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FUNCTIONAL FORM FOR UNITED STATES – MEXICO TRADE EQUATIONS

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Abstract

Previous empirical research regarding the demand for imports in the U.S. has been conducted using aggregate data and equation specifications that impose potentially ill-advised coefficient restrictions. While a large volume of research has been published for import demand functions, comparatively little effort has been directed toward the more difficult, but equally important, area of export demand. Additionally, the subset of the literature concerning bilateral trade flows between Mexico and the U.S. is virtually nonexistent. With the passage of the North American Free Trade Agreement and the growing importance of international trade between the United States and Mexico, insights into the potential response of these trade flows to changes in relative prices and income performance represent a topic of study that deserves more attention. This paper attempts to partially fill this gap in the literature by estimating bilateral trade flow equations for the U.S. and Mexico that decompose relative import and relative export prices into foreign prices, domestic prices, and the exchange rate.

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I. Introduction

Over the last several decades a large literature has developed concerning the empirical estimation of the demand for imports in the U.S. The typical paper in this literature provides long-run estimates of the income and price elasticities of the aggregate demand for imports. As an example, the surveys by Goldstein and Khan (1985), Stern, Francis, and Schumacher (1976), and Sawyer and Sprinkle (1996) contain more than 100 empirical estimates on the demand for imports and exports by the United States. With such a large literature on this subject one might well question the necessity for still another paper on the determinants of U.S. foreign trade flows. Part of the rationale for this paper lies with the words aggregate and exports above.

The vast majority of the papers on U.S. foreign trade are concerned with the demand for aggregate imports. There are far fewer papers on the aggregate demand for U.S. exports and the subset of the literature concerning bilateral trade flows between Mexico and the U.S. is virtually nonexistent. While this is obviously of interest and convenient in a data sense, U.S. trade with Mexico has become more important in a trade policy sense with the passage and implementation of the North American Free Trade Agreement (NAFTA). The estimated response of these trade flows to changes in relative prices (i.e., tariff reductions and/or exchange rate changes) and income changes will remain important as NAFTA tariff reductions occur over the next 15 years. Further, U.S. trade with Mexico has become more important in an absolute sense because Mexico is now the third largest trading partner of the United States. The United States, it should be added, is also by far Mexico's largest trading partner.

While a large number of previous studies have provided estimates of price and income elasticities of foreign trade for the U.S. on an aggregate level, only eight studies have estimated these elasticities for Mexico. To briefly summarize, the literature consists of papers by Agarwal (1984), Clavijo and Faini (1990), Clark (1992), Cline (1989), Faini, Pritchett, and Clavijo (1992), and Salas (1982a,b and 1988). Estimates of the income and price elasticities of imports and exports reported in these papers for Mexico are shown in Tables 1 and 2 below, respectively.

The tables highlight some of the problems in this literature. In each of the above cases, the price and income elasticities have been estimated only for aggregate Mexican trade flows not bilateral trade flows between the U.S. and Mexico. This is useful information though somewhat limited. While these previous studies have provided long-run estimates in an aggregate sense dealing with the effects of changes in domestic income and those of relative prices, these types of estimates leave several unanswered questions.² As shown in Equation 1, part of the potential problem arises from specifications that rely upon a single price variable.

$$\begin{aligned}
1. \quad \ln(QM) &= a_0 + a_1 \ln(Y) + a_2 \ln(PFM/PD) + U1 \\
&= a_0 + a_1 \ln(Y) + a_2 \ln(PFM) - a_2 \ln(PD) + U1 \\
&= a_0 + a_1 \ln(Y) + a_2 \ln(P) + U1,
\end{aligned}$$

where individual parameter hypotheses are $a_1 > 0$ and $a_2 < 0$.

