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Source Differentiated Mexican Dairy Import Demand

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Abstract

Mexico is a major destination of dairy exports and is the single largest importer of US dairy exports. We use a restricted source almost ideal demand system to estimate the demand for dairy products imported into Mexico. The estimation facilitates an examination of the demand for dairy imports and the results have implications for exporting firms and countries. Our estimates indicate fierce competition for the Mexican market between the US, Oceania, and "other countries" primarily from South America.

Keywords: dairy trade, import demand, almost ideal demand system, source differentiation

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Introduction

Mexico is consistently one of the largest importers of dairy products in the world. Although domestic milk production has been growing, population demands continue to outstrip the ability of the domestic supply to meet the Mexico's consumption needs. Because of its size and proximity, Mexico has been the largest destination of United States (US) dairy product exports since 1990. In the ten-year period following 1994 implementation of the North America Free Trade Agreement (NAFTA), tariff rates for all US dairy exports to Mexico, with the exception of milk powder, gradually declined to zero. [1] Despite this advantage, the US continued to face fierce competition for the Mexican dairy export market from the European Union and Oceania.

Understanding the demand for dairy imports into Mexico has implications for dairy producers, cooperatives, processors, and exporters throughout the world as they make long-term investment and strategic decisions. This study utilizes a framework wherein Mexican importers are allowed to differentiate similar products by source of origin. This approach accounts for preferences and interactions between different dairy products, allowing an evaluation of market prospects for dairy exporters. The objectives of this paper are to: analyze dairy import demand in Mexico during the period 1990 through 2005; assess the import behavior and determine the demand elasticities for imported dairy products differentiating by source of origin; and, thus, to evaluate the Mexican market prospects for exporters.

The paper is organized as follows. In the next section, we briefly examine the dairy production, consumption and import situation in Mexico. Data are explained in the third section. The fourth section presents estimation results and implications. The final section concludes. The source differentiated AIDS model that provides the demand estimates is discussed in an appendix.

The Mexican Dairy Market

Mexican milk production has been steadily growing (Table 1) and several domestic government programs have discouraged dependence on imports. As a result, domestic milk production increased from 5.81 million metric tons in 1990 to 10.02 million metric tons in 2004. However, not all of the milk produced in Mexico can be effectively utilized to meet dairy product demand due to lack of marketing infrastructure (efficient supply chain, forward pricing and other risk management tools), as well as preferences for certain import products (Dobson and Proctor, 2002). Also, the cost of milk produced in Mexico is often higher than the price of subsidized

[1]The milk powder tariff is scheduled be eliminated for US milk powder into Mexico in 2008. Prior to that time, there is a non-tariff quota of 40,000 MT allocated to US Imports exceeding the quota are subjected to a 139% tariff. Under the NAFTA guidelines the US will be the only country capable of exporting non-tariff milk powder to Mexico in 2008.

dairy imports from abroad, especially milk powder, creating an incentive for processors and government social programs to procure dairy products from abroad. Fragmented geography and semi-tropical weather contribute to insufficient feed production and contribute to higher costs of milk production compared to dairy product imports.

Additionally, the mix of dairy imports to Mexico has changed in recent years from low-value commodities such as milk powder, to high-value products such as ice cream, specialty cheeses and protein fractions used in the manufacture of baby formulas, for which there are no domestic substitutes.

Table 1: Mexico Dairy Statistics, 1990 - 2004

Year	Production	Imports	Total consumption
	(million tons)	(million tons)	(million tons)
1990	5.81	2.73	8.54
1991	6.18	1.14	7.32
1992	6.38	2.45	8.83
1993	7.40	2.73	10.13
1994	7.32	2.29	9.61
1995	7.40	1.69	9.09
1996	7.59	1.91	9.50
1997	7.85	2.12	9.97
1998	8.32	2.02	10.34
1999	8.88	2.22	11.09
2000	9.31	2.31	11.62
2001	9.50	2.78	12.28
2002	9.80	3.21	13.01
2003	9.93	3.33	13.26
2004	10.02	3.63	13.65

Data source: The Mexican Secretariat of Agriculture and Natural Resources (SAGARPA) and the US Department of Agriculture Foreign Agricultural Service.

