Exchange Rate Effects on Canadian/U.S. Agricultural Prices*

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* Paper presented at the annual meeting of the American Agricultural Economics Association, Long Beach, California, July 28-31, 2002.

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ABSTRACT

Exchange rate effects on prices in Canada and the United States are evaluated for five traded farm outputs (wheat, soybeans, corn, feeder steers, and slaughter steers) and four traded non-farm-produced inputs (fertilizer, pesticides, petroleum, and farm machinery). Unit root tests suggest the series are stationary in first differences. Short-run dynamic models based on the differences specification adopted earlier by Carter, Grey and Furtan (1990) are re-estimated using similar data over an extended period that encompasses recent exchange rate movements. The analysis confirms that short-run adjustments toward the law of one price occur for the five agricultural outputs and to a lesser extent for the three intermediate inputs, while such price adjustment is refuted for farm machinery. Cointegration tests also show price convergence to stationary long-run equilibrium relationships for the five farm outputs but not for the inputs.

With the emergence of well-integrated international capital markets and movement away from the Bretton Woods system of fixed currency values, the exchange rate has become a crucial transmission mechanism by which macroeconomic factors affect agricultural prices and trade. Most analyses of exchange rate effects on prices have focused on markets for traded agricultural outputs (e.g. Ardeni 1989, Bradshaw and Orden 1990, Goodwin and Schroeder 1991, Froot, Kim, and Rogoff 1995, Maloney 1999). Adjustments of the prices of traded non-farm-produced agricultural inputs to the exchange rate has 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.

There are a few exceptions to the focus on output prices in evaluating exchange rate effects. 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 found a contemporaneous relationships between quarterly input prices, but adjustments to the LOP did not occur. Carter, Gray, and Furtan (1990) subsequently estimated dynamic exchange rate effects on four agricultural outputs and four traded non-farm-produced inputs using quarterly data over the period 1975-1988. Carter *et al.* 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 United States using cross-sectional annual data over the period 1993-1999. Carlson *et al.* concluded that restrictions on the movement of pesticides across the border are one factor creating price differentials for similar products.

In this paper, the dynamic econometric analysis of Carter *et al.* is replicated and extended to evaluate short-run and long-run exchange rate pass-through and the LOP for five traded farm outputs (wheat, soybeans, corn, feeder steers, and slaughter steers) and four traded non-farm-produced inputs (fertilizer, pesticides, petroleum, and farm machinery) over the period 1975-1999. By re-investigating the price relationships highlighted by Carter *et al.*, we test the robustness of their earlier analysis over a longer time period characterized by substantial recent exchange rate movements. Our empirical results provide evidence in favor of short-run adjustments to the LOP for agricultural output prices. Evidence of exchange rate pass-through is somewhat weaker for prices of the three non-farm-produced intermediate inputs and the LOP is clearly violated for prices of the capital input farm machinery. These results generally confirm the Carter *et al.* original findings. However, some conclusions they drew on the beef sector are not robust in the re-estimation. In addition, we provide evidence of the LOP as a long-run equilibrium relationship, especially for farm outputs, which was not investigated by Carter *et al.*, but has been investigated in depth recently for Canadian and U.S. durum and spring wheat prices by Mohanty, Peterson and Smith (1996).

The paper is organized as follows. In the next section, the theory of the LOP and a partial equilibrium framework in which to analyze exchange rate effects on prices and production are described, a dynamic equation of short-run exchange rate pass-through is specified, and Canadian/U.S. exchange rate movements since 1975 are depicted. In the empirical analysis, the stationarity properties of the exchange rate and price series are examined, the short-run dynamics of exchange rate effects on prices are evaluated, and the validity of the LOP is assessed in both the short run and long run. The final section provides conclusions.

EXCHANGE RATE MOVEMENTS AND THE LOP

The LOP asserts that identical goods sold in competitive markets of different countries will receive the same price when evaluated in a common currency and adjusted for transportation costs and tariffs. The static LOP is expressed as:

$$P_i = E\, P_i^* \qquad (1)$$

where P_i and P_i^* are the domestic and the corresponding foreign currency prices of a commodity i and E is the exchange rate defined as the home-currency price of foreign currency. The LOP serves as a measure of international market integration, particularly for agriculture and food where highly-traded commodities are generally homogeneous and likely to conform to price parity. Profit opportunities through arbitrage drive the price-adjustment process. However, commodity arbitrage may be obstructed, and thus price convergence prevented, if transaction costs are too high, the availability of substitutes is limited due to spatially dispersed markets and price-setting power, or the movement of goods across country borders is overly constrained by trade barriers.