One of the constraints embodied in Equation 1 results because the effects of changes in foreign prices and exchange rates cannot be separated using a single price ratio formulation for the demand function. In addition, the use of a price ratio constrains the import demand function to have equal, but opposite in sign, magnitude elasticities with respect to import prices and export prices (Murray and Ginman, 1976). This formulation presumes that trade flows react in a similar manner to changes in either import prices or domestic prices.³ To the extent that this is not the case, the price-ratio specification is masking potentially useful information. It may also be useful to decompose import prices into their two components: foreign prices and the exchange rate. Finally, it would also be useful to decompose export prices into their two components: domestic prices and the exchange rate. Empirical evidence reported for other Latin American economies indicates that exchange rates can exercise important independent effects on both exports and imports (Fullerton, 1993a, 1993b).

To summarize the paper has three purposes. First, the price variable in both the import and export demand functions are decomposed into their three respective components in order to determine if trade flows react differently in any significant way to changes in relative prices or exchange rates. Second, the data series and the estimated elasticities are based on bilateral trade flows between the United States and Mexico. Both of these additions improve the information content of the results. Finally, both of the import and export functions are estimated over the period 1981-1994 which includes all six years of the pre-NAFTA structural adjustment effects in Mexico and the first full year of the complete NAFTA effects. This latter point allows one to determine the initial impact of the tariff reductions on each of the trade flows that will slowly emerge under the 1994 trilateral commercial treaty between Canada, Mexico, and the United States.

II. Model and Methodology

The trade flows model utilized is fairly standard. Economic theory suggests that the long-run quantity demanded of imports (QM) is related to domestic income or an activity variable (YD) in the importing country (U.S.), the foreign currency price of imported goods (PFM), the price of domestic goods competitive with imports (PD), the exchange rate relevant to import class (ERM), quarterly dummy variables for seasonal variation (Q), and an impact dummy variable for the passage of NAFTA (D). In an analogous manner, the long-run export quantity demanded (QX) should be related to foreign income or an activity variable in Mexico (YF), the dollar price of exports (PD), the price of export substitute goods in Mexico (PFX), the exchange rate relevant to exports (ERX), quarterly dummy variables for seasonal variation (Q), and an impact dummy variable for the passage of NAFTA (D).

A frequent practice in this type of research is to assume that the demand function is homogeneous of degree zero in price, in which case import and export prices then are defined as a relative price (i.e., the relative price of imports $RPM=(PFM/ERM*PD)$ or the relative price of exports $RPX=(PD*ERX/PFX)$). The legitimacy of this specification has been debated in the literature since the paper of Murray and Ginman (1976). Given that domestic goods and international goods may not always be homogenous commodities or perfect substitutes, this consideration is potentially important. Equation 2 incorporates the partially disaggregated version of the import function wherein heterogeneous price effects are allowed.

$$2. \quad \ln(QM) = b_0 + b_1 \ln(YD) + b_2 \ln(PFM) + b_3 \ln(PD) + U_2,$$

where individual coefficient hypotheses are $b_1, b_3 > 0$, and $b_2 < 0$.

The homogeneity assumption is not imposed in this paper for several reasons. First, the bivariate price specification is generally less restrictive and is valid even if the demand function in question is in fact homogeneous.⁴ Second, the homogeneity assumption implicitly forces one to define imports and exports in terms of the domestic price of the importing country. As a consequence, a significant amount of information is lost as it becomes impossible to determine the effects of exchange rate changes on trade flows in isolation from changes in relative prices. This is especially important if the effects of the exchange rate changes are different in magnitude than changes in relative prices. Accordingly, in order to fully differentiate the individual effects of changes in these variables on import and export quantities we have split prices into three components: import price, domestic price, and the exchange rate.

In semi-log-linear form, the respective theoretical models for U.S. imports from Mexico and U.S. exports to Mexico can be stated as shown in Equations 3 and 4.

$$3. \quad \ln(QM) = c_0 + c_1 \ln(YD) + c_2 \ln(PD) + c_3 \ln(PFM) + c_4 \ln(ERM) + c_5 Q_2 + c_6 Q_3 \\ + c_7 Q_4 + c_8 D + U_3,$$

where individual parameter hypotheses include $c_1, c_2, c_4 > 0$ and $c_3 < 0$.

$$4. \quad \ln(QX) = d_0 + d_1 \ln(YF) + d_2 \ln(PFX) + d_3 \ln(PD) + d_4 \ln(ERX) + d_5 Q_2 + d_6 Q_3 \\ + d_7 Q_4 + d_8 D + U_4,$$

where coefficient hypotheses include $d_1, d_2 > 0$ and $d_3, d_4 < 0$.

