Partial equilibrium modeling of trade zeros

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Abstract

This paper develops a partial equilibrium model that allows for zero trade flows from some sources. CES demand functions do not allow for changes in demand for sources which have no baseline trade flows and do not allow trade barriers to prohibit trade from sources which have positive baseline trade flows. Therefore, I use a linear supply and demand model which allows sources to have zero trade flows both in the baseline and in the estimated results. Monte Carlo simulations indicate that the estimated impact of small changes in tariffs in the linear model is similar to the estimated impact for models assuming CES demand. Applying the linear model to the U.S. premium cigar market indicates that removing the ban on imports of Cuban cigars would allow for Cuban cigars to become the largest source of premium cigars in the U.S. market in the long run, but would not entirely drive imports of premium cigars from other countries such as the Dominican Republic, Honduras, and Nicaragua out of the U.S. market.

Introduction

The standard models which assume CES preferences do not allow either for trade flows to initially be zero or for the implementation of trade barriers that prohibit trade of a good from a particular source. The problem of estimating the impact of removing or implementing prohibitive trade barriers is especially important for partial equilibrium models applied to highly disaggregated products. Trade zeros are more like to occur for these disaggregated products than for more highly aggregated product categories that are typically analyzed in general equilibrium models.

This paper examines market characteristics which in the past have been ignored in the past. I use a simple linear model which depends on 'choke prices' at which demand or supply for a particular product has been driven to zero and the responsiveness of demand and supply to changes in price. The linear model allows for initial trade zeros and for trade restrictions to shift demand drive demand from some sources out of the market.

First I review the literature on trade zeros and linear supply and demand models. Second, I present a linear model which allows for imperfect substitution between country specific varieties. Next, I compare simulated model results from the linear model with results generated from a model using the CES preferences for products that have initial non-zero trade. Finally, I apply the model to estimate the impact of removing of restrictions on U.S. imports of premium cigars Cuban on competing U.S. imports of premium cigars from other countries.

Literature Review

Ottaviano, Tabuchi, and Thisse (2002) use a monopolistic competitive framework in which firms face linear demand curves. The linear demand curves allow for demand to be zero when the price increase to the intercept or "choke" price. Melitz and Ottaviano (2008) extend this model to allow for heterogeneous firms. Also, Lee and Pitt (1986) and Fémény and Gohin (2007)) develop demand systems that account for zero trade flows, but do not estimate equilibrium conditions and use functional forms that require parameterization that is well suited for simulation analysis.

Baldwin and Harrigan (2007) find that most potential export flows are not present, that the incidence of these "export zeros" is strongly correlated with distance and the size of the importing countries market, and that export unit values are positively related to distance. They also find that models using use a monopolistic competitive framework in which firms face linear demand curves such as Ottaviano, Tabuchi, and Thisse (2002) and Melitz and Ottaviano (2008) are inconsistent with at least some of these facts. They propose a new version of heterogeneous-firms trade model in Melitz (2003) in which high quality firms are the most competitive, with heterogeneous quality increasing with firm's heterogeneous cost. Since the quality is comparable between the different types of premium cigars that I consider in the U.S. market, I feel that the linear model still appropriate for the analyzing the market of premium cigars in the U.S.

Some econometric work has estimated the impact of changes in trade policy for products with zero trade flows. Yue and Beghin (2007) use the Kuhn-Tucker approach to corner solutions in consumer choice from Wales and Woodland (1983) to estimate to overcome the lack of observed data on bilateral trade flows while also accounting for differentiated goods by place of origin. They apply this model to the apple trade between Australia and New Zealand.

