Examining the Effects of Exchange Rate Movements on Price Behavior of Major Tradable Agricultural Outputs and Inputs and Financial Performance of Canadian Agriculture

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Executive Summary

Exchange rate volatility between the US and Canadian dollars has increased dramatically in the past few years. Ongoing large U.S. trade deficits coupled with fiscal deficits, and the slow down in the dollarization of trade have eroded the value of the US currency. At the same time, Canadian trade surpluses driven by high commodity prices have increased the value of the Canadian dollar. Increased volatility in oil, metals and grains, indicate that exchange rates could continue for be volatile for the foreseeable future.

The Canada/U.S. exchange rate is a key economic factor that affects the prosperity of the Canadian economy , in general, and the agricultural sector specifically through changes in Canadian farm output and input prices. As statistics show, the United States is Canada's most important trading partner. In 2006, 79 percent of all Canadian exports were shipped to the U.S., and the U.S. supplied 65 percent of Canadian merchandise imports. The corresponding shares in the agri-food sector were 59 and 55 percent, respectively. The significant appreciation of the Canadian dollar in recent years has created great interest in the effects of this appreciation on Canadian agricultural economy.

The purpose of this study is to investigate the effects of changes in Canadian/US dollar exchange rates on Canada's agriculture sector. We first estimate the timing and the extent of exchange rate pass-through (ERPT), which has direct effects on relative output/input prices, for selected agricultural inputs and outputs. We then use these estimated relationships along with representative farm partial budgets to simulating the effects of a ten percent appreciation of the Canadian/US dollar exchange rate on the per-acre profitability of selected farm types based on the estimated pass-through coefficients. This in turn helps us to identify and understand those markets which are more at risk from large variations in exchange rates, which in turn can help in designing appropriate policies.

As the provided literature review shows, the exchange rate pass-through is based on the law of one price (LOP) which states that the traded commodity prices in two countries must be the same, after adjustment for transaction costs. When there is free trade and all markets are competitive, LOP should hold and ERPT=1 after controlling for transaction costs. If one or some of the conditions of competitive markets and free trade such as; lack of market power, trade restrictions, inventory pricing decisions and price pooling are violated, or if transaction costs are not controlled appropriately, the extent and timing of ERPT are not clear and should be investigated empirically.

To estimate the extent and timing of ERPT we examine the changes in relative Canadian and U.S. prices as a function of lagged changes in exchange rate:

$$Log(P_t^c/P_t^u) - Log(P_{t-1}^c/P_{t-1}^u) = C + \sum_{i=0}^{n} \beta_i Log(E_{t-i}/E_{t-i-1}) + \varepsilon_t$$

where n denotes the numbers of lagged terms in models.

The first-difference specification is used in the empirical model because we were interested in the effects of exchange rate changes on price changes and because the unit root tests conducted in this study show almost all prices are non-stationary in level which could lead spurious regression problems. In this first difference specification, the intercept term could represent the trend growth rate in transaction costs. In each specification, we have included dummy variables for each month of the year to capture any seasonal effects in the data. In the base model the appropriate lag length for each variable was determined using the standard Akaike Information Criterion (AIC). The ERPT equations were estimated for wheat, barely, oats, corn, soybeans, potato, calves, cattle, hogs, lamb, sheep, egg and turkey and nominal price indexes for fertilizer, agricultural chemicals, fuel and farm machinery in the U.S. and Canada, using monthly data for 1984 -2006. The results are shown in TableA below. The second last column reports the statistical probability that the coefficients sum to 1 i.e. that ERPT is complete and the LOP hold. The last column reports the probability that coefficients sum to zero i.e. no ERPT. When ERPT is less than one, this can be attributed to many factors, such as transaction costs, government regulations on trade, market power and other conditions violating competitive markets and free trade.

TableA- Estimation Results (Base Model AIC)

Commodity	β_0	β_1	β_2	β_3	β_4	$\sum\beta$	P-val. $\sum\beta=1$	P-val. $\sum\beta=0$
Fertilizer	0.08	0.36**	0.00			0.44	0.00	0.00
Chemical	-0.03	0.11	-0.04			0.04	0.00	0.63
Machinery	0.03	0.16**	0.01	0.29**		0.49	0.00	0.00
Fuel	0.64**	0.47**	-0.23			0.88	0.51	0.00
Wheat	0.25	0.20	0.54	0.88**		1.87	0.21	0.00
Barley	0.16	0.41	0.18	0.27	0.99*	2.01	0.23	0.02
Corn	0.17	0.22	0.36*			0.75	0.45	0.01
Oats	0.68**	-0.02	0.50			1.16	0.72	0.01
Soybean	0.30**	0.40**	-0.32*	0.48**		0.86	0.62	0.00
Potato	0.22	-0.11	0.12			0.23	0.31	0.78
Calves	-0.43	1.03**	1.03**			1.63	0.38	0.02
Cattle	-0.49	0.95**	1.29**			1.75	0.33	0.02
Hog	0.81**	0.34	-0.16			0.99	0.98	0.00
Lamb	-0.29	-0.00	1.17			0.88	0.86	0.21
Sheep	0.91	-0.22	-0.01	-1.13*	-0.72	-1.22	0.06	0.05
Egg	-0.21	0.25	-0.16	1.36		1.24	0.69	0.69
Turkey	0.08	0.02	0.44			0.54	0.37	0.25

1- * denotes statistically different from zero at the 10 percent significance level.
2- ** denotes statistically different from zero at the 5 percent significance level.
3- β_i, where i is months lag.

As reported in TableA, except for barley and sheep, which have appropriate lag lengths of four months, in most cases two or three month lag models are indicated by the AIC.

Based on the reported p-values, the hypothesis of complete pass-through is rejected just for fertilizer, agricultural chemicals, farm machinery and sheep, while the hypothesis of zero pass-through is rejected in most cases, including; fertilizer, farm machinery, fuel, wheat, barley, corn, oats, soybeans, calves, cattle and hogs. For potatoes, lamb, eggs and turkey neither the complete pass-through hypothesis nor the zero pass-through hypothesis is rejected.

There are several plausible reasons for low rates of pass-through:

1) Complete price parity in traded goods between two markets may be obstructed due to transportation and storage costs, delivery lags, interest forgone, insurance costs, rate of return to arbitragers, tariff and non-tariff barriers, and inefficiencies in the transmission of information.

2) The input prices used in this study are aggregated indexes. For example, the fertilizer indexes are aggregated from prices of different types of fertilizer including nitrogen fertilizer, mixed fertilizer, and potash and phosphate materials. If the mix of products in Canadian agriculture differ from their U.S. counterparts, the aggregation problem with these indexes may occur and deviation from LOP is expected.

3) 3) Non tariff trade barriers can also have an important role to play in explaining the lack of the LOP. The government regulation on agricultural chemicals trade, which makes it illegal to import formulated products into Canada, but allows Canadian chemical manufactures to import the active ingredients contained in the formulated product, is one of the main reasons for price differential of similar pesticides between dealers in the U. S. and those in Canada. The exchange rate pass-through on new machinery prices is low because the farmer is probably precluded from buying in the other country by the inability to have the machine serviced by the local dealer in the event of a breakdown. There is a similar, but somewhat weaker, story for fertilizer. In this case the local dealer often provides service in terms of timely delivery and occasionally the rental of application equipment. Potato trade with the U.S. is restricted by the Canada/U.S. Management Plan for potato viruses that cause Tuber Necrosis. In the case of sheep, following the detection of BSE in Canadian sheep in May 2003, all exports now need Canadian veterinary health certificates.

4) Tariffs also play a role. Canada has import tariff rate quotas in place for eggs and poultry.

We use the ERPT estimates reported in TableA to evaluate the impacts of exchange rate movements on farm return. Both farm revenue and production costs are affected by exchange rate movements depending on the degree of ERPT for outputs and inputs respectively. For example if the value of $CDN against $US increases, the price of each output and therefore corresponding income could decrease, depending on the degree of ERPT for that product. On the other hand, the production cost will decrease depending on the share of fertilizer, farm machinery, agricultural chemicals and fuel costs in production costs and the degree of ERPT for these inputs. Therefore, the net effects of exchange rate movements on farm return will depend on the magnitude of revenue and production cost changes. The TableB shows the effects of a ten percent appreciation of the Canadian dollar on 2006 per acre crop budgets for wheat, barley, oats, corn and soybean, with return changes based on the significant ERPT estimations in base model.

TableB- Farm Return Changes per acre by Ten% Appreciation of $CDN

Commodity	Wheat	Barley	Oats	Corn	Soybean
Return over Cash Costs (Before Shock)	20.68	15.19	20.40	37.80	29.89
Return over Cash Costs (After Shock)	10.49 (49.27%)	4.43 (70.83%)	14.08 (27.51%)	32.79 (13.25%)	13.54 (54.70%)
Changes in Return over Gross Revenue	6.22%	7.11%	4.07%	1.53%	6.80%

The results show that appreciation of the Canadian dollar relative to the US dollar can have rather large impacts on net returns. Returns over cash costs per acre decrease as a result of exchange rate appreciation from 20.68 to 10.49 (-49.27 percent) for wheat, from 15.19 to 4.43 (-70.83 percent) for barley, from 20.40 to 14.08 (-27.45 percent) for oats, from 37.80 to 32.79 (-13.25 percent) for corn and from 29.89 to 13.54 (-54.70 percent) for soybeans.

The changes in net return over gross revenue are between 1.53 and 7.11 percent depending on the degree of pass-through for each output, and the share of tradable inputs in total production costs and their pass-through rates. As shown in TableB, a 10 percent appreciation in the Canadian dollar reduces net income for wheat by -6.22 percent of gross income; in other words, it has an impact equivalent to a 6 percent reduction in wheat prices. For corn this impact is much smaller due to the larger budget share and ERPT for fertilizer.

The results of this analysis have several policy implications. The lack of complete ERPT indicates relative prices, production decisions and farm income impacted by changes in exchange rates. Large increases in the Value of the Canadian vs. the US dollar have large short-term negative impacts on farm income, which become somewhat muted over time. These impacts on the agricultural sector should be included in the many considerations in the development of macro economic and monetary policy of Canada.

The potential impacts of exchange rate changes on relative prices and farm income suggest that agricultural producers need to be able to anticipate the risks associated with exchange rate changes and develop risk management strategies. Some of the strategies would include hedging, and marketing and procurement strategies to mitigate the financial risk associated with exchange rate volatility. The public sector may play a role in the development and extension of these tools for producers.

The lack of ERPT can be symptomatic of the lack of arbitrage opportunities and the presence of market power in this sector. For inputs and outputs with slow or limited ERPT, there is a need to further explore the reasons for that limited ERTP. When issues are identified, there may be need for policy action to reduce barriers to trade or to take measures to enhance the competitiveness of the sector. Low or constricted ERPT also suggests that investment in the better provision of price information may be warranted, in part to better measure ERPT, but also to identify opportunities for arbitrage between the markets.

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1 Introduction

The exchange rate is a key economic factor that affects the prosperity of the U.S. and Canadian agriculture. Its changes are an important source of risk to farmers and ranchers, both in production and trade. Prices of traded outputs and inputs make up an important part of farm incomes and production costs (more than 60 percent)[1] and represent a major concern for farmers. In addition to relatively free trade for major agricultural outputs, many important agricultural inputs such as fertilizer, farm machinery and fuel move across the Canadian/U.S. border duty free. As statistics show, in 2006, 59 percent of all Canadian exports in agri-food sector were shipped to the U.S., and the U.S. supplied 55 percent of Canadian merchandise imports in this sector. The prices of traded agricultural products and most inputs are primarily determined in the larger U.S. market. Therefore, the $CDN/$US exchange rate has an important bearing on Canadian farm output and input prices. If there are large changes in the exchange rate, both the timing and extent of exchange rate pass-through will affect relative prices and farm profitability.

The significant appreciation of the Canadian dollar in recent years, as well as the anticipation of its volatility for the foreseeable future through increased volatility in oil, metals and grain prices, have generated great interest in the effects of this appreciation on the Canadian agricultural economy. The purpose of this study is to estimate the degree to which Canadian agricultural output and input prices have reacted to changes in the Canadian dollar/U.S. dollar exchange , and to gain a better understanding of the effects of the Canadian dollar's appreciation in recent years on farm returns and on the overall competitiveness of Canadian agriculture. In turn, this helps us to identify and understand those markets which are more at risk from large variations in exchange rates. This can help in designing appropriate policies. Econometric models are estimated to examine the exchange rate pass-through for traded agricultural output and input during 1995 - 2007. Then, based on the estimated pass-through rates, the implications of appreciation of the Canadian dollar on the financial performance of the agricultural sector are investigated.

This study is organized as follows: Section 2 is allocated to the review of some empirical studies related to the law of one price (LOP)[2] , as the fundamental theoretical basis of this study, in Canadian agriculture. A brief explanation about the theoretical framework is presented in Section 3, Section 4 provides an introduction to the econometric models and the techniques used for estimating the exchange rate pass-through and testing the LOP. A description of the data used in this study is presented in Section 5. The empirical analysis contains two parts. First, estimation results of exchange rate pass-through in short, intermediate, and medium time frames [3]are provided in Section 6. Second, the concept of co-integration and its application to the LOP as a long-run equilib-

[1]This share is based on production costs for wheat, barley and oats in Saskatchewan and corn and soybean in Manitoba in 2007.

[2]Law of one price states that, in the long run, traded commodity prices in two countries must be the same, after adjustment for transaction costs.

[3]The model lagged three months is considered for the case that the LOP is assumed as a short-run relationship. An intermediate-run model is assumed to have six months lags and the medium-run model includes twelve months lags.

rium and the corresponding empirical results are presented in Section 7. Section 8 estimates the effects of appreciation of the Canadian dollar on the financial performance of agricultural sector. Policy implications are discussed in Section 9. Summary and conclusions are provided in Section 10.

2 Literature Review

The exchange rate pass-through (ERPT), which is based on the theory of the law of one price, has been the subject of studies by many economists since late 1970's, in the years subsequent to the Breton Woods collapse. Since our study of ERPT focuses only on domestic prices in the Canadian agricultural sector, our review is confined to the studies which have examined the ERPT in Canadian agriculture.

Richardson (1978) examined a disaggregated commodity arbitrage between the United States and Canada using regression analysis. His dataset includes monthly observations on Canadian price indexes at the 4 and 7-digit level of Standard Industrial Classifications, and roughly comparable U.S. price indexes, from the first month of 1965 to sixth month of 1974. To avoid problems arising from autocorrelation and lack of information on transaction costs, Richardson regressed the growth rate of the domestic prices in Canada on the growth rates of the U.S. prices and the exchange rate instead of their levels. He draws three conclusions from his empirical results: (1) Inability to find commodity arbitrage characterizes a majority of commodity classes, which can potentially be described as non-tradables. (2) When commodity arbitrage does take place, it is never perfect even for comparatively homogeneous commodity groups. (3) The hypothesis that exchange rates affect Canadian prices in precisely the same way and to the same degree that U.S. prices do is rarely rejected. Specifically, the estimated exchange rate pass through for different groups in agricultural sector are: 0.31 (insignificant) for animal feeds, 0.44 for agricultural implements and tractor, 0.19 (insignificant) fertilizer, 1.16 (insignificant) for poultry products, 0.18 (insignificant) for fruits and vegetables and 0.21 (insignificant) for petroleum refining products.