Variable mnemonics are as follows:

QM	=	the volume of real imports by the United States from Mexico ⁵
QX	=	the volume of real exports by the United States to Mexico
YD	=	real GDP in the United States
YF	=	industrial production in Mexico
PD	=	the producer price index of the United States
PFM & PFX	=	the wholesale price index of Mexico
ERM & ERX	=	the exchange rate index defined as Mexican pesos per U.S. dollar
Q _i	=	quarterly dummy variables for seasonal effects
D	=	an impact dummy for the enactment of NAFTA, defined as 1 for 1994, and 0 otherwise

It is generally agreed, however, that trade flows will not adjust instantaneously to their long-run equilibria following changes in any of their determinants (for empirical discussions, see Tegene, 1989, or Demirden and Pastine, 1995). Thus, the actual level of imports (exports) observed in any period, QM_t (QX_t), is commonly expressed as a distributed lag function of the independent variables. Given this, each of the demand specifications incorporates the assumption of a partial adjustment process by including a lagged value of the dependent variable (QM_{t-1} or QX_{t-1}) as an explanatory variable. This form allows one to estimate both short-run and long-run coefficients and assumes that the impact of both a change in income and prices on trade flows declines at a geometric rate. The coefficient on the lagged dependent variable indicates the speed of adjustment of actual to desired trade flows. Thursby and Thursby (1984) indicate that the models most frequently accepted in their specification tests are those which include dynamic behavior through lagged values of the dependent variable.

As a result, the respective import and export specifications employed in estimation appear in Equations 5 and 6.⁶

$$5. \quad \ln(QM) = f_0 + f_1 \ln(YD) + f_2 \ln(PD) + f_3 \ln(PFM) + f_4 \ln(ERM) + f_5 Q_2 + f_6 Q_3 \\ + f_7 Q_4 + f_8 D + f_9 \ln QM_{t-1} + U5,$$

where individual parameter hypotheses include $f_1, f_2, f_4, f_9 > 0$ and $f_3 < 0$.

$$6. \quad \ln(QX) = g_0 + g_1 \ln(YF) + g_2 \ln(PFX) + g_3 \ln(PD) + g_4 \ln(ERX) + g_5 Q_2 + g_6 Q_3 \\ + g_7 Q_4 + g_8 D + g_9 \ln QX_{t-1} + U6,$$

where coefficient hypotheses include $g_1, g_2, g_9 > 0$ and $g_3, g_4 < 0$.

The sample estimation period, using quarterly data, is 1981:I to 1994:IV. Data on imports are obtained from The Survey of Current Business. All other variables are published in International Financial Statistics.

Obtaining useful estimates from time-series data of this type frequently presents one or more problems. Because the equations to be estimated contain lagged dependent variables, Fuller's (1976) two-step procedure is employed. This procedure uses an instrumental variables approach to correct for the non-stationarity introduced by the presence of the lagged left-hand-side variables. Using lagged values of the independent variables as instruments predicted values for QM and QX are obtained and then substituted for the respective lagged dependent variable in each equation. Initial ordinary least squares results contained serially correlated residuals. A Cochrane-Orcutt procedure is implemented to correct this problem in all of the parameter estimates reported below.

Until recently this was all that would have been considered necessary in terms of checking the validity of coefficient estimates. Further tests to check for the presence of several other problems are now becoming routine. First, the Johansen (1988) test is utilized to verify that the variables, excluding the lagged dependent variable, in both estimated equations are cointegrated. Second, each equation passes a standard test for ARCH effects, Engle (1982). Third, each estimated equation passes the normality of the residuals test proposed by Jarque and Bera (1980). Fourth, a 2nd order RESET procedure is employed to examine whether both equations pass a specification error test.

