Quantity	0.223***	0.260***	0.282***	0.275***	0.141***
	(0.00164)	(0.00109)	(0.000516)	(0.000489)	(0.000622)
Constant	-18.40***	-18.65***	-16.44***	-16.20***	-9.896***
	(0.406)	(0.292)	(0.145)	(0.140)	(0.212)
Observations	151777	400258	2271552	2597488	1801680
Number of Countries	11800	35536	268702	329907	337767
R-squared	0.657	0.609	0.538	0.527	0.440

*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Standard errors in parentheses

Table 5 -- Export Supply Test Equation					
	NAICS 4	**NAICS 6**	**HS 6**	**HS 8**	**HS 10**
Quantity	-0.400***	-0.378***	-0.340***	-0.341***	-0.402***
	(0.00132)	(0.000792)	(0.000323)	(0.000303)	(0.000397)
Domestic Price	0.0466***	0.0347***	0.00554***	0.00584***	0.0278***
	(0.00141)	(0.000834)	(0.000342)	(0.000317)	(0.00141)
Other Exports Price	0.509***	0.492***	0.359***	0.346***	0.244***
	(0.00213)	(0.00147)	(0.000823)	(0.000802)	(0.00158)
U.S. Real Interest Rate	0.0213***	0.0152***	0.00658***	0.00600***	1.707***
	(0.00158)	(0.00104)	(0.000433)	(0.000404)	(0.0542)
U.S. GDP Deflator	-2.054***	-2.292***	-1.565***	-1.428***	3.119***
	(0.100)	(0.0659)	(0.0291)	(0.0276)	(0.0756)
U.S. Wage Rate	2.186***	2.370***	1.564***	1.455***	-1.452***
	(0.0909)	(0.0594)	(0.0263)	(0.0250)	(0.0515)
Lagged Price	0.0314***	0.0509***	0.104***	0.103***	0.0113***
	(0.00143)	(0.00103)	(0.000542)	(0.000516)	(0.000633)
Constant	-4.157***	-5.554***	-2.410***	-1.897***	12.66***
	(0.413)	(0.270)	(0.120)	(0.114)	(0.237)
Observations	151777	400258	2271552	2597488	1801680
Number of Countries	11800	35536	268702	329907	337767
R-squared	0.754	0.685	0.536	0.522	0.431

*** p<0.01, ** p<0.05, * p<0.1
Standard errors in parentheses

Table 6 -- Comparison with Gawande and Bandyopadhyay

	Original Sample	Restricted Sample	New Elasticities
z/e	-11.36***	-13.37***	-4.553**
	(3.622)	(3.835)	(1.775)
I*z/e	10.59***	13.08***	4.100**
	(3.940)	(4.237)	(1.836)
Intermediate tariffs	0.588*	0.335	0.596*
	(0.309)	(0.374)	(0.336)
Intermediate NTBs	0.426***	0.517***	0.398***
	(0.0851)	(0.103)	(0.0876)
Constant	-0.0274	-0.0262	-0.0255
	(0.0215)	(0.0239)	(0.0240)
Observations	242	213	213

*** p<0.01, ** p<0.05, * p<0.1
Standard errors in parentheses