We categorize the major players in the Mexican dairy market as the US, European Union (EU), Oceania, including New Zealand and Australia, and a residual category entitled "Other countries" (e.g., India, Costa Rica, Argentina, Poland and Uruguay).[2] Import source categories are a necessity for the demand model we utilize. These particular categories were chosen because the US, EU, and Oceania have been the traditional major sources of dairy exports onto the world market. Figure 1 displays import shares of the main exporters to Mexico from 1990 through 2005. While there is a large degree of variation from year to year, it is clear that the EU share declined over that period while the US and "Other countries" became more important suppliers to the Mexican market.

[2] For our purposes, the EU refers to the EU-15. While Poland is now part of the EU, it was not at the beginning period we analyze and to be consistent it was included in the "Other countries" source category.

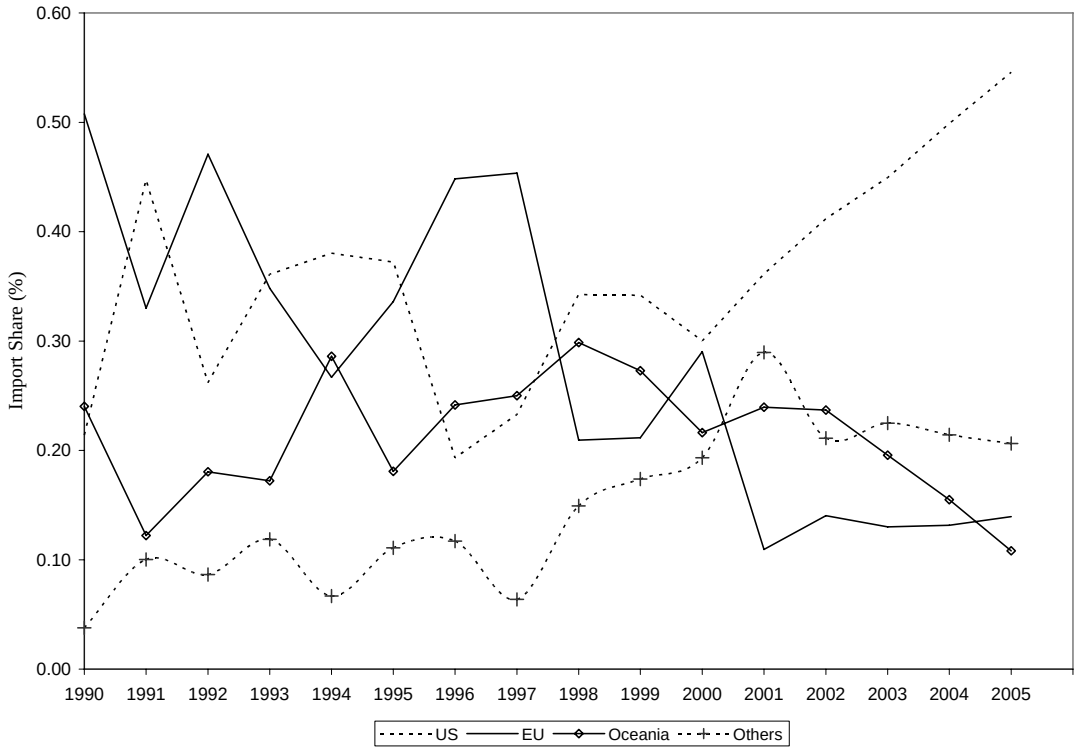

Figure 1. Mexican Dairy Import Shares (by value).
Data source: Mexican Secretariat of Economy.

Table 2 displays average product shares based on the value of imports exported to Mexico by source from 1990 through 2005. The US had the largest share in fluid milk, cheese, skim milk powder (albeit just slightly more than the EU), whey and other dairy imports to Mexico. The EU had the largest average share of milk powder imports while Oceania had the largest butter import share.

Table 2: Average Exporter Value Shares to Mexico by Product, 1990-2005.