A partial equilibrium framework to analyze exchange rate effects on prices and production in a single country is shown in figure 1. With initial equilibrium at (P_1, Q_1), a domestic currency devaluation 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. Initially, a depreciation results in increases in the output price and production to P_2 and Q_2, respectively. The currency depreciation may then increase traded input prices, and thus the cost of production, in the longer run. If all of the inputs are traded and there is eventually a complete exchange rate pass-through to their costs, then output supplied would remain unchanged at Q_1 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 Q_1 and Q_2 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.

An empirical model to capture the short-run dynamics of exchange rate effects on Canadian versus U.S. output or input prices can be specified for nonstationary time series in logged first differences as:

$$Log(P^{c}_{i,t}/P^{c}_{i,t-1}) - Log(P^{u}_{i,t}/P^{u}_{i,t-1}) = C + \sum_{j=0}^{n}\beta_j * Log(E_{t-j}/E_{t-j-1}) + \varepsilon_{i,t} \quad (2)$$

where $P^{c}_{i,t}$ and $P^{u}_{i,t}$ are the Canadian and U.S. dollar prices of the commodity *i* at time *t*, the number of lagged terms is *n*, the exchange rate pass-through effect with a lag *j* is β_j, and E_{t-j} is the exchange rate ($CN/$US) at time (*t-j*). The importance for Canadian and U.S. agriculture of exchange rate effects measured by equation 2 is evident from the magnitude of the exchange rate movements since 1975, as shown in figure 2. There have been two principal periods of depreciation of the Canadian dollar versus the U.S. dollar and one period of sustained appreciation. The exchange rate has also shown short–term fluctuations around these principal movements, and with rates of inflation generally similar the nominal and real exchange rates track fairly closely together.

EMPIRICAL ANALYSIS

The Data

The five outputs included in the analysis are significant for Canadian and U.S. agriculture because of their contributions to farm income and foreign exchange earnings. Three of the farm outputs (soybeans, corn and feeder steers) also are inputs into slaughter steer production. The output data include quarterly average prices for specific qualities of grains, oilseeds and livestock at a specific location in each country, closely matching the series used in the earlier analysis by Carter *et al*.[1] The specific price series for wheat are No.1 hard red winter at Kansas City and No.1 Canadian western red spring at St. Lawrence, both compiled in the publication *Wheat Situation and Outlook Yearbook.* Average monthly cash prices of No.1 yellow soybeans and No. 2 yellow corn at Chicago and equivalent prices at Chatham, Ontario are utilized. The livestock prices are for medium No. 1 feeder steers at Oklahoma City and Calgary (1975-93) or Saskatchewan (1994-99), and choice steers in Texas and Winnipeg (1975-93) or Manitoba (1994-99). The corn, soybean and livestock prices for the U.S. were obtained from the Economic Research Service (ERS), USDA, and the corresponding Canadian data were obtained from Statistics Canada and Agriculture and Agri-Food Canada (AAFC). The input price series are indices calculated with the four-quarter average for 1986 equal to 100. The input price series are derived from *Agricultural Prices* published by the National Agricultural Statistics Service (NASS), USDA and Statistics Canada's *Farm Input Price Indexes*. The Canadian/U.S. exchange rate is compiled by ERS. Monthly data are converted to quarterly averages for consistency in the analysis, since the input price series are only available on a quarterly basis.

Stationarity of the Exchange Rate and Price Series

Carter *et al.* used ordinary least squares (OLS) to estimate equation 2 with two quarterly lags over the period 1975:1 to 1988:2. Their study did not report evidence for utilizing first differences of the series in the estimated models. To determine whether such estimation in differences is well specified, the exchange rate and price series are tested for unit roots both over the Carter *et al.* sample period (CS) and over the full sample period (FS) 1975:1 to 1999:4. Augmented Dickey-Fuller (ADF) statistics for these tests are shown in table 1 for regressions with two lags included to account for serial correlation.

As shown in table 1, there is no evidence against a unit root in the exchange rate series or any of the price series for either the CS or FS period, with the exception of U.S prices of soybeans over FS. Similar results are obtained in alternative tests (not shown) with fewer or larger numbers of lags, although for the FS there is somewhat more evidence against unit roots when four lags are included. Tests for second unit roots (also not shown) strongly reject nonstationarity of the differenced series in all cases. These results indicate that the exchange rate and price series are reasonably characterized as nonstationary and integrated of order one $I(1)$. Presence of unit roots supports the Carter *et al.* approach of first-differencing the series for the regression estimation, and we replicate their approach over the initial and the full sample periods.