Ardeni (1989) argues that this assumption that commodity prices are (at least in the long run) perfectly arbitraged is counterfactual and that much of the empirical evidence provided to support it is flawed and affected by econometric shortcomings (spurious regressions, nonstationarity in the data, inappropriate use of first differences). An alternative methodology (co-integration), by which a long-run relationship between nonstationary series can be tested, is proposed. Then, using this approach, he investigates the LOP for four countries: the United States, Canada, Australia and the United Kingdom. The data are quarterly export (import) prices adjusted for exchange rates for the time period of twenty years: 1965 to 1985. Tests of nonstationarity and co-integration are conducted for a group of commodities including wheat, wool, beef, sugar, tea, tin and zinc. The results of this study show that exchange rates and commodity prices appear to be nonstationary but not co-integrated, thus showing a lack of empirical support for the LOP as a long-run relationship. For only three cases (U.S. wheat (export price) and Australian wheat (import price), U.S. wheat (export price) and Canadian wheat (export price), and for U.S. tea (import price) and British tea (import price)) out of fifteen the null hypothesis of non-co-integration can be rejected at the 5 percent level in favour of the alternative of co-integration. In general, he concludes that the presumption that deviations from the long-run equilibrium are transitory indeed cannot be sustained.

Considering that the adjustment of agricultural input prices to exchange rate changes has not received much attention in the literature, Carter and Hamilton (1989) contribute to the LOP literature by testing the LOP for wheat inputs tradable between Canada and the U.S. They regress the rate of changes in Canadian prices expressed in $CDN on the rate of changes in the U.S. prices, expressed in $CDN using the quarterly data from 1977 to 1986. The estimated coefficients for fertilizer, farm machinery, petroleum products and agricultural chemicals are 0.56, 0.45, 0.56 and 0.39 respectively. These results show that Canadian input prices did not increase as rapidly as U.S. prices between 1977-86 and this means that, ceteris paribus, Canadian wheat producers were made relatively better off. The statistical test results denied the LOP as applied to wheat inputs; however, the authors argued that one cannot conclude there is no relationship between the U.S. wheat input prices and Canadian wheat input prices. The price differential is possibly due to government regulation, varying levels of product differentiation, and the lack of competitive forces.

The other paper by Carter, Gray and Furtan (1990), which our study follows, estimates exchange rate effects on tradable inputs and output prices in Canadian agriculture. They regress the difference between the rate of changes in Canadian prices and the rate of changes in U.S. prices on the rate of changes in exchange rate and its two lags using quarterly data from 1975 to the second quarter of 1988 for three outputs (wheat, canola/soybeans, feeder steers) and five inputs (fat steers, fertilizer, pesticides, petroleum, and farm machinery) for Canadian and U.S. agriculture. The point-estimate values of contemporaneous pass-through are different across commodities, among which only the coefficients of wheat, canola, and petroleum are significantly different from zero, rejecting the null hypothesis of no contemporaneous exchange rate pass-through. None of the first lagged coefficients are statistically different from zero, although the point estimates of pass-through increase for all commodities except petroleum with a one-quarter lag. Just for fertilizer and pesticides, the second lagged coefficients are statistically significant, hence, it appears to take three to six months to get significant exchange rate pass-through for fertilizer and pesticide prices. The general implication from the regressions supports a contemporaneous LOP for canola and petroleum, one-lagged LOP for wheat, and two-lagged LOP for feeder steers, fat steers, and pesticides. They found essentially no pass-through for farm machinery.

Engel and Rogers (1996) examine how much the distance between cities and the national border between the United States and Canada can explain the deviations from the LOP. They use Consumer Price Index data disaggregated into 14 categories of goods (food at home, food away from home, alcoholic beverages, shelter, fuel and other utilities, household furnishings and operations, men's and boys' apparel, women's and girls' apparel, footwear, private transportation, public transportation, medical care, personal care and entertainment) for nine Canadian cities and fourteen cities in the U.S., covering the period from 1978 to 1994. The empirical results indicate that the distance between cities explains a significant amount of the variation in the prices of similar goods in different cities. But the variation of the price is much higher for two cities located in different countries than for two equidistant cities in the same country. Therefore, the major message of the results is that both distance and the border matter for relative price variability and despite the relative openness of the U.S.-Canadian border, the markets are still segmented. Nominal price stickiness, integration of labour markets and trade barriers are possible explanations for this price variability.

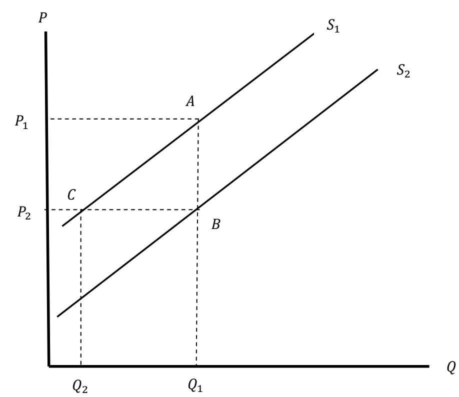
Carlson et al. (1999) compare pesticide prices between the U.S. and Canada and investigated the reasons that pesticide prices might differ across areas. They select spring wheat, barley, canola and potatoes as the study crops and Manitoba and North Dakota as the study areas because of their similarities in climates, technology and general concerns among farmers for pesticide prices. The trade restriction on agricultural chemicals, which makes it illegal to import formulated product into Canada, but possible for Canadian chemical manufactures to import the active ingredient contained in the formulated product, is mentioned as one of the main reasons for price differential of similar pesticides between dealers in the U. S. and those in Canada. Moreover, different patent status of products, different costs to provide pesticide products in different locations, a different willingness of growers to pay for products, and the pest control demand from other locations, crops and substitute products are other factors that contribute to the observed differences in pesticide prices.

3 Theoretical Framework to Examine Exchange Rate Effects on Agricultural Sector

The theoretical framework to analyze the exchange rate effects on prices and production is shown in Figure 1-3. Based on Carter et al. (1990), a model of partial equilibrium analysis is considered and it is assumed Canada and the U.S. are the exporter and importer, respectively, and both affect world prices as large countries. Based on LOP, a change in exchange rates may result in a change in the nominal and real prices and therefore production of the tradable commodities. On the other hand, since inputs may also be traded, a change in the exchange rate would cause changes in cost of exporting production and thus export prices and trade volumes between the two countries. Moreover, it is hypothesized that there is complete exchange rate pass through for agricultural outputs in short run; in other words, output prices respond quickly to the exchange rate movements, while the adjusting process of the traded input prices is slow in the short run.

Initially the price of good i expressed in Canadian dollars is OP_1 and production volume is equal to OQ_1. If the value of the Canadian dollar appreciates for example by ten percent, this results in an immediate decrease in the output price by 10 percent, an amount equal to P_1P_2, as well as a contraction of production by an amount equal to Q_1Q_2. There are not any changes in traded-input prices in short time due to the assumed lagged effect. In the long run, the currency appreciation will eventually decrease traded input prices and thus the cost of

Figure 1: Effects of an Exchange Rate Appreciation



production. Production volume therefore increases. In an extreme case where all inputs are traded, the supply curve would shift forward from S1to S_2 as a response to the exchange rate shock. This expansion effect in production offsets the contraction effect due to output price decreases, resulting in an unchanged production volume OQ_1. Point B in Figure 1 shows complete exchange rate pass-through on both input and output prices. In the case that S_1 may not shift all the way to S_2, since all inputs are not traded or complete exchange rate pass-through may not occur, the supply curve would shift somewhere between S_1 and S_2. The net change in price and production of good i is determined by a combination of factors including the elasticity of the supply curve S_1, the percentage of traded inputs in total production costs and responses to exchange rate changes in their prices.

4 Specification of the Econometric Model

The estimation of exchange rate pass-through, which is one way to measure the degree of tradability of inputs and outputs, has focused on the law of one price (LOP). In this study, based on Carter et al's paper (1990), we will specify a dynamic econometric model to estimate exchange rate pass-through on agricultural output and input prices and test the LOP hypothesis for these products. Our analysis is different from Carter et al's analysis in the following ways: first, the sample includes monthly observations from the first month of 1995 to the fifth month of 2007 (149 observations), while they employed quarterly data from 1975 to the second quarter of 1988 (54 observations). Moreover, eight additional price series have been included in our estimations. Second, to choose the most appropriate model specification, alternative lag lengths (zero lags, two lags, three lags, six lags, and twelve lags) are examined. By doing this, we are also able to test the validity of LOP hypothesis as a short-run, intermediate-run, or medium-run relationship. Finally, we examine the stationarity properties of the individual series and linear combination of prices expressed in a common currency to determine whether the LOP hypothesis is valid in a co-integrating equilibrium relationship.

Based on law of one price, in the presence of market arbitrage, the price of the same good in two locations will differ only by the transaction cost in moving the commodity from one market to another. When there is free trade and all markets are competitive, LOP should hold and ERPT=1 after controlling for transaction costs. If one or some of the conditions of competitive markets and free trade, such as a lack of market power, trade restrictions, inventory pricing decisions or price pooling, are violated or transaction costs are not controlled appropriately, the extent and timing of ERPT are not clear and should be investigated empirically. In our case study, which is aimed to estimate exchange rate pass-through and test LOP hypothesis for inputs and outputs in Canadian and U.S agriculture sector, the LOP predicts that Canadian prices should equal the U.S. prices converted to Canadian dollars, plus any transfer costs (tariffs and transportation). This relationship can be written as:

$$P_t^c = P_t^u.E + \Phi \tag{1}$$

where P_t^c and P_t^u are the Canadian and U.S. commodity prices at time t, respectively; E is the exchange rate measured as the units of Canadian dollar per U.S. dollar; and Φ is the anticipated transfer cost from one market to another.

There are some data and statistical issues involved in the estimation of this specified equation. The first consideration is that data on transfer costs are difficult to obtain. Some authors (Ardeni (1989)) in the literature assumed that the transfer cost is constant or proportional to commodity prices over the sample period and removed this variable from the equation. Thus, the transaction cost is often ignored in the LOP analysis. In this study, the intercept term could be represented as transaction costs.

Secondly, as literature emphasizes and also based on the unit root tests conducted in this study that show almost all prices to be non-stationary, estimation of this equation could lead to spurious regression problems. Davidson and Mackinnon (1993) showed some of the consequences of spurious regressions in econometrics induced by the time-series properties of the variables analyzed. They argued that many variables are non-stationary in their levels and appear to be near-random walks. Non-stationarity would make classical asymptotic theory inapplicable and the usual estimation procedures would be invalidated. To avoid these problems, their general solution is to take first differences of all non-stationary variables before estimating the model. Moreover, we are interested to estimate the effect of exchange rate changes on the price changes and not price levels. Thus, we selected the first difference as an appropriate specification.

Thirdly, the LOP relationship is nonlinear in levels, but linear in log-levels. Thus, testing in a linear regression should be done with logged (natural logs) data. This has the additional advantage that taking the natural logarithm of variables could induce stationarity for one type of non-stationary time series. Even for first-differenced level series, the sequence might exhibit an explosive portion, where fluctuations are more violent for a particular segment of the sequence than for others. Then a constant variance does not exist throughout the differenced series. By taking the natural logarithm of each observation, so differences are percent changes, the fluctuations of the levels which constitute the variance non-stationarity will decrease and induce variance stationarity in the series.

Finally, utilizing the data in differences and percentage changes reduces the potential for another problem associated with using time-series data, i.e. serial correlation. The serial correlation violates the standard assumption of regression theory that disturbances are not correlated, causing ordinary least squares estimates (OLS) to be inefficient and makes inference based on them invalid.

Therefore, rates of change in logged price levels are used in estimation rather than absolute price levels as in equation (1). Taking logs and first differencing equation (1) yields the equation:

$$Log(P_t^c/P_{t-1}^c) = Log(P_t^u/P_{t-1}^u) + Log(E_t/E_{t-1}) \tag{2}$$

To estimate, the above equation is rewritten as:

$$Log(P_t^c/P_t^u) - Log(P_{t-1}^c/P_{t-1}^u) = C + \beta_0 Log(E_t/E_{t-1}) + \varepsilon_t \tag{3}$$

where C is intercept term, β_0 represents the contemporaneous exchange rate pass-through and ε_t shows the residual term.

As it was mentioned, the factors such as transaction costs, market power, trade restrictions, inventory pricing decisions, price pooling and reversal of trade flow could affect the timing of ERPT as well as its extent. For example, in the case of agricultural chemicals, it is illegal to import formulated product into Canada but it is possible for Canadian chemical manufactures to import the active ingredients contained in the formulated product. Under this regulation, it is clear that the effects of exchange rate changes on agricultural chemical prices will appear with some lag. Moreover, transaction costs may impede instantaneous adjustment of prices at spatially separate locations, thus contributing to the presence of short-run deviation from the LOP. An example of the empirical validation of this notion is provided in an analysis by Williams and Wright (1991), who examine the influence of the physical and monetary costs of storage on the price adjustment process. The authors conclude that transactions costs preclude contemporaneous adjustment in prices. To allow for lagged exchange rate effects, the general form of the model can be specified as:

$$Log(P_t^c/P_t^u) - Log(P_{t-1}^c/P_{t-1}^u) = C + \sum_{i=0}^{n} \beta_i Log(E_{t-i}/E_{t-i-1}) + \varepsilon_t \tag{4}$$

where n denotes the numbers of lagged terms in models.

If the summation of coefficients is equal to one, we can conclude that ERPT is complete; otherwise the results should be justified based on the factors such as transaction costs (because we do not have direct control variable for this factor), government regulations on trade, market power and other conditions violating competitive markets and free trade. Regarding the lags length of exchange rate, theoretically we should include all the relevant lags and not just significant lags. Based on this approach, since we do not know the exact number of the relevant lags, we have estimated the models with different lags length including zero, two, six and twelve lags. Here, there is not any reasonable theoretical or statistical justification (such as the significancy of variables) to choose a specific lag length as the appropriate specification. We can only interpret these results as short-run, intermediate-run and medium run results.

The other standard approach to determine the lags length of independent variable is to use the Akaike Information Criterion (AIC). It is a measure of the goodness of fit of an estimated statistical model and not just based on the significant coefficients. It is in effect offering a relative measure of the information lost when a given model is used to describe reality. The AIC is an operational way of trading off the complexity of an estimated model against how well the model fits the data. The lag length determined by AIC should be included in the model without considering the significancy of coefficients. In this study, the model estimated based on this criteria has been chosen as the base model.