	Fluid Milk	Cheese	Skim Milk Powder	Whey	Butter	Other Dairy*
			(percent)			
US	84.20	33.57	31.89	72.01	16.21	80.29
EU	0.49	25.31	30.84	12.95	31.58	13.08
Oceania	0.59	19.38	23.69	2.04	48.77	0.00
Other	14.72	21.74	13.58	13.00	3.44	6.64

Data source: Mexican Secretariat of Economy.
*Includes ice cream and yogurt.

Data

Data from the Mexican Secretariat of Economy on import monetary values and quantities for fluid milk, cheese, milk powder, whey, butter, ice cream and yogurt were utilized. Fluid milk, whey, butter, ice cream and yogurt were grouped to save degrees of freedom and classified as "other dairy products." Thus, the resulting

product categories were cheese, milk powder and other dairy. Cheese and skim milk powder were chosen as they were the largest product categories by value of imports during the period examined (Figure 2). Using the value and quantity information, unit prices and import shares from the respective sources of origin were derived.

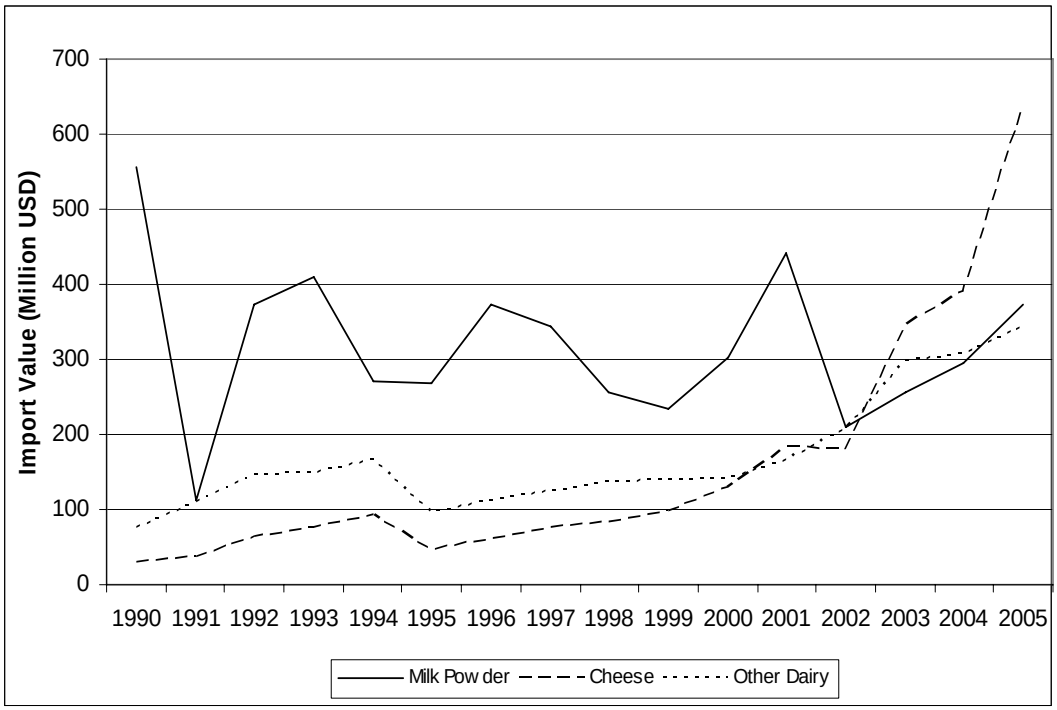

Figure 2. Value of Mexican Dairy Imports by Category, 1990-2005.
Data Source: Mexican Secretariat of Economy

Dollar export values were divided by their corresponding quantities to obtain the price importers paid in Mexico, which accounted for export subsidies and transportation costs. Prices were adjusted by Mexican import tariffs to better reflect the actual price in Mexico. Two different tariff schedules were applied to the prices, one for the United States specified under the North American Free Trade Agreement[3] (NAFTA) that considers the phasing out of tariffs in a 10-year period, and another tariff schedule for all the other countries. [4] Table 3 displays tariff schedules for dairy imports into Mexico. Another factor that was considered when calculating prices is the milk powder quota. Under the WTO and GATT guidelines, there was an 80,000 metric tons duty free quota for all the WTO countries exporting milk powder to Mexico. Quantities that surpassed the quota were subject to a 139%