Short-Run Effects of Exchange Rate Changes

Results from the original Carter *et al.* models (CM), from re-estimation of the models with similar data over the Carter *et al.* sample period (RCM), and from estimation of full sample models (FSM) are shown in tables 2 and 3 for farm outputs and non-farm-produced inputs, respectively. The estimated contemporaneous, one-lag and two-lag coefficients, $\hat{\beta}_0$, $\hat{\beta}_1$ and $\hat{\beta}_2$, are shown with *t*-statistics, together with the sums of estimated parameters, ($\hat{\beta}_0+\hat{\beta}_1$) and ($\hat{\beta}_0+\hat{\beta}_1+\hat{\beta}_2$), and the R^2 for the regressions. The null hypothesis that the contemporaneous plus the lagged exchange rate effects sum to one ($\sum\beta = 1$) implies complete exchange rate pass-through and adherence to the LOP within a six-month period, whereas the null hypothesis that the sum of coefficients is zero ($\sum\beta = 0$) implies no exchange rate pass-through and invalidity of the LOP.

The CM contemporaneous point estimates are statistically significant and indicate exchange rate pass-through close to unity (implying contemporaneous LOP) for soybeans and petroleum. Only two lagged regression coefficients are significant in the CM ($\hat{\beta}_2$ for fertilizer and pesticides), but the sums of estimated coefficients suggest the LOP for wheat with one lag and for feeder steers, slaughter steers and pesticides with two lags. Exchange rate pass-through is limited for fertilizer even after two quarters (the sum of coefficients is only 0.46) and there is essentially no pass-through for farm machinery.[2] Zero pass-through is rejected (for the sum of estimated coefficients) for wheat, soybeans, and pesticides, while the LOP is not rejected in these models. For feeder steers, slaughter steers and fertilizer, 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 farm machinery, LOP is strongly rejected but zero pass-through is not.

We obtain similar results when models for the 1975:1-1988:2 period are re-estimated with our similar price series. The RCM contemporaneous coefficients are again significant for wheat, soybeans and petroleum (the fertilizer contemporaneous coefficient is also significant and of unexpected sign). Re-estimated values of the parameters support a contemporaneous LOP for wheat and one-lagged LOP for soybeans (the reverse of CM), as well as one-lagged pass-through near unity for corn and slaughter steers. Estimates of the two-lag effect on feeder steers is smaller in RCM than CM, while the RCM parameter estimates for the non-farm produced inputs are similar to CM as are the results of the zero pass-through and LOP hypotheses tests on the sums of coefficients in all cases.

The contemporaneous coefficient estimates of the full sample model (FSM) show a statistically significant and relatively large pass-through for wheat and soybeans, as well as a smaller significant effect for feeder steers.[3] Based on the coefficient estimates, there is a one-lagged LOP for corn, feeder steers and slaughter steers, and two-lagged LOP for petroleum, with less pass-through for fertilizer and pesticides. Again, there is essentially no pass-through for farm machinery.

Comparing FSM to RCM, the point estimates of the contemporaneous exchange rate effects increase for all of the farm outputs, while for the non-farm-produced inputs the estimated contemporaneous effects are similar or smaller. When the sample period is extended by eleven years in FSM versus RCM, the estimated cumulative exchange rate pass-through for over six months is greater for wheat, feeder steers, slaughter steers, fertilizer, petroleum, and farm machinery. Overall, the average deviation from the LOP (excluding farm machinery) of the sums of coefficient point estimates is 0.25 for FSM compared to 0.38 for RCM. The LOP is again only rejected for farm machinery, while the hypothesis of zero exchange rate pass-through is rejected in FSM for wheat, feeder steers, slaughter steers, fertilizer, and pesticides. Thus, evidence in favor of the LOP is somewhat stronger in the models for the longer time period.

A second test of robustness of the exchange rate effects is related to the lag length specification of the estimated models. Carter *et al.* did not report criteria for lag selection. In the re-estimation, the Akaike information and Schwartz criteria were evaluated and models with less than two lags were preferred by at least one selection criterion for wheat, soybeans, corn, and petroleum, while a longer lag specification was indicated for fertilizer.

To examine the implications of lag-selection decisions, the sums of point estimates indicating the cumulative pass-through effects of the exchange rate on Canadian versus U.S. prices are shown in table 4 for FSM with lags constrained to shorter (contemporaneous or one-lag) effects or measured over longer periods of one or two years (four or eight lags). The point estimates indicate that models with only a contemporaneous effect provide weaker evidence of the LOP for the outputs corn, feeder steers and slaughter steers and for the inputs fertilizer, pesticides and petroleum. Models with eight lags give somewhat lager cumulative effects than the two-lag models for soybeans, corn, slaughter steers, and fertilizer. For farm machinery, the pass-through effect is only 0.37 even after two years, suggesting that price adjustment to exchange rate movements remains incomplete.