III. Empirical Results

The estimated results for imports and exports of the United States to Mexico are reported in Table 3. In addition, this table presents both the short-run and long-run price and income elasticities. In the equation for U.S. import demand, the estimated coefficient of YD has the correct sign and is significant in both regressions.⁷ The estimated elasticities for the price and exchange rate variables contain the correct signs, but only the domestic price term (PD) is significant. In addition, the NAFTA impact dummy variable indicates that the implementation of the tariff reductions has had a positive, but insignificant effect on U.S. imports. These results indicate that the primary determinants of U.S. import demand from Mexico seem to be changes in the level of U.S. income and changes in domestic U.S. prices. Sensitivity to both variables is fairly strong, falling well above the unit elasticity threshold. In contrast to Thursby and Thursby (1984), the lagged dependent variable is not significant at the 5-percent level.⁸

As with the import model, the estimated demand for U.S. exports to Mexico indicates that the foreign income elasticity (YF) has the correct sign and is significant. The results for the price and exchange rate variables indicate that the estimated coefficients all have the correct signs and all but PD are statistically significant. Once again, the NAFTA impact dummy indicates that the implementation of the tariff reductions has had a positive but statistically insignificant effect on U.S. exports. Lack of statistical significance for the latter coefficient possibly reflects the small number of sample observations currently available (McCloskey and Ziliak, 1996). The primary determinants of U.S. export demand to Mexico seem to be the change in the level of Mexican income and Mexican domestic price levels, with a particularly strong response of exports to income performance. The latter difference in coefficient magnitudes implies that U.S. sales volumes to Mexico can be expected to react very sensitively to the business cycle in Mexico. Exchange rate uncertainty, and the concomitant pass-through effects on product sales prices denominated in pesos, will not pose nearly as serious a threat to subsidiary balance sheets. Lastly, the lagged dependent variable is not significant at the standard 5-percent threshold.

With respect to whether the qualitative information summarized in the preceding discussion of the disaggregated estimation results are statistically valid, a series of hypothesis tests are relevant. For individual parameter heterogeneity in the U.S. imports from Mexico equation, t-tests confirm that all three coefficients are significantly different from an aggregate measure at the one-percent level. A likelihood ratio test for the U.S. imports from Mexico equation also confirms, at the 5-percent level, the empirical superiority of the less restricted version of the function shown in Equation 5. Similar results are encountered at the one-percent level in all three t-tests as well as the specification likelihood ratio test for the U.S. exports to Mexico equation. Consequently, empirical verification of the less restrictive version of the function shown in Equation 6 is also obtained in support of the econometric results reported in Table 3.

IV. Summary and Conclusions

This paper has three purposes. First, this study was designed to estimate bilateral trade elasticities between the United States and Mexico. Second, the trade flows are modeled with a price variable that is decomposed into three respective components in order to determine if the trade flows react differently to foreign price changes, domestic price variations, and international currency movements. The model specifications also attempt to measure initial impacts associated with the implementation of NAFTA on the trade flows between these two economies.

Results indicate that the estimated equations are consistent with several of the important recently developed tests in time-series econometrics. In addition, the estimated short-run and log-run coefficients all exhibit the hypothesized signs. Importantly, the income and activity variables in both equations were significant. In the case of the price and exchange rate terms, the short-run and long-run price and exchange rate coefficients all had the correct signs but some of the coefficients were not statistically significant. Even the latter coefficients, however, fell outside the confidence bounds for aggregate versions of the models implied by Equation 1. The results confirm the conventional wisdom that the responsiveness of U.S. imports and exports to changes in income is quite large and the responsiveness of these trade flows to changes in the exchange rate and/or foreign prices is relatively small. In addition, the NAFTA impact variable indicates that the implementation of the tariff reductions has had an initial positive effect on U.S. exports to and imports from Mexico. The small size of the regression coefficient to its standard deviation potentially reflects the long-run nature of the treaty implementation schedule.