Linear Supply and Demand Model

The representative consumer faces a maximization problem with quadratic utility functions as in Singh and Vives (1984) (and similar to the continuous framework in Melitz and Ottaviano (2008)) yielding linear inverse demand curves:

(1) $$P_i = b_i + a_{ii}Q_i + \sum_{j \neq i} a_{ij}Q_j \quad \forall\, i \text{ where } \lambda_i = 0 \text{ (no import ban)}$$

$$P_i = b_i \; \forall\, i \text{ where } \lambda_i = 1 \text{ (import ban)}$$

Where P_i is the price for product i, Q_i is the quantity for product for product i, b_i is demand price intercept (or "choke price") for product i, a_{ii} is the own quantity slope, and a_{ij} are the cross quantity slopes. I can rewrite the direct demands as:

(2) $$Q_i = (1-\lambda_i)\left(b_{di} + \sum_i m_{dij}(1-\lambda_i)P_j + \sum_i m_{dij}\lambda_i b_j\right),$$

where b_{di} is demand quantity intercept for product i, m_{dii} is the own price slope, and m_{dij} are the cross price slopes for demand. Note that if the import ban is in place, $\lambda_i = 1$ and $Q_i = 0$. Supply is also linear and takes the form:

(3) $$P_i = d_i + c_iQ_i,$$

Where d_i is supply price intercept (or "choke price") for product i, c_i is the own quantity supply slope. I can rewrite this as a direct supply function:

(4) $$Q_i = (1-\lambda_i)(b_{si} + m_{si}P_i),$$

where b_{si} is supply quantity intercept for product i and m_{si} is the own price supply slope.

If each variety is supplied in a competitive environment, the equilibrium is:

(5) $$Q_i = (1-\lambda_i)(b_{si} + m_{si}P_i) = (1-\lambda_i)\left(b_{di} + \sum_i m_{dij}(1-\lambda_i)P_j + \sum_i m_{dij}\lambda_i b_j\right).$$

Comparison with CES model

As a first step, I compare results for the linear model to a nonlinear CES model that is typically used for this type of analysis. While the two models can't be compared for cases where one of the sources is not in the market, they can be compared when all sources have positive market share.[1] I assume a domestic and foreign source of supply, select elasticities randomly from a uniform distribution, and simulate the impact of changing the duty on imports by -0.50 to 0.50 percent.

The impact of an increasing a duty for the linear model is generally greater relative to the CES model. For an increase in the duty with the linear model, both domestic prices and import prices increase by more and import volume falls by more than for the CES model. However, for a decrease in the duty with the linear model, the import price decreases by more, but the decline in domestic price and the increase in import volume are both dampened. The impact on the domestically produced quantity could be either larger or smaller when the linear model is used.

For the linear model, changes in the size of the tariff change are most highly correlated with changes in the prices and shipments, with correlation coefficients larger than 0.82 in magnitude in all cases. This indicates that changes in the tariff change explain at least two-thirds of the variation in these prices and shipments (see table 2).[2] None of the model parameters have correlation coefficients over 0.04 in magnitude, indicating that they explain less than one percent of the variation in prices and shipments.

For the CES model, the size of the shock explains most of the variation in prices and shipments, but to a lesser degree than the linear model. The correlation coefficient for the tariff

[1] Elasticities for the CES model were drawn 5,000 times from uniform distributions of 1.5 to 6.0 for the substitution elasticity, -1.5 to -0.25 for the aggregate demand elasticity, 2 to 10 for the domestic supply elasticity and 10 to 100 for the import supply elasticity. In addition, the market share of the domestic source was drawn from a uniform distribution of 0 to 1 and the change in the duty charged to imports was selected from a uniform distribution of -50 percent to 50 percent. Own and cross price elasticities and intercepts used in the linear model are derived from the CES model elasticities and the market shares (see Francois and Hall (1997), 138).

[2] The explanatory power is measured as coefficient of determination or R-squared which are calculated as the square of the correlation coefficient. For this example, in the case of a correlation coefficient of 0.82, the coefficient of determination is $0.82^2=0.67$.

change is at least 0.74 in all cases, indicating that a least half of the variation is explained by changes in the tariff. None of the parameters have correlation coefficients greater than 0.22 in magnitude, indicating that they explain no more than five percent of the variation in prices and shipments.

Inputs needed for simulation with initial zero trade flows

Intercepts and slopes for the supply and demand equations are needed to identify the model. For sources which currently supply the market, these can be derived from the baseline price and quantity and either own and cross price elasticities at the baseline or intercepts. In instances where a source is not currently supplying the market, other information is needed to derive the slopes and intercepts. For example, if the lowest price at which the source would supply the market and the highest price purchasers would pay for the product are known, they can be used to calculate the intercepts for the supply and demand curves respectively. Also, an average of the intercepts or slopes calculated for the other sources can be used as slopes for the own and cross prices.