Results of tests of the null hypotheses that the contemporaneous plus lagged exchange rate effects sum to zero or one are also reported in table 4. The null hypothesis of zero pass-through is rejected in models with short lag lengths for wheat and soybeans. The evidence becomes weaker as lags are added. Conversely, the evidence for rejecting zero pass-through becomes stronger with longer lags than with shorter lags for some of the other farm outputs and non-farm-produced inputs. For the null hypothesis of the LOP, models with only contemporaneous or one-lag effects indicate more rejections for feeder steers, slaughter steers, fertilizer, and pesticides than the longer-lag models. There are few changes compared to the two-lag model when additional lags are added. For the models with four or eight lags, the LOP hypothesis is accepted in most cases, except for farm machinery where LOP is rejected in all models.

Comparing the sets of *p*-values for the two alternative null hypotheses provides further evidence about exchange rate pass-through. Except for farm machinery, the *p*-values for the LOP are generally higher than those for zero pas-through, indicating less likelihood of rejection. The average *p*-values for the LOP tests for all outputs and inputs excluding farm machinery is 0.51 across all lag specifications. The *p*-values for zero pass-through are generally lower, even if they are not less than 0.10. The average (again excluding farm machinery) is 0.15 across the models. Hence, the results overall provide evidence that tend to reject zero pass-through and support the LOP, even though the evidence is not always statistically significant at usually reported levels. Farm machinery is a different story. The results strongly indicate that there is no adherence to the LOP in the short run for farm machinery.

One final issue in extension of the Carter *et al.* short-run analysis is that they found seasonal dummy variables were significant in their feeder steer equation. With seasonal dummies included, Carter *et al.* estimated a negative contemporaneous exchange rate pass-through (-0.22) on feeder steer prices. Although this coefficient is not statistically significant, they argued that the immediate pass-through on grains and the one-quarter lag effect on slaughter steer prices reduced feeding margins when the Canadian dollar devalues, resulting in the reduced prices of feeder steers given by the negative contemporaneous pass-through coefficient. Re-estimation is not consistent with this interpretation by Carter *et al.* The contemporaneous pass-through in RCM and FSM with seasonally-adjusted feeder steer models (not shown) are both positive numbers: 0.37 and 0.50, respectively. The feeder steer sector seems not to be adversely affected by devaluation of the Canadian dollar as in the Carter *et al.* argument.[4] Carter *et al.* also argued that the seasonal dummy variables indicated a pattern of larger pass-through at the times of year when feeder steers are actively traded (the second and fourth quarters of the year). Again this related argument is not very convincing in the re-estimation, because there is not a consistent season timing pattern of price pass-through on feeder steers.

Long-Run LOP

Evidence from the differenced dynamic regressions suggest short-run exchange rate pass-through for farm outputs near the LOP with some pass-through adjustments also for non-farm-produced inputs other than farm machinery. Stochastic variables integrated of order one $I(1)$ tend to diverge over time, but the LOP implies a long-run cointegrating equilibrium relationship between prices of traded goods. A test for the LOP as a long-run cointegrating relationship between Canadian and U.S. prices takes the form:

$$P_{i,t}^{c} = C + \alpha\ (E_t P_{i,t}^{u}) + \mu_{i,t} \qquad (3)$$

where $P_{i,t}^{c}$ and $(E_t P_{i,t}^{u})$ are prices of commodity i at time t in Canada and the U.S., with both expressed in a common currency, \$CN. If $P_{i,t}^{c}$ and $(E_t P_{i,t}^{u})$ are each nonstationary and $I(1)$, but their linear combination produces a residual series $\mu_{i,t}$ that is stationary, then $P_{i,t}^{c}$ and $(E_t P_{i,t}^{u})$ are cointegrated with cointegrating vector $(1, \alpha)$. This cointegrating relationship corresponds to the LOP when $\alpha = 1$.

Cointegration is tested for outputs and inputs over the full sample using the two-stage Engle-Granger (1987) procedure. When preliminary (unrestricted) tests suggested the prices were cointegrated, the cointegrating parameter α was restricted to unity and the residuals again retrieved and tested for unit roots. For each test, the null hypothesis is no cointegration. Results for cointegration-test regressions with zero, one, two and four lags of the residuals included are reported in table 5.

Cointegration is supported for wheat, corn and feeder steers for all lag specifications, and for soybeans except in the four-lag model, suggesting these prices converge to the LOP in Canada and the United States in the long run. Prices of slaughter steers and petroleum show some evidence of cointegration. Cointegration is supported for slaughter steers at the 0.01 level of significance with zero or one lag, and for petroleum at the 0.05 level with zero lags, but not even at the 0.10 level of significance in the models with additional lags. For fertilizer prices, the null hypothesis of no cointegration cannot be rejected when the LOP is imposed. The statistics shown for pesticides and farm machinery are obtained from the unrestricted models, since prices of pesticides and farm machinery are not cointegrated even when estimation of α is unrestricted. The evidence for the LOP as a long-run relationship is stronger for farm outputs than for non-farm-produced inputs.

CONCLUSIONS

Effects of the exchange rate on agricultural output and input markets are reflected in the price signals facing farm producers. This article investigates the effects of the exchange rate on the prices in Canada and the United States of five traded farm outputs (wheat, soybeans, corn, feeder steers, and slaughter steers) and four traded non-farm-produced inputs (fertilizer, pesticides, petroleum, and farm machinery). Unit root tests suggest that the exchange rate and price series are stationary in first differences. Short-run dynamic models based on the difference specification adopted earlier by Carter *et al.* are re-estimated using similar data over their initial sample period and over a time period extended by eleven years and encompassing substantial recent exchange rate movements. The empirical results confirm that short-run adjustments to the LOP tend to occur for the five agricultural outputs and to a somewhat lesser extent for the three non-farm-produced intermediate inputs, while the LOP is refuted for farm machinery. Short-run pass-through effects of exchange rate fluctuations on prices of non-farm-produced intermediate inputs tend to lag the effects on farm outputs. Cointegration of farm output and input prices is investigated to determine whether there is convergence to the LOP as a stationary long-run equilibrium. The results suggest long-run stationarity of the LOP for the five farm outputs but not for the inputs.

Evidence that the LOP holds more strongly for farm outputs than for non-farm-produced inputs suggests that an exchange rate depreciation does not have full impact on agricultural input markets and affects output prices to a greater extent. This 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. Since the LOP does not hold for Canada and the Unites States for all traded non-farm-produced inputs either in the short run or long run, the input price increases associated with a devaluation would not completely offset an increase in output price. Exchange rate movements have been quite substantial, as shown in figure 1, and farmers in Canada and the United States are affected by different production incentives when currency revaluations occur.

The effects of the exchange rate on output versus input prices can be illustrated for the period 1990-1991 to 1999-2000. During this period, the Canadian dollar depreciated by 27.6 percent, but farm machinery prices in Canada relative the United States rose by only 4.5 percent. With LOP holding approximately for farm outputs, Canadian versus U.S. prices of wheat, soybeans, corn, feeder steers, and slaughter steers relative to farm machinery prices rose from 20.9 to 34.9 percent. Agricultural output prices in Canada and the United States were also subject to substantial common fluctuations over this period and the depreciation-related rising prices of the farm-produced outputs raised costs of slaughter steer production in Canada. But the lack of exchange rate pass-through to farm machinery prices compared to farm outputs demonstrates that depreciation provides some positive price incentives. With nominal and real depreciation tracking closely, farm output prices also rise relative to costs of non-traded inputs or a broad index of the price level when there is a currency depreciation, again providing a positive price incentive.

NOTES

[1] Carter *et al.* were not able to provide their original data (personal correspondence). We followed their approach by using similar farm output price series, and available price indices for non-farm-produced inputs fertilizer, pesticides, petroleum, and farm machinery. Carter *et al.* used Canadian canola prices and U.S. soybean prices, respectively, in their equation to estimate the exchange rate effects on oilseeds, whereas we use soybean prices in both countries. They used the term “fat steers” which is our slaughter steers. Because their precise data series were not available, our re-estimation of their models will not yield identical results for their sample period.

[2] Carter *et al.* (p. 741) gave a somewhat different conclusion: “the data strongly support a contemporaneous pass-through for wheat, canola, and petroleum, a one-quarter lagged pass-through for feeder steers, fat steers, and pesticides, and a two-quarter lagged pass-through for fertilizer and no pass-through for farm machinery.” They also use slightly different notation (their β_0 is our constant C) and they report F statistics not p-values for the hypothesis tests on sums of estimated coefficients.

[3] For wheat, in particular, the estimated contemporaneous coefficient indicates a more than proportionate effect of the exchange rate on prices. Recursive regressions for wheat prices were estimated over 1976:1-1999:4 and the estimate of the contemporaneous coefficient was found quite sensitive to sample period. The estimate of the contemporaneous coefficient initially rises from 0.91 in 1976:1 to a peak of 1.63 in 1977:2, then falls near LOP until the end of Carter *et al.*’s sample (1988:2). The recursive estimates increase through most of the full sample, peaking at 1.72 in 1998:4.

[4] Results from RCM and FSM with seasonal dummies are available upon request.

REFERENCES

Agricultural and Agri-Food Canada. *Livestock Market Review*. Selected issues.

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

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

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

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

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

Engle, R. F., and C. W. J. Granger. 1987. Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica* 55: 251-76.

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

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

Mackinnon, J. G. 1994. Approximate Asymptotic Distribution Functions for Unit-Root and Cointegration Tests. *Journal of Business and Economic Statistics* 12:167-76.

Maloney, W. F. 1999. Exchange Rate Uncertainty and the Law of One Price. *Review of International Economics* 7: 328-41.

Mohanty, S., E. W. F. Peterson, and D. B. Smith. 1996. Relationships between U.S. and Canadian Wheat Prices: Cointegration and Error Correction Approach. *Canadian Journal of Agricultural Economics* 44: 265-76.

Saghaian, S. H., M. R. Reed, and M. A. Marchant. 2002. Monetary Impacts and Overshooting of Agricultural Prices in an Open Economy. *American Journal of Agricultural Economics*. Forthcoming.

Statistics Canada. *Farm Input Price Indexes*. Selected issues.

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

U. S. Department of Agriculture (USDA), Economic Research Service (ERS). *Wheat Situation and Outlook Yearbook.* Selected issues.

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

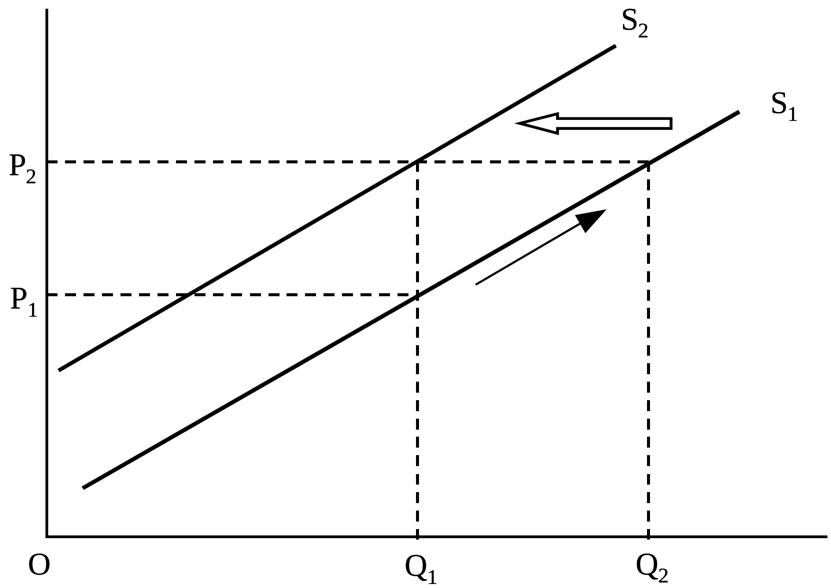

Figure 1. Effects of an exchange rate depreciation.

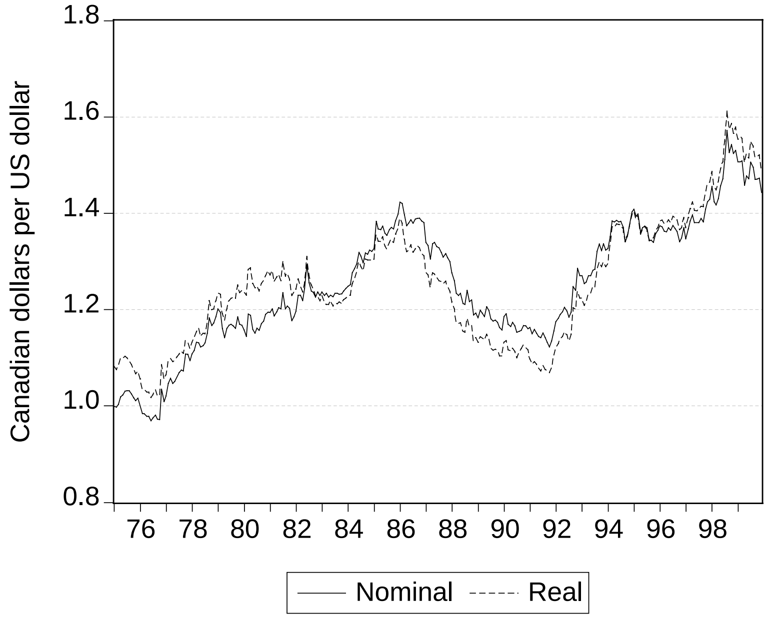

Figure 2. The nominal and real exchange rate between Canada and the United States.

Table 1. Unit Root Tests on Levels of Series

		CS	FS
		ADF test-statistic[a]	
Exchange Rate		-0.27	-1.78
Wheat	P^u	-1.79	-2.79
	P^c	-1.99	-2.93
Soybeans	P^u	-2.95	-3.59**
	P^c	-2.69	-2.93
Corn	P^u	-1.99	-3.09
	P^c	-1.51	-2.85
Feeder Steers	P^u	-1.84	-2.42
	P^c	-1.61	-2.59
Slaughter Steers	P^u	-1.49	-1.70
	P^c	-1.22	-1.93
Fertilizer	P^u	-2.02	-2.39
	P^c	-0.67	-1.41
Pesticides	P^u	-1.92	-2.70
	P^c	-1.02	-1.03
Petroleum	P^u	-1.00	-1.29
	P^c	-0.46	-1.32
Farm Machinery	P^u	-0.21	-1.49
	P^c	-0.42	-1.02

[a] The * denotes statistically different from zero at the 0.10 significance level, ** at the 0.05 level, and *** at the 0.01 level. Critical values are from MacKinnon (1994).

Table 2. Short-Run Exchange Rate Effects, Farm Outputs

	Model	β_0 (*t*-stat)[a]	β_1 (*t*-stat)[a]	β_2 (*t*-stat)[a]	$\beta_0+\beta_1$	$\beta_0+\beta_1+\beta_2$ H$_0$: $\sum\beta=1$ [*p*-value][a]	H$_0$: $\sum\beta=0$ [*p*-value][a]	R^2
Wheat	CM	.64	.39	.09	1.03	1.12		.14
		(2.03)**	(1.21)	(.27)		[.79]	[.02]**	
	RCM	1.09	.28	.28	1.38	1.66		.19
		(2.72)***	(.67)	(.66)		[.27]	[.007]***	
	FSM	1.74	-.002	-.07	1.74	1.68		.23
		(5.17)***	(-.01)	(-.19)		[.17]	[.001]***	
Soybeans	CM	.93	.65	-.15	1.58	1.43		.12
		(1.82)*	(1.25)	(.27)		[.58]	[.07]*	
	RCM	.65	.47	-.29	1.12	.83		.20
		(2.38)**	(1.62)	(.99)		[.68]	[.04]**	
	FSM	1.19	-.32	-.05	.87	.82		.10
		(3.14)***	(-.82)	(-.13)		[.75]	[.14]	
Corn	CM	--	--	--	--	--		--
						--	--	
	RCM	.16	.90	.26	1.06	1.32		.05
		(.25)	(1.31)	(.37)		[.73]	[.17]	
	FSM	.45	.48	.07	.93	1.00		.03
		(.95)	(.99)	(.15)		[1.00]	[.15]	
Feeder Steers	CM	.14	.46	.63	.60	1.23		.06
		(.27)	(.88)	(1.12)		[.76]	[.12]	
	RCM	.21	.45	.05	.66	.71		.04
		(.55)	(1.59)	(.11)		[.61]	[.22]	
	FSM	.39	.55	.21	.94	1.15		.11
		(1.65)*	(2.24)**	(.86)		[.68]	[.001]***	
Slaughter Steers	CM	.60	.14	.19	.74	.93		.05
		(1.32)	(.32)	(.42)		[.94]	[.17]	
	RCM	.22	.68	-.48	.90	.42		.07
		(.52)	(1.50)	(-1.05)		[.35]	[.50]	
	FSM	.40	.52	-.14	.92	.78		.08
		(1.63)	(2.05)**	(-.56)		[.54]	[.03]**	

[a] The * denotes the null hypothesis is rejected at the 0.10 significance level, ** at the 0.05 level, and *** at the 0.01 level.

Table 3. Short-Run Exchange Rate Effects, Non-Farm-Produced Inputs

	Model	β_0 (*t*-stat)[a]	β_1 (*t*-stat)[a]	β_2 (*t*-stat)[a]	$\beta_0+\beta_1$	$\beta_0+\beta_1+\beta_2$		R^2
						H_0: $\sum\beta=1$ [*p*-value][a]	H_0: $\sum\beta=0$ [*p*-value][a]	
Fertilizer	CM	-.41 (1.56)	.35 (1.32)	.52 (1.85)*	-.06	.46		.13
						[.17]	[.24]	
	RCM	-.62 (-2.17)**	.66 (2.20)**	.45 (1.49)	.04	.49		.19
						[.23]	[.24]	
	FSM	-.37 (-1.64)	.37 (1.62)	.61 (2.72)***	.01	.62		.13
						[.25]	[.06]*	
Pesticides	CM	.13 (.65)	.31 (1.51)	.57 (2.57)**	.44	1.01		.20
						[.97]	[.001]***	
	RCM	.05 (.19)	.41 (1.47)	.62 (2.21)**	.46	1.09		.17
						[.82]	[.007]***	
	FSM	.04 (.22)	.33 (1.94)*	.31 (1.88)*	.36	.68		.10
						[.17]	[.006]***	
Petroleum	CM	1.27 (2.91)***	-.33 (.74)	-.21 (.46)	.94	.73		.15
						[.68]	[.27]	
	RCM	1.07 (2.30)**	-.17 (-.35)	-.28 (-.57)	.90	.61		.11
						[.57]	[.37]	
	FSM	.32 (.75)	.41 (.93)	.25 (.58)	.73	.98		.03
						[.97]	[.12]	
Farm Machinery	CM	.19 (1.23)	.09 (.61)	-.17 (1.05)	.28	.11		.06
						[.001]***	[.63]	
	RCM	.04 (.21)	.35 (1.60)	-.27 (-1.19)	.40	.13		.07
						[.006]***	[.67]	
	FSM	.09 (.74)	.23 (1.81)*	-.08 (-.64)	.32	.24		.05
						[.001]***	[.18]	

[a] The * denotes the null hypothesis is rejected at the 0.10 significance level, ** at the 0.05 level, and *** at the 0.01 level.

Table 4. Effects of Lag Length Selection

	Sum of Coefficients [P-value of F statistic][a]							
	0 Lags		1 Lag		4 Lags		8 Lags	
	H_0: $\sum\beta=1$	H_0: $\sum\beta=0$	H_0: $\sum\beta=1$	H_0: $\sum\beta=0$	H_0: $\sum\beta=1$	H_0: $\sum\beta=0$	H_0: $\sum\beta=1$	H_0: $\sum\beta=0$
Wheat	1.70		1.72		1.51		1.46	
	[.03]**	[.001]***	[.09]*	[.001]***	[.38]	[.011]**	[.54]	[.06]*
Soybeans	1.12		.88		.99		1.01	
	[.73]	[.003]***	[.80]	[.06]*	[.98]	[.13]	[.99]	[.24]
Corn	.53		.97		1.11		1.31	
	[.31]	[.24]	[.95]	[.10]*	[.90]	[.17]	[.76]	[.20]
Feeder Steers	.42		.91		1.08		1.11	
	[.03]**	[.11]	[.78]	[.005]***	[.84]	[.009]***	[.83]	[.001]***
Slaughter Steers	.36		.91		1.09		1.06	
	[.02]**	[.19]	[.78]	[.004]***	[.82]	[.009]***	[.90]	[.049]**
Fertilizer	-.31		.13		.49		.86	
	[.001]***	[.19]	[.003]***	[.67]	[.17]	[.18]	[.74]	[.03]**
Pesticides	-.02		.46		.52		.70	
	[.001]***	[.93]	[.011]**	[.03]**	[.08]*	[.07]*	[.41]	[.053]*
Petroleum	.44		.83		.83		.70	
	[.18]	[.29]	[.75]	[.12]	[.82]	[.26]	[.75]	[.45]
Farm Machinery	.12		.26		.37		.37	
	[.001]***	[.33]	[.001]***	[.11]	[.004]***	[.08]*	[.014]**	[.14]

[a] The * denotes the null hypothesis is rejected at the 0.10 significance level, ** at the 0.05 level, and *** at the 0.01 level.

Table 5. Cointegration Tests for LOP

	Lag Length			
	0	1	2	4
	LOP: $\hat{\alpha}$ Restricted to Unity[a]			
Wheat	-3.05*	-3.31**	-3.58**	-3.13*
Soybeans	-8.40***	-5.21***	-3.94***	-2.49
Corn	-6.04***	-5.83***	-4.41***	-4.08***
Feeder Steers	-5.73***	-4.76***	-4.00***	-3.65**
Slaughter Steers	-5.52***	-3.58***	-2.28	-1.61
Fertilizer	-1.83	-1.42	-0.55	-1.04
Petroleum	-3.20**	-2.86	-2.30	-2.57
	Any Long-Run Relationship: $\hat{\alpha}$ Unrestricted[a]			
Pesticides	-1.39	-1.53	-1.12	-1.81
Farm Machinery	-2.32	-2.15	-1.73	-2.29

[a] The * denotes statistically different from zero at the 0.10 significance level, ** at the 0.05 level, and *** at the 0.01 level. Critical values are taken from Engle and Granger (1987).