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Exchange Rates Impacts on Agricultural Inputs Prices using VAR

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The effects of the U.S. dollar exchange rate versus the Mexican peso are evaluated for four traded nonfarm-produced inputs (fertilizer, chemicals, farm machinery, and feed) in the U.S. Unit root tests suggest that the exchange rate and the four input price ratios support the presence of unit roots with a trend model but the presence unit roots can be rejected in the first difference model. This result is consistent with a fixed price/flex price conceptual framework, with industrial prices more likely to be unresponsive to the exchange rate than farm commodity prices.

Key Words: exchange rate, pass-through, law of one price, SUR, VAR

JEL Classifications: F14, F31, F36, F42, C23

Over the past few years, the dollar has depreciated against a number of currencies. In principle, the dollar's fall should help to correct the U.S. trade deficit through a fall in imports, if they are elastic. However, the dollar's recent slide has produced neither a substantial fall in imports nor a sizable shrinking of the trade imbalance. One possible explanation for the U.S. experience of the past few years is that the rate of exchange rate "pass-through"—the degree to which a change in the value of a country's currency induces a change in the price of the country's imports and exports—has fallen relative to historical values. Indeed, while pass-through is almost always "incomplete," recent studies (Campa and Goldberg, 2005; Goldberg and Knetter, 1997) suggest that import prices in a number of industrial nations may have become progressively less responsive to changes in exchange rates over the past decade or so.

A potential decline in exchange rate pass-through has important implications for the U.S. economy. First, it has significant bearing on U.S. efforts to correct the country's trade imbalance. If import prices have become much less responsive to changes in currency values, a larger devaluation of the dollar will be needed to narrow the imbalance. Second, pass-through has implications for the stability of domestic prices. Low import prices are believed to contribute to low rates of inflation—in part by constraining domestic producers to keep their prices competitive.

Though exchange rate pass-through has long been of interest, the focus of this interest has evolved considerably over time. After a long period of debate over the law of one price (LOP) and convergence across countries, beginning in the late 1980s exchange rate pass-through studies emphasized industrial organization and the role of segmentation and price discrimination across geographically distinct product markets (Campa and Goldberg, 2006). More recently pass-through studies focused on

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prices of traded agricultural outputs (Ardeni, 1989; Bradshaw and Orden, 1990; Goodwin and Schroeder, 1991; Froot, Kim, and Rogoff, 1995). Adjustments of the prices of traded nonfarm-produced agricultural inputs to the exchange rate have not received as much attention. Yet these purchased inputs comprise an important component of agricultural production costs, and whether their prices also respond to exchange rate movements will affect the net impacts from currency revaluations.

Carter and Hamilton (1989) examined the validity of the law of one price (LOP) for traded inputs used in production of wheat between the closely-integrated Canadian and U.S. economies. Over the period 1977–1986, during which there were substantial movements in Canadian/U.S. currency values, Carter and Hamilton (1989) found a contemporaneous relationship between quarterly input prices, but adjustments to the LOP did not occur. Also, while Carter, Gray, and Furtan (1990) evaluated exchange rates effects on both output and input prices, most of studies focus on output prices. In their study, Carter, Gray, and Furtan (1990) used the LOP to examine the exchange rate pass-through for the prices of five Canadian inputs—petroleum, fertilizer, pesticides, machinery, and fat steers—and three Canadian outputs—wheat, canola, and feeder steers—using quarterly data over the period 1975–1988. Carter, Gray, and Furtan (1990) found that the exchange rate had significant pass-through effects on some of the input prices as well as the output prices, although differences occurred in the timing and extent of this pass-through. More recently, Carlson, Deal, McEwan, and Deen (1999) have provided a descriptive analysis of the relationships between herbicide prices in Canada and the U.S. using cross-sectional annual data over the period 1993–1999. Carlson et al. (1999) concluded that restrictions on the movement of pesticides across the border are one factor creating price differentials for similar products.

This study develops a system of empirical models that capture the short-run dynamics of exchange rate and the LOP effects on four traded nonfarm produced inputs (chemicals, farm machinery, feed and fertilizers) between the U.S. and Mexico over the period 1981–2008 using an vector autoregressive (VAR) model in seemingly unrelated regression (S.U.R) framework. Mexico is one of the U.S.'s major trade partners and a member of NAFTA. Mexico agricultural imports from the U.S. grew by 228% between 1994 and 2007 (post NAFTA period) while the growth was only 25% from 1989 to 1993 (pre NAFTA membership) (FATUS, 2007).