Cross price slopes are calculated by the cross price elasticity, quantity, and price of the other good involved. If the there is no production of the "cross" good, the initial demand price can be used. If there is no production of the "own" good, the cross supply slope for the cross good with respect to the price of the own good can be used. Elasticities and intercepts for the zero trade source could be based on elasticities and slopes for the product in other markets, elasticities and slopes for a competing product in the market being analyzed, or other information.

Applying the linear model to the U.S ban on imports of Cuban cigars

Cuban cigars are banned from the U.S. market, but are sold in other markets such as the EU. Reportedly, Spain has been the largest consumer of Cuban cigars, with strong demand as well in the UK, France, Germany, Switzerland, and the Benelux nations.[3] Almost 70 percent of

[3] Bell (2008).

Cuban cigar exports are to the EU.[4] Also, one observer believes that between 4 and 5 million Cuban cigars are still being smoked in the United States despite the import ban.[5] This observer also believes that Cuba can produce about 170 million cigars per year, with about 150 million of these cigars exported. Another observer believes that it would take a minimum of four years after the of the export ban for additional cigars of “decent” quality to be produced in Cuba.[6]

Premium cigars are imported into the U.S. market under HS tariff line 2402.10.8070, and totaled 271.247 million cigars in 2008 according to import data adjusted by Cigar Association of America. [7] Imports of premium cigars into the U.S. market from the Dominican Republic (41 percent of imports in 2008), Honduras (32 percent of imports in 2008), and Nicaragua (26 percent of imports in 2008) made up 99 percent of the imports in 2008. Average unit values (AUVs)[8] of imports under HS tariff line 2402.10.8070 in 2008 were $553 per thousand cigars for imports from Dominican Republic, $949 per thousand cigars for imports from Honduras, and $649 per thousand cigars for imports from Nicaragua, and $640 per thousand cigars from all three countries combined.[9] I assume that the baseline unit value for the U.S. market in 2008 is $649 per thousand cigars since Nicaragua is the only one of the top three importing countries for which Cigar Association of America did estimated machine-made cigars, which bias the AUVs for the Dominican Republic and Nicaragua downward.

There are limited number of estimated of cigar elasticities. Kee, et al. (2008) estimate the import demand for all cigars in the HS 2402.10 subheading (not just premium cigars) to be -1.91.

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[4] Ibid.
[5] Ibid.
[6] Perleman (2009).
[7] Machine-made cigars, which are not considered to be premium cigars are also imported into the United States under HS tariff line 2402.10.8070. The Cigar Association of America estimated U.S. imports of premium cigars in 2008 by subtracting off estimates of U.S. imports of machine made cigars from total U.S. imports under HS tariff line 2402.10.8070.
[8] I use the term average unit value instead of price in discussing results to emphasize that there are product difference between different types of premium cigars. Because of the level of aggregation of the data, my results assume that the proportion of different types of premium cigars does not changes and therefore will not capture shifts in between different types of premium cigars that would occur from removal of the import ban on Cuban cigars.
[9] USITC Dataweb.

Using Spanish data, Escario and Molina (2004) estimate the own price elasticity of demand for cigars to be -0.93.

The demand curve for non-Cuban cigars is derived by using the baseline values of 271.247 million cigars and $649 per thousand cigars and assuming that the intercept (choke price) of the demand curve ranges from $1,100 to $1,200 per thousand cigars and the cross price elasticity of demand for non-Cuban cigars with respect to the price of Cuban cigars ranges from 1.5 to 2.0. The demand choke price of $1,100 to $1,200 per thousand cigars is based on the maximum AUV of $1,026 per thousand cigars for top three U.S. importers of premium cigars since.[10] These values imply an initial own price elasticity ranging from -1.2 to -1.4.

The supply curve for non-Cuban cigars is based on the 2008 baseline values and a supply intercept ranging from $300 to $400 per thousand cigars, which implies a slope ranging from 777 thousand cigars per $ to 1,089 thousand cigars per $ and an initial supply elasticity ranging from 1.9 to 2.6. The supply choke price range is based on the minimum AUV of $464 per thousand cigars for the top three U.S. importers of premium cigars since.

