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Trade, Production Networks and the Exchange Rate

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Abstract. This paper examines the effect of cross-border production sharing on trade and exchange-rate behavior. When a country's exports contain imported components, changes in exchange rates tend to have offsetting effects on imports and exports. Imports may fall, remain unchanged or even rise with depreciation, depending on the share of domestic value-added in exports. The effect of domestic and foreign GDP on imports and exports is also altered by production sharing. These behavior patterns are identified in trade in motor vehicles between the United States and Mexico with the aid of OLS and VEC techniques.

JEL Classification: F14, F15, F32
Keywords: Trade balance, Fragmentation, Intra-industry trade, Exchange rates, NAFTA

1. Introduction

Exchange rates, home and foreign prices, and home and foreign incomes are key explanatory variables in standard trade equations. The empirical evidence suggests overwhelmingly that exchange rates and incomes matter in determining the flow of trade. Domestic GDP helps explain imports, while foreign GDP influences exports. These findings apply to trade in end products and to intermediate products destined for use in the importing country. In recent years, however, the growth of cross-border fragmentation of production has generated trade patterns in which parts and components flow from one country to another, to be assembled into products that are then exported rather than used at home.

The object of this study is to assess the extent to which goods flowing within production networks alter the sensitivity of trade to the aforementioned determinants. The focus is on U.S.-Mexico trade, where we find that cross-border production sharing reduces the responsiveness of trade to movements in the exchange rate and that a country's own GDP affects the demand for its exports.

The rest of the paper proceeds as follows. Section 2 sets out the basic analytical framework and discusses some stylized facts. The focus is on production sharing in the automobile sector between the U.S. and Mexico. Section 3 presents and assesses the empirical evidence; and section 4 concludes the study.

2. Trade Patterns under Cross-border Production Sharing

Production sharing between the U.S. and Mexico came into its own in the maquiladora program and continues under the North American Free Trade Agreement (NAFTA). It plays a key role in several industries, including textiles and apparel, motor vehicles, electronics, and processed foods. In its original manifestation in the motor vehicles sector, for example, Mexico's primary contribution was to assemble U.S.-made parts and components into finished automobiles destined mainly for the U.S. market. In more recent years, the nature of production sharing between the two countries has become more complex, as Mexican producers have begun to supply components, in addition to providing assembly. While U.S. firms play a dominant role in this relationship, multinationals from Europe and Japan are also active in Mexico.

Similar forms of interaction may be found in other sectors, including textiles and apparel, where cotton and various types of fibers are exported to Mexico, to be used in the manufacture of apparel destined for the United States. In the agricultural sector, raw produce is shipped to Mexico and returns to the U.S. in processed form. In this instance, the transformation is from imports of non-manufactures into exports of manufactures. We explore the implications of this phenomenon below.

2.1 Fragmentation and factor intensities

Cross-border production sharing pushes specialization from the level of products to that of components. Hence, if factor intensities vary across the components of products, then the factor-proportions theory should be useful in explaining component specialization across countries. Labor-abundant countries like Mexico would be expected to specialize in labor-intensive components and labor-intensive assembly, while capital- and skill-rich countries like the United States have comparative advantage in capital- and skill-intensive components and skill-intensive assembly. These considerations have been examined in the recent literature on fragmentation; our focus here is on the key determinants of trade flows when production sharing is present.[2]

2.2 The role of GDP

According to the standard trade model, Mexican GDP is an important determinant of imports from the U.S., while U.S. GDP helps determine Mexican exports to the U.S. In the context of cross-border production sharing, however, Mexico's imports from the U.S. include parts and components for use not by Mexicans, but in the manufacture of exports to the U.S. For this type of import, variations in Mexican GDP should be unimportant, while U.S. GDP should play a larger role, because it determines the demand for imported automobiles. In this context, Mexico's demand for component imports is a derived demand, which rises when U.S. demand for automobile imports rises. Variations in Mexico's GDP would, of course, continue to explain traditional imports (which may include imported components for direct use by Mexicans). Hence, the relative importance of the two GDPs in explaining Mexican imports depends on the share of network trade in total imports.

Our expectation, therefore, is that the explanatory power of Mexican GDP falls and that of U.S. GDP rises as the share of network trade in the dependent variable rises. These response patterns should be apparent in a comparison, for example, of imports of auto parts and components with merchandise imports generally. We test this expectation by examining trade at both aggregate and sector-specific levels.

2.3 The exchange rate

Traditionally, appreciation of a country's currency raises imports and lowers exports, ceteris paribus. In the presence of production sharing, on the other hand, the rise in the peso price of U.S.-made components tends to raise the peso price of the Mexican end product, but the dollar price of that product is affected in the opposite direction by the peso's depreciation.[3] These offsetting tendencies affect the degree of pass-through and thus the sensitivity of trade flows to changes in the exchange rate. The extent to which the dollar's appreciation reduces the dollar price of the end product declines as the share of Mexican value-added in the end product declines.

Note, moreover, that the decline in its dollar price is expected to raise the demand for the imported end product, which in turn will raise the demand for imports of U.S. components. Here, an appreciation of the dollar *raises* the demand for U.S. exports. The traditional negative response of exports following a dollar appreciation continues to hold, of course, for products and components that are not part of the production-sharing loop. Thus, the net effect of the appreciation on overall U.S. exports to Mexico may be negative, zero, or positive, depending on the share of production-sharing trade in total exports, the share of Mexican value added in exported end products, and the price elasticity of U.S. demand for the end product.[4]

2.4 Changes in the terms of trade

The trade-balance implications of terms-of-trade changes may also be affected by production sharing. Mexican inflation, for example, raises the demand for imports and reduces exports in the traditional model, causing the trade balance to deteriorate. Inflation raises the cost of Mexican value-added in motor vehicles shipped to the United States and thus reduces the U.S. demand for them. Such a decline in vehicle exports, however, reduces the demand for component imports from the U.S., which tends to mute the overall effect of the price change on the trade balance. Analogous considerations apply to the effects of price inflation in the United States. Together, the weakened or ambiguous influence of the nominal exchange rate and of relative prices suggests that the effect of the real exchange rate is also more tenuous.

3. Econometrics

The preceding discussion suggests, first, that the sensitivity of trade to the exchange rate declines with the rise of production sharing. Hence, in sectors with high shares of trade flowing within production networks, the exchange-rate effect should be weaker than in sectors in which network trade is low or absent. The sensitivity of trade in motor vehicles and motor vehicle components, for example, should be lower than that of overall manufacturing imports and exports. Second, the role of the component-importing country's GDP in explaining imports should decline and the role of the component-exporting country's GDP should grow as the importance of cross-border sourcing and of network trade rises.

Trade policy plays an important role in determining the feasibility of production sharing, particularly as it pertains to restrictions on investment flows, foreign ownership, and right-of-establishment issues. In the U.S.-Mexico case, NAFTA relaxed or removed a variety of restrictive policies pertaining to trade and foreign investment. Of course, other acts of trade liberalization, including completion of the Uruguay Round, helped reduce the costs associated with cross-border production sharing, and innovations in communications and transportation technologies made a major contribution to cost reduction.

As noted earlier, production sharing between the U.S. and Mexico predates NAFTA, and was already widespread under the maquiladora program. The focus of this paper is on the extent to which implementation of NAFTA has intensified cross-border linkages. However, shortly after the official inception of NAFTA in early 1994, Mexico experienced a major exchange-rate crisis, with significant disruptions of economic activity. The coincidence of these events raises potential problems for the empirical analysis, an issue which we explore more fully below.

3.1 Data analysis and regressions

The purpose of the empirical analysis is to explore the implications of production sharing for the key relationships of the standard trade model. The point is not to test alternative trade theories, but to compare the results when the model is applied to different categories of exports and imports, where a key feature distinguishing the trade categories is the relative importance of production sharing.

We take as our standard import-export equation a specification that includes GDP, the real exchange rate, and variables representing NAFTA on the right-hand side. We examine those relationships with quarterly data for bilateral trade between the U.S. and Mexico covering the period from the first quarter of 1989 to the fourth quarter of 2002.[5]

The basic model is then applied to U.S. trade with Mexico in three categories: exports and imports of manufactures, exports of non-manufactures and imports of non-manufactures excluding petroleum,[6] and imports of passenger vehicles and exports of motor vehicle parts and components. The degree to which the categories can be classified as traditional or non-traditional trade is summarized in Table 1. On the side of U.S. imports, non-manufacturing trade is the most traditional of the three categories, in that it contains virtually no network trade. It should thus display behavior most consistent with the predictions of the traditional model.