5 Data Description and Analysis

In this study, we are trying to estimate exchange rate pass-through for thirteen farm outputs, namely: wheat, barely, oats, corn, soybeans, potatos, calves, cattle, hogs, lamb, sheep, eggs and turkey. In addition, the rate of exchange rate pass-through is examined for four tradable inputs: fertilizer, agricultural chemicals, fuel, and farm machinery. Together, these farm outputs and tradable inputs comprise a large percentage of the total value of farm output and costs involved in agricultural production besides labour, management, and land. The data used in the analysis are monthly at national levels in each country. The sample covers the period from the first month of 1995 to the fifth month of 2007.

The commodity price data in Canada were provided by Statistics Canada. While Table 002-0043 of CANSIM provides farm product prices data in provincial level, data at the Canadian level was constructed by the Agriculture Division of Statistics Canada for this study. The corresponding U.S data was collected from various issues of *Agricultural Prices* published by National Agricultural Statistics Service(NASS), USDA. The input price data in Canada and U.S, and the monthly prices of fertilizer, agricultural chemicals, fuel and farm machinery are all price indexes based on the twelve-month average for 1997 = 100 and 1992=100 respectively. In Canada, these input price series have been derived from Table 329-0039 and 329-0048 "*Industry Price Indexes*"of CANSIM. The U.S counterparts were obtained from various issues of *Agricultural Prices*.

Time plots of the exchange rate and the output and input price series are shown in Figures 1 through 18 (Appendix), which provide a visual picture of the price movements in the U.S. and Canada from 1995 to 2007. Both the Canadian and U.S. output prices are expressed in Canadian dollars ($CDN), so based on the LOP we expect close movement of their levels. For the input price index series, the U.S. indices are multiplied by the exchange rate, and then re-scaled to 100 for first month of 1995. Canadian indices are also re-scaled to 100 for first month of 1995. Thus, for inputs, the index values are identical in first month of 1995. In this case, although the LOP can not be evaluated in absolute terms for the levels of these inputs, the LOP implies that these series move closely together over time.

As shown in Figure 1, there are two distinguishable patterns for the exchange rate \$CDN/\$US movements during our study period: significant depreciation during 1995 - 2002 (although it was slow during 1995 through 1997); and, dramatic appreciation during 2002 - 2007. In Figures 2 and 5 through 14, although a gap could be observed in some periods, the fertilizer, fuel, wheat, barley, corn, oats, soybean, potato, calves, cattle, and hog prices in Canada and the U.S. generally move closely together and it is expected that the LOP to hold for these commodities. The time plots for farm machinery, lamb and sheep prices do not show an apparent relationship of persistent close movements between the two countries, so it is expected the LOP to hold somewhat less for these input and outputs. Agricultural chemicals, egg and turkey prices do not tend to move together throughout the whole sample period and, thus it is expected the prices show a deviation from the LOP. If the LOP is not observed for Canadian and the U.S. input, the country which experiences an increase in relative costs will experience a competitive disadvantage. The empirical evidence in the following sections will statistically show the relationships between prices in Canada and the U.S.

6 Empirical Results

Our analysis extends Carter et al's assessment of exchange rate pass-through on some inputs and outputs in Canadian agriculture, using different lag structure on the explanatory variable. Besides the contemporaneous model (zero lag) and the two months lags model (as it was applied in Carter et al's paper), the model lagged three months is considered for the case that the LOP is assumed as a short-run relationship. An intermediate-run model is assumed to have six months lags and the medium-run model includes twelve months lags. Tables 1 to 10 report regression estimates with different lag length as monthly adjusted and unadjusted for the four inputs and the thirteen outputs over our sample period 1995-2007. Table 11 shows the sum of the point estimates for each model . Tests of the LOP and zero pass-through are shown for the sum of coefficients in Tables 12 and 13.

As shown in Tables 1 and 2, the values of the parameter estimates in zero lags model support a contemporaneous pass-through (contemporaneous coefficients are significantly different from zero) for fuel, oats, soybeans and hog in both adjusted and unadjusted cases as well as for fertilizer in the adjusted model. The coefficient point estimates for fuel, oats and hog suggest a proportionate change in prices in Canada versus the U.S. These results are also confirmed by provided estimations in Tables 3 and 4 (model with two months lags). Moreover, these tables show that there is a one-lagged pass-through for calves, cattle, and to a less extent for fertilizer, farm machinery, fuel and soybeans. We found a two-lagged pass-through again for calves and cattle in both models as well as for eggs solely in the adjusted case, and to a lesser extent for farm machinery (in both models), corn and lamb (in adjusted case). In this two month lags model, there is essentially no pass-through for agricultural chemicals, wheat, barley, potato, sheep and turkey.

Table 1: Regression Results of Model Zero Lagged

Commodity	Parameter Estimates		R^2	DW
	C	β_0		
Fertilizer	-0.0006	0.1569	0.013	1.74
	(-0.3737)	(1.4134)		
Chemical	-9.36E-05	0.0100	0.052	2.04
	(-0.1176)	(0.1604)		
Machinery	-0.0017	0.0821	0.016	2.14
	(-2.3579)	(1.5700)		
Fuel	0.0006	0.8497	0.200	2.07
	(0.3273)	(5.9708)**		
Wheat	-0.0011	0.1538	0.096	1.92
	(-0.1078)	(0.2833)		
Barley	-0.0005	0.6345	0.008	2.14
	(-0.0685)	(1.0932)		
Corn	-0.0006	0.1482	0.003	1.85
	(-0.2094)	(0.6841)		
Oats	0.0016	1.0507	0.059	2.00
	(0.3040)	(2.5391)**		
Soybean	-0.0007	0.3864	0.034	1.85
	(-0.3194)	(2.2909)**		
Potato	-0.0022	0.8135	0.047	2.02
	(-0.2176)	(1.0014)		
Calves	-0.0034	-0.6052	0.055	1.86
	(-0.4149)	(-1.3309)		
Cattle	-0.0030	-0.5311	0.054	1.85
	(-0.3623)	(-1.1280)		
Hog	0.0003	1.0449	0.336	2.29
	(0.1596)	(6.3258)**		
Lamb	0.0008	0.2788	0.001	1.89
	(0.0822)	(0.4067)		
Sheep	0.0023	0.6624	0.007	2.20
	(0.2606)	(1.0516)		
Egg	-0.0027	-0.4506	0.161	2
	(-0.3974)	(-0.7765)		
Turkey	-0.0004	0.2381	0.001	1.81
	(-0.0595)	(0.5132)		

1. Calculated t-statistics are shown in parenthesis.
2.(*) denotes statistically different from zero at the .10 significance level.
3.(**) denotes statistically different from zero at .05 significance level.

Table 2: Regression Results of Model Zero Lagged-Monthly Adjusted

Commodity	Parameter Estimates		R^2	DW
	C	β_0		
Fertilizer	0.0027	0.2088	0.152	1.75
	(0.5140)	(1.8946)*		
Chemical	-0.0021	0.0128	0.132	2.04
	(-0.6159)	(0.1990)		
Machinery	0.0065	0.0816	0.149	2.06
	(2.5445)	(1.5692)		
Fuel	0.0138	0.8115	0.323	2.06
	(1.8255)	(5.8463)**		
Wheat	0.0755	0.3599	0.499	1.74
	(3.6604)	(0.8604)		
Barley	0.0837	0.3797	0.277	1.97
	(3.1221)	(0.7535)		
Corn	-0.0218	0.2352	0.234	2.04
	(-2.1793)	(1.1579)		
Oats	0.0058	0.6965	0.320	2.01
	(0.2851)	(1.9685)**		
Soybean	-0.0133	0.4063	0.151	1.90
	(-1.5975)	(2.4019)**		
Potato	-0.0185	0.1763	0.608	2.04
	(-0.6150)	(0.3221)		
Calves	-0.0325	-0.3817	0.138	1.88
	(-1.4433)	(-0.8203)		
Cattle	-0.0077	-0.4936	0.148	1.88
	(-0.3368)	(-1.0331)		
Hog	-0.0159	0.9896	0.484	2.27
	(-1.5234)	(6.4288)**		
Lamb	0.1020	-0.2743	0.512	2.04
	(3.9594)	(-0.5541)		
Sheep	-0.0676	0.8783	0.163	2.13
	(-2.2148)	(1.4193)		
Egg	0.0063	0.0300	0.548	2.05
	(0.2044)	(0.0711)		
Turkey	0.0977	0.1029	0.471	2.07
	(5.3398)	(0.3021)		

Table 3: Regression Results of Model Lagged Two Months

Commodity	Parameter Estimates				R^2	DW
	C	β_0	β_1	β_2		
Fertilizer	-0.0005	0.0710	0.3515	0.0297	0.079	1.75
	(-0.3558)	(0.6400)	(3.0350)**	(0.2615)		
Chemical	-4.04E-05	-0.0143	0.0667	-0.0307	0.058	2.05
	(-0.0493)	(-0.2001)	(0.8511)	(-0.4279)		
Machinery	-0.0015	0.0577	0.1213	0.1387	0.125	2.05
	(-2.5450)	(1.1011)	(2.1107)**	(2.6011)**		
Fuel	0.0006	0.7219	0.3245	-0.2111	0.219	2.06
	(0.3643)	(4.5742)**	(1.8739)*	(-1.3166)		
Wheat	-0.0020	0.1410	-0.2181	0.4218	0.097	1.93
	(-0.1824)	(0.2539)	(-0.3940)	(0.7481)		
Barley	-0.0002	0.5397	0.3058	-0.0207	0.009	2.13
	(-0.0274)	(0.8879)	(0.4826)	(-0.0332)		
Corn	-0.0001	0.0811	0.3246	0.3019	0.035	1.88
	(-0.0404)	(0.3635)	(1.3943)	(1.3195)		
Oats	0.0023	1.1008	0.0352	-0.0474	0.044	2.25
	(0.3714)	(2.4527)**	(0.0755)	(-0.1032)		
Soybean	-0.0007	0.2877	0.4059	-0.1518	0.068	1.80
	(-0.2897)	(1.6555)*	(2.2405)**	(-0.8527)		
Potato	-0.0024	0.5746	0.6632	-0.6304	0.052	2.01
	(-0.2256)	(0.6287)	(0.6600)	(-0.6798)		
Calves	-0.0001	-0.5488	1.1138	1.1768	0.137	1.89
	(-0.0140)	(-1.2280)	(2.4945)**	(2.6004)**		
Cattle	0.0005	-0.4734	1.2060	1.4252	0.157	1.88
	(0.0650)	(-1.0348)	(2.6648)**	(3.1044)**		
Hog	0.0004	0.9207	0.2474	-0.0714	0.341	2.29
	(0.2155)	(4.4915)**	(1.0230)	(-0.3442)		
Lamb	0.0015	0.1935	0.3716	0.8366	0.014	1.92
	(0.1525)	(0.2712)	(0.4995)	(1.1445)		
Sheep	0.0016	0.6522	-0.2002	-0.1101	0.007	2.18
	(0.1766)	(0.9959)	(-0.2932)	(-0.1641)		
Egg	-0.0016	-0.5287	0.0262	1.0797	0.181	2.01
	(-0.2428)	(-0.7588)	(0.0323)	(1.5279)		
Turkey	0.0001	0.2137	0.2301	0.3466	0.008	1.80
	(0.0220)	(0.4413)	(0.4558)	(0.6987)		

Table 4: Regression Results of Model Lagged Two Months-Monthly Adjusted

Commodity	Parameter Estimates				R^2	DW
	C	β_0	β_1	β_2		
Fertilizer	0.0032	0.1247	0.3457	0.0224	0.213	1.75
	(0.6108)	(1.1333)	(3.0181)**	(0.2005)		
Chemical	-0.0020	-0.0289	0.1105	-0.0374	0.146	2.04
	(-0.6003)	(-0.3946)	(1.3876)	(-0.5196)		
Machinery	0.0070	0.0575	0.1132	0.1434	0.244	2.05
	(2.7921)	(1.1011)	(1.9844)**	(2.7077)**		
Fuel	0.0138	0.6280	0.4721	-0.2301	0.360	2.05
	(1.8454)	(4.0835)**	(2.7627)**	(-1.4853)		
Wheat	0.0778	0.3202	0.1393	0.7641	0.514	1.82
	(3.8044)	(0.7469)	(0.3123)	(1.7485)		
Barley	0.0853	0.1912	0.4015	0.3627	0.285	1.98
	(3.1469)	(0.3382)	(0.6522)	(0.6370)		
Corn	-0.0206	0.1831	0.2328	0.3458	0.262	2.09
	(-2.0689)	(0.8743)	(1.0686)	(1.6204)*		
Oats	0.0071	0.6870	0.0195	0.5047	0.332	2.03
	(0.3522)	(1.6824)*	(-0.0424)	(1.2239)		
Soybean	-0.0135	0.3225	0.3623	-0.2098	0.182	1.83
	(-1.6277)	(1.8473)*	(1.9946)**	(-1.1791)		
Potato	-0.0180	0.2129	-0.0846	0.1034	0.608	2.03
	(-0.5998)	(0.3394)	(-0.1214)	(0.1626)		
Calves	-0.0290	-0.4068	1.0827	1.1006	0.212	1.90
	(-1.3326)	(-0.8880)	(2.3627)**	(2.3842)**		
Cattle	-0.0038	-0.4906	0.9541	1.2978	0.224	1.90
	(-0.1720)	(-1.0438)	(2.0479)**	(2.7593)**		
Hog	-0.0158	0.8177	0.3420	-0.1638	0.492	2.25
	(-1.4904)	(4.2420)**	(1.4881)	(-0.8435)		
Lamb	0.1052	-0.2948	-0.0037	1.1735	0.529	2.05
	(4.0871)	(-0.5496)	(-0.0065)	(2.1615)**		
Sheep	-0.0684	0.9266	-0.3320	-0.1882	0.156	2.11
	(-2.2159)	(1.4318)	(-0.4930)	(-0.2853)		
Egg	0.0085	0.1041	-0.3373	0.8821	0.561	2.09
	(0.2722)	(0.1952)	(-0.5226)	(1.6289)*		
Turkey	0.0990	0.0894	0.0268	0.4444	0.478	2.07
	(5.3619)	(0.2340)	(0.0640)	(1.1484)		

The regression results of the short-run model, where adjustments are measured over a quarter, are reported in Tables 5 and 6. As it can be observed, the values of contemporaneous, one-lagged and two-lagged pass-through support the provided results in Tables 3 and 4, except that the two-lagged pass-through results for farm machinery, corn and egg are not statistically significant in this case. The estimated coefficients show that three-lagged pass-through is significant for wheat (in both models) and egg (in the adjusted model), and to a lesser extent, for farm machinery and soybean(in both models) as well as oats in the adjusted case. Moreover, in both adjusted and unadjusted models, the three-lagged pass-through for sheep is negative and significant and the coefficient point estimates show a more than proportionate change in prices in Canada versus the U.S.