The remainder of this paper is structured as follows: Section 2 discusses the literature review on exchange rate pass-through; Section 3 describes a partial equilibrium framework which analyzes exchange rate effects on prices and production; Section 4 provides the theoretical framework of the LOP and the specifications of the exchange rate pass-through model; Section 5 discusses the development of the VAR/SUR empirical model; Section 6 discusses the data and estimation procedures; Section 7 discusses the results; and Section 8 provides conclusion of the study.

Literature Review

This section of the paper provides information on several studies that provide background information on the impact of exchange rates on prices. The articles reviewed in this study serve as a selective set of articles by the authors.

Abeysinghe and Yeok (1998) used an econometric model to estimate the effects of import content on exports and the dynamic effects of productivity improvements on the competitiveness of Singapore's exports. Results reveal that, in general, the higher the imported input content, the less impact of exchange rate changes on exports. At one extreme, exchange rate changes had no effect on re-exports, while at the other extreme, service exports, being relatively less intensive than imported inputs, were most affected by currency exchanges. The authors further found that productivity gains were not sufficiently large enough to contribute significantly to enhance export price competitiveness. This result suggested that domestic value-added was not as significant as imported input content in influencing export prices.

Byrne, Darby, and MacDonald (2008) measured the impact of exchange rate volatility on the volume of bilateral U.S. trade (both exports and imports) using sectoral data. The authors used bilateral imports from and exports to the U.S. from a sample of six European countries. In this analysis, the authors used disaggregate price data as the trade deflator, rather than the U.S. consumer price index (CPI), and they constructed new disaggregate sectors to examine the importance of exchange rate uncertainty. Results reveal that pooling all industries together provides evidence of a negative effect on trade from exchange rate volatility. However, when the authors used an econometric model, they found evidence that this effect may be different across industries. In addition, the authors found that output and relative price coefficients are different on a disaggregated basis. Moreover, the effect of exchange rate uncertainty is negative and significant for differentiated goods, and insignificant for homogeneous goods.

Campa and Goldberg (2006) found that border prices of traded goods are highly sensitive to exchange rates; however, they found that the CPI and the retail prices of goods that make up the CPI are more stable. The authors decomposed the sources of that price stability for 21 OECD (Organization for Economic Cooperation and Development) countries, focusing on the important role of distribution margins and imported inputs in transmitting exchange rate fluctuations into consumption prices. The authors found that distribution costs, relevant to consumer price pass-through calculations, were on average 32–50% of the total costs of goods across OECD countries. The authors also found that imported input use is larger in tradable goods industries than in nontradables production, and varied widely across countries.

Hahn (2007) investigated the impact of exchange rate shocks on sectoral activity and prices in the euro area. Using a VAR framework, the author provides evidence on the magnitude and speed of the impact of exchange rate shocks on activity in all main euro area sectors and on the activity and producer prices in a large set of subsectors of industry. The results from this analysis suggest a high degree of heterogeneity in the exchange rate sensitivity across both sectoral activity and prices in the euro area. Overall, the sector results suggest that within industry (excluding construction), the main industrial groupings (MIGs), capital and intermediate goods, account for almost all of the impact on production (around 90%), while among the main subsectors the whole impact comes via the manufacturing sector. On the price side, the most important contributor to the effect on producer prices in industry among MIGs is the energy sector, accounting for more than 50% of the overall effect, while among subsectors the largest contribution may be ascribed to producer prices in manufacturing; however, in contrast to the effects on activity, the electricity, gas, and water supply sector contributes significantly.

Parsley and Popper (2006) reexamined decompositions of the real exchange rate that apportioned its movements into a part that reflected international deviations from the law of one price and a part that reflected the relative prices of traded and nontraded goods within countries. Using a partial equilibrium model with Japanese and U.S. data, the authors showed that in such decompositions the traded/nontraded distinction was irrelevant at the consumer level. Also, the authors, motivated by a model of trade in intermediate products, used implied import weights and found that relative traded/nontraded price changes accounted for much of the real exchange's rate variation.