The demand curve for Cuban cigars is derived from assuming that has the same intercept, own slope, and cross slopes as for non-Cuban cigars. Because of the evidence that Cuban cigar producers would only be gradually able to adjust to the lifting of the ban on Cuban cigars, I assume that in the short run would The short run supply curve for Cuban cigars is based on a choke price that ranges from $700 to $800 per thousand cigars and slope that is 10 percent of the magnitude of the slope for supply of non-Cuban cigars. The choke price range is based on the mean AUV of $749 per thousand cigars for imports of premium cigars since 2000. The long run supply curve for Cuban cigars is based on the same slopes and intercepts used for non-Cuban supply.

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[10] Prior to 2008, data for U.S. imports under HS2402.10.8070 are not available, but were included in a broader category HS 2402.10.8000 that also includes imports of "little cigars" that not considered to be premium cigars. Therefore these AUVs are based on imports from HS 2402.10.8000.

The estimated results indicate that in the short run when Cuban would be less responsive than supply from other sources, premium cigars imported from Cuba would make up about 7 to 14 percent of the U.S. market and sell at a premium of about 60 to 80 percent. After Cuban supply is able to adjust to supply in the long run, Cuban cigars would make up about 54 to 77 percent of the U.S. market and sell at a premium ranging from about a 6 to 39 percent.

If the ban on importing Cuban cigars into the U.S. market is lifted, imports of Cuban cigars are estimated to be from 20 to 41 million cigars in the short run at AUVs ranging from $1,020 to $1,137 per thousand cigars. As a result of new Cuban imports, the AUV of non-Cuban cigars imported into the U.S. would decrease by 2 to 5 percent, the volume of non-Cuban cigars imports would decrease by 4 to 11 percent, and total consumption of premium cigars in the U.S. market would increase by up to 8 percent.

In the long run when Cuban imports are able to match supply of the other major suppliers to the U.S. market, imports of Cuban cigars are estimated to be 175 to 294 million cigars at AUVs ranging from $528 to $691 per thousand cigars. The new imports from Cuba are estimated to decrease the price of premium cigars from other sources down by 17 to 32 percent, decrease the volume of non-Cuban imports 35 to 72 percent and increase overall consumption of premium cigars in the U.S. market by 3 to 61 percent.

Conclusion

The linear model of supply and demand provides a method of estimating the impact of market entry and exit that models that depend on initial market share are not able to analyze. If information about initial market conditions, choke points, demand and supply responsiveness are known, this model can be used a tool to estimate the impact of changes in trade policy and market conditions for sources with zero trade flows.

Table 1. Difference between estimated impact from linear model and CES model (percent)

	Price		Quantity	
	Domestic	Import	Domestic	Import
Range of absolute value of tariff change				
0 to 10 percent	**0.0 to 0.2**	**0.7 to 38.3**	-0.5 to 1.0	*-6.9 to 0.0*
0 to 25 percent	**0.0 to 1.4**	**0.0 to 82.1**	-5.8 to 4.1	*-75.2 to 0.0*
0 to 50 percent	**0.0 to 5.0**	**0.0 to 133.3**	-61.0 to 16.7	*-41.6 to 0.0*
0 to -10 percent	**0.0 to 0.2**	*-70.8 to -0.1*	-1.9 to 1.1	*-15.1 to 0.0*
0 to -25 percent	**0.0 to 1.6**	*-190.0 to 0.0*	-6.0 to 6.6	*-38.5 to 0.0*
0 to -50 percent	**0.0 to 8.0**	*-687.5 to 0.0*	-25.1 to 24.5	*-480.0 to 0.0*
5^{th} to 95^{th} percentile of absolute value of tariff change				
0 to 10 percent	**0.0 to 0.2**	**2.0 to 32.2**	-0.1 to 3.7	*-4.0 to 0.0*
0 to 25 percent	**0.0 to 7.1**	**3.3 to 65.5**	-1.8 to 1.8	*-17.4 to 0.0*
0 to 50 percent	**0.0 to 2.4**	**6.6 to 110.1**	-3.5 to 8.0	*-34.7 to -0.1*
0 to -10 percent	**0.0 to 0.2**	*-33.8 to -1.0*	-0.6 to 0.3	*-3.3 to 0.0*
0 to -25 percent	**0.0 to 1.0**	*-112.0 to -2.0*	-1.9 to 2.3	*-29.3 to 0.0*
0 to -50 percent	**0.0 to 4.2**	*-345.2 to -5.2*	-7.0 to 10.3	*-168.6 to 0.0*

Note: Ranges with all positive values are bold and ranges with all negative values in italics.