The regression results of the intermediate-run model, in which adjustments are measured over six months, are shown in Tables 7 and 8. In general, the results of this model are similar to those obtained in the short-run model, i.e. a contemporaneous pass-through for fuel, soybean, hog (in both adjusted and unadjusted models) as well as oats in the unadjusted model; one lagged pass-through for fertilizer, farm machinery, soybean, calves and cattle(in both adjusted and unadjusted models) as well as fuel and hog in the adjusted model; two-lagged pass-through for calves and cattle; and, three-lagged pass-through for farm machinery, wheat, soybean and eggs. The pass-through in the fourth lags is significant (but negative) for egg and turkey in the adjusted model as well as for barley and sheep (negative) in the unadjusted model. Five-lagged pass through is significant for soybean and turkey in both models as well as hogs (negative) and eggs in the adjusted model. Finally, exchange rate pass-through is significant after six months for barley (negative), corn, and potatoes in both models, for wheat and egg(negative) in the adjusted model, and for hogs in the unadjusted model. As it can be observed, there is no pass-through for agricultural chemicals.

Table 5: Regression Results of Model Lagged Three Months

Commodity	Parameter Estimates					R^2	DW
	C	β_0	β_1	β_2	β_3		
Fertilizer	-0.0004	0.0604	0.3631	0.0039	0.0987	0.084	1.74
	(-0.2673)	(0.5361)	(3.1005)**	(0.0332)	(0.8624)		
Chemical	-4.07E-05	-0.0159	0.0719	-0.0396	0.0165	0.058	2.05
	(-0.0490)	(-0.2188)	(0.8923)	(-0.4949)	(0.2281)		
Machinery	-0.0014	0.0331	0.1759	0.0197	0.2571	0.270	2.11
	(-2.5591)	(0.6851)	(3.2028)**	(0.3595)	(5.2137)**		
Fuel	0.0005	0.7316	0.3125	-0.1751	-0.0857	0.220	2.06
	(0.3052)	(4.5846)**	(1.7597)*	(-0.9885)	(-0.5289)		
Wheat	-0.0004	0.1268	-0.1222	0.4852	0.98531	0.117	1.92
	(-0.0413)	(0.2292)	(-0.2182)	(0.8622)	(1.7536)*		
Barley	0.0001	0.5230	0.3410	-0.1306	0.4845	0.013	2.16
	(0.0205)	(0.8466)	(0.5318)	(-0.2026)	(0.7727)		
Corn	-0.0004	0.1190	0.2999	0.3258	0.0277	0.037	1.89
	(-0.1289)	(0.5258)	(1.2764)	(1.3792)	(-0.1206)		
Oats	0.0025	1.1109	0.0536	-0.1426	0.4751	0.053	2.26
	(0.4033)	(2.4425)**	(0.1136)	(-0.3004)	(1.0291)		
Soybean	-0.0004	0.2806	0.4305	-0.2377	0.3919	0.101	1.85
	(-0.1727)	(1.6154)*	(2.3876)**	(-1.3112)	(2.2230)**		
Potato	-0.0029	0.6750	0.4273	-0.1456	-1.0161	0.059	2.01
	(-0.2734)	(0.7329)	(0.4163)	(-0.1424)	(-1.0870)		
Calves	-0.0001	-0.5465	1.0922	1.1865	-0.1218	0.137	1.89
	(-0.0197)	(-1.2138)	(2.3987)**	(2.5979)**	(-0.2671)		
Cattle	-0.0001	-0.4548	1.1742	1.4381	-0.4897	0.164	1.87
	(-0.0241)	(-0.9910)	(2.5538)**	(3.1175)**	(-1.0632)		
Hog	0.0005	0.8813	0.3206	-0.1987	0.1810	0.343	2.28
	(0.2787)	(4.1861)**	(1.2360)	(-0.7698)	(0.8512)		
Lamb	0.0017	0.2180	0.3867	0.7252	0.5850	0.019	1.91
	(0.1696)	(0.3010)	(0.5144)	(0.9595)	(0.7958)		
Sheep	0.0010	0.6307	-0.2488	0.1317	-1.1985	0.028	2.19
	(0.1138)	(0.9598)	(-0.3647)	(0.1920)	(-1.7968)*		
Egg	-0.0014	-0.6654	0.3777	0.4772	0.8779	0.189	2.02
	(-0.2061)	(-0.9383)	(0.4421)	(0.5602)	(1.2224)		
Turkey	-0.0005	0.2564	0.1727	0.4941	-0.6036	0.018	1.81
	(-0.0752)	(0.5227)	(0.3391)	(0.9650)	(-1.2122)		

Table 6: Regression Results of Model Lagged Three Months-Monthly Adjusted

Commodity	Parameter Estimates					R^2	DW
	C	β_0	β_1	β_2	β_3		
Fertilizer	0.0036	0.1111	0.3566	-0.0042	0.0924	0.218	1.74
	(0.6967)	(0.9943)	(3.0850)**	(-0.0368)	(0.8186)		
Chemical	-0.0021	-0.0272	0.1069	-0.0305	-0.0138	0.146	2.04
	(-0.6110)	(-0.3671)	(1.3069)	(-0.3761)	(-0.1870)		
Machinery	0.0084	0.0302	0.1639	0.0119	0.2955	0.423	2.10
	(3.7477)	(0.6562)	(3.1528)**	(0.2295)	(6.3115)**		
Fuel	0.0132	0.6427	0.4518	-0.1670	-0.1328	0.364	2.04
	(1.7490)	(4.1339)**	(2.5764)**	(-0.9580)	(-0.8484)		
Wheat	0.0824	0.2562	0.2036	0.5446	0.8841	0.529	1.82
	(4.0368)	(0.5959)	(0.4577)	(1.2175)	(2.0350)**		
Barley	0.0887	0.1332	0.5266	0.0345	0.7238	0.292	1.98
	(3.2405)	(0.2341)	(0.8335)	(0.0547)	(1.2631)		
Corn	-0.0204	0.2147	0.2150	0.3518	0.0552	0.265	2.09
	(-2.0297)	(1.0126)	(0.9800)	(1.5949)	(0.2580)		
Oats	0.0101	0.5999	0.1828	0.1107	0.6748	0.349	2.04
	(0.5019)	(1.4652)	(0.3868)	(0.2352)	(1.6315)*		
Soybean	-0.0110	0.3036	0.3875	-0.3206	0.4819	0.227	1.92
	(-1.3517)	(1.7586)*	(2.1696)**	(-1.7849)*	(2.7629)**		
Potato	-0.0189	0.2281	-0.1374	0.1778	-0.1188	0.608	2.02
	(-0.6100)	(0.3590)	(-0.1914)	(0.2482)	(-0.1844)		
Calves	-0.0301	-0.3937	1.0535	1.1254	-0.1931	0.213	1.90
	(-1.3628)	(-0.8521)	(2.2591)**	(2.4077)**	(-0.4149)		
Cattle	-0.0061	-0.4688	0.9502	1.3181	-0.4125	0.229	1.89
	(-0.2733)	(-0.9915)	(2.0098)**	(2.7800)**	(-0.8721)		
Hog	-0.0147	0.7610	0.4524	-0.3553	0.2571	0.497	2.23
	(-1.3662)	(3.8637)**	(1.8396)*	(-1.4531)	(1.2974)		
Lamb	0.1072	-0.3212	-0.0087	1.0380	0.4004	0.530	2.06
	(4.1350)	(-0.5948)	(-0.0147)	(1.7547)*	(0.7326)		
Sheep	-0.0753	0.9261	-0.3700	0.0947	-1.3604	0.183	2.13
	(-2.4569)	(1.4337)	(-0.5538)	(0.1410)	(-2.0845)**		
Egg	0.0144	-0.2111	0.2507	-0.1631	1.3681	0.583	2.07
	(0.4640)	(-0.3931)	(0.3678)	(-0.2395)	(2.5096)**		
Turkey	0.0968	0.1332	-0.0262	0.6425	-0.4675	0.485	2.06
	(5.1940)	(0.3468)	(-0.0611)	(1.4997)	(-1.2010)		

Table 7: Regression Results of Model Lagged Six Months

Commodity	Parameter Estimates								R^2	DW
	C	β_0	β_1	β_2	β_3	β_4	β_5	β_6		
Fertilizer	-0.0004	0.0624	0.3652	0.0065	0.0947	0.0160	0.0644	0.0410	0.090	1.75
	(-0.2459)	(0.5356)	(3.0068)**	(0.0536)	(0.7776)	(0.1324)	(0.5306)	(0.3447)		
Chemical	5.16E-05	-0.0070	0.0694	-0.0485	0.0398	-0.0704	0.0399	0.0410	0.068	2.05
	(0.0602)	(-0.0941)	(0.8300)	(-0.5755)	(0.4745)	(-0.8442)	(0.4827)	(0.5441)		
Machinery	-0.0012	0.0424	0.1631	0.0264	0.2296	0.0505	0.0453	0.0380	0.290	2.14
	(-2.2074)	(0.8591)	(2.8756)**	(0.4584)	(3.9883)**	(0.8830)	(0.8025)	(0.7512)		
Fuel	0.0006	0.4700	0.2840	-0.1245	-0.1609	0.1550	-0.1318	0.0469	0.223	2.06
	(0.3366)	(4.5045)**	(1.5569)	(-0.6756)	(-0.8775)	(0.8478)	(-0.7250)	(0.2792)		
Wheat	0.0037	0.1772	-0.2980	0.6029	0.9858	0.2109	0.5384	0.3964	0.131	1.86
	(0.3489)	(0.3201)	(-0.5340)	(1.0625)	(1.7497)*	(0.3734)	(0.9585)	(0.7009)		
Barley	-0.0001	0.3207	0.2087	0.1267	0.2274	1.3648	0.4063	-1.6004	0.097	2.18
	(-0.0220)	(0.5236)	(0.3270)	(0.1972)	(0.3549)	(2.1440)**	(0.6362)	(-2.5569)**		
Corn	0.0002	0.1743	0.2892	0.3038	-0.0519	0.0324	0.0350	0.5297	0.076	1.91
	(0.0759)	(0.7588)	(1.2080)	(1.2611)	(-0.2161)	(0.1360)	(0.1462)	(2.2570)**		
Oats	0.0020	1.0532	0.0396	-0.1118	0.5418	-0.1304	0.6131	-0.6807	0.071	2.21
	(0.3041)	(2.2579)**	(0.0816)	(-0.2282)	(1.1107)	(-0.2692)	(1.2608)	(-1.4284)		
Soybean	0.0005	0.3067	0.3954	-0.2628	0.3658	0.1412	0.4732	0.1212	0.167	1.92
	(0.2339)	(1.7702)*	(2.1894)**	(-1.4458)	(2.0182)**	(0.7846)	(2.6193)**	(0.6851)		
Potato	0.0008	0.7361	0.6862	-0.5767	-1.4526	1.2232	-0.7135	1.6672	0.095	2.04
	(0.0799)	(0.8028)	(0.6694)	(-0.5568)	(-1.4094)	(1.1914)	(-0.6991)	(1.7789)*		
Calves	-0.0011	-0.5236	1.0606	1.2435	-0.0986	-0.3145	-0.2575	-0.1407	0.143	1.87
	(-0.1431)	(-1.1276)	(2.2674)**	(2.6249)**	(-0.2097)	(-0.6678)	(-0.5485)	(-0.2975)		
Cattle	-0.0003	-0.507	1.1431	1.5063	-0.4649	-0.0573	0.4583	-0.4159	0.178	1.86
	(-0.0441)	(-1.0758)	(2.4236)**	(3.1516)**	(-0.9801)	(-0.1207)	(0.9680)	(-0.8715)		
Hog	0.0007	0.9179	0.3201	-0.1800	0.1073	0.1353	-0.4257	0.3978	0.362	2.27
	(0.3376)	(4.2480)**	(1.1929)	(-0.6429)	(0.3820)	(0.4926)	(-1.6151)	(1.8219)*		
Lamb	0.0033	0.2625	0.2023	0.6736	0.6150	0.1137	0.0696	-0.5173	0.020	1.95
	(0.3239)	(0.3559)	(0.2633)	(0.8708)	(0.7973)	(0.1484)	(0.0905)	(-0.6865)		
Sheep	0.0009	0.8227	-0.1528	-0.2042	-0.7662	-1.2592	0.6699	0.2427	0.056	2.16
	(0.1028)	(1.2406)	(-0.2211)	(-0.2936)	(-1.1047)	(-1.8274)*	(0.9690)	(0.3582)		
Egg	-0.0010	-0.6933	0.4818	0.1274	1.5519	-1.2117	1.2907	-0.4164	0.204	1.98
	(-0.1460)	(-0.9513)	(0.5351)	(0.1356)	(1.6446)*	(-1.3089)	(1.4488)	(-0.5610)		
Turkey	0.0008	0.3645	0.80048	0.3543	-0.3888	-0.7096	1.2134	0.0710	0.064	1.77
	(0.1195)	(0.7339)	(0.1638)	(0.6801)	(-0.7484)	(-1.3750)	(2.3433)**	(0.1399)		