Parsley and Wei (2003) studied the movement of real exchange rates based on prices of Big Macs. The authors matched these prices to the prices of individual ingredients (ground beef, bread, lettuce, labor cost, rent and other items) in 34 countries during 1990–2002. Results showed that the nontraded component of Big Mac prices was substantial, ranging between 55–64%. The authors also studied the persistence of the real exchange rate in a setting free of possible biases induced by noncomparability of consumption baskets across countries, product aggregation bias, and time aggregation bias. The authors found that the speed of convergence for the Big Mac real exchange rates was slower than the speed for its tradable inputs, but faster than for its nontradable inputs. Finally the authors showed that

Engel's result that deviations from the law of one price are all that matters does not hold generally (Engel, 1999).

Partial Equilibrium Analysis

Devaluation in the exchange rates means an increase in the nominal and real prices in the tradable sector. When the domestic currency depreciates it increases the traded commodity price, but its impact on supply also depends on input price changes. If a fixed price/flex price model is assumed (Saghaian, Reed, and Marchant, 2002), then output prices respond contemporaneously to exchange rate movements while traded input prices are unresponsive in the short run. But inputs may also be traded if the home country is assumed to import at least some inputs from the foreign country. However, in this study, Mexico (the foreign country) imports agriculture inputs from the U.S., such as machinery and agriculture chemicals. When the domestic currency depreciates, the prices of goods imported into that country are typically expected to rise.

The underlying partial equilibrium framework to examine the effects of exchange rate changes on small specific industries using a simple model of the firm is developed and also presented graphically in Figure 1. The primary assumptions include the exogenous nature of the exchanges rates and that the countries are large nations, i.e., both countries' trade has impacts on

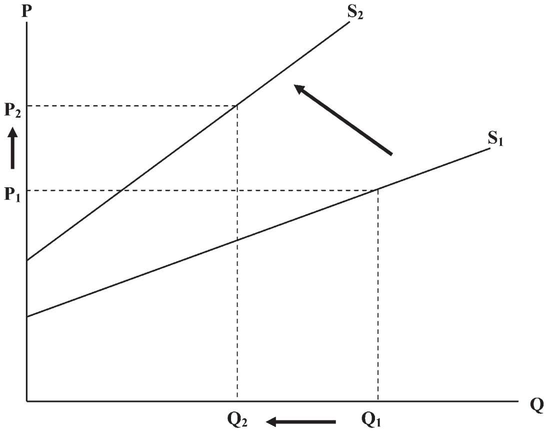

Figure 1. Effects of Exchange Rate Depreciation

world prices. The currency depreciation may then increase traded input prices—P_1 to P_2—and thus the cost of production, in the longer run. If all of the inputs are traded as in this study and there is eventually a complete exchange rate pass-through to their costs, then output supplied would remain unchanged at $Q1$ after full adjustment to the depreciation. In the case that not all inputs are traded, or that exchange rate pass-through effects on input prices are incomplete, output supplied would be determined between $Q1$ and $Q2$ by factors including the elasticity of the supply function, the proportion of traded inputs in production, and output responses to changes in the input prices.

Model Specification of Exchange Rate Pass-Through and LOP

The law of one price (LOP) states that in the absence of transportation and other transaction costs, competitive markets will equalize the prices of an identical good in two countries when the prices are expressed in the same currency. In mathematical notation, the law of one price can be expressed as follows:

$$(1) \qquad P_{i,t}^{d} = E\,P_{i,t}^{f}$$

where P_t^d and P_t^f are the domestic and the corresponding foreign currency price respectively of a commodity i for the time period t and E is the exchange rate defined as the domestic-currency price of foreign currency.

Given transportation and storage costs and the imperfect competitive world market, the absolute version of the LOP as expressed in Equation (1) is very unlikely to hold. However, the following relative version of the law of one price may hold:

$$(2) \qquad P_{i,t}^{d} = \alpha E\,P_{i,t}^{f}$$

where α indicates the deviation from the law of one price, and is constant over time. Equation (2) can be rewritten as:

$$(3) \qquad \frac{P_{i,t}^{d}}{P_{i,t}^{f}} \equiv P_{i,t}^{df} = \alpha E$$

with the advent of time-series analysis, VAR and vector error correction (VEC) processes have gained popularity due to their flexibility and ability to estimate relationships of the variables of interest for stationary and non-stationary with cointegration correction, respectively. Theories examining the short and long run relationships between exchange rates and domestic prices have been examined in a dynamic framework (Carter, Gray, and Furtan, 1990; Chambers and Just, 1981). Earlier studies have examined independently the relation between each input price and exchange rate using VAR or VEC process.