In summary, trade flows between the U.S. and Mexico conform well to structure implied by a relatively simple model. Importantly, however, trade flows between the two countries do not respond by exactly the same amount to changes in relative prices and the inflation adjusted peso-dollar exchange rate. This result implies that the disaggregated specification utilized herein merits additional empirical testing for other bilateral trade flows such as those analyzed above. The approach may prove particularly helpful for policy and balance of payments analysis during periods in which widely variant business cycle conditions are observed in both economies. Finally, because both equations meet the conditions set by recent advances in time-series econometrics, these more informative results can be viewed with somewhat more confidence than the earlier aggregate estimates.

TABLE 1

Previous Estimates of Income and Price
Elasticities of Mexican Import Demand

Author (Year)	Y	PR	PFM	PD	ERM
Agarwal (1984)	3.86	-0.563			8.34
Cline (1989)	1.89	-0.51			
Clavijo & Faini (1990)	1.213	-1.044			
Clark (1992)	2.87		-0.234	-0.199	
Faini, Pritchett, & Clavijo (1992)	1.29	-1.12			
Salas (1982a & 1982b)					
Capital Goods	1.890	-1.409			-1.297
Intermediate Goods	0.422	-2.309			-1.347
Consumer Goods	0.624	-3.401			-1.747
Salas (1988)					
Capital Goods	0.788		-1.857	1.255	
Intermediate Goods	0.494	1.411			-1.658
Consumer Goods	0.839	2.427			-1.885

TABLE 2

Previous Estimates of Income and Price
Elasticities of Mexican Export Demand

Author (Year)	YF	PR	PFX	PD	ERX
Agarwal (1984)	0.58	-0.87			10.87
Faini, Pritchett, & Clavijo (1990)	0.93	-0.85			

TABLE 3

Price and Income Elasticities of U.S. Import and Export Demand from Mexico

Variable	Imports, 1981-1994		Exports, 1981-1994	
	Short-Run	Long-Run	Short-Run	Long-Run
Constant	-17.6797 (-2.4590)*		.6171 (0.1682)	
YD	1.8218 (2.2067)*	2.5775		
YF			2.4482 (4.8112)*	2.9415
PFM	-.1005 (-0.8054)	-.1422		
PFX			.5002 (2.7986)*	.6010
PD	1.8865 (3.0612)*	2.6691	-1.0754 (-1.1730)	-1.2921
ERM	.3200 (0.3095)	.4527		
ERX			-.4079 (-2.3897)*	-.4901
QM _{t-1}	.2932 (1.5321)			
QX _{t-1}			.1677 (0.1351)	
Q ₂	.0083 (0.6039)		.0032 (0.1351)	
Q ₃	-.0406 (-2.4385)*		.0868 (3.1458)*	
Q ₄	-.0134 (-0.8973)		-.0246 (-1.0129)	
D	.0864 (1.5635)		.0629 (0.9351)	
R ²	.9817		.9808	
SE	.0483		.0756	

* denotes statistical significance at the 0.05 level

ENDNOTES

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² The relative price variable for imports (PR) is equal to import prices (PFM) divided by domestic prices (PD). For exports the price ratio is the Mexican export price (PD) divided by the foreign price index (PFX).

³ The debate over homogeneity of import demand functions can be traced back to the paper by Murray and Ginman (1976). The approach we take in this paper is that the issue is not so much a technical specification issue as it is one of the amount of information contained in the estimates. This is particularly true if the price variable contains any significant lag structure.

⁴ Warner and Kreinin (1983) present evidence that the homogeneity of the U.S. import demand function may be related to the time-frame under consideration.

⁵ The volume of real imports (exports) were computed by deflating the nominal values of the variables by the appropriate import (export) unit value measures reported in International Financial Statistics.

⁶ For a discussion of this choice of functional form for imports and exports see Khan and Ross (1975).

⁷ All results reported in this paper have been corrected for first-order serial correlation by using Fuller's two step procedure. Cochrane-Orcutt parameter estimates are reported. For a discussion of this procedure see Fuller (1976).

⁸ Deyak, Sawyer, and Sprinkle (1990) obtain statistically significant estimates of U.S. import and export functions with respect to delayed income effects by employing a polynomial lag structure.

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