Table 8: Regression Results of Model Lagged Six Months-Monthly Adjusted

Commodity	Parameter Estimates								R^2	DW
	C	β_0	β_1	β_2	β_3	β_4	β_5	β_6		
Fertilizer	0.0039	0.1268	0.3356	0.0009	0.1028	-0.0296	0.0817	0.0583	0.229	1.75
	(0.7222)	(1.0976)	(2.8001)**	(0.0082)	(0.8541)	(-0.2487)	(0.6795)	(0.4983)		
Chemical	-0.0016	-0.0251	0.1123	-0.0420	0.0081	-0.0808	0.0546	0.0527	0.162	2.04
	(-0.4593)	(-0.3269)	(1.3225)	(-0.4926)	(0.0957)	(-0.9583)	(0.6504)	(0.6875)		
Machinery	0.0082	0.0372	0.1579	0.0163	0.2703	0.0460	0.0089	0.0430	0.431	2.12
	(3.5800)	(0.7810)	(2.9072)**	(0.2965)	(4.9261)**	(0.8424)	(0.1654)	(0.8847)		
Fuel	0.0127	0.6550	0.4225	-0.1340	-0.1929	0.1180	-0.0790	0.0135	0.363	2.06
	(1.6406)	(4.0546)**	(2.3198)**	(-0.7294)	(-1.0554)	(0.6487)	(-0.4369)	(0.0832)		
Wheat	0.0841	0.3678	0.1915	0.4179	0.8376	-0.0079	0.3048	0.7334	0.548	1.85
	(4.0751)	(0.8379)	(0.4205)	(0.9138)	(1.8304)*	(-0.0174)	(0.6670)	(1.6479)*		
Barley	0.0773	-0.0051	0.3733	0.3283	0.3423	0.8747	0.3514	-1.5610	0.349	1.93
	(2.8483)	(-0.0090)	(0.5882)	(0.5116)	(0.5367)	(1.3773)	(0.5559)	(-2.7195)**		
Corn	-0.0189	0.2536	0.2057	0.3502	-0.0201	0.1054	-0.0714	0.5144	0.298	2.09
	(-1.8716)	(1.1755)	(0.9191)	(1.5580)	(-0.0893)	(0.4731)	(-0.3182)	(2.3520)**		
Oats	0.0082	0.4693	0.3196	0.0318	0.7513	-0.1458	0.3020	-0.5702	0.357	2.03
	(0.4014)	(1.1190)	(0.6592)	(0.0645)	(1.5303)	(-0.2993)	(0.6263)	(-1.3410)		
Soybean	-0.0129	0.3165	0.3699	-0.3470	0.4274	0.2265	0.4918	0.0633	0.303	2.02
	(-1.6106)	(1.8534)*	(2.0879)**	(-1.9503)**	(2.4009)**	(1.2844)	(2.7665)**	(0.3658)		
Potato	-0.0192	0.2743	-0.0992	0.2072	-0.6972	0.8285	-0.6871	1.0560	0.633	2.07
	(-0.6211)	(0.4371)	(-0.1358)	(0.2780)	(-0.9378)	(1.1228)	(-0.9420)	(1.6504)*		
Calves	-0.0292	-0.3721	0.9733	1.2031	-0.1352	-0.2038	-0.1456	-0.1239	0.219	1.90
	(-1.2908)	(-0.7781)	(2.0218)**	(2.4757)**	(-0.2803)	(-0.4221)	(-0.3016)	(-0.2561)		
Cattle	-0.0091	-0.5546	0.8675	1.4423	-0.3702	0.1147	0.5368	0.5460	0.254	1.89
	(-0.3991)	(-1.1456)	(1.7935)*	(2.9519)**	(-0.7633)	(0.2364)	(1.1055)	(-1.1204)		
Hog	-0.0137	0.7801	0.4279	-0.2619	0.1221	0.1937	-0.4212	0.3177	0.512	2.23
	(-1.2771)	(3.8217)**	(1.6585)*	(-0.9693)	(0.4511)	(0.7347)	(-1.6707)*	(1.5544)		
Lamb	0.1078	-0.2810	-0.0014	0.9916	0.4088	0.0389	-0.0385	0.1964	0.518	2.06
	(4.0250)	(-0.4997)	(-0.0023)	(1.5883)	(0.6590)	(0.0629)	(-0.0623)	(0.3431)		
Sheep	-0.0708	1.0332	-0.2617	-0.1510	-1.0755	-0.8849	0.5032	0.3852	0.188	2.12
	(-2.2738)	(1.5595)	(-0.3807)	(-0.2188)	(-1.5572)	(-1.2930)	(0.7297)	(0.5739)		
Egg	0.0178	-0.4112	0.6171	-0.8245	2.4426	-1.4633	1.3193	-0.9258	0.597	2.03
	(0.5483)	(-0.7415)	(0.8329)	(-1.0225)	(2.9747)**	(-1.8499)*	(1.7998)*	(-1.6418)*		
Turkey	0.0990	0.1721	-0.0309	0.5106	-0.1994	-0.7264	0.8089	0.0276	0.506	2.06
	(5.2623)	(0.4392)	(-0.0706)	(1.1533)	(-0.4530)	(-1.6562)*	(1.8509)*	(0.0691)		

The empirical results provided in Tables 9 and 10 for the twelve-lagged model do not show significant change relative to those obtained from the short or intermediate-run models. Among agricultural inputs, the pass-through is significant for fertilizer in first lag, machinery in the first and third lags, and for fuel in zero, first, eleventh and twelfth lags. For crop products, pass-through is significant for wheat in third lag, for barley in forth (just in the unadjusted model), sixth, eighth and tenth lags, for corn in sixth lag, for oats in zero lag and twelfth lag just in the adjusted model, for soybeans in zero, first, third, fifth and tenth lags as well as second and eleventh lags of the adjusted models, and for potato in sixth lag in unadjusted model. For livestock products, pass-through is significant for: calves and cattle in first and second lags; hogs in zero, fifth (negative) and sixth lags as well as seventh lag (negative) in the unadjusted model; sheep in zero, third (negative) and twelfth lags in the adjusted model and forth lag (negative) in the unadjusted model; eggs in third and seventh lags as well as eighth lag in adjusted model; and, finally, for turkey in fifth, eighth (negative) and ninth lags. As it can be observed, again, there is no pass-through for agricultural chemicals even after one year.

Table 9: Regression Results of Model Lagged Twelve Months

Commodity	Parameter Estimates							
	C	β_0	β_1	β_2	β_3	β_4	β_5	β_6
Fertilizer	-0.0004	0.0473	0.3383	0.0079	0.0983	0.0120	0.0737	0.0712
	(-0.2377)	(0.3856)	(2.6341)**	(0.0618)	(0.7650)	(0.0931)	(0.5657)	(0.5419)
Chemical	-7.41E-05	-0.0176	0.0860	-0.0494	0.0500	-0.0533	0.0339	-0.0090
	(-0.0820)	(-0.2273)	(0.9959)	(-0.5673)	(0.5769)	(-0.6178)	(0.3853)	(-0.1023)
Machinery	-0.0014	0.0385	0.1614	0.0220	0.2277	0.0456	0.0637	0.0063
	(-2.5289)	(0.7673)	(2.7619)**	(0.3685)	(3.8071)**	(0.7611)	(1.0508)	(0.1045)
Fuel	0.0002	0.6815	0.2951	0.2208	-0.1477	0.2103	-0.1094	0.0680
	(0.1172)	(4.4039)**	(1.7191)*	(-1.2714)	(-0.8543)	(1.2130)	(-0.6242)	(0.3863)
Wheat	0.0014	0.1041	-0.3946	0.6472	0.9897	0.2687	0.7368	0.2902
	(0.1188)	(0.1787)	(-0.6696)	(1.0814)	(1.6710)*	(0.4520)	(1.2299)	(0.4784)
Barley	0.0031	0.1375	0.1065	0.2346	0.2054	1.3617	0.3131	-1.5503
	(0.3440)	(0.2199)	(0.1627)	(0.3566)	(0.3135)	(2.0714)**	(0.4710)	(-2.3122)**
Corn	0.0009	0.1457	0.3154	0.2878	-0.0786	0.1262	-0.0822	0.4642
	(-0.2787)	(0.6223)	(1.2866)	(1.1684)	(-0.3204)	(0.5128)	(-0.3303)	(1.8496)*
Oats	0.0015	0.9767	0.0695	-0.2499	0.5384	-0.0822	0.6402	-0.6759
	(0.2349)	(2.0253)**	(0.1347)	(-0.4803)	(1.0416)	(-0.1586)	(1.2211)	(-1.2803)
Soybean	9.25E-05	0.3320	0.3980	-0.2637	0.3730	0.1004	0.4805	0.1941
	(0.0359)	(1.8730)*	(2.1445)**	(-1.4142)	(2.0082)**	(0.5389)	(2.5505)**	(1.0217)
Potato	0.0019	0.8972	0.5669	-0.4899	-1.7210	1.1600	-0.6546	1.8445
	(0.1753)	(0.9430)	(0.5283)	(-0.4500)	(-1.5865)	(1.0661)	(-0.5946)	(1.6690)*
Calves	-0.0011	-0.4736	1.1772	1.2986	-0.2198	-0.3550	-0.1814	-0.1790
	(-0.1300)	(-0.9799)	(2.4119)**	(2.6291)**	(-0.4496)	(-0.7234)	(-0.3664)	(-0.3573)
Cattle	-0.0026	-0.3403	1.2878	1.5306	-0.5788	-0.1328	0.4732	-0.4254
	(-0.3021)	(-0.6948)	(2.6152)**	(3.0714)**	(-1.1734)	(-0.2683)	(0.9474)	(-0.7416)
Hog	0.0009	0.8889	0.2587	-0.2423	0.1120	0.2184	-0.5895	0.7856
	(0.4560)	(3.9897)**	(0.9384)	(-0.8421)	(0.3879)	(0.7577)	(-2.0244)**	(2.6911)**
Lamb	0.0019	0.2903	0.2314	0.7155	0.6762	-0.1301	0.0690	-0.2541
	(0.1754)	(0.3805)	(0.2897)	(0.8916)	(0.8460)	(-0.1623)	(0.0851)	(-0.3108)
Sheep	0.0022	0.8679	-0.0382	-0.3324	-0.7981	-1.3280	0.6658	0.4878
	(0.2277)	(1.2804)	(-0.0538)	(-0.4661)	(-1.1237)	(-1.8641)*	(0.9243)	(0.6713)
Egg	-0.0004	-0.6158	0.3223	0.1196	1.7136	-0.9438	0.3138	1.2481
	(-0.0597)	(-0.8339)	(0.3599)	(0.1281)	(1.8285)*	(-1.0068)	(0.3311)	(1.3136)
Turkey	0.0006	0.2975	-0.1054	0.3451	-0.2952	-0.6817	1.3010	-0.0757
	(0.0849)	(0.5854)	(-0.1982)	(0.6454)	(-0.5543)	(-1.2761)	(2.4085)**	(-0.1390)

Continued-Regression Results of Model Lagged Twelve Months

Commodity	Parameter Estimates						R^2	DW
	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}		
Fertilizer	-0.0659	0.0592	0.0309	0.0332	-0.0017	0.1248	0.102	1.78
	(-0.5061)	(0.4576)	(0.2404)	(0.2591)	(-0.0131)	(0.9877)		
Chemical	0.0903	-0.1030	0.0790	0.0899	-0.0235	-0.0923	0.117	2.05
	(1.0248)	(-1.1726)	(0.9082)	(1.0354)	(-0.2722)	(-1.1709)		
Machinery	0.0665	-0.0046	-0.0267	0.0646	-0.0891	0.0562	0.331	2.16
	(1.0967)	(-0.0775)	(-0.4468)	(1.0834)	(-1.5155)	(1.0809)		
Fuel	-0.0988	-0.2774	-0.0950	-0.0065	0.5377	-0.2760	0.340	2.00
	(-0.5631)	(-1.5843)	(-0.5480)	(-0.0377)	(3.1179)**	(-1.7305)*		
Wheat	-0.1390	-0.3659	-0.04816	-0.0822	0.4669	-0.0535	0.150	1.92
	(-0.2300)	(-0.6075)	(-0.0814)	(0.1368)	(0.7789)	(-0.0887)		
Barley	-0.4883	1.4648	-0.3663	1.1809	-0.3522	0.6560	0.158	2.11
	(-0.7352)	(2.2187)**	(-0.5575)	(1.8037)*	(-0.5351)	(1.0177)		
Corn	0.1742	-0.1199	0.3342	-0.0002	-0.2417	0.1717	0.098	1.87
	(0.7004)	(-0.4530)	(1.3587)	(-0.0008)	(-0.9810)	(0.7118)		
Oats	0.3184	-0.1295	0.2600	-0.2924	-0.2690	0.7920	0.117	2.01
	(0.6058)	(-0.2472)	(0.5019)	(-0.5629)	(-0.5186)	(1.5956)		
Soybean	-0.1327	0.1524	-0.0594	-0.4805	0.2232	-0.1823	0.229	1.82
	(-0.7052)	(0.8147)	(-0.3193)	(-2.5897)**	(1.5719)	(-0.9980)		
Potato	-0.1455	-0.3241	-0.0555	-1.1813	0.4979	1.3344	0.132	1.99
	(-0.1321)	(0.2951)	(-0.0510)	(-1.0882)	(-0.4617)	(1.3591)		
Calves	0.5001	0.0374	-0.4320	0.1266	-0.6216	0.3186	0.176	1.87
	(1.0031)	(0.0753)	(-0.8782)	(0.2558)	(-1.2569)	(0.6395)		
Cattle	0.6079	-0.2909	-0.2460	-0.5318	-0.8736	-0.1973	0.215	1.87
	(1.2086)	(-0.5804)	(-0.4958)	(-1.0647)	(-1.7510)*	(-0.3926)		
Hog	-0.5128	0.1239	0.0279	-0.1699	0.3773	0.1546	0.407	2.28
	(-1.7610)*	(0.4265)	(0.0971)	(-0.6001)	(1.3821)	(0.6822)		
Lamb	-0.2710	0.8901	-0.0994	-0.6023	-0.8125	0.7804	0.056	1.92
	(-0.3346)	(1.1055)	(-0.1241)	(-0.7543)	(-1.0122)	(0.9928)		
Sheep	0.0725	-0.1848	-0.3515	-0.3210	-0.1794	0.9319	0.078	2.23
	(0.1007)	(-0.2584)	(-0.4936)	(-0.4524)	(-0.2515)	(1.3342)		
Egg	-2.6955	1.2777	0.2458	0.5942	-0.7784	0.1587	0.280	1.96
	(-2.8436)**	(1.3513)	(0.2621)	(0.6423)	(-0.8664)	(0.2094)		
Turkey	-0.1774	-0.9406	0.8910	0.0380	0.4108	-0.1965	0.117	1.73
	(-0.3287)	(-1.7532)*	(1.6686)*	(0.0714)	(0.7681)	(-0.3753)		