Equation (3) is used to examine the importance of exchange rate on four input prices, and hence can be rewritten as:

$$(4) \qquad P^{df}_{i,t} = \sum_{j=0}^{s} \alpha E_{t-j}$$

where E is the exogenous variable and s are lags in exogenous component.

As we are interested in examining the short analysis, the VAR model of Equation (4) with contemporaneous and lagged exogenous and lagged endogenous variables can be represented as:

$$(5) \qquad P^{df}_{i,t} = \sum_{j=0}^{s} \alpha E_{t-j} + \sum_{j=1}^{r} \beta P^{df}_{i,t-j}$$

where $P = \left[P^{df}_{1,t}, P^{df}_{2,t}, P^{df}_{3,t}, P^{df}_{4,t}\right]'$ represent vectors of endogenous variables, and E is the exogenous variable; s and r are lags in exogenous and autoregressive components respectively.

Next, this study develops a system of equations estimation model that captures the short-run dynamics of U.S. vs. Mexican exchange rate effects on U.S. input prices using an SUR model. The SUR/VAR representation of input prices and exchanges rate for Equation (5) is:

$$(6) \qquad \begin{aligned}
\ln\frac{P^{d}_{feed,t}}{P^{f}_{feed,t}} &= \sum_{j=0}^{r}\alpha_{1j}\ln E_{t-j} + \sum_{j=1}^{s}\beta_{11,j}\ln\frac{P^{d}_{feed,t-j}}{P^{f}_{feed,t-j}} + \sum_{j=1}^{s}\beta_{12,j}\ln\frac{P^{d}_{fert,t-j}}{P^{f}_{fert,t-j}} \\
&\quad + \sum_{j=1}^{s}\beta_{13,j}\ln\frac{P^{d}_{chem,t-j}}{P^{f}_{chem,t-j}} + \sum_{j=0}^{s}\beta_{14,j}\ln\frac{P^{d}_{mach,t-j}}{P^{f}_{mach,t-j}} + \varepsilon_1 \\
\ln\frac{P^{d}_{fert,t}}{P^{f}_{fert,t}} &= \sum_{j=0}^{r}\alpha_{2j}\ln E_{t-j} + \sum_{j=1}^{s}\beta_{21,j}\ln\frac{P^{d}_{feed,t-j}}{P^{f}_{feed,t-j}} + \sum_{j=1}^{s}\beta_{22,j}\ln\frac{P^{d}_{fert,t-j}}{P^{f}_{fert,t-j}} \\
&\quad + \sum_{j=1}^{s}\beta_{23,j}\ln\frac{P^{d}_{chem,t-j}}{P^{f}_{chem,t-j}} + \sum_{j=0}^{s}\beta_{24,j}\ln\frac{P^{d}_{mach,t-j}}{P^{f}_{mach,t-j}} + \varepsilon_2 \\
\ln\frac{P^{d}_{chem,t}}{P^{f}_{chem,t}} &= \sum_{j=0}^{r}\alpha_{3j}\ln E_{t-j} + \sum_{j=1}^{s}\beta_{31,j}\ln\frac{P^{d}_{feed,t-j}}{P^{f}_{feed,t-j}} + \sum_{j=1}^{s}\beta_{32,j}\ln\frac{P^{d}_{fert,t-j}}{P^{f}_{fert,t-j}} \\
&\quad + \sum_{j=1}^{s}\beta_{33,j}\ln\frac{P^{d}_{chem,t-j}}{P^{f}_{chem,t-j}} + \sum_{j=0}^{s}\beta_{34,j}\ln\frac{P^{d}_{mach,t-j}}{P^{f}_{mach,t-j}} + \varepsilon_3 \\
\ln\frac{P^{d}_{mach,t}}{P^{f}_{mach,t}} &= \sum_{j=0}^{r}\alpha_{4j}\ln E_{t-j} + \sum_{j=1}^{s}\beta_{41,j}\ln\frac{P^{d}_{feed,t-j}}{P^{f}_{feed,t-j}} + \sum_{j=1}^{s}\beta_{42,j}\ln\frac{P^{d}_{fert,t-j}}{P^{f}_{fert,t-j}} \\
&\quad + \sum_{j=1}^{s}\beta_{43,j}\ln\frac{P^{d}_{chem,t-j}}{P^{f}_{chem,t-j}} + \sum_{j=0}^{s}\beta_{44,j}\ln\frac{P^{d}_{mach,t-j}}{P^{f}_{mach,t-j}} + \varepsilon_4
\end{aligned}$$

where t is years; α and β are estimated parameters associated with exchange rate and lagged endogenous variables; and $\varepsilon_1, \varepsilon_2, \varepsilon_3$ and ε_4 are errors for each of the four input price equations.