[3] This schedule is only valid for the United States under the NAFTA guidelines. Canada excluded its dairy sector from the NAFTA negotiations.
[4] Even though a Free Trade Agreement with the European Union was signed in 2000, the dairy category was excluded from the negotiation because of the high level of subsidies utilized by the European Union.

tariff. For the U.S. under NAFTA guidelines[5], there was a quota of 40,000 metric tons of milk powder independent from the WTO quota, subject to the same tariff for exceeding quantities, but scheduled to be phased out over a 15-year period ending in 2008. The tariffs phased out by 24% over the first six years of the agreement and the remainder of the over-quota tariff were to be eliminated linearly over the remaining time period ending in 2008. These considerations were taken into account while calculating the import prices of milk powder by source country. Data on private consumption was obtained from the Central Bank of Mexico (Banxico).

Table 3. Mexican Tariff Schedules (products other than milk powder)

Product	WTO countries Tariff	NAFTA Tariff in 1993	NAFTA Tariff in 2003 (and later)*
		Tariff rate (%)	
Fluid milk	10	10	0
Yogurt	20	20	0
Whey	10	10	0
Butter	20	20	0
Cheese	20	20	0
Ice cream	20	20	0

Data Source: Mexican Secretariat of Economy
*These reflect the impact of NAFTA which linearly phased out tariffs over a 10-year-period ending in 2003.

As discussed above, the sources of origin for dairy products imported into Mexico were categorized as US, EU, Oceania, and "Other countries." Many of the countries in the "Other countries" category did not have a stable presence in the Mexican market. The "Other countries" that maintained relatively constant presence throughout the period of study were Argentina, Uruguay and Poland.

Estimation Results and Implications

The source differentiated almost ideal demand system (SD-AIDS) which was estimated is described in detail in the Appendix. The resulting coefficients reveal the response of quantity demanded for each product category to their own prices and prices of the other categories by source country.

Product demand results

With respect to demand for cheese, all own-price elasticities (on the diagonal of each block) were negative and at least unit elastic (Table 4). Demand for cheese from the EU was the least sensitive to its own price (-1.00). US cheese was sensitive to

[5] These guidelines under NAFTA started in 1993. Prior to that date, the U.S. was subject to the same WTO schedule.

Table 4. Marshallian Elasticities of Mexican Dairy Import Demand using the Restricted Source Differentiated AIDS Model

	Cheese				**Milk Powder**				**Other Dairy**			
Price	US	EU	OC	OT	US	EU	OC	OT	US	EU	OC	OT
P_{CHUS}	**-1.55***	-0.16	0.09	**0.36**								
P_{CHEU}	-0.23	**-1.00***	-0.24	**0.28**								
P_{CHOC}	0.26	-0.30	**-1.91***	**0.87***								
P_{CHOT}	**0.57***	**0.27***	**0.60***	**-2.65***								
P_{MPUS}					-0.51	**-1.05***	**1.11***	**-0.61***				
P_{MPEU}					**-0.63***	-0.42	**-0.41***	**0.81***				
P_{MPOC}					**1.25***	**-0.73***	**-1.12***	**-0.41***				
P_{MPOT}					**-1.33***	**1.60***	**-0.79***	**-1.10***				
P_{ODUS}									**-1.05***	**0.07***	**0.11***	-0.09
P_{ODEU}									**0.43***	**-1.04***	**-0.11***	-0.11
P_{ODOC}									**0.68***	**-0.19***	**-1.14***	-0.96
P_{ODOT}									-0.84	-0.23	-0.24	-3.26
P_{CH}					0.79	0.37	-0.18	-0.78	0.04	-0.04	0.13	-0.16
P_{MP}	**-2.48***	**-1.24***	-0.33	**-1.55***					0.04	0.22	-0.07	0.03
P_{OD}	**1.47***	**0.54***	0.02	0.70	**-0.77***	-0.01	0.10	0.42				
Expenditure	**2.27***	**1.87***	**1.39***	**2.07***	**0.97***	0.28	**1.17***	**1.74***	**0.89***	**0.74***	**0.92***	1.17
Marginal Share	0.17	0.09	0.05	0.10	0.13	0.02	0.14	0.12	0.12	0.01	.02	0.03