Table 10: Regression Results of Model Lagged Twelve Months-Monthly Adjusted

Commodity	Parameter Estimates							
	C	β_0	β_1	β_2	β_3	β_4	β_5	β_6
Fertilizer	0.0038	0.1243	0.2900	-0.0105	0.1093	-0.0513	0.1119	0.1128
	(0.6465)	(1.0285)	(2.2982)**	(-0.0829)	(0.8648)	(-0.4048)	(0.8712)	(0.8720)
Chemical	-0.0016	-0.0452	0.1249	-0.0323	0.0224	-0.0722	0.0543	0.0136
	(-0.4157)	(-0.5723)	(1.4335)	(-0.3680)	(0.2566)	(-0.8228)	(0.6109)	(0.1523)
Machinery	0.0081	0.0373	0.1618	0.0112	0.2711	0.0361	0.0205	0.00189
	(3.2418)	(0.7669)	(2.8858)**	(0.1968)	(4.7297)**	(0.6295)	(0.3518)	(0.3233)
Fuel	0.0180	0.6291	0.4039	-0.1976	-0.1630	0.1439	-0.0889	0.0939
	(2.3520)	(4.1155)**	(2.3590)**	(-1.1409)	(-0.9431)	(0.8307)	(-0.5059)	(0.5323)
Wheat	0.0847	0.3769	0.1467	0.6058	0.8135	-0.1681	0.4710	0.7212
	(3.8384)	(0.8379)	(0.3124)	(1.2800)	(1.7285)*	(-0.3563)	(0.9849)	(1.4971)
Barley	0.0785	-0.1502	0.4562	0.5842	0.3167	0.9316	0.2167	-1.6690
	(2.7246)	(-0.2624)	(0.7092)	(0.8947)	(0.4858)	(1.4254)	(0.3267)	(-2.5078)**
Corn	-0.0230	0.2187	0.2382	0.2776	-0.0147	0.2239	-0.2123	0.5061
	(-2.1527)	(1.0050)	(1.0474)	(1.2113)	(-0.0647)	(0.9804)	(-0.9168)	(2.1699)**
Oats	-0.0010	0.4035	0.3685	0.0691	0.7033	-0.1569	0.4336	-0.8293
	(-0.0482)	(0.9200)**	(0.7299)	(0.1345)	(1.3680)	(-0.3046)	(0.8289)	(-1.5810)
Soybean	0.0122	0.3392	0.3557	-0.3909	0.4564	0.2139	0.4796	0.1138
	(-1.4561)	(1.9745)**	(1.9826)**	(-2.1620)**	(2.5388)**	(1.1875)	(2.6254)**	(0.6187)
Potato	-0.0169	0.3286	-0.0913	0.2267	-0.8305	0.7421	-0.3382	0.5929
	(-0.5039)	(0.4995)	(-0.1216)	(0.2961)	(-1.0841)	(0.9662)	(-0.4334)	(0.7585)
Calves	-0.0348	-0.2989	1.0258	1.2157	-0.2838	-0.2157	-0.1027	-0.1481
	(-1.4042)	(-0.5972)	(2.0312)**	(2.3777)**	(-0.5612)	(-0.4255)	(-0.2002)	(-0.2859)
Cattle	-0.0097	-0.4063	1.0144	1.4645	-0.4683	0.0338	0.5392	-0.5715
	(-0.3875)	(-0.7995)	(1.9823)**	(2.8278)**	(-0.9141)	(0.0658)	(1.0375)	(-1.0889)
Hog	-0.0113	0.7578	0.3670	-0.2923	0.0900	0.3120	-0.5691	0.6109
	(-0.9685)	(3.5640)**	(1.3707)	(-1.0420)	(0.3178)	(1.1012)	(-1.9817)**	(-2.1206)**
Lamb	0.0996	-0.1319	-0.1361	0.9926	0.4811	-0.0689	-0.0992	0.6676
	(3.4394)	(-0.2234)	(-0.2207)	(1.5974)	(0.7787)	(-0.1114)	(-0.1581)	(1.0556)
Sheep	-0.0702	1.0996	-0.2323	-0.2988	-1.1844	-0.7946	0.4271	0.5406
	(-2.1152)	(1.6260)*	(-0.3288)	(-0.4198)	(-1.6736)*	(-1.1202)	(0.5940)	(0.7464)
Egg	0.0151	-0.4274	0.4891	-0.6387	2.2203	-0.7229	-0.0990	0.9923
	(0.4506)	(-0.7580)	(0.6623)	(-0.8016)	(2.7106)**	(-0.8774)	(-0.1184)	(1.1822)
Turkey	0.1015	0.0939	-0.0001	0.5193	-0.1100	-0.7192	0.8054	-0.0819
	(5.0197)	(0.2320)	(-0.0003)	(1.1457)	(-0.2434)	(-1.5868)	(1.7514)*	(-0.1775)

Continued-Regression Results of Model Lagged Twelve Months-Monthly Adjusted

Commodity	Parameter Estimates						R^2	DW
	β_7	β_8	β_9	β_{10}	β_{11}	β_{12}		
Fertilizer	-0.0775	0.0667	-0.0277	-0.0157	0.0886	0.1359	0.258	1.78
	(-0.6068)	(0.5266)	(-0.2186)	(-0.1242)	(0.6957)	(1.0946)		
Chemical	0.0551	-0.0971	0.0810	0.1105	-0.0394	-0.1065	0.224	2.03
	(0.6196)	(-1.0961)	(0.9241)	(1.2559)	(-0.4497)	(-1.3294)		
Machinery	0.0812	0.0033	-0.0254	0.0358	-0.0602	0.0360	0.464	2.15
	(1.3948)	(0.0577)	(-0.4423)	(0.6243)	(-1.0573)	(0.7150)		
Fuel	-0.1143	-0.2555	-0.0131	-0.1012	0.5077	-0.2998	0.458	1.99
	(-0.6514)	(-1.4599)	(-0.0756)	(-0.5830)	(2.9378)**	(-1.9130)*		
Wheat	0.0405	-0.2475	0.0507	-0.2078	-0.0233	-0.1287	0.559	1.90
	(0.0852)	(-0.5248)	(0.1076)	(-0.4408)	(-0.0492)	(-0.2785)		
Barley	-0.1779	1.4374	-0.1117	1.1005	-0.4322	-0.0475	0.415	1.96
	(-0.2686)	(2.1779)**	(-0.1709)	(1.6807)*	(-0.6636)	(-0.0807)		
Corn	0.0317	0.0196	0.2900	0.0599	-0.2737	0.2337	0.336	2.07
	(0.1378)	(0.0861)	(1.2697)	(0.2623)	(-1.1919)	(1.0445)		
Oats	0.4433	-0.2650	0.5954	-0.1345	-0.2859	0.2213	0.383	2.03
	(0.8491)	(-0.5090)	(1.1550)	(-0.2612)	(-0.5604)	(0.4913)*		
Soybean	-0.1255	0.1021	-0.0117	-0.5094	0.3647	-0.1456	0.383	1.92
	(-0.6906)	(0.5668)	(-0.0653)	(-2.8280)**	(2.0138)**	(-0.8248)		
Potato	0.7812	-0.3372	0.3902	-1.2534	0.7495	-0.0356	0.646	2.07
	(1.0044)	(-0.4349)	(0.5084)	(-1.6313)*	(0.9822)	(-0.0523)		
Calves	0.3990	0.0967	-0.6321	0.1661	-0.5970	0.5348	0.248	1.87
	(0.7750)	(0.1889)	(-1.2451)	(0.3236)	(-1.1638)	(1.0376)		
Cattle	0.5107	-0.2468	-0.2969	-0.4487	-0.7117	-0.1708	0.279	1.89
	(0.9793)	(-0.4760)	(-0.5774)	(-0.8629)	(-1.3697)	(-0.3275)		
Hog	-0.4000	0.0807	0.0337	-0.0806	0.3132	0.1402	0.542	2.26
	(-1.3950)	(0.2821)	(0.1191)	(-0.2905)	(1.1738)	(0.6486)		
Lamb	-0.8802	0.5220	-0.3830	0.1497	-0.5239	0.4264	0.518	2.26
	(-1.4088)	(0.8429)	(-0.6185)	(0.2419)	(-0.8416)	(0.7029)		
Sheep	0.0925	-0.2825	-0.5623	-0.1579	-0.2238	1.2145	0.219	2.15
	(0.1293)	(-0.3984)	(-0.7928)	(-0.2228)	(-0.3139)	(1.7477)*		
Egg	-2.3928	1.3543	0.1757	0.2892	-0.3685	0.1878	0.639	2.01
	(-2.8657)**	(1.6269)*	(0.2137)	(0.3641)	(-0.4927)	(0.3218)		
Turkey	0.1262	-0.7988	0.9995	-0.0155	0.0500	-0.1521	0.533	2.05
	(0.2748)	(-1.7459)*	(2.2071)**	(-0.0341)	(0.1103)	(-0.3642)		

The LOP validity or invalidity (complete or incomplete exchange rate pass through) can be examined with the summed estimated parameters which are reported in Table 11. The overall results indicate that the cumulative pass-through effects of the exchange rates on prices are considerable, although a zero pass-through is possible for some commodities. In the three-lag model over our sample period, there is a pass-through of 0.80 for fuel; 1.87, 1.35, 0.82, 1.55, 0.84 for wheat, barley, corn, oats and soybeans respectively ;1.94, 2.31, 1.11, 1.46 and 1.24 for calves, cattle, hog, lamb and egg respectively and to a less extent for fertilizer (0.55), farm machinery (0.49), potato (0.15), sheep (-0.72) and turkey (0.29), and there is essentially no pass-through for agricultural chemicals. Models with shorter lags generally give weaker evidence for the LOP for fertilizer, farm machinery and soybean showing the pass-through effects increase after two months for these commodities. On the other hand, models with longer lags give stronger evidence on LOP for fertilizer, farm machinery, potato and turkey. The pass-through on agricultural chemicals is characterized differently, the greatest cumulative pass-through is 0.08 in the models with twelve lags, suggesting that the price adjustment process is almost zero even after two years.

To examine more accurately the validity of LOP, test results for the null hypothesis that the cumulative effects are equal to one (complete exchange rate pass-through) are provided in Table 12 for each model separately (zero, two, three, six and twelve lags models). As shown in the Table, the LOP is rejected most clearly for agricultural chemicals among all the commodities in all estimated models. In the short-run model (three months lags), the null hypothesis of the LOP is rejected for fertilizer, farm machinery and eggs. Turning to models with longer lags (6 and 12 lags), there are few changes compared to the three-lag model. Except in the case of agricultural chemicals, the LOP hypothesis is rejected just for farm machinery and wheat in six-lag model while this hypothesis is rejected only for farm machinery in the model with twelve lags. In general, the LOP is accepted more and more strongly with the increase of lag length from zero to twelve across commodities.

The p-values of the F statistic for the test that the cumulative effects are equal to zero(zero exchange rate pass-through) are provided in Table 13. In general, p-values reported in Table 13 are lower than in Table 12 indicating more rejection of zero exchange rate pass-through than the rejection of complete exchange rate pass-through. Even with no lags, the p-values show rejections of zero pass-through for fertilizer, fuel, oats, soybeans and hogs. In the two-month lag model, zero pass-through is strongly rejected for fertilizer, farm machinery, fuel, wheat, barely, corn, oats, soybeans, calves, cattle and hogs. Turning to models with longer lags (3, 6 and 12 lags), there are few changes compared to the two-lag model. In the three-lag model, the hypothesis of zero pass-through is also rejected for eggs while it cannot be rejected for cattle. This hypothesis cannot also be rejected for barley, calves and eggs in models with six and twelve lags.

So far, we have reported the rate of pass-through in models with different lag lengths on exchange rate. The question is: what is the appropriate lag length, and therefore the preferred model specification? The Akaike Information Criterion (AIC) is often used as a guide in model selection for choosing the appropriate length of a lag distribution. Table 14 presents the estimation results of the models in which the lag length has been chosen based on AIC. As it can be observed, except for barley and sheep which we found to have appropriate lag lengths of four, in most cases two-lag models and in some cases (farm machinery, wheat, soybean and eggs) three-lag models are preferred. Based on p-values reported in Table 14, the hypothesis of complete pass-through is rejected just for fertilizer, agricultural chemicals, farm machinery and sheep while the hypothesis of zero pass-through is rejected in most cases including fertilizer, farm machinery, fuel, wheat, barley, corn, oats, soybeans, calves, cattle and hogs. Therefore, these results show statistically significant complete pass-through for fuel, wheat, barley, corn, oats, soybeans, calves, cattle and hogs and incomplete pass-through for fertilizer (0.36) and farm machinery (0.45), and zero pass-through for agricultural chemicals and sheep. For potatoes, lamb and eggs, neither the complete pass-through hypothesis nor the zero pass-through hypothesis is rejected. The cumulative pass-through for these three products based on significant coefficients are zero while; without considering significancy, they are estimated to be 0.35, 1.24 and -1.17 for potatoes, eggs and sheep respectively.

7 Unit Roots Tests and Co-integration

In this section, after a brief explanation of the concept of co-integration and how it is used to test for the LOP as a long-run equilibrium relationship, unit root tests are undertaken to see whether the price series used in this study are non-stationary, which would indicate that the correct model specification is differences of the price series. Moreover, tests for co-integration are undertaken to determine if there is information in estimating co-integration of price levels, which is omitted from a model in difference form.

7.1 Co-integration: A Brief Discussion with Application to the LOP

The co-integration approach has been increasingly applied in economic studies in recent years because this theory gives a way to solve the problems arising from non-stationarity of individual series with the possibility of testing stationary relationships among the levels of economic variables.

Table 11: Sum of Estimated Parameters

Commodity	0 Lags		2 Lags				3 lags					
	β_0		β_0		$\sum_0^2 \beta$		β_0		$\sum_0^2 \beta$		$\sum_0^3 \beta$	
	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.
Fertilizer	0.21	0.15	0.12	0.07	0.49	0.45	0.11	0.06	0.46	0.42	0.55	0.52
Chemical	0.01	0.01	-0.02	-0.01	0.06	0.04	-0.02	-0.01	0.05	0.03	0.04	0.04
Machinery	0.08	0.08	0.05	0.05	0.30	0.30	0.03	0.03	0.20	0.21	0.49	0.46
Fuel	0.81	0.84	0.62	0.72	0.86	0.83	0.64	0.73	0.93	0.87	0.80	0.79
Wheat	0.35	0.15	0.32	0.14	1.21	0.35	0.25	0.12	0.99	0.48	1.87	1.46
Barley	0.37	0.63	0.19	0.61	0.95	0.90	0.13	0.52	0.63	0.73	1.35	1.21
Corn	0.23	0.14	0.18	0.08	0.75	0.70	0.21	0.11	0.77	0.72	0.82	0.70
Oats	0.69	1.05	0.68	1.10	1.17	1.09	0.59	1.11	0.88	1.00	1.55	1.47
Soybean	0.40	0.38	0.32	0.28	0.48	0.53	0.30	0.28	0.36	0.48	0.84	0.87
Potato	0.17	0.81	0.21	0.57	0.23	0.60	0.22	0.67	0.26	0.95	0.15	-0.05
Calve	-0.38	-0.60	-0.40	-0.54	1.78	1.74	1.20	0.96	-0.29	-0.47	1.94	1.99
Cattle	-0.49	-0.53	-0.49	-0.47	1.75	2.15	-0.46	-0.45	2.72	2.15	2.31	1.66
Hog	0.98	1.04	0.81	0.92	0.99	0.99	0.76	0.88	0.86	1.01	1.11	1.19
Lamb	-0.27	0.27	-0.29	0.19	0.88	1.39	-0.32	0.21	1.06	1.31	1.46	1.89
Sheep	0.87	0.66	0.92	0.65	0.41	0.34	0.92	0.63	0.64	0.52	-0.72	-0.67
Egg	0.03	-0.45	0.10	-0.52	0.65	0.57	-0.21	-0.66	-0.12	0.18	1.24	1.05
Turkey	0.10	0.23	0.08	0.21	0.54	0.78	0.13	0.25	0.75	0.91	0.29	0.31