Parameter estimates from Equation (6) would still allow us to recover the short-run relationships between exchange rate and the four endogenous price variables.

Data and Estimation Procedures

The input price series are derived from *Agricultural Prices* published by the National

Table 1. Summary Statistics of the Variables Used in the Analysis

Variable	N	Mean	Std Dev	Median	Minimum	Maximum
Chemicals	105	32.6	74.4	2.53	0.74	323
Machinery	105	31.2	75.5	2.23	0.69	327
Feed	105	99.8	265.1	2.21	0.76	1283
Fertilizer	105	72.2	188.3	2.80	0.95	890
U.S. MexicoEX	105	0.093	0.018	0.095	0.058	0.188

Agricultural Statistics Service (NASS) of the USDA. The U.S./Mexican exchange rate is compiled by the Economic Research Service (ERS) of the USDA. Monthly data are converted to quarterly averages for consistency in the analysis, since the input price series are only available on a quarterly basis. Data on exchange rates were obtained from the Foreign Agricultural Trade of the United States (FATUS) database on the USDA's ERS website. The exchange rate data are measured as the U.S. dollar per the Mexican Peso, which means that an increase indicates a depreciation of the U.S. dollar, and a decrease means depreciation. The parameter(s) of Equation (7) is estimated in dynamic model accounting for the system of equations. This consists of first choosing the optimum lag using Akaike Information Criteria (AIC) by estimating an unrestricted model with one lag of each endogenous variable. Based on the AIC model selection, the specification included one lag for all the endogenous variables. Due to the use of quarterly data, we include four lags of exogenous exchange rate variable for each of the four input price equation. The dynamic model with one lagged endogenous variable of all four input prices and four lagged exogenous exchange rate in each equation is estimated using with iterative SUR system of equations.

For a complete exchange rate pass-through and adherence to the LOP, we hypothesized the sum of the coefficients of the contemporaneous and that of the lags sum up to one, whereas a sum equal to zero represents the null hypothesis which implies no exchange rate pass-through and invalidity of the LOP.

Results

Table 1 presents the summary statistics of input price indices and the exchange rate of the U.S. dollar vs. the Mexican peso. The mean index for chemicals for the 105 quarters is 32.6 with a minimum of 0.74 and maximum of 323 while farm machinery has 31.2 as mean index and 0.69 and 327 minimum and maximum. Thus chemicals and machinery have almost the same range as indicated by the standard deviations of 74.4 and 75.5. Feed and fertilizer indices are completely different from each other and from both chemicals and machinery. The means of these indices are 99.8 and 72.2 with minimums of 0.76 and 0.95, respectively, whereas the maximums are as large as 1283 and 890. The mean exchange rate of the dollar to the peso for the study period is about 9 cents with a minimum and maximum of about 19 cents to the peso.

Results of the unit root tests are presented in Table 2. The results in Table 2 indicated that all of the four input price ratios—feed, fertilizer, machinery and chemicals—support the presence of unit roots with a trend model. The results of the first difference indicate that the presence of unit roots can be rejected.

To account for unit roots, the SUR/VAR model defined in Equation (6) is estimated using the first difference of exogenous and endogenous variables. The SUR/VAR model was estimated with four lags for exogenous components and just one lag for the autoregressive. Use of higher lag for the autoregressive was avoided as the model did not converge due to high colinearity. Equation (6) can be rewritten roots as:

$$
\begin{aligned}
\Delta P^{df}_{feed,t} &= \alpha_1 + \alpha_{11}\Delta E_t + \alpha_{12}\Delta E_{t-1} + \alpha_{j3}\Delta E_{t-2} + \beta_{11}\Delta P^{df}_{feed,t-1} \\
&\quad + \beta_{12}\Delta P^{df}_{fert,t-1} + \beta_{13}\Delta P^{df}_{chem,t-1} + \beta_{14}\Delta P^{df}_{mach,t-1} + \varepsilon_1 \\
\Delta P^{df}_{fert,t} &= \alpha_2 + \alpha_{21}\Delta E_t + \alpha_{22}\Delta E_{t-1} + \alpha_{23}\Delta E_{t-2} + \beta_{21}\Delta P^{df}_{feed,t-1} \\
&\quad + \beta_{22}\Delta P^{df}_{fert,t-1} + \beta_{23}\Delta P^{df}_{chem,t-1} + \beta_{24}\Delta P^{df}_{mach,t-1} + \varepsilon_2 \\
\Delta P^{df}_{chem,t} &= \alpha_3 + \alpha_{31}\Delta E_t + \alpha_{32}\Delta E_{t-1} + \alpha_{33}\Delta E_{t-2} + \beta_{31}\Delta P^{df}_{feed,t-1} \\
&\quad + \beta_{32}\Delta P^{df}_{fert,t-1} + \beta_{33}\Delta P^{df}_{chem,t-1} + \beta_{34}\Delta P^{df}_{mach,t-1} + \varepsilon_3 \\
\Delta P^{df}_{mach,t} &= \alpha_4 + \alpha_{41}\Delta E_t + \alpha_{42}\Delta E_{t-1} + \alpha_{43}\Delta E_{t-2} + \beta_{41}\Delta P^{df}_{feed,t-1} \\
&\quad + \beta_{42}\Delta P^{df}_{fert,t-1} + \beta_{43}\Delta P^{df}_{chem,t-1} + \beta_{44}\Delta P^{df}_{mach,t-1} + \varepsilon_4
\end{aligned} \tag{7}
$$

where, $\Delta P^{df}_{feed,t} = \ln(P^{d}_{feed,t}/P^{f}_{feed,t}) - \ln(P^{d}_{feed,t-1}/P^{f}_{feed,t-1})$, is the first difference of the ratio of the feed price between the domestic and foreign country. Similarly the first difference of the exchange rate ratio between the domestic and foreign country is defined as $\Delta E_t = \ln E_t - \ln E_{t-1}$. Even though it is possible to test for the presence of autocorrelation and heteroskedasticity for each equation, it is more appropriate to test for autocorrelation and heteroskedasticity in an SUR/VAR framework to account for possible error correlation across equations (Breusch and Pagan, 1979; White, 1980; and Godfrey, 1978). Results did not indicate the presence of autocorrelation or heteroskedasticity.

The estimated contemporaneous, one-lag up to four-lag coefficients of the VAR/SUR model are presented with *t*-statistics Table 3. In all, the input prices show a less response to exchange rate, especially in the feed and fertilizer equations, where none of the elasticities of the lags are significant. Also, none of the contemporaneous point estimates are statistically significant. Most importantly, we fail to reject the null hypothesis that the coefficients of the contemporaneous and those of the lags sum up to zero which implies no exchange rate pass-through and invalidity of the LOP. Exchange rate pass-through is limited for all the inputs—fertilizer, feed, chemical, and farm machinery—even after four quarters. The sums of coefficients are 0.70 for feed, 0.08 for fertilizers, and 0.45 for machinery, while that of chemicals is 0.00. These results are not exceptional as most studies (Carter, Gray, and Furtan, 1990; Xu and Orden, 2002) find input prices to be sticky. Xu and Orden (2002) finds the farm pass-through effect on farm machinery to be only 0.37, even after two years, suggesting that price

Table 2. Dickey-Fuller Unit Root Tests of the Variables

Variable	Type	Rho	Pr < Rho	Tau	Pr < Tau
Levels					
Chemicals	Trend	−2.26	0.9615	−1.76	0.7175
Machinery	Trend	−3.71	0.8998	−2.11	0.5355
Feed	Trend	−2.4	0.9572	−1.52	0.8161
Fertilizer	Trend	−1.53	0.9792	−1.28	0.8861
MexicoEX1	Trend	−19.78	0.059	−3.2	0.0907
First Difference					
Chemicals	Trend	−54.2	0.0003	−5.12	0.0003
Machinery	Trend	−44.76	0.0003	−4.79	0.0009
Feed	Trend	−85.27	0.0003	−6.43	<0.0001
Fertilizer	Trend	−77.4	0.0003	−6.12	<0.0001
MexicoEX1	Trend	−105.47	0.0001	−8.91	<0.0001