Imports of manufactures have a higher content of network trade, including motor vehicles, processed foods, textiles and electronics. They should thus display results that conform less well with, or deviate from, the predictions of the traditional model. Finally, motor vehicle imports are fully embedded in network trade and should thus display behavior that differs significantly from the traditional model.

On the side of U.S. exports, manufactures should display behavior that is most consistent with the traditional model, because the share of network trade is relatively small. The share is larger in non-manufacturing exports to Mexico, in view of the importance of exports of agricultural raw materials for use in the manufacture of processed food for the United States market and of cotton and textiles for use in the manufacture of apparel exports to the United States.

3.2 Statistical properties of the time series

Time series tests of the variables suggest that the logs of real imports, real U.S. GDP, and the real exchange rate, defined as the peso price of the dollar adjusted by the ratio of U.S. to Mexican wholesale prices, are all I(1) variables (Appendix Table A.1).[7] As reflected by the Engle-Granger[8] test statistics reported in the relevant tables, the I(1) variables appear to be cointegrated. This enables us to run the OLS regressions in level terms and thereby provides an easy means of assessing the nature of the long-run relationships involved.[9]

Still, the concern may be raised that the relationship is misspecified by the traditional OLS representation, particularly with respect to the designation of dependent and independent variables. Contemporaneous relationships may be statistically consistent, but erroneous representations of the true underlying relationships. For example, Torres and Vela (2003) present evidence suggesting that Mexican GDP may be a lagged or contemporaneous function of U.S. GDP, exports and the dollar exchange rate.

The traditional specification of the trade equation adopts the perspective that causality runs from GDP and the real exchange rate to exports and imports. The standard open-economy macro model, on the other hand, allows for the possibility that changes in exports may affect GDP. This raises another potential concern about causality: in the presence of production sharing, exports affect imports and imports of components may thus appear to Granger-cause[10] domestic output. Analogous concerns arise with respect to the direction of causality between bilateral imports and exports and the exchange rate. The correlation matrices presented in Appendix Table A.2 reflect both the strong contemporaneous co-movements and the common trends among our variables of interest. The real exchange rate is the exception.

We adopted two approaches to address these problems. First, we performed Granger tests to determine if consistent causality relations can be established among and across the variables of interest. However, Granger tests for inter-temporal causal relationships among the variables produced results which varied with the lag length. So much so, in fact, that no clear and consistent set of causal relations could be established using the Granger technique.

Second, remaining agnostic with respect to the question of causality, we estimated a vector-error-correction (VEC) specification of the relationship between the import and export series and their explanatory variables. The vector-error-correction estimations were constrained by the OLS-generated coefficients and then re-estimated in unconstrained form.[11] We calculated likelihood ratios (LR) for constrained (OLS) versus unconstrained representations. The likelihood of the import regression results was not significantly improved by the unconstrained VEC model, and so we accept the null hypothesis of the OLS representations for imports. However, the LR statistics indicated that the constraints on the export specifications were significant.

Moreover, the Durbin-Watson statistics from the OLS regressions gave consistent indication of error auto-correlation for the level regressions for exports. However, we show below that this apparent rejection of the OLS specification is likely to be spurious and due to an unconstrained error-correction component: the real peso-dollar exchange rate is weakly exogenous in the export model VEC specifications and, therefore, should not be included in the cointegrating vector. When corrected for the weak exogeneity of the peso, the trace and max-eigenvalue statistics indicate cointegrating relations for all our VEC specifications (with one notable exception), allowing us to reject non-cointegration of the VEC, and allowing us to further discount the probability of spurious regression for the level regressions.

Given the ambivalent causal relationships between the variables used in estimation, we thought it prudent to first identify contemporaneous relations with level OLS regressions. Lagged dependent and independent variables are present in the VEC model, and there the complex interrelations can be more carefully articulated.

3.3 Dealing with the effects of NAFTA

On the part of the United States, implementation of trade liberalization with Mexico during the period occurred in two significant steps in 1992 and 1994, as Figure 1 indicates. That figure presents the ratio of duty collections to the value of imports of manufactures, non-manufactures and passenger vehicles, respectively. There is a steep drop in duty collections in 1992, followed by another drop in 1994, and then a gradual decline over the remainder of the period. To underscore the preferential nature of these changes, we compare average duty collections on passenger vehicle imports from Mexico, Japan, and the rest of the world in Figure 2. Duty rates on imports from Japan are largely unchanged, while those for the rest of the world decline moderately and gradually over the period without any sharp reductions in 1992 and 1994.

A widely used approach to modeling the effect of NAFTA is by means of mean-shift dummies, which switch from zero to one in 1994, the year in which NAFTA went into effect.[12] As noted and as the figures suggest, however, there were two episodes of tariff liberalization vis-à-vis Mexico during the period. A simple 1994 dummy risks misspecification, particularly in view of the possibility that it may pick up effects associated with the beginning of the peso crisis.[13]

In order to test for the effect of trade liberalization prior to the official start date of NAFTA, we use a dummy for 1992 as an alternative specification. In order to further explore this issue, we use a two-stage dummy, which shifts to the value one in 1992 and takes on the value two beginning in 1994. We also tested regressions with an interaction term between the mean-shift variable and U.S. GDP on the right-hand side, but that specification did not significantly improve the fit or explanatory power of the model with dummies alone.

As an alternative to the dummy-variable approach, we employ the duty ratios of Figure 1 to construct a trade-liberalization variable defined as 1 plus the duty ratio.[14] We expect imports in each of the three categories to increase as the ratio of duty collections relative to the value of imports in each category declines. Hence, the coefficient is expected to be negative.

3.4 U.S. imports from Mexico

Table 2 presents regressions for U.S. imports from Mexico at the three levels of aggregation, with the four alternative specifications of trade liberalization during the period. The regressions are significant, reflecting the very high degrees of correlation among the variables noted earlier. Real U.S. GDP is significant in all regressions, with large coefficients across all levels of aggregation.

The real exchange rate carries the largest coefficient and greatest t-value for non-manufactures, the most "traditional" of the three categories (See Table 1). Its explanatory power is generally weaker as predicted for manufacturing imports and disappears altogether for imports of motor vehicles.[15] The results confirm our prediction that the influence of exchange-rate changes is eroded by the rise of network trade.

The effect of the NAFTA dummies varies across the import categories; it is significant for manufactures and motor vehicles, but insignificant for non-manufacturing imports. The latter result is consistent with the notion that the commodities contained in that category were least affected by NAFTA-based trade liberalization.[16] The sign on the fourth NAFTA variable, namely, the ratio of duties collected on each of the three categories of imports relative to the value of those imports is negative, as predicted: a decline in the ratio is a sign of trade liberalization and should thus stimulate imports (Table 2d). The coefficients are statistically significant in all three trade categories.[17]

3.5 U.S. exports to Mexico

U.S. exports are divided into manufactures, non-manufactures, and motor vehicle parts and components. This is not the only way to break up total exports into groups reflecting different production arrangements, but data constraints typically come into play. The main purpose here is to see whether the presence of network trade in the variable on the left-hand side affects the explanatory power of the widely-used export equation. The right-hand-side variables include the real exchange rate, Mexican GDP, and a NAFTA dummy. As noted above, manufacturing exports are the most "traditional" of the three export categories in that the share of goods destined for use by Mexicans is highest. Hence, this category should display behavior that is most consistent with the standard trade model. We expect the fit to be weaker for non-manufacturing exports, because the share of goods destined for use by Mexicans is smaller and the share of network trade is larger.[18] Finally, we expect the fit of the standard model to be relatively poor in the regression for exports of motor vehicle parts.

U.S. exports of goods destined for use by Mexicans should respond negatively to depreciation of the peso. For goods moving within production networks, on the other hand, the effect should be weaker. Hence, the exchange-rate coefficient may become insignificant for exports of non-manufactures and of motor vehicle parts. Indeed, the sign of the coefficient may turn positive, if depreciation of the peso raises U.S. imports of motor vehicles, which in turn raises the demand for U.S.-made parts and components. As discussed earlier, the power of Mexican GDP in explaining U.S. exports should fade as the importance of network trade rises.

Table 3 reports results testing these hypotheses. Our expectations with respect to the real exchange rate are largely confirmed. The response of manufactures exports, the most traditional of the three categories, conforms more closely with the predictions of the standard model than non-manufactures and motor vehicle parts. The latter, in particular, is closely tied to production sharing.