Continued-Sum of Estimated Parameters

Commodity	6 Lags								12 lags									
	β_0		$\sum_0^2 \beta$		$\sum_0^3 \beta$		$\sum_0^6 \beta$		β_0		$\sum_0^2 \beta$		$\sum_0^3 \beta$		$\sum_0^6 \beta$		$\sum_0^{12} \beta$	
	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.
Fertilizer	0.12	0.04	0.46	0.40	0.56	0.49	0.67	0.63	0.12	0.04	0.40	0.37	0.50	0.47	0.68	0.65	0.85	0.83
Chemical	-0.02	-0.00	0.05	0.02	0.05	0.05	0.07	0.06	-0.04	-0.01	0.05	0.03	0.07	0.08	0.06	0.04	0.06	0.08
Machinery	0.03	0.04	0.19	0.22	0.46	0.45	0.58	0.59	0.03	0.03	0.20	0.21	0.47	0.43	0.57	0.56	0.62	0.63
Fuel	0.65	0.74	0.94	0.90	0.75	0.74	0.80	0.80	0.62	0.68	0.83	0.75	0.67	0.61	0.82	0.77	0.54	0.56
Wheat	0.36	0.17	0.96	0.48	1.79	1.46	2.85	2.61	0.37	0.10	1.11	0.93	1.92	1.91	2.97	2.64	2.45	2.58
Barley	-0.00	0.32	0.69	0.64	1.03	0.86	0.70	1.05	-0.15	0.13	0.88	0.46	1.19	0.66	0.68	0.80	2.45	2.90
Corn	0.25	0.17	0.80	0.75	0.78	0.70	1.34	1.31	0.21	0.14	0.71	0.73	0.70	0.66	1.24	1.18	1.60	1.51
Oats	0.46	1.05	0.80	0.97	1.55	1.51	1.16	1.32	0.40	0.97	0.82	1.12	1.52	1.65	0.99	1.22	1.57	1.90
Soybean	0.31	0.30	0.33	0.43	0.75	0.79	1.55	1.54	0.33	0.33	0.29	0.46	0.74	0.83	1.57	1.61	1.24	1.21
Potato	0.27	0.73	0.38	0.84	-0.31	-0.66	0.88	1.57	0.32	0.89	0.45	0.97	-0.38	-0.75	0.63	1.60	0.92	1.38
Calve	-0.39	-0.54	1.78	1.73	1.59	1.61	-0.37	-0.52	1.80	1.78	1.67	1.69	1.66	1.78	1.19	1.07	1.16	0.99
Cattle	-0.55	-0.50	1.75	2.14	1.38	1.68	1.49	1.66	-0.40	-0.34	2.07	2.47	1.61	1.90	1.61	1.81	0.24	0.28
Hog	0.78	0.91	0.94	1.15	1.06	1.25	1.15	1.27	0.75	0.88	0.82	0.89	0.91	1.10	1.27	1.43	1.36	1.43
Lamb	-0.28	0.26	0.71	1.13	1.11	1.74	1.13	1.41	-0.13	0.29	0.73	1.23	1.21	1.90	1.70	1.59	1.01	1.48
Sheep	1.03	0.82	0.62	0.17	-0.45	-0.59	-0.45	-0.64	1.09	0.86	0.57	0.50	-0.61	-0.29	-0.44	-0.47	-0.36	-0.50
Egg	-0.41	-0.69	-0.62	0.33	3.06	1.88	0.75	1.13	-0.42	-0.61	-0.57	-0.18	1.65	1.53	1.81	2.15	1.05	0.96
Turkey	0.17	0.36	0.65	0.79	0.46	0.41	0.56	0.98	0.09	0.29	0.60	0.53	0.49	0.24	0.50	0.78	0.71	0.81

Table 12: P-values of F-tests for the Law of One Price

Commodity	P-value of F-statistic for H_0: $\sum \beta = 1$(Law of One Price)									
	0 Lags		2 Lags		3 Lags		6 Lags		12 Lags	
	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted
Fertilizer	0.00	0.00	0.00	0.00	0.01	0.01	0.18	0.19	0.66	0.62
Chemical	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Machinery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel	0.17	0.29	0.49	0.42	0.33	0.35	0.48	0.53	0.18	0.23
Wheat	0.12	0.12	0.72	0.52	0.21	0.69	0.04	0.30	0.24	0.49
Barley	0.22	0.52	0.95	0.91	0.60	0.83	0.76	0.96	0.25	0.28
Corn	0.00	0.00	0.44	0.38	0.64	0.46	0.46	0.53	0.31	0.44
Oats	0.39	0.90	0.72	0.89	0.29	0.52	0.82	0.74	0.54	0.47
Soybean	0.00	0.00	0.04	0.08	0.60	0.64	0.13	0.15	0.60	0.68
Potato	0.13	0.81	0.33	0.74	0.33	0.43	0.91	0.73	0.95	0.86
Calves	0.00	0.00	0.30	0.33	0.49	0.49	0.86	0.97	0.92	0.99
Cattle	0.00	0.00	0.33	0.14	0.67	0.47	0.68	0.59	0.64	0.67
Hog	0.94	0.78	0.98	0.67	0.61	0.47	0.60	0.41	0.35	0.31
Lamb	0.01	0.29	0.85	0.70	0.89	0.45	0.76	0.79	0.99	0.82
Sheep	0.84	0.59	0.53	0.50	0.11	0.13	0.30	0.25	0.46	0.43
Egg	0.02	0.01	0.54	0.60	0.03	0.94	0.75	0.90	0.95	0.97
Turkey	0.00	0.10	0.37	0.77	0.18	0.41	0.53	0.99	0.76	0.89

Table 13: P-values of F-tests for Zero Exchange Rate Pass-Through

Commodity	P-value of F-statistic for H_0: $\sum \beta = 0$(Zero Exchange Rate Pass-Through)									
	0 Lags		2 Lags		3 Lags		6 Lags		12 Lags	
	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted
Fertilizer	0.06	0.15	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01
Chemical	0.84	0.87	0.63	0.81	0.73	0.75	0.55	0.063	0.69	0.65
Machinery	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.23
Wheat	0.39	0.77	0.05	0.73	0.00	0.22	0.00	0.10	0.04	0.26
Barley	0.45	0.27	0.19	0.30	0.08	0.24	0.48	0.43	0.05	0.10
Corn	0.24	0.49	0.01	0.03	0.01	0.06	0.00	0.00	0.00	0.02
Oats	0.05	0.01	0.01	0.11	0.00	0.05	0.10	0.19	0.09	0.13
Soybean	0.01	0.02	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.01
Potato	0.74	0.31	0.76	0.61	0.86	0.96	0.40	0.35	0.51	0.52
Calves	0.41	0.18	0.02	0.02	0.07	0.07	0.31	0.42	0.48	0.55
Cattle	0.30	0.26	0.02	0.00	0.12	0.07	0.22	0.18	0.88	0.86
Hog	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lamb	0.58	0.68	0.21	0.19	0.12	0.12	0.21	0.37	0.53	0.49
Sheep	0.15	0.29	0.67	0.73	0.50	0.54	0.74	0.65	0.84	0.79
Egg	0.94	0.43	0.26	0.47	0.04	0.23	0.33	0.32	0.28	0.51
Turkey	0.76	0.60	0.25	0.28	0.60	0.70	0.42	0.36	0.44	0.57

Table 14: Regression Results of Model Lagged based on AIC

Commodity	Parameter Estimates															
	C		β_0		β_1		β_2		β_3		β_4		P-val. $\sum\beta=1$		P-val. $\sum\beta=0$	
	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.	Ad.	Unad.
Fertilizer	0.00	-0.00	0.08	0.07	0.36**	0.35**	0.00	0.02					0.00	0.00	0.00	0.00
Chemical	-0.00	-0.00	-0.03	-0.01	0.11	0.06	-0.04	-0.03					0.00	0.00	0.63	0.81
Machinery	0.00	0.00	0.03	0.03	0.16**	0.17**	0.01	0.01	0.29**	0.25**			0.00	0.00	0.00	0.00
Fuel	0.00	0.00	0.64**	0.72**	0.47**	0.32*	-0.23	-0.21					0.51	0.42	0.00	0.00
Wheat	0.08	-0.00	0.25	0.12	0.20	-0.12	0.54	0.48	0.88**	0.98*			0.21	0.69	0.00	0.22
Barley	0.08	0.00	0.16	0.46	0.41	0.24	0.18	0.01	0.27	0.11	0.99*	1.50**	0.23	0.23	0.02	0.04
Corn	-0.01	-0.00	0.17	0.06	0.22	0.39*	0.36*						0.45	0.04	0.01	0.10
Oats	0.00	0.00	0.68*	1.10**	-0.02	0.03	0.50	-0.04					0.72	0.89	0.01	0.11
Soybean	-0.00	-0.00	0.30*	0.28*	0.40**	0.43**	-0.32*	-0.23	0.48**	0.39**			0.62	0.64	0.00	0.00
Potato	-0.02	-0.00	0.22	0.57	-0.11	0.66	0.12	-0.63					0.31	0.61	0.78	0.74
Calves	-0.00	-0.00	-0.43	-0.54	1.03**	1.11**	1.03**	1.17**					0.38	0.33	0.02	0.02
Cattle	-0.00	0.00	-0.49	-0.47	0.95**	1.20	1.29**	1.42					0.33	0.14	0.02	0.00
Hog	-0.01	0.00	0.81**	0.92**	0.34	0.24	-0.16	-0.07					0.98	0.67	0.00	0.00
Lamb	0.10	0.01	-0.29	0.11	-0.00	0.37	1.17	0.83					0.86	0.71	0.21	0.19
Sheep	-0.07	-0.00	0.91	0.68	-0.22	-0.05	-0.01	-0.04	-1.13*	-0.88	-0.72	-1.04	0.06	0.05	0.32	0.27
Egg	0.01	-0.00	-0.21	-0.52	0.25	0.02	-0.16	1.07	1.36				0.69	0.60	0.69	0.47
Turkey	0.09	0.00	0.08	0.21	0.02	0.23	0.44	0.34					0.37	0.77	0.25	0.28

Economic theory often suggests that there should be a long-run equilibrium relationship between certain pairs or groups of economic variables. Although the variables may deviate from equilibrium for a while, it is expected that economic forces to act so as to restore equilibrium. According to the definition, variables integrated of order one I(1) (time series which are non-stationary and requires 1 differencing transformations to be stationary is said to be integrated of order 1, denoted I(1))tend to diverge over time. Thus it might seem that such variables could never be expected to follow any sort of long-run equilibrium relationship. However, Engle and Granger (1987) demonstrated that although individual I(1) economic series may diverge through time, there may exist some linear combination of the variables that, over time, converges to an equilibrium. That is, it is possible for two or more variables to be I(1) and yet the certain linear combinations of those variables to be stationary, i.e. I(0). If that is the case, the variables are said to be co-integrated.

As an alternative to regression analysis with differenced series, co-integration provides an appropriate framework for testing the LOP. Specifically, in our case of testing the LOP between Canada and the U.S., the co-integrating regression model is:

$$P_t^c = C + \alpha P_t^{uc} + \mu_t \tag{5}$$

where P_t^c and P_t^{uc} are prices of a specific commodity at time t in two countries Canada and the U.S., expressed in the common currency $CDN. C and α denote parameters to be estimated and μ_t is the residual term.

If P_t^c and P_t^{uc} are each non-stationary and I(1), but their combination in (5) produces a residual series μ_t that is stationary, P_t^c and P_t^{uc} are co-integrated with co-integrating vector (1,α), implying a long-run relationship although deviations from this relationship may occur in the short run with a stable mean of zero. If $\alpha = 1$, this co-integrating relationship supports the LOP.

As it was mentioned, co-integration is appropriate when the individual economic series are integrated of order one. Therefore, individual series must be examined to determine their orders of integration before applying co-integration tests. The Augmented Dickey-Fuller (ADF) test proposed by Dickey and Fuller (1979) is utilized to test for unit roots. If variables are integrated of order 1, existence of co-integration between the non-stationary series could be examined.

The empirical test for co-integration is a two-stage procedure. In the first stage, the co-integrating equation, given in (5) , is estimated by OLS. Two co-integrating regressions are formed: first, Canadian prices in $CDN are regressed on the U.S. prices in $CDN then the order is reversed i.e. the U.S. prices in $CDN are regressed on Canadian prices in $CDN. In the second stage, the residuals from the co-integrating regressions are derived and an ADF test is undertaken. If the null of a unit root is rejected, then the residuals are concluded to be stationary from a co-integration relationship. Otherwise, co-integration does not exist between the prices.

7.2 Results of Unit Root Tests

The exchange rate and the price series employed in this study are tested for unit roots over the sample period 1995-2007. In Table 15, the ADF test-statistics on the levels of exchange rate and price series are reported for U.S. prices in

\$U.S. $P^{U,\$US}$, U.S. prices in \$CDN $P^{U,\$CDN}$, and Canadian prices in \$CDN $P^{C,\$CDN}$, respectively. The lengths of lagged terms in the regressions to test for a unit root have been chosen based on AIC.

As it can be observed, the results generally tend to suggest non-stationarity of the series in levels with a few exceptions. With the exceptions of oats, soybean, potato and hog prices, which seem to be stationary, most other commodities generally appear to be non-stationary in levels. Unit root is not rejected for any of the farm inputs i.e. fertilizer, agricultural chemicals, farm machinery and fuel.

Since most of the series present a single unit root, the next step is to test if the series have a second unit root by examining the stationarity of the first-differenced series. As it can be observed from Table 15, the results strongly reject the hypothesis of a unit root for exchange rate and all farm inputs and outputs. Therefore, except for oats, soybean, potato and hog prices, which are I (0), all other outputs and farm inputs as well as exchange rate are I(1). There is not a second unit root for any of these price series.

Table 15: Unit Root Results for Individual Series

Series		ADF-Test Statistic	
		Level	First Difference
Fertilizer	$P^{U,\$US}$	-1.44	-6.64**
	$P^{U,\$CN}$	-3.18*	-7.90**
	$P^{C,\$CN}$	-1.89	-7.77**
Chemical	$P^{U,\$US}$	-1.57	-15.26**
	$P^{U,\$CN}$	-1.13	-9.49**
	$P^{C,\$CN}$	-2.98	-13.98**
Machinery	$P^{U,\$US}$	-0.45	-14.65**
	$P^{U,\$CN}$	-1.47	-9.40**
	$P^{C,\$CN}$	-1.36	-12.23**
Fuel	$P^{U,\$US}$	-0.92	-9.80**
	$P^{U,\$CN}$	-2.77	-10.04**
	$P^{C,\$CN}$	-1.99	-9.85**
Wheat	$P^{U,\$US}$	0.44	-7.10**
	$P^{U,\$CN}$	-2.42	-7.63**
	$P^{C,\$CN}$	-3.00	-6.82**
Barley	$P^{U,\$US}$	1.17	-10.80**
	$P^{U,\$CN}$	-2.76	-7.51**
	$P^{C,\$CN}$	-2.66	-3.30*
Corn	$P^{U,\$US}$	-1.94	-6.10**
	$P^{U,\$CN}$	-3.13	-6.80**
	$P^{C,\$CN}$	-2.69	-4.09**
Oats	$P^{U,\$US}$	-3.27*	-4.22**
	$P^{U,\$CN}$	-3.89**	-9.57**
	$P^{C,\$CN}$	-3.30*	-3.80*
Soybean	$P^{U,\$US}$	-2.49	-6.55**
	$P^{U,\$CN}$	-3.69**	-6.40**
	$P^{C,\$CN}$	-2.74	-8.08**

1. $P^{U,\$US}$ denotes the U.S. prices expressed in \$US.
$P^{U,\$CN}$ denotes the U.S. prices expressed in $\$CN$.
$P^{C,\$CN}$ denotes Canadian prices expressed in $\$CN$.
2. * denotes stationary at the .10 significance level.
3.** denotes stationary at .05 significance level.