Notes: System $R^2 = 0.78$. Bold * denotes significance at the five percent level. P=price, Y=income; CH=cheese, MP= milk powder, OD= other dairy products; US= United States, EU= European Union, OC= Oceania, OT= Other countries.

changes in own-price as a one percent increase in price brings about 1.55 percent decrease in US cheese imports. Cheese imports from Oceania (-1.91) and "Other countries" (-2.65) were even more sensitive in changes to their own prices. These elastic own-price values indicate that all sources would increase revenues from cheese sales to Mexico by lowering cheese price.

Cheese cross-price elasticities revealed competitive relations among products. As US cheese price increased, more cheese from Oceania and "Other countries," and less cheese from the EU was demanded. The results indicate that US cheese directly competed in terms of price with Oceania and "Other countries" cheese.

The Mexican government imports milk powder for social programs and these government purchases are a substitute for domestic and imported products. Therefore, if milk powder prices were to rise, prices for other products such as cheese would increase, and importing more milk powder to produce a portion of these products domestically would be cheaper than importing the finished products. Traditionally, the US and EU have been the primary suppliers of subsidized milk powder to Mexico. This long-term relationship and the need for milk powder were reflected in the inelastic demand estimates for the US and EU. In contrast Oceania and the "Other countries" sources had elastic own-price estimates. This meant that the milk powder quantity imported from those countries decreased in larger amounts (more than one percent quantity change for a one percent change in price) when prices from these sources increased, suggesting that these sources were important when product was not readily available from the US or US price was above world price.

"Other dairy products" own-price elasticities suggest that demand for these products was price elastic from every source. In terms of price competition, the results suggest that one percent increase in other dairy products price from Oceania lead to a 0.68 percent increase in US imports. The US share of this import category similarly benefits from increase in EU price increases but lost large portions of "other dairy product" market share from price declines by those sources.

Projecting shares of additional imports

Mexico is projected to continue to import dairy products for many years to come (Dobson and Proctor). The estimates from this study have implications for how the Mexican dairy product deficit will be filled. To estimate how increases in income affect the demand for dairy imports, expenditure elasticities and marginal import shares were calculated following the approach of Seale, Marchant, and Basso (2002). Marginal shares are defined as $\beta_i + w_i^*$, where β_i is the expenditure parameter from the RSAIDS model and w_i^* is the average import share for source *i*.

The expenditure elasticity and marginal share are closely related. Expenditure elasticities estimate the percent change in quantity demanded when total expenditures increase by one percent. Marginal shares estimate how an additional dollar spent on dairy product imports would be allocated across products and sources. A country has strong potential in an import market if demand for the product is insensitive to price changes but increases with import expenditure (Yankg and Koo, 1994). Based on these measures and our estimates, it is possible to evaluate the potential for US dairy exports to Mexico by category.

All expenditure elasticities were positive and most were significant. Our results suggest that, if total expenditure on imported dairy products were to rise, holding all other factors constant, imported cheese demanded from the US would increase the most, followed by cheese from "Other countries," and Oceania. European cheese imports would be least favored.

In terms of import cheese market, if expenditure on imported dairy products in Mexico were to rise, *ceteris paribus* the demand for US cheese would increase by the estimate of expenditure elasticity (2.27) (Table 4). This increase was larger than the cheese demand response from any other source (although the "other country" category was close).