Table 2. Correlation between inputs and results for the linear and CES models

	Price				Quantity			
	Domestic		Import		Domestic		Import	
	Linear	CES	Linear	CES	Linear	CES	Linear	CES
Demand elasticities								
Linear elasticities								
Domestic own price	0.033	0.070	0.024	0.026	0.006	-0.066	0.006	0.105
Import own price	-0.047	-0.017	-0.043	-0.044	-0.020	0.054	-0.016	-0.219
Domestic-import cross	-0.044	-0.084	-0.030	-0.031	-0.020	0.056	0.000	-0.116
Import-domestic cross	0.036	0.003	0.038	0.038	0.006	-0.064	0.022	0.208
CES elasticities								
Substitution elasticity	0.026	0.049	-0.008	-0.009	0.021	0.021	0.029	0.022
Aggregate demand	-0.010	-0.010	0.033	0.031	0.002	-0.005	-0.030	-0.006
Supply elasticities								
Domestic	0.003	-0.059	0.012	0.011	0.000	0.002	0.014	0.093
Import	-0.034	-0.047	-0.017	-0.018	-0.045	-0.033	0.019	-0.036
Domestic market share	0.051	0.062	0.052	0.053	0.019	-0.054	-0.006	0.162
Change in duty	**0.794**	**0.795**	**0.999**	**0.999**	**0.822**	**0.823**	**-0.912**	**-0.745**

Table 3. Demand and supply parameters

	Demand		Supply	
	Non-Cuban	Cuba	Non-Cuban	Cuba
Intercept				
AUV ($/thousands of cigars)	**1,100 to 1,200**	**1,100 to 1,200**	**300 to 400**	**700 to 800/** ***300 to 400***
Quantity (millions of cigars)	53 to 252	234 to 486	-233 to -436	-55 to -86/ *-243 to -429*
Slopes				
Own (thousands of cigars/$)	-492 to -601	**-492 to -601**	777 to 1,089	**78 to 109/** ***777 to 1,089***
Cross (thousands of cigars/$)	34 to 490	**34 to 490**	-	-
Initial elasticity				
Own	-1.2 to -1.4	**-**	1.9 to 2.6	-
Cross	**1.5 to 2.0**	**-**	-	-
Final elasticity (short run)				
Own	-1.2 to -1.5	-14.8 to -28.7	1.9 to 2.8	2.7 to 4.3
Cross	0.8 to 1.2	9.5 to 24.8	-	-
Final elasticity (long run)				
Own	-1.6 to -3.2	-1.1 to -1.9	2.4 to 6.6	1.9 to 3.1
Cross	1.1 to 2.8	0.7 to 1.6	-	-

Note: Assumed values are in bold and long run parameters are in italics. Other values are derived.

Table 4. Estimated impact of removing the ban on Cuban cigars in short run and long run

	Non-Cuban	Cuba	All sources
Baseline			
AUV ($/thousands of cigars)	649	-	-
Quantity (millions of cigars)	271	0	271
Cuba included (short run)			
AUV($/thousands of cigars)	619 to 636	1,020 to 1,137	-
Quantity (millions of cigars)	240 to 261	20 to 41	272 to 293
Percent change			
Price	-2 to -5	-	-
Quantity	-4 to -11	-	0 to 8
Cuba included (long run)			
AUB($/thousands of cigars)	441 to 539	528 to 691	-
Quantity (millions of cigars)	76 to 176	175 to 294	279 to 436
Percent change			
Price	-17 to -32	-	-
Quantity	-35 to -72	-	3 to 61

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