Our expectations regarding the role of Mexican GDP remain largely unconfirmed by the results, at least as far as significance levels are concerned. While the magnitude of the coefficient is smaller for non-manufactures than for manufactures, the coefficient in the regression for motor vehicle parts is larger in panels 2a and 2b. The results are more consistent with our expectations in panels 2c and 2d, in which U.S. GDP is added on the right-hand side. There, Mexican GDP is insignificant for U.S. exports of non-manufactures and carries weaker significance (but a larger coefficient) for exports of motor vehicle parts. U.S. GDP is significant in the regressions for all three categories. The magnitude of the coefficient rises as we move from manufactures to non-manufactures, but the level of significance declines and is weakest for motor vehicle parts imports.

As for the role of NAFTA, panel 2a reports results incorporating the 1994 NAFTA dummy in the standard export equation. As Figure 3 suggests, liberalization of trade in motor vehicle parts begins on the Mexican side in 1994. U.S. exports rise with the inception of NAFTA. We have no specific evidence of significant trade liberalization in 1992, apart from the duty reductions reported on U.S. imports.[19] However, to allow for the possibility of spill-over effects resulting from the U.S. reductions, panel 2b employs the two-stage specification of NAFTA, the coefficient of which is significant in all three regressions. The results are largely similar when U.S. GDP is added on the right-hand side of panels 2c and 2d.

3.6 Vector error correction results

As noted previously, VEC representations were also estimated for imports and for exports.[20] The import results are based on the specification presented in Table 2d. The duties/imports variable is our preferred representation of NAFTA, not least because it provides a continuous series for identifying the error-correction component of the model. There is, moreover, no empirical reason for preferring one of the other specifications (on a log likelihood basis). The VEC coefficient estimates are robust to sample size, lag length of the error-correction components, as well as the presence or absence of a constant term in the error-correction component.[21]

In the import equations, the cointegrating vectors display significant coefficients and have signs that are consistent with the OLS representations. The real peso is weakly exogenous to the system, and has very little significance, both contemporaneously and at various lags. However, in the VEC for imports of non-manufactures, the real peso is endogenous to the system, and so is included in the cointegrating equation. The common trend term is significant throughout for U.S. GDP, but less so for non-manufactured imports and not at all for aggregate manufactured and passenger vehicle imports.

The system of VEC equations generates impulse response functions. There is a positive import response to U.S. GDP changes, and a negative response to import duties. The size of both impulse responses increases as we proceed from manufactured imports to passenger vehicle imports, with the non-manufactured import response located somewhere in the middle. Apart from the exchange-rate effect on non-manufactured imports, there is only a slight impulse response running to or from the other variables, consistent with the results of our basic OLS regressions.

The export VEC specification is based on Table 3c[22], which is consistent with the time-line of Mexican trade liberalization. Here, both the real peso and U.S. GDP are weakly exogenous to the system and are thus relegated to the error-correction component of the specification. When OLS coefficients are used to calculate restricted versions of the VECs, the restrictions are non-binding, thus further mitigating our concerns about the adequacy of the OLS estimates.

For manufactured and non-manufactured exports, the impulse responses and coefficients are consistent with the OLS regressions. The significance of U.S. GDP in explaining U.S. exports to Mexico can now be seen in terms of its effect on the export error-correction response. Manufactured exports are weakly influenced by U.S. GDP, but only Mexican GDP is significantly influenced by deviations from the cointegrating vector. The reverse appears to be true for exports of non-manufactures, which are significantly positively influenced by Mexican GDP and trade liberalization, with U.S. GDP operating directly on non-manufactured exports and indirectly through its effect on Mexican GDP. Mexican GDP is not significantly influenced by U.S. exports of non-manufactures.

U.S. GDP was used in these VEC models in lieu of a direct measure of U.S. demand for commodities embodying exported components. However, in the case of motor vehicle parts, we do have just such a measure in passenger vehicle imports. When included in the cointegrating equation, passenger vehicle imports are significantly cointegrated with motor vehicle parts exports, while Mexican GDP is not. Table 10 presents the results, with Mexican GDP now relegated to a weakly exogenous influence on parts demand. Interestingly, the unconstrained estimate presents a cointegrating regression coefficient on passenger vehicles of 0.93, indicating a long-run relationship in which all but 7 percent of parts exports are fully embodied in passenger vehicle imports. The sign of the dummy term is now positive (though not significant), but that would appear to reflect the relatively greater significance of the NAFTA reforms to the importation of passenger vehicles, given the positive coefficient on error correction to that variable (and relatively insignificant response of parts exports to the same cointegrating relationship).

The VEC model has been applied in a number of open-economy macroeconomic studies. The suitability of the approach for identifying relationships between variables that are not macroeconomic aggregates (or between aggregates and specific commodity flows) is still unclear. However, the import relationships estimated are consistent with our OLS results and reinforce the conclusions reached. The export results reveal a relatively more complicated relationship, but indicate the importance of U.S. income changes in the determination of Mexican production, affecting Mexican component imports from the U.S., and ultimately impacting Mexican GDP. In the specific case of auto parts, Mexican GDP appears not to matter at all (or very little), with virtually all of the export demand being driven by the need for components for the production and importation of passenger vehicles for the U.S. market.

4. Concluding Remarks

The focus of this study has been to ascertain the extent to which the cross-border integration of production affects well-known relationships involving trade, the exchange rate, and key macroeconomic variables. An argument is developed which suggests that the sensitivity of exports and imports to the real exchange rate should decline when cross-border fragmentation expands and when the share of trade associated with production networks rises.

The evidence presented in this paper strongly supports that conjecture, showing that while the exchange-rate effect follows traditional lines for variables in which network trade is unimportant, the relationship fades as the share of network trade rises.

A country's imports may become less sensitive to movements in domestic GDP and more responsive to foreign GDP as the share of trade related to cross-border production sharing rises. The evidence indicates that the explanatory power of Mexican GDP is weaker and that of U.S. GDP stronger in the regression on motor vehicle parts exports to Mexico than in the other export regressions. From the VEC specification, we can identify the strong effect of U.S. GDP transmitted by U.S. imports of passenger vehicles.

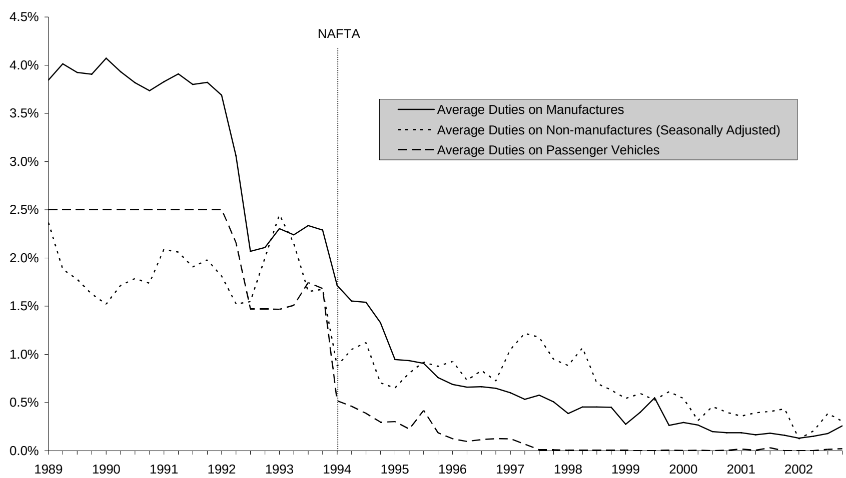
The official start of NAFTA in 1994 was preceded by U.S. trade liberalization vis-à-vis Mexico in 1992. Regressions using dummies based on 1992 provide superior performance to those based on 1994, and a two-step dummy outperforms both in our import equations. In order to capture the continuity in trade liberalization over the length of the period, we construct a time series variable for the United States which relates duty collections to the flow of imports. The variable is significant and has the correct sign, suggesting an important evolving role for trade liberalization in the region. The export regressions confirm the role of NAFTA in U.S.-Mexico trade.

Table 1. U.S. Trade with Mexico

	Most Traditional	Semi-traditional	Least Traditional
Exports	Manufactures	Non-manufactures	Motor Vehicle Parts
Imports	Non-manufactures	Manufactures	Passenger Vehicles

Note: Traditional in this context refers to traded goods intended for final consumption or use by the importing country and not containing value-added of the importing country (parts and components). Least Traditional refers to traded goods with a high proportion of commodities used in production sharing networks, in this instance intended for final consumption in the United States.

Figure 1. Average U.S. ad valorem Duties on Mexican Merchandise Imports

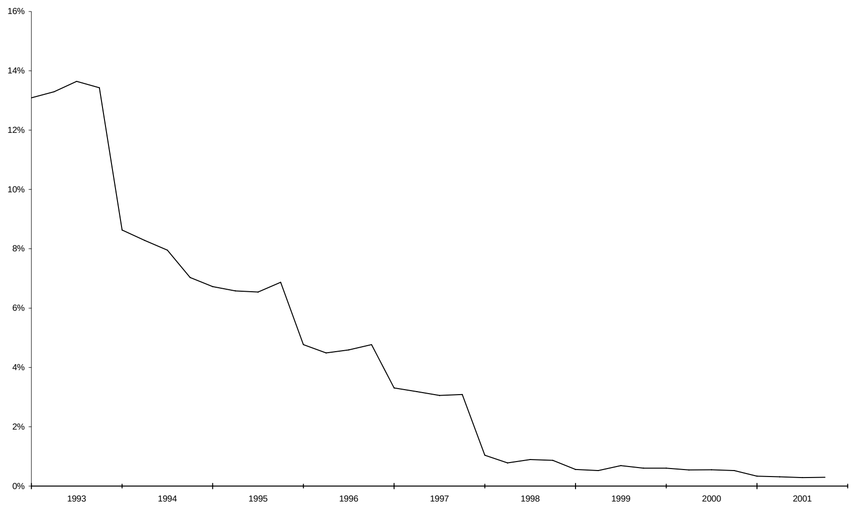


Source: USITC Trade and Duties; Authors' Calculations.

Figure 2. Average Ad Valorem US Duties on PV Imports

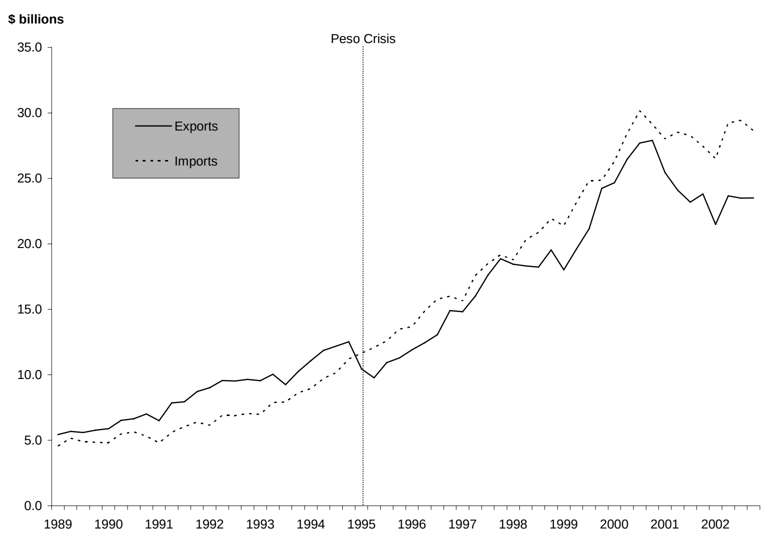
Source: USITC Trade and Duties; Authors' Calculations.

Figure 3. Average Mexican Ad Valorem Tariff on Imports of U.S. MV Parts (selected)



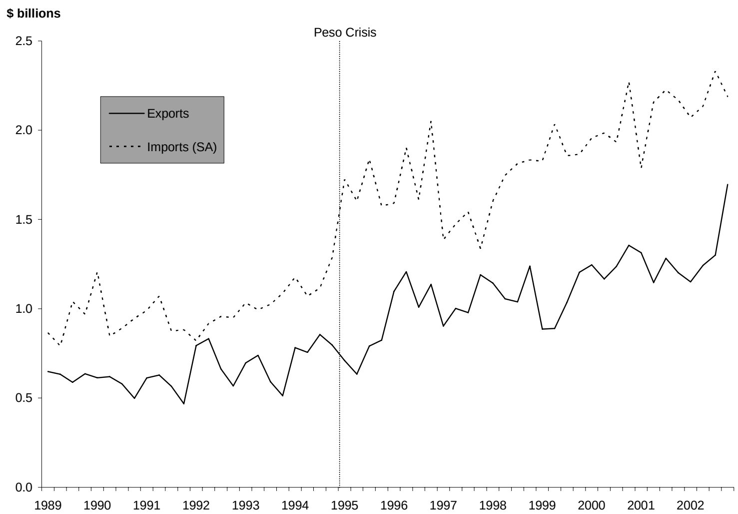
Source: USITC Trade Data, U.S. Commerce Department Tariff Data; Authors' Calculations.

Figure 4. U.S.-Mexico Manufactures Trade



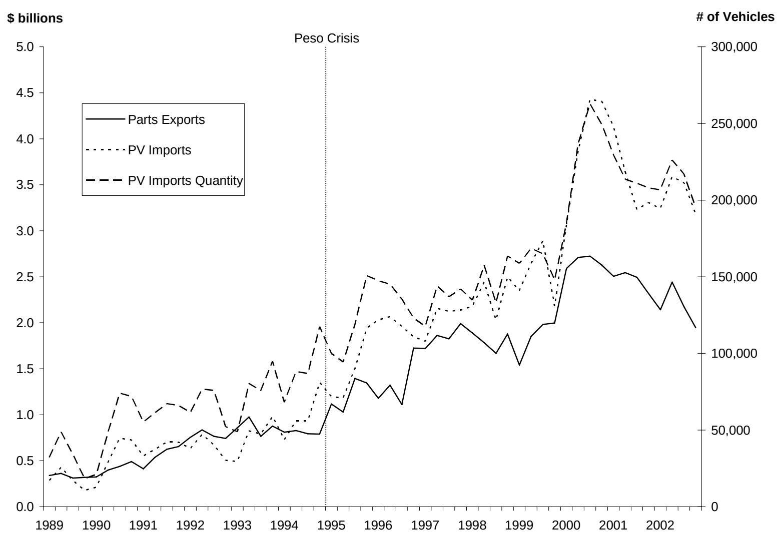
Source: USITC Trade Data.

Figure 5. U.S.-Mexico Non-Manufactures Trade



Source: USITC Trade Data.

Figure 6. U.S.-Mexico Passenger Vehicle Trade



Source: USITC Trade Data; Authors' Calculations.

Table 2. Imports

(a)	Manufactures	Non-Manu-factures	PV
C	4.98*** (5.74)	10.08*** (8.02)	0.07 (0.02)
GDP_{US}	3.92*** (23.07)	2.13*** (8.52)	4.49*** (6.48)
$Peso/\$_{Real}$	-0.01 (-0.12)	0.54*** (4.00)	-0.8 (-0.21)
D_{94}	0.23*** (5.7)	0.07 (1.21)	0.38** (2.34)
R^2	0.99	0.89	0.88
Adj. R^2	0.99	0.88	0.87
LL	72.72	50.95	-6.1
D-W	0.81	1.84	0.78
E-G	-3.00	-4.7	-4.02

(b)	Manufactures	Non-Manu-factures	PV
C	2.25*** (4.92)	9.27*** (12.27)	-4.48** (-2.19)
GDP_{US}	4.39*** (48.56)	2.32*** (15.53)	5.27*** (13.06)
$Peso/\$_{Real}$	0.33*** (4.76)	0.64*** (5.54)	0.5 (1.6)
D_{92}	0.19*** (7.28)	0.04 (0.93)	0.33*** (2.78)
R^2	0.99	0.89	0.88
Adj. R^2	0.99	0.88	0.88
LL	78.8	50.64	-5.02
D-W	1.16	1.86	0.78
E-G	-4.07	-4.69	-4.09

(c)	Manufactures	Non-Manu-factures	PV
C	4.32*** (7.69)	9.85*** (9.79)	-0.97 (-0.36)
GDP_{US}	3.99*** (35.33)	2.2*** (10.9)	4.61*** (8.47)
$Peso/\$_{Real}$	0.15** (2.25)	0.59*** (5.11)	0.18 (0.59)
$D_{92/94}$	0.13*** (8.51)	0.03 (1.2)	0.23*** (3.00)
R^2	0.99	0.89	0.89
Adj. R^2	0.99	0.88	0.89
LL	83.55	50.94	-4.44
D-W	1.22	1.86	0.81
E-G	-4.21	-4.7	-4.16

(d)	Manufactures	Non-Manu-factures	PV
C	7.15*** (8.67)	11.99*** (7.99)	1.51 (0.41)
GDP_{US}	3.49*** (21.57)	1.81*** (6.33)	4.23*** (6.00)
$Peso/\$_{Real}$	0.08 (1.15)	0.51*** (4.15)	0.04 (0.11)
$1+\tau_i/M_i$	-11.57*** (-8.67)	-11.87** (-2.25)	-21.05*** (-2.69)
R^2	0.99	0.89	0.88
Adj. R^2	0.99	0.89	0.88
LL	84.16	52.77	-5.25
D-W	1.1	1.98	0.77
E-G	-4.35	-5.02	-4.21

Number of Observations: 56 (t-stats in parentheses)

Table 3. Exports

(a)	Manu-factures	Non-Manu-factures	MV Parts
C	12.59*** (11.13)	14.25*** (7.38)	4.87** (2.09)
GDP_{Mx}	2.38*** (11.5)	1.28*** (3.61)	3.41*** (7.9)
$Peso/\$_{Real}$	-0.37** (-2.38)	0.14 (0.58)	0.5 (1.15)
D_{94}	0.24*** (5.65)	0.19** (2.46)	0.38*** (3.72)
R^2	0.97	0.73	0.89
Adj. R^2	0.96	0.71	0.88
LL	61.95	30.36	8.34
D-W	1.27	1.34	0.95
E-G	-2.55	-4.41	-2.76

(b)	Manu-factures	Non-Manu-factures	MV Parts
C	11.69*** (12.04)	12.94*** (7.88)	7.7*** (3.48)
GDP_{Mx}	2.52*** (13.98)	1.5*** (4.83)	2.87*** (6.98)
$Peso/\$_{Real}$	-0.17 (-1.28)	0.32 (1.6)	-0.22 (-0.66)
$D_{92/94}$	0.13*** (5.92)	0.09** (2.16)	0.3*** (5.39)
R^2	0.97	0.72	0.91
Adj. R^2	0.97	0.71	0.9
LL	62.99	29.69	14.14
D-W	1.42	1.37	0.92
E-G	-2.89	-4.34	-3.19

(c)	Manu-factures	Non-Manu-factures	MV Parts
C	11.46*** (10.64)	13.12*** (7.00)	-1.5 (-0.54)
GDP_{Mx}	1.5*** (4.75)	-0.04 (-0.07)	1.41** (2.01)
GDP_{US}	1.14*** (3.48)	1.63*** (2.67)	3.26*** (3.47)
$Peso/\$_{Real}$	-0.4*** (-2.86)	0.04 (0.16)	0.56* (1.55)
D_{94}	0.16*** (3.7)	0.09 (1.13)	0.07 (0.58)
R^2	0.97	0.76	0.91
Adj. R^2	0.97	0.74	0.9
LL	67.92	34.04	14.27
D-W	0.67	1.41	0.67
E-G	-1.92	-5.57	-2.43

(d)	Manu-factures	Non-Manu-factures	MV Parts
C	11.31*** (13.74)	12.78*** (8.36)	3.83 (1.66)
GDP_{Mx}	1.36*** (4.7)	-0.07 (-0.13)	1.22* (2.00)
GDP_{US}	1.29*** (4.69)	1.71*** (3.00)	2.42*** (3.39)
$Peso/\$_{Real}$	-0.32** (-2.76)	0.1 (0.47)	0.08 (0.26)
$D_{92/94}$	0.1*** (5.17)	0.05 (1.29)	0.2*** (3.41)
R^2	0.98	0.76	0.92
Adj. R^2	0.98	0.74	0.92
LL	73.04	34.24	19.84
D-W	0.68	1.41	0.73
E-G	-2.19	-5.59	-2.91

Number of Observations: 56 (t-stats in parentheses)

Table 4. $\textbf{Manufactures Imports} - 8.06 - 3.32 \cdot GDP_{US} + 12.97 \cdot (1 + \tau_i / M_i)$

$(-14.02) \quad (6.81)$

Error Correction:	Δ(Manuf. Imports)	$\Delta(GDP_{US})$	$\Delta(1+\tau_i/M_i)$
Cointegrating Eq(-1)	-0.36**	0.02	-0.02***
	(-2.3)	(1.28)	(-3.16)
Δ(Manuf. Imports(-1))	0.03	-0.01	0.003
	(0.18)	(-0.52)	(0.62)
$\Delta(GDP_{US}(-1))$	2.13	0.35**	-0.05
	(1.6)	(2.41)	(-1.21)
$\Delta[(1+\tau_i/M_i)(-1)]$	3.97	-0.11	0.28**
	(1.03)	(-0.27)	(2.36)
$\Delta(Peso_{Real})$	0.04	-0.002	-0.01*
	(0.74)	(0.23)	(-1.84)
Linear Data Trend	-0.04	0.005***	-0.0003
	(-0.53)	(3.7)	(-0.73)
R^2	0.17	0.13	0.28
Adj. R^2	0.08	0.04	0.2
Trace Statistic		36.5***	
Max-Eigenvalue Statistic		21.43**	
Log Likelihood		569.33	
Log Likelihood (d.f. adjusted)		564.37	
Number of Observations:		54	

(t-stats in parentheses)

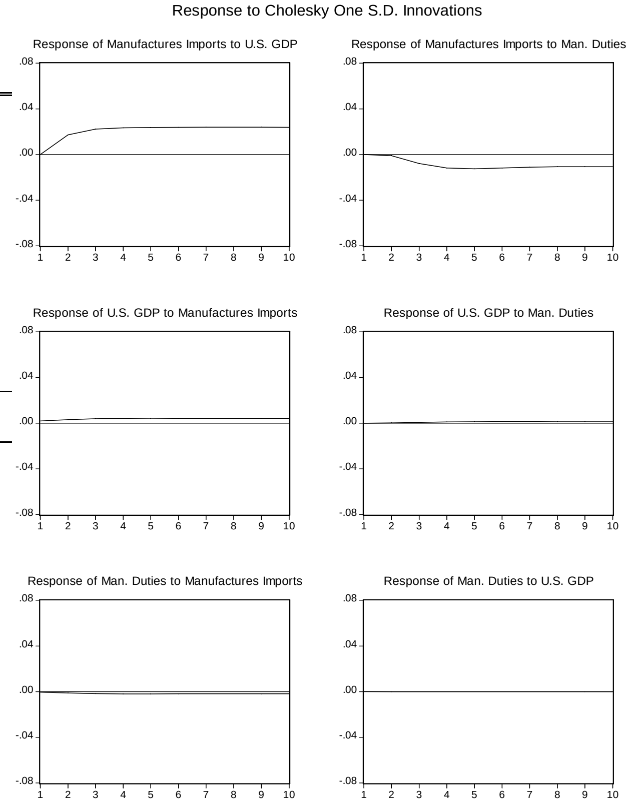


Table 5. $\textbf{Non - Manufactures Imports} - 14.85 - 1.25 \cdot GDP_{US} - 0.43 \cdot Peso_{Real} + 23.37 \cdot (1+\tau_i/M_i)$

$$(-4.04) \qquad (-3.51) \qquad (3.99)$$

Error Correction:	Δ(N-M Imports)	$\Delta(GDP_{US})$	$\Delta(Peso_{Real})$	$\Delta(1+\tau_i/M_i)$
Cointegrating Eq(-1)	-0.8***	0.02*	-0.12	-0.01
	(-3.93)	(1.69)	(-0.93)	(-1.52)
Δ(N-M Imports(-1))	-0.1	-0.01*	0.13	0.003
	(-0.7)	(-1.83)	(1.38)	(0.93)
$\Delta(GDP_{US}(-1))$	-3.28	0.31**	1.8	-0.003
	(1.25)	(2.35)	(1.1)	(-0.05)
$\Delta(Peso_{Real}(-1))$	-0.21	-0.01	-0.19	0.001
	(-0.91)	(-0.48)	(-1.3)	(0.14)
$\Delta[(1+\tau_i/M_i)(-1)]$	3.82	-0.57	-4.67	0.07
	(0.54)	(-1.6)	(-1.06)	(0.45)
Linear Data Trend	0.04*	0.005***	-0.02	-0.0003
	(1.74)	(4.06)	(-1.6)	(-0.59)
R^2	0.46	0.21	0.12	0.05
Adj. R^2	0.4	0.12	0.03	-0.04
Trace Statistic			49.23**	
Max-Eigenvalue Statistic			28.41**	
Log Likelihood			595.76	
Log Likelihood (d.f. adjusted)			583.04	
Number of Observations:			54	
(t-stats in parentheses)				

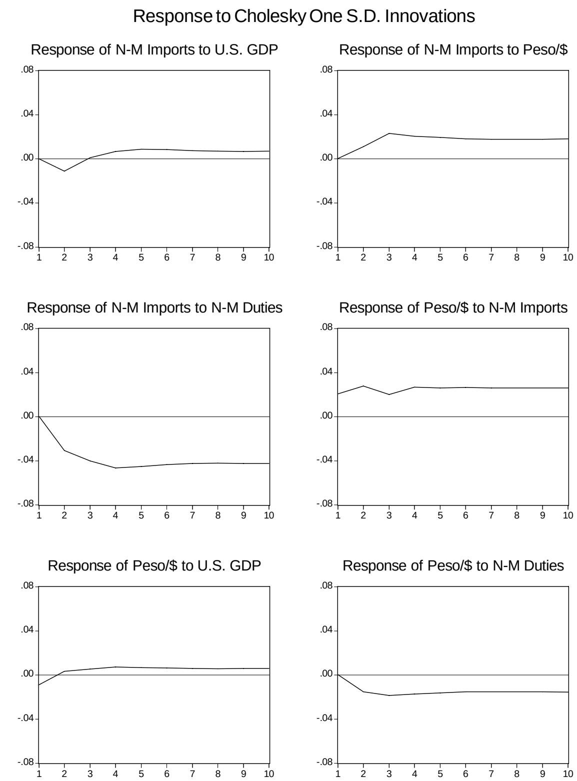


Table 6. $\mathbf{PV\ Imports - 8.16 - 2.86 \cdot GDP_{US} + 45.93 \cdot (1 + \tau_i / M_i)}$

$$\mathbf{(-3.2) \qquad (4.15)}$$

Error Correction:	Δ(PV Imports)	Δ(GDP_{US})	$\Delta\,(1+\tau_i/M_i)$
Cointegrating Eq(-1)	-0.43***	-0.002	-0.003***
	(-3.81)	(-0.86)	(-2.94)
Δ(PV Imports(-1))	0.27*	-0.004	0.001
	(1.88)	(-1.13)	(0.68)
Δ(GDP_{US}(-1))	-5.3	0.29**	-0.13***
	(-0.96)	(2.03)	(-2.75)
$\Delta[(1+\tau_i/M_i)$ (-1)]	9.42	-0.36	0.13
	(0.62)	(-0.92)	(0.96)
Δ($Peso_{Real}$)	-0.41	-0.002	-0.001
	(-0.92)	(-0.14)	(-0.2)
Linear Data Trend	0.06	0.005***	0.0004
	(1.29)	(3.97)	(1.15)
R^2	0.24	0.2	0.22
Adj. R^2	0.16	0.12	0.13
Trace Statistic		30.7**	
Max-Eigenvalue Statistic		21.9**	
Log Likelihood		489.46	
Log Likelihood (d.f. adjusted)		479.92	
Number of Observations:		54	
(t-stats in parentheses)			

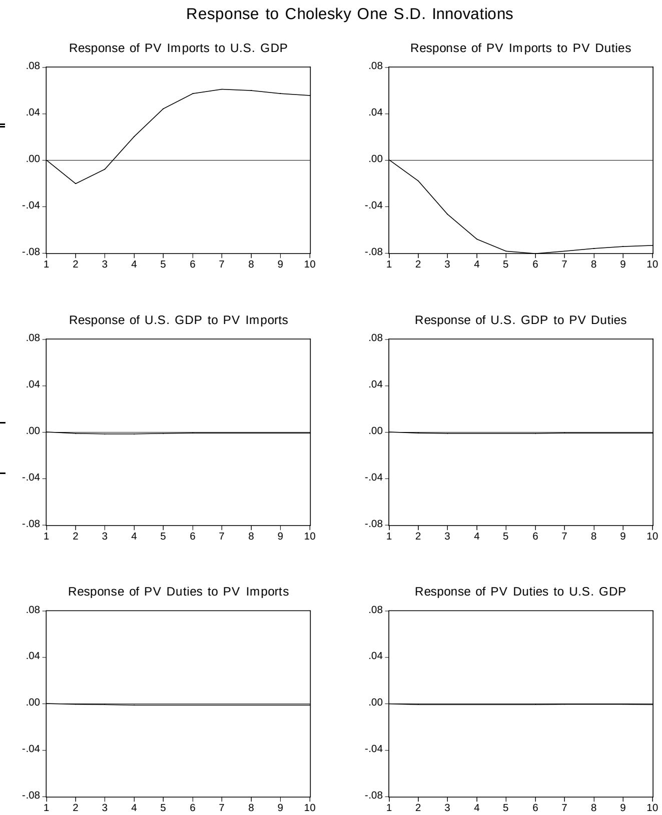


Table 7. $\textbf{Manufactures Exports} - 9.73 - 2.9 \cdot GDP_{Mx} - 0.11 \cdot D_{92/94}$

$$(-19.75) \qquad (-4.88)$$

Error Correction:	Δ(Manuf. Exports)	$\Delta(GDP_{Mx})$
Cointegrating Eq(-1)	0.01 (0.08)	0.29*** (4.31)
Δ(Manuf. Exports(-1))	0.27 (1.39)	-0.01 (-0.12)
$\Delta(GDP_{Mx}(-1))$	-0.74** (-2.51)	-0.5*** (-3.58)
$\Delta(GDP_{US})$	3.41** (2.44)	0.95 (1.44)
$\Delta(Peso_{Real})$	-0.32*** (-2.77)	-0.04 (0.83)
Linear Data Trend	-0.002 (-0.2)	0.005 (0.8)
R^2	0.42	0.75
Adj. R^2	0.34	0.71
Trace		28.92*
Max-Eigen Statistic		21.7**
Log Likelihood		232.00
Log Likelihood (d.f. adjusted)		224.68
Number of Observations:		54

(t-stats in parentheses)

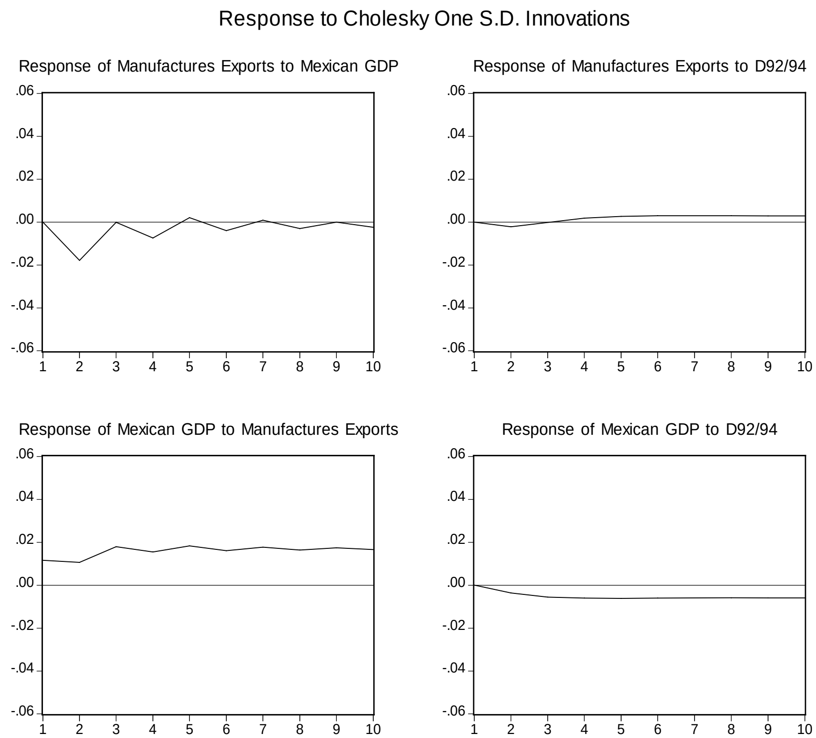


Table 8. $\textbf{Non-Manufactures Exports} - 14.2 - 1.36 \cdot \textbf{GDP}_{\textbf{Mx}} - 0.07 \cdot \textbf{D}_{\textbf{92/94}}$

$$(-4.6) \qquad (-1.54)$$

Error Correction:	Δ(N-M Exports)	$\Delta(GDP_{Mx})$
Cointegrating Eq(-1)	-0.68***	0.03
	(-3.85)	(0.82)
Δ(N-M Exports(-1))	0.11	-0.002
	(0.55)	(-0.06)
$\Delta(GDP_{Mx}(-1))$	0.08	-0.72***
	(0.19)	(-7.26)
$\Delta(GDP_{US})$	4.62	1.63*
	(1.27)	(1.99)
$\Delta(Peso_{Real})$	-0.27	0.04
	(-0.89)	(0.59)
Linear Data Trend	-0.02	0.002
	(-0.56)	(0.25)
R^2	0.31	0.59
Adj. R^2	0.22	0.54
Trace		31.95**
Max-Eigen Statistic		23.44**
Log Likelihood		175.02
Log Likelihood (d.f. adjusted)		168.09
Number of Observations:		54

(t-stats in parentheses)

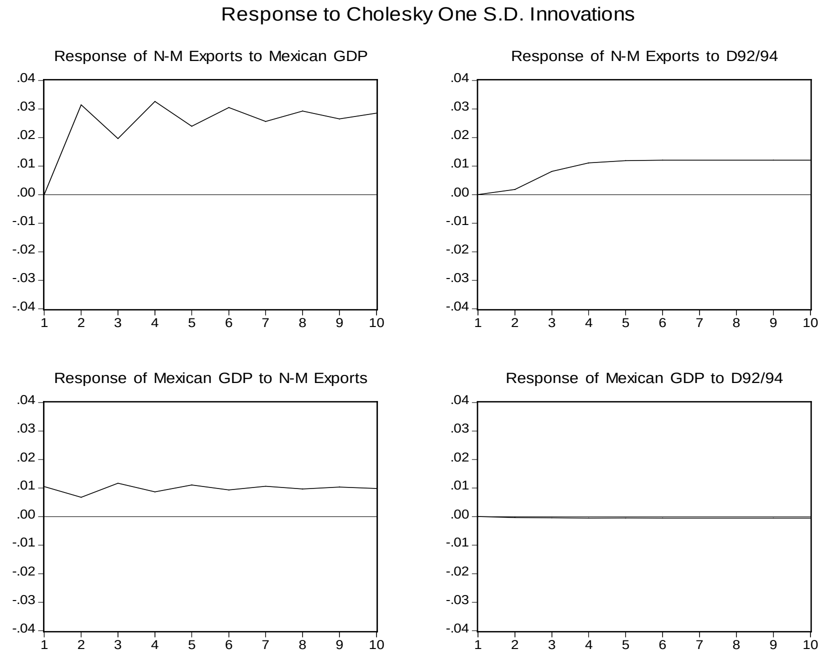


Table 9. $\textbf{MV Parts Exports} - 7.64 - 2.74 \cdot \text{GDP}_{Mx} - 0.45 \cdot D_{92/94}$

$(-4.52) \qquad (-4.66)$

Error Correction:	Δ(MV Parts Exports)	$\Delta(GDP_{Mx})$
Cointegrating Eq(-1)	-0.003 (-0.03)	0.08*** (3.19)
Δ(MV Parts Exports(-1))	-0.27* (-1.75)	-0.08** (-2.41)
$\Delta(GDP_{Mx}(-1))$	-0.4 (-0.96)	-0.62*** (-6.79)
$\Delta(GDP_{US})$	0.86 (0.26)	1.74** (2.39)
$\Delta(Peso_{Real})$	0.48 (1.61)	0.11 (1.66)
Linear Data Trend	0.04 (1.32)	0.04 (1.32)
R^2	0.17	0.67
Adj. R^2	0.07	0.63
Trace		19.19
Max-Eigen Statistic		14.34
Log Likelihood		172.6
Log Likelihood (d.f. adjusted)		171.78
Number of Observations:		54

(t-stats in parentheses)

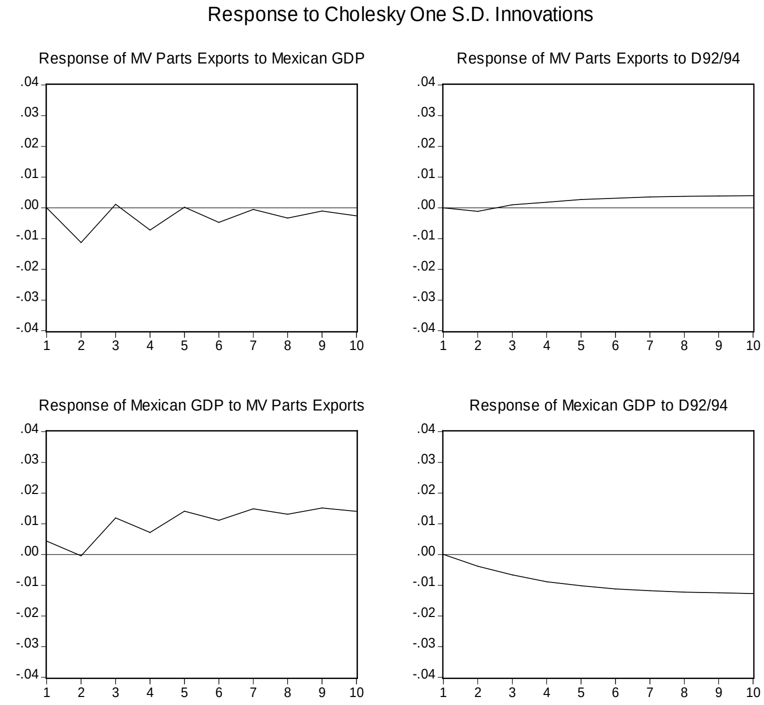
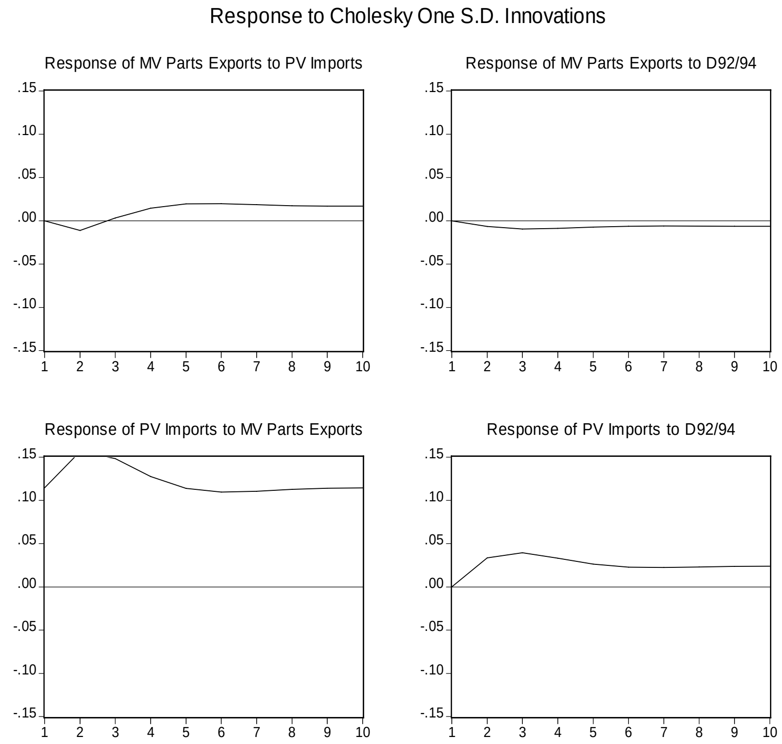


Table 10. $\mathbf{MV\ Parts\ Exports + 0.1 - \underset{(-8.28)}{0.93} \cdot PV\ Imports + \underset{(1.42)}{0.15} \cdot D_{92/94}}$

Error Correction:	Δ(MV Parts Exports)	Δ(PV Imports)
Cointegrating Eq(-1)	-0.06 (-0.73)	0.46*** (3.35)
Δ(MV Parts Exports(-1))	-0.15 (-0.94)	-0.04 (-0.15)
Δ(PV Imports(-1))	-0.13 (-1.37)	0.3** (1.95)
$\Delta(GDP_{Mx})$	0.49 (1.23)	1.26** (1.99)
$\Delta(Peso_{Real})$	0.57** (2.05)	-0.23 (-0.52)
R^2	0.22	0.27
Adj. R^2	0.12	0.18
Trace		27.15*
Max-Eigen Statistic		20.41*
Log Likelihood		77.6
Log Likelihood (d.f. adjusted)		65.41
Number of Observations:		54

(t-stats in parentheses)



Appendix

Table A.1. Unit Root Tests

Unit Root Tests		Augmented Dickey-Fuller		Phillips-Perron	
		Level	1st Difference	Level	1st Difference
GDP_{US} (1995 = 100)	intercept	0.75	-5.09***	0.42	-5.13***
	Intercept+trend	-2.03	-5.09***	-2.17	-5.15***
GDP_{MX} (1995 = 100)	intercept	-0.74	-3.33**	-1.2	-22.55***
	Intercept+trend	-3.0	-3.29*	-5.76***	-22.26***
Manufactured Exports	intercept	-1.28	-7.4***	-1.28	-7.4***
	Intercept+trend	-1.88	-7.43***	-1.94	-7.43***
Manufactured Imports	intercept	-1.6	-2.24	-1.31	-7.86***
	Intercept+trend	-0.52	-2.5	-1.56	-7.81***
Non-Manufactured Exports	intercept	-1.81	-5.69***	-1.65	-15.67***
	Intercept+trend	-5.16***	-5.63***	-4.87***	-16.62***
Non-Manufactured Imports (SA)	intercept	-1.2	-12.53***	-1.4	-14.52***
	Intercept+trend	-2.71	-12.41***	-4.62***	-14.32***
MV Parts Exports	intercept	-1.49	-9.51***	-1.6	-9.51***
	Intercept+trend	-2.47	-9.61***	-2.32	-9.68***
PV Imports	intercept	-1.6	-7.01***	-1.52	-9.91***
	Intercept+trend	-3.56**	-6.95***	-2.91	-9.98***
Real Peso/$	intercept	-1.76	-6.05***	-1.84	-7.88***
	Intercept+trend	-1.99	-5.99***	-2.18	-7.8***

All variables in log terms. All trade figures deflated with U.S. WPI.
Sample: 1989:Q1 – 2002:Q4

Table A.2. Correlation Matrices

	GDP_{US}	GDP_{MX}	$Peso_{Real}$	Man Ex	NoMan Ex	MVP Ex	Trend
GDP_{US}	1						
GDP_{MX}	0.95	1					
$Peso_{Real}$	-0.48	-0.63	1				
Man Ex	0.97	0.97	-0.58	1			
NoMan Ex	0.87	0.81	-0.36	0.85	1		
MVP Ex	0.94	0.92	-0.47	0.97	0.82	1	
Trend	0.99	0.95	-0.51	0.97	0.85	0.96	1

	GDP_{US}	GDP_{MX}	$Peso_{Real}$	Man Im	NoMan Im	PV Im	Trend
GDP_{US}	1						
GDP_{MX}	0.95	1					
$Peso_{Real}$	-0.48	-0.63	1				
Man Im	0.99	0.94	-0.43	1			
NoMan Im	0.92	0.89	-0.37	0.89	1		
PV Im	0.93	0.9	-0.4	0.96	0.84	1	
Trend	0.99	0.95	-0.51	0.99	0.9	0.95	1

	Man Ex	Man Im	NoMan Ex	NoMan Im	PV Im	MVP Ex
Man Ex	1					
Man Im	0.97	1				
NoMan Ex	0.85	0.86	1			
NoMan Im	0.83	0.91	0.79	1		
PV Im	0.93	0.96	0.8	0.84	1	
MVP Ex	0.97	0.96	0.82	0.84	0.95	1

Period: 1989:Q1 – 2002:Q4

Notes

[1] Sven W. Arndt is a Professor at the Department of Economics at Claremont McKenna College and Director of the Lowe Institute of Political Economy. Alex Huemer is a Research Fellow at the Lowe Institute of Political Economy at Claremont McKenna College. Corresponding Author: Sven W. Arndt, Lowe Institute of Political Economy, Claremont McKenna College, 850 Columbia Avenue, Claremont, CA 91711-6420. Telephone: (909) 621-8012, Fax: (909) 607-8008, E-mail: lowe@claremontmckenna.edu. Earlier versions of these results were reported at workshops and conferences in Claremont, Beijing, Cambridge, U.K. and Tokyo. Helpful comments from conference participants are gratefully acknowledged. Thanks to Alan Winters for especially valuable comments and suggestions.

[2] For detailed discussions, see Arndt (1997, 1998), Deardorff (2001), and Jones and Kierzkowski (2001). See also Feenstra (1998).

[3] Where multinational companies are involved, transfer-pricing policies may result in cost allocations that may differ from arms-length operations. We ignore the problem in what follows.

[4] For a related study, see Landon and Smith (2007). These features have potentially important implications for the choice of the exchange-rate regime. The declining sensitivity of the trade balance to the exchange rate can be used as an argument to support floating exchange rates, because it reduces the effect of exchange-rate volatility on the volume of trade. It may, however, also be used against floating rates, because it reduces the importance of the exchange rate as buffer.

[5] The trade data are taken from the International Financial Statistics of the International Monetary Fund (IMF) and publications of the U.S. Census Bureau, while import-duty information comes from the U.S. International Trade Commission (USITC). The latter two series are available in sufficient detail only after 1989 and undergo considerable redefinition in the Harmonized System classification after 2002.

[6] Manufactures and non-manufactures are identified by their SIC/NAICS classifications. Non-manufactured imports from Mexico are net of oil and gas (which are subject to dollar pricing in the world petroleum market), and are seasonally adjusted with the Tramo/Seats methodology (to correct for seasonality in agriculture). Inclusion of petroleum (the largest U.S. non-manufactured import from Mexico) generates some non-manufactured import regression results that are similar to those for production-sharing trade, but for very different reasons. The dollar value of petroleum imports remains unaffected by real peso changes, since Mexican petroleum is priced in dollars.

[7] Wholesale prices are used because measures of bilateral import and export prices were not available for Mexico.

[8] See Engle and Granger (1991), pp. 81-111.

[9] While the Durbin-Watson statistics are likely to indicate serial correlation in view of the relatively small size of our sample, the super-consistency properties of the OLS estimators assure rapid convergence as the sample size increases. When AR(1) terms are included in the regressions, the Durbin-Watsons and Q-statistics typically move into the desired range.

[10] See Engle and Granger (1991), pp. 65-80, and Granger (1969).

[11] The constraints are applied to the cointegrating vector coefficients. The method of Johansen and Juselius (1990) was adopted in estimating the VEC representation. Following Johansen (1992), a variant of the method of Pantula (1989) was used to identify the model rank of cointegration (consistently one) and to assess the role of the constant and trend terms in the cointegrating and error-correction components of the model.

[12] Market anticipations of a policy shift may make the official start date an improper indicator of the impact of that policy.

[13] It might be argued that NAFTA generated both a mean shift and a trend shift. We experimented with various specifications, including separate trend variables and interactions between the mean shift variable and U.S. GDP, interpreting the latter as the dominant trend variable. The results were uniformly inferior to those reported here. As noted earlier, the main variables in these bilateral trade relations are highly correlated and exhibit strong common trends. The fact that they are identified as of common order of integration and of being cointegrated argues against the need for an additional independent trend in the dependent variable. A theoretical motivation for inclusion of a trend found in the literature is based on the assumption of declining transport costs and/or border effects. In our specification, however, some of those effects are already controlled for in the duty rate variable and others in the trade liberalization dummies.

[14] The measure is constructed for U.S. imports only, because comparable data were not available for Mexico.

[15] There is the possibility of strong J-curve effects arising from the large real peso depreciation of 1994. However, the data are quarterly, which allows sufficient time to overcome most short-term demand inelasticities. Further, as figures 4-5 show, the balance-of-payments movements after the peso crisis do not suggest a J-curve effect; and Figure 6 shows that the subsequent slight decrease in passenger vehicle imports was consistent with a decline in import quantities, not a valuation effect arising from the depreciation.

[16] Recall that the two-step representation of NAFTA switches to the value one in 1992 and to the value two in 1994.

[17] We might be concerned about erroneously attributing to NAFTA effects stemming from the peso crisis of 1994, especially in the NAFTA measure used in Table 2d. The depreciation of the peso reduces the dollar value of U.S. imports and thus the dollar value of duty collections, especially when duties are of the *ad valorem*

type. However, examination of average U.S. dollar prices for passenger vehicle imports from Mexico indicates no significant deviation from trend over the period 1989-2002, thus limiting the likely significance of such concerns.

[18] The top six SIC/NAICS non-manufactured goods exported to Mexico by the United States over the period were various feed grains and cotton. While end-use of these commodities cannot be clearly identified, they comprise categories of commodities used in other types of production (baked goods, livestock, leather goods and apparel, etc.) likely to be exported back to the United States in some quantity.

[19] It is apparent, in the context of production sharing, that U.S. exports to Mexico will be affected by trade liberalization in two ways. First, liberalization on Mexico's part will encourage imports. Second, U.S. liberalization will encourage imports from Mexico and imports incorporating U.S.-made components will raise the demand for U.S. exports.

[20] Import results are reported in Tables 4 through 6; export results in Tables 7 through 10.

[21] Note that all the import and export categories have only one significant cointegrating vector.

[22] Separate estimates were made using the 1994 dummy, with little or no change in the overall result, and no qualitative change in the conclusions drawn from the use of the two-step dummy variables. Following Johansen (1995), the dummies were centered to prevent bias to the intercept variables.

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