The marginal shares indicate how an additional dollar would be allocated. An additional dollar spent on dairy imports would include a total of 41 cents spent on cheese. US cheese would benefit the most by taking 17 cents of that dollar. Taken with the own product price elasticities, these results suggest that US exporters should consider price carefully to maintain an advantage in the Mexican market as US cheese imports were sensitive to price increases. In addition the results indicate that the real competition for the US in the Mexican cheese market came from "Other countries," with similar quality and characteristics at a lower price, more so than from the EU or Oceania.

In terms of the market for milk powder, the US was very competitive in the Mexican import market and this category was expected to grow as the NAFTA deadline for import quotas arrived. With respect to own-price elasticity, US milk powder exhibited an inelastic estimate (-0.51) as contrasted with the relatively elastic estimates for milk powder from Oceania (-1.12) and "Other countries" (-1.10). In terms of the marginal share, milk powder as a product category would collect a total of 41 cents of an additional dollar allocated to milk powder imports. Of this, milk powder from Oceania would take 14 cents of, followed by the US (13 cents) and "Other countries" (12 cents). These large estimates for the marginal shares highlight the constant need for milk powder in Mexico.

In the case of the "Other dairy" products category, the US faces a competitive market, but has positive market prospects. However, the US would receive the

largest share of an additional dollar allocated to dairy imports by taking 12 cents, by far the largest marginal share, posing a great advantage compared to other exporters, and demonstrating the strong presence of US dairy brands in Mexico.

During the period studied (1990-2005), the US became the main supplier of dairy products to Mexico surpassing the European Union. The analysis of the marginal shares suggests that the US would take 42 cents of an additional dollar allocated to dairy imports in Mexico. The results obtained in this study are consistent with opinions of analysts in the Mexican industry and point out that Oceania is a strong competitor that could represent a challenge to the US. Dobson and Proctor (2002) point out that the New Zealand Dairy Board, now Fonterra, is superior to any single American company operating in Mexico. The marginal share analysis suggests that Oceania would obtain 21 cents of an extra dollar allocated to dairy imports. The EU would receive only 12 cents of that dollar spent on dairy imports while "Other countries" would take 25 cents in total. In addition to increasing competition in the world dairy market, the decline in EU share over the period analyzed marks a shift away from direct production subsidies which necessitate dumping product on the world market towards decoupled payments leading to a smaller dairy surplus.

Implications for dairy firm managers

For managers of dairy cooperatives and other investor-owned dairy plants, the results have many implications for strategic decisions. These firms must make decisions as to what type of product facilities to invest in, which is a major long-term decision, as well as how much effort to put into expanding export market in the shorter term. The Mexican market is a major destination for dairy products but the key factor is clearly price and commodity products (and perhaps increasingly whey proteins), rather than higher prices specialty products, have been the major exports. The exchange rate will play a major role in determining which countries' products have the price advantage. For example, the weak US dollar in the past year has made US imports even more attractive. Traditionally, the US and EU have used the Mexican market to eliminate surpluses of dairy products. Growing a presence in the Mexican market as consumer incomes there rise will help result in a place for those countries premium dairy products in the future. Our results indicate that firms would increase revenues from lowering price on cheese exports to Mexico if possible and profitable. Milk powder from US and EU firms has some latitude to increase price but this is likely due to the subsidies on that product from those sources as the milk powder from Oceania, which is not subsidized, exhibited an elastic demand.

The results also have implications for policy preferences in the exporting countries. The US has utilized dairy export subsidies from the government and, in recent years, from industry cooperatives through a voluntary program. The weaker US dollar has meant that these subsidies are less or unnecessary as US products

become the low cost products. The EU has traditionally also subsidized exports and used markets such as Mexico to eliminate excess dairy stocks. In more recent years, however, the EU has moved away from direct market interference to have an agricultural policy that focuses more on factors such as the environment. Part of the decline in EU exports may reflect some of these policy changes. Oceania, in contrast to the US and EU, has had a long-term free market approach that has depended on being the low cost producer. A new World Trade Organization agreement would almost certainly result in even freer trade making price and cost of production of utmost importance in dairy export markets.