Table 3. Exchange Rate Pass-Through for U.S. Agricultural Inputs

	Estimate	t Value	Estimate	t Value
Variable	Δfeed		Δfertilizer	
Intercept	−0.0005	−0.06	0.0006	0.07
ΔUSMexicoEX(t)	0.0946	0.84	0.0490	0.48
ΔUSMexicoEX(t-1)	0.1814	1.52	0.1185	1.11
ΔUSMexicoEX(t-2)	0.2879	1.22	−0.0505	−0.24
ΔUSMexicoEX(t-3)	0.1432	1.04	−0.0342	−0.28
ΔUSMexicoEX(t-4)	0.0534	0.52	0.0481	0.52
Δchemicals(t-1)	−0.1411	−0.99	0.1110	0.87
Δmachinery(t-1)	0.0059	0.02	−0.1351	−0.59
Δfeed(t-1)	−0.3744	−3.7	0.1643	1.81
Δfertilizer(t-1)	0.0106	0.08	−0.5245	−4.43
	Δchemicals		Δmachinery	
Intercept	−0.0005	−0.08	−0.0011	−0.23
ΔUSMexicoEX(t)	0.0258	0.34	0.1485	2.35
ΔUSMexicoEX(t-1)	0.2216	2.78	0.1386	2.07
ΔUSMexicoEX(t-2)	−0.3378	−2.14	0.0910	0.69
ΔUSMexicoEX(t-3)	0.0432	0.47	0.0715	0.93
ΔUSMexicoEX(t-4)	0.1168	1.7	−0.0002	0
Δchemicals(t-1)	−0.5523	−5.81	0.0015	0.02
Δmachinery(t-1)	−0.1016	−0.59	−0.4910	−3.42
Δfeed(t-1)	0.1042	1.54	0.1441	2.55
Δfertilizer(t-1)	0.0903	1.02	−0.0277	−0.37

adjustment to exchange rate movements remains incomplete.

Only four lagged regression coefficients are significant in the VAR/SUR model (α_{t-1} and α_{t-2}) for both chemicals and (α_t and α_{t-1}) farm machinery. A 1% depreciation of the dollar today raises the prices of chemicals by 0.22% in three months while the prices fall by 0.34 in the sixth month. This result can be explained by "J-curve effects." Due to the lagged adjustments in trade volume on prices changes, a depreciation will reduce export values and increase import values which will trigger inflationary conditions before prices fall to improve trade balance. For farm machinery, a 1% depreciation of the dollar contemporaneously increases the price by 0.15% and 0.14% in three months. For feed, although the estimated pass-through increases over time, the evidence is not strong enough to reject either the null hypothesis of zero exchange rate effect or the LOP. For chemicals, LOP and zero pass-through are strongly rejected.

Conclusion

This paper investigates the effects of the U.S. dollar exchange rate versus the Mexican peso on the prices of four traded nonfarm-produced inputs (fertilizer, chemicals, farm machinery, and feed) in the U.S. Unit root tests suggest that the exchange rate and the four input price ratios—feed, fertilizer, machinery and chemicals—support the presence of unit roots with a trend model but the presence of unit roots can be rejected in the first difference model. To account for unit roots and the system of four inputs, a VAR model in SUR framework was developed to identify the importance of exchange rates on agricultural inputs. Further, the autocorrelation and heteroskedasticity for the four system of inputs was tested in SUR framework along with a VAR model.

The empirical results confirm that short-run adjustments to the LOP do not occur even after five quarters for all of the agricultural input prices. Therefore, the LOP is refuted for all four inputs. This result is consistent with a fixed price/flex price conceptual framework with industrial prices more likely to be unresponsive to the exchange rate than farm commodity prices.

Future research looks forward to extending the analysis to specific inputs that are traded extensively and insignificantly; examining the robustness of the results under the presence and absence of cross input equation correlation; and finally, extending the analysis under VEC framework to account for the cointegration.

References

Abeysinghe, T., and T.L. Yeok. "Exchange Rate Appreciation and Export Competitiveness: The Case of Singapore." *Applied Economics* 30(1998):51–55.

Ardeni, P.G. "Does the Law of One Price Really Hold for Commodity Prices?" *American Journal of Agricultural Economics* 71(1989): 661–69.

Bradshaw, G.W., and D. Orden. "Granger Causality from the Exchange Rate to Agricultural Prices and Export Sales." *Western Journal of Agricultural Economics* 15(1990):100–10.