Continued-Unit Root Results for Individual Series

Series		ADF-Test Statistic	
		Level	First Difference
Potato	$P^{U,\$US}$	-3.86**	-3.47**
	$P^{U,\$CN}$	-3.49**	-3.17*
	$P^{C,\$CN}$	-3.33*	-9.63**
Calves	$P^{U,\$US}$	-2.92	-6.79**
	$P^{U,\$CN}$	-1.62	-6.93**
	$P^{C,\$CN}$	-1.27	-7.54**
Cattle	$P^{U,\$US}$	-3.09	-8.59**
	$P^{U,\$CN}$	-1.02	-7.66**
	$P^{C,\$CN}$	-1.79	-6.75**
Hog	$P^{U,\$US}$	-3.49**	-3.18*
	$P^{U,\$CN}$	-4.80**	-3.29*
	$P^{C,\$CN}$	-4.07**	-6.96**
Lamb	$P^{U,\$US}$	-2.75	-12.92**
	$P^{U,\$CN}$	-3.64**	-12.83**
	$P^{C,\$CN}$	-1.83	-3.90**
Sheep	$P^{U,\$US}$	-2.79	-5.16**
	$P^{U,\$CN}$	-2.62	-3.16*
	$P^{C,\$CN}$	-2.21	-3.46**
Egg	$P^{U,\$US}$	-2.36	-6.68**
	$P^{U,\$CN}$	-3.41**	-7.31**
	$P^{C,\$CN}$	-1.76	-12.03**
Turkey	$P^{U,\$US}$	-0.95	-3.44**
	$P^{U,\$CN}$	-2.31	-3.89**
	$P^{C,\$CN}$	-2.19	-15.57**
Exchange Rate		-0.90	-9.53**

1. $P^{U,\$US}$ denotes the U.S. prices expressed in \$US.
$P^{U,\$CN}$ denotes the U.S. prices expressed in $\$CN$.
$P^{C,\$CN}$ denotes Canadian prices expressed in $\$CN$.
2. * denotes stationary at .10 significance level.
3.** denotes stationary at .05 significance level.

7.3 Co-integration Results and the LOP

Test results for co-integration between Canadian and the U.S. prices, both expressed in Canadian dollars, are reported in Table 16. For each test, the null hypothesis is no Co-integration and the residuals contain a unit root. Tests are conducted with each U.S. price in Canadian dollar as the dependent variable and Canadian price as independent variable with zero, one, two, three, six and twelve lags. Then, the direction of independent and dependent variables is reversed, by regressing the Canadian price on the U.S. price (in Canadian dollars) with different lag. A dummy variable to capture border restrictions as a result of BSE was included in the calves, cattle, lamb and sheep equations but it was significant only in the calves and cattle equations.

As it can be observed , the unit root tests on residuals from the co-integrating regressions show co-integration for farm machinery, fuel, barley, corn, oats, soybean, potatoes, calves, cattle and hogs in both regression directions. Therefore, for these commodities, non-stationarity of the residual series is rejected. Co-integration for fertilizer, chemical, lamb, sheep and eggs are supported only in one direction. Wheat price shows evidence of co-integration in six and twelve lag models for only one direction. Co-integration is supported for turkey in the three, six and twelve-lag models. Finally, co-integration is not supported for cattle prices between Canada and the U.S., since a unit root cannot be rejected in each case with various lag lengths. In general, except for cattle, it appears that a long-run equilibrium relationship holds for all farm inputs and outputs.

As a final point, it should be noted that the LOP requires not only that the two prices are Co-integrated, but also that the co-integrating parameter should be equal to one in these regressions. Table 17 shows the estimates of co-integrating vectors from the two co-integrating regressions for prices between Canada and the U.S. Based on the provided results, although the hypothesis of complete pass-through cannot be rejected just for agricultural chemicals (1.01), corn (0.98) and soybeans (1.05), the estimated parameter for fuel (0.87), wheat (0.80),barley (0.88), calves (0.82) and hogs (0.81) are close enough to unity at least in one of the directions to provide evidence in favour of the LOP. However, the estimated co-integration parameter for fertilizer (0.62), oats (0.71), potatoes (0.34), cattle (0.47), sheep (0.41) and eggs (0.55) are somewhat far from one, suggesting the long-run relationships between the levels of these prices are less than proportional and therefore pass-through is incomplete for these commodities. The hypothesis of zero pass-through cannot be rejected for farm machinery (0.22), lamb (0.01) and turkey (-0.03), supporting zero pass-through for these products.

Table 16: Co-integration Test Results

Commodity	Dependent Variable: $P^{U,\$CN}$, Regressor: $P^{C,\$CN}$						Dependent Variable: $P^{C,\$CN}$, Regressor: $P^{U,\$CN}$					
	Lag Length of Regressor						Lag Length of Regressor					
	0	1	2	3	6	12	0	1	2	3	6	12
Fertilizer	-3.21*	-3.41**	-3.22*	-3.26*	-3.25*	-3.19*	-2.71	-2.47	-2.37	-2.72	-2.51	-3.00
Chemical	-0.95	-0.94	-1.06	-1.12	-1.21	-1.35	-3.45**	-3.07	-3.24*	-3.40**	-3.74**	-3.68**
Machinery	-3.74**	-4.07**	-4.05**	-4.00**	-4.11**	-4.06**	-4.00**	-3.68**	2.91	-2.51	-2.74	-2.16
Fuel	-4.39**	-2.62	-4.42**	-4.37**	-4.51**	-4.38**	-2.44	-2.42	-3.06	-3.14*	-3.20*	-3.26*
Wheat	-1.43	-1.44	-1.59	-1.83	-3.56**	-3.35*	-1.98	-1.58	-1.32	-1.58	-1.34	-1.98
Barley	-3.79**	-3.77**	-3.76**	-3.79**	-3.64**	-3.68**	-3.73**	-3.49**	-3.14*	-3.12*	-3.35*	-3.20*
Corn	-6.57**	-3.15*	-2.63	-2.58	-2.48	-5.03**	-5.97**	-2.62	-2.88	-2.62	-3.18*	-4.50**
Oats	-5.73**	-3.30*	-3.50**	-3.20*	-3.27*	-5.25**	-5.53**	-5.27**	-4.94**	-4.78**	-4.85**	-5.08**
Soybean	-5.78**	-5.74**	-6.07**	-5.30**	-6.06**	-5.74**	-5.27**	-5.60**	-5.90**	-5.45**	-5.32**	-5.08**
Potato	-3.22*	-3.18*	-3.17*	-2.92	-3.04	-4.78**	-3.47**	-4.03**	-3.74**	-3.76**	-3.60**	-9.19**
Calves	-11.28**	-11.25**	-6.89**	-6.90**	-11.17**	-7.44**	-7.72**	-7.63**	-7.55**	-7.44**	-6.89**	-8.42**
Cattle	-3.80**	-3.49**	-3.43**	-3.47**	-3.55**	-3.36*	-8.51**	-8.74**	-8.57**	-8.56**	-8.44**	-8.15**
Hog	-3.33*	-3.86**	-3.13*	-3.08	-3.66**	-3.64**	-3.11*	-3.33*	-3.07	-2.96	-2.84	-2.65
Lamb	-3.68**	-3.66**	-3.62**	-3.72**	-3.99**	-4.34**	-1.71	-1.64	-1.65	-2.15	-1.81	-1.83
Sheep	-2.61	-3.29*	-2.19	-5.06**	-5.32**	-4.50**	-2.20	-2.20	-3.34*	-2.96	-2.10	-2.22
Egg	-3.14*	-3.12*	-3.12*	-2.72	-3.61**	-2.79	-2.46	-2.49	-2.54	-2.10	-2.15	-2.79
Turkey	-2.51	-2.57	-2.42	-2.49	-2.55	-2.06	-2.89	-2.93	-2.95	-3.74**	-3.28*	-3.45**

1. * denotes co-integrated price series at .10 significance level.
2.** denotes co-integrated price series at .05 significance level.

Table 17: Co-integrating Regressions for Prices between Canada and the U.S.

Commodity	Dependent Variable:$P^{U,\$CN}$, Regressor:$P^{C,\$CN}$				Dependent Variable:$P^{C,\$CN}$, Regressor:$P^{U,\$CN}$			
	$\hat{\alpha}$	p-val. for $\alpha = 1$	p-val. for $\alpha = 0$	R^2	$\hat{\alpha}$	p-val. for $\alpha = 1$	p-val. for $\alpha = 0$	R^2
Fertilizer	0.62**	0.00	0.00	0.95	0.51**	0.00	0.00	0.95
Chemical	1.01**	0.90	0.00	0.98	0.23**	0.00	0.00	0.94
Machinery	0.22	0.00	0.18	0.97	0.05	0.00	0.16	0.89
Fuel	0.79**	0.00	0.00	0.99	0.87**	0.00	0.00	0.99
Wheat	0.80**	0.01	0.00	0.44	0.54**	0.00	0.00	0.44
Barley	0.68**	0.00	0.00	0.60	0.88**	0.05	0.00	0.60
Corn	0.70**	0.00	0.00	0.96	0.98**	0.73	0.00	0.96
Oats	0.38**	0.00	0.00	0.91	0.71**	0.01	0.00	0.95
Soybean	1.05**	0.17	0.00	0.97	0.72**	0.00	0.00	0.97
Potato	0.14**	0.00	0.05	0.70	0.34**	0.00	0.00	0.46
Calves	0.72**	0.01	0.00	0.89	0.79**	0.00	0.00	0.66
Cattle	0.29**	0.00	0.00	0.93	0.60**	0.00	0.00	0.84
Hog	0.81**	0.00	0.00	0.97	1.13**	0.00	0.00	0.97
Lamb	0.01	0.00	0.81	0.70	0.02	0.00	0.83	0.65
Sheep	0.41**	0.00	0.00	0.70	0.33**	0.00	0.00	0.82
Egg	0.55**	0.00	0.00	0.59	0.03*	0.00	0.08	0.92
Turkey	-0.03	0.00	0.70	0.55	-0.02	0.00	0.76	0.69

1. * denotes statistically different from zero at the .10 significance level.
2.** denotes statistically different from zero at the .05 significance level.

Comparing the co-integration results and those provided in Table 14 (our base model which is in difference form and the lag length of independent variable is based on AIC) indicates that both models provide evidence in support of LOP and therefore complete pass-through for fuel, wheat, barley, corn, oats, soybean, calves and hog and zero pass-through for lamb. Both models show incomplete pass-through for fertilizer, although the rates are considerably different (0.62 in the co-integration model and 0.36 in the base model). While co-integration results indicate incomplete pass-through for potatoes, sheep and eggs, the base model supports zero pass-through (based on significant coefficients) for these products. On the other hand, the base model shows incomplete pass through (0.45) for farm machinery and complete pass-through for cattle while the estimated co-integrating parameters are 0.22 (insignificant) and 0.47 respectively. The main difference between these two models is related to agricultural chemicals. The base model strongly supports zero pass-through (0.04) for agricultural chemicals while the co-integration results strongly support complete pass through (1.01). The reasonable justification for a higher degree of pass-through in the co-integration results is that this approach is based on long run relationship.

In general, the statistical tests conducted in this study support the LOP for farm outputs such as wheat, barley, corn, oats, soybeans, calves, cattle and hogs, but not for tradable farm inputs (except for fuel), potatoes, lamb, sheep, eggs, and turkey. Considering that Canadian and the U.S. markets have become more integrated under NAFTA, one wonders why the input prices do not fully adjust to changes in the exchange rate. There are some general and specific reasons for the low rates of pass-through in these cases. Considerable transaction costs, which have not been explicitly incorporated in the model, are a large general factor. Transaction costs involves all expenses that occur during the process of shipping a commodity from one place to another, represented as the physical and monetary costs associated with transportation, storage, handling and processing, and delivery. Consequently, complete price parity in traded goods between two markets may be obstructed due to transportation and storage costs, delivery lags, interest forgone, insurance costs, rates of return to arbitragers, tariff and non-tariff barriers, and inefficiencies in the transmission of information.

The other reason is related to the aggregation and index problem. The input prices used in this study are aggregated indexes. For example, the fertilizer indexes are aggregated from prices of different types of fertilizer including nitrogen fertilizer, mixed fertilizer, and potash and phosphate materials. The pesticide indexes are aggregated from prices of herbicides, insecticides and fungicides. If the applied products in Canadian agriculture differ from their U.S. counterparts, the aggregation problem with these indexes may occur and deviation from LOP is expected.

The government regulation on agricultural chemicals trade, which makes it illegal to import formulated product into Canada, but possible for Canadian chemical manufactures to import the active ingredients contained in the formulated product, is as one of the main reasons for price differentials of similar pesticides between dealers in the U. S. and Canada. The exchange rate pass-through on new machinery prices is low because the farmer probably avoids buying in the other country because of the inability to have the machine serviced by the local dealer in the event of a breakdown. There is a similar, but somewhat weaker, story for fertilizer. In this case the local dealer often provides service in terms of timely delivery and occasionally the rental of application equipment. Government regulations may also explain the low rate of pass-through for potatoes, sheep, eggs and turkey. Potato trade with the U.S. is restricted by the Canada/U.S. Management Plan for potato viruses that cause Tuber Necrosis. Following the detection of BSE in Canadian sheep, May 2003, all exports of sheep need Canadian veterinary health certificates. Finally, Canada has import quotas in place for eggs and poultry.

8 Effects of Exchange Rate Changes on Farm Return

Using the exchange rate pass-through estimates, we are now able to evaluate the impacts of exchange rate movements on farm return. Both farm income and production costs are affected by exchange rate movements depending on the degree of ERPT for outputs and inputs respectively. For example if the value of $CDN against $U.S. increases, the price of each output and therefore corresponding income will decrease depending on the degree of ERPT for that product. On the other hand, the production costs will decrease depending on the share of fertilizer, farm machinery, agricultural chemicals and fuel costs in production costs and the degree of ERPT for these inputs. Therefore, the net effects of exchange rate movements on farm return will depend on the magnitude of income and production cost changes. Tables 18 and 19 show monthly and total effects of a ten percent appreciation of the Canadian dollar on wheat, barley, oats, corn and soybeans return, based on the ERPT estimations (significant and insignificant) in the base model and in the twelve months lags model respectively.

As it can be observed from Table 18, based on significant coefficients for pass through, return over cash costs [4] per acre decreases as a result of exchange rate appreciation from 20.68 to 10.49 (49.27 percent) for wheat, from 15.19 to 4.43 (70.83 percent) for barley, from 20.40 to 14.08 (27.45 percent) for oats, from 37.80 to 32.79 (13.25 percent) for corn and from 29.89 to 13.54 (54.70 percent) for soybeans. Based on significant and insignificant coefficients for pass through, it decreases to -5.54 (126.78 percent), -10.82 (171.23 percent), 6.79 (66.71 percent), 20.37 (46.11 percent) and 13.65 (54.33 percent) for wheat, barley, oats, corn and soybeans, respectively. The changes in return over gross revenue are between 1.53 and 7.11 percent depending on the degree of pass-through for each output, the share of tradable inputs in total production costs and their respective pass-through rates. Similar results are shown in Table 19 which is based on the ERPT estimations