Conclusions

Despite a yearly milk production growth rate of over five percent during the 1990's, Mexican milk supply was not able to keep pace with domestic milk consumption. Therefore, imports continue to fill 20 percent or more of total dairy product consumption in Mexico. The Mexican market attracts many exporters and the US faces increasing competition from Oceania and South America. Using a demand model, we estimated the relationship of Mexican dairy product import demand both across product types and source of origin. We found that the US had a strong position that was enhanced by NAFTA, proximity, and export subsidies. "Other countries," which reflects a group of nations outside the traditional major dairy exporters, were also increasingly important sources of dairy imports during the period analyzed while the EU share declined precipitously. Our results indicate the US should continue to be a primary supplier in the Mexican dairy market by taking 42 percent of every additional dollar allocated to imported dairy products. Oceania, particularly New Zealand, would take almost 21 percent of the additional a dollar and "Other countries" would increase their shares as well, especially in the cheese market.

As income and population grow in Mexico, there will likely be demand for more dairy products and because of infrastructure and supply chain issues, domestic milk production will not be enough to cover the additional demand for some time. Therefore, dairy imports will continue to fill the gap between domestic production and total dairy demand, not only in low value commodities such as milk powder, but also in more sophisticated products such as whey proteins or specialty cheeses.

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Appendix: Source Differentiated Demand Model

The Almost Ideal Demand System (AIDS) model allows estimation demand relationships across different commodity categories (Deaton and Muellbauer). Empirical applications of the AIDS model to import demand typically assume product aggregation, under which the demand system does not differentiate products by source, which means the model consists of share equations for a good

from different origins, and does not account for different perceptions in quality and other preferences by source. An AIDS model based on only one product from different origins, in this case dairy products, assumes aggregation over products that is possible only if all prices move together by the same proportion, which does not hold true in international trade (Yang and Koo; Alston et al.). This aggregation, for example, ignores that Mexican importers may perceive US dairy products differently from European or Australian products. Thus, the marginal utility of consuming US cheese would not be affected by the consumption of European cheese. This aggregation would lead to modeling the demand for milk independently of the demand for cheese, and fail to represent the different interactions between the different dairy products. If these interactions exist, since goods compete for the same expenditure allocation, this assumption will bias elasticity estimates. We hypothesized that source differentiation is important in dairy import demand analysis and, therefore, utilize a Restricted Source Differentiated Almost Ideal Demand System (RSAIDS) based on the import value shares. This model has previously been applied to Japanese meat import demand (Yang and Koo), wine in British Columbia (Carew, Florkowski, and He), and Indonesian fruit imports (Andayani and Tilley).

The AIDS model is derived from a price-independent generalized logarithmic expenditure function (Deaton and Muellbauer). To incorporate source differentiation, this expenditure function is rewritten to approximate importer behavior that differentiates goods by origin. The expenditure function given utility level u can be written as:

(1) $$\ln E(u,p) = (1 - u)\ln[a(p)] + u \ln[b(p)]$$

where

$$\ln[a(p)] = \alpha_0 + \sum_i \sum_h \ln(p_{i_h}) + \frac{1}{2} \sum_i \sum_j \sum_h \sum_k \gamma^*_{i_h j_k} \ln(p_{i_h}) \ln(p_{j_k}),$$

and

$$\ln[b(p)] = \ln[a(p)] + \beta_0 \prod_i \prod_h p_{i_h}^{\beta_{i_h}},$$

where α, β, and γ^* are parameters (Yang and Koo). The subscripts *i* and *j* denote goods (*i, j* = 1,...,*N*) and *h* and *k* denote sources of origin (*h,k* = 1,...,*M*). Applying Shephard's Lemma provides the source differentiated share equations as:

(2) $$w_{i_h} = \alpha_{i_h} + \sum_j \sum_k \gamma_{i_h j_k} \ln(p_{j_k}) + \beta_{i_h} \ln(\frac{E}{P*}),$$

where *w* is the import share of a given product, *p* represents price of the product in question, *E* is expenditure on imported dairy products, and *P** represents an index of price for all imported dairy products from all the origins. M is the total number of dairy product categories and N is the total number of sources considered. The price index is:

$$(3) \qquad \ln(P^*) = \alpha_0 + \sum_i \sum_h \alpha_{ih} \ln(p_{i_h}) + \tfrac{1}{2} \sum_i \sum_h \sum_j \sum_k \gamma^*_{i_h j_k} \ln(p_{i_h}) \ln(p_{j_k}).$$

Stone's price index is a linear approximation of the price index defined as:

$$(4) \qquad \ln(P^*) = \sum_i \sum_h w_{i_h} \ln(P_{i_h}).$$

To avoid simultaneity problems in the expenditure share w_{i_h}, which is also the dependent variable in equation (2), average share was utilized.

The Source Differentiated Almost Ideal Demand System (SDAIDS) model in equation (2) is data intensive. With four sources and three products, there are a total of 14 coefficients for each equation and 16 years of Mexican dairy import data available. Therefore, following the approach of Yang and Koo, we estimate a restricted model that incorporates the following assumption:

$$(5) \qquad \gamma_{i_h j_k} = \gamma_{i_h j} \forall k \in j \neq i.$$

This assumption is "block substitutability" and means that cross-price effects of commodity *i* from origin *h* are the same for all commodities *j* regardless of their origin. In this analysis, this assumption means that Mexican demand for US cheese imports exhibits the same cross-price response to milk powder from Europe as to milk powder from Oceania.

Substituting (5) into (2) results in a restricted model:

$$(6) \qquad w_{ih} = \alpha_{ih} + \sum_k \gamma_{i_{hk}} \ln(P_{ik}) + \sum_{j \neq i} \gamma_{i_h j} \ln(P_j) + \beta_{ih} \ln(\frac{E}{P^*}),$$

where $\gamma_{i_{hk}}$ is a cross-price response parameter for the same good for different origins, and the parameter $\gamma_{i_h j}$ is the block substitutability cross-price parameter. The restricted model in (6) has fewer parameters (only eight total coefficients) to estimate which is important given data constraints.

Marshallian price elasticities for model are:

$$(7) \qquad \begin{aligned} \varepsilon_{i_h i_h} &= -1 + \frac{\gamma_{i_{hh}}}{w_{i_h}} - \beta_{i_h}, \\ \varepsilon_{i_h i_k} &= \frac{\gamma_{i_{hk}}}{w_{i_h}} - \beta_{i_h}(\frac{w_{i_k}}{w_{i_h}}), \\ \varepsilon_{i_h j} &= \frac{\gamma_{i_h j}}{\gamma_{i_h}} - \beta_{i_h}(\frac{w_j}{w_{i_h}}). \end{aligned}$$

While the expenditure elasticity is:

(8) $$\eta_{i_h} = 1 + \frac{\beta_{i_h}}{w_{i_h}}.$$

Consistent with demand theory, and to facilitate estimation, the following conditions were also imposed:

(9) adding-up: $\sum_i \sum_h \alpha_{i_h} = 1; \sum_h \gamma_{i_{hk}} = 0; \sum_i \sum_h \gamma_{i_h j} = 0; \sum_i \sum_h \beta_{i_h} = 0,$

(10) homogeneity: $\sum_k \gamma_{i_{hk}} + \sum_{j \neq i} \gamma_{i_{hj}} = 0$, and

(11) symmetry across sources for a given good: $\gamma_{i_{hk}} = \gamma_{i_{kh}}$.

Because of block substitutability, symmetry conditions among goods are not applicable; symmetry is applied only within each good from different origins. This means that the cross-price response of US milk to EU milk is the same cross-price response from EU milk to US milk. (Yang and Koo). Finally, we impose separability between domestic and import products as is common in other examinations of import demand (Yang and Koo).

Elasticities between and across products and with respect to income were calculated from the estimated model parameters. The significance of the elasticities was tested following the approach of Chalfant (1987) by calculating the standard errors (SE), as a function of the average share (w_i) and the β_i parameter from the regressions, and testing their significance with the Wald statistic.[1]

[1] The Wald test statistic is $SE(\varepsilon) = (1/w_i)SE(\beta_i)$.