Breusch, T.S., and A.R. Pagan. "A Simple Test for Heteroscedasticity and Random Coefficient Variation." *Econometrica* 47,5(1979):1287–94.

Byrne, J.P., J. Darby, and R. MacDonald. "US Trade and Exchange Rate Volatility: A Real Sectoral Bilateral Analysis." *Journal of Macroeconomics* 30(2008):238–59.

Campa, J.M., and L.S. Goldberg. "Distribution Margins, Imported Inputs, and Sensitivity of the CPI to Exchange Rates." Federal Reserve Bank of New York Staff Reports, Staff Report No. 247, April 2006.

———. "Exchange Rate Pass-Through into Import Prices." *The Review of Economics and Statistics* 87,4(2005):679–90.

Carlson, G., J. Deal, K. McEwan, and B. Deen. "Pesticide Price Differentials between Canada and the U.S." Prepared for Economic Research Service (ERS) of the United States Department of Agriculture (USDA) and Agriculture and Agri-Food Canada, Fall 1999.

Carter, C.A., R.S. Gray, and W.H. Furtan. "Exchange Rate Effects on Inputs and Outputs in Canadian Agriculture." *American Journal of Agricultural Economics* 72,3(August 1990): 738–43.

Carter, C.A., and N.A. Hamilton. "Wheat Inputs and the Law of One Price." *Agribusiness* 5(1989):489–96.

Carter, A., R.S. Collin, and W.H. Gray. "Furtan Source." *American Journal of Agricultural Economics* 72,3(1990):738–43.

Chambers, R.G., and R.E. Just. "Effects of Exchange Rate Changes on U.S. Agriculture: A Dynamic Analysis." *American Journal of Agricultural Economics* 63(1981):32–46.

Engel, C. "Accounting for U.S. Real Exchange Rate Changes."*Journal of Political Economy* 107(1999):507–38.

Euromonitor International. 30th ed. International Marketing Data and Statistics, 2006.

Foreign Agricultural Trade of United States (FATUS). (2006) USDA Economic Research Service (ERS). Internet site: www.ers.usda.gov/.

Foreign Agricultural Trade of U.S. (FATUS). (2007) USDA Economic Research Service (ERS). Internet site: www.ers.usda.gov.

Froot, K.A., M. Kim, and K. Rogoff. "The Law of One Price Over 700 Years." National Bureau of Economic Research Working Paper 5132, May 1995.

Goldberg, P.K., and M.M. Knetter. "Goods Prices and Exchange Rates: What Have We Learned?" *Journal of Economic Literature* 35,3(1997): 1243–72.

Godfrey, L.G. "Testing for Higher Order Serial Correlation in Regression Equations when the Regressors Include Lagged Dependent Variables." *Econometrica* 46(1978a):1303–10.

———. "Testing Against General Autoregressive and Moving Average Error Models when the Regressors Include Lagged Dependent Variables." *Econometrica* 46(1978b): 1293–301.

Goodwin, B.K., and T.C. Schroeder. "Price Dynamics in International Wheat Markets." *Canadian Journal of Agricultural Economics* 39(1991):237–54.

Hahn, E. "The Impact of Exchange Rate Shocks on Sectoral Activity and Prices in the Euro Area." European Central Bank Eurosystem Working Paper Series No. 796, August 2007.

Parsley, D., and H. Popper. "Understanding Real Exchange Rate Movements with Trade in Intermediate Products." (2006). Internet site: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=904323 (Accessed November 16, 2008).

Parsley, D., and S. Wei. "The Micro-Foundations of Big Mac Real Exchange Rates." Hungarian Academy of Sciences Institute of Economics Discussion Papers, New Series MT-DP 2003/6, Budapest, Hungary, June 2003.

Saghaian, S.H., M.R. Reed, and M.A. Marchant. "Monetary Impacts and Overshooting of Agricultural Prices in an Open Economy." *American Journal of Agricultural Economics* 84,1(February 2002):90–103.

U.S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS). *Agricultural Prices*. Selected issues.

U.S. Department of Agriculture (USDA), Economic Research Service (ERS). *Agricultural Outlook*. Selected issues.

White, H. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica* 48,4(1980): 817–38.

Xu, M., and D. Orden. "Exchange Rate Effects on Canadian/U.S. Agriculture." Paper presented at the annual meeting of the American Agricultural Economics Association, Long Beach, California, July 28–31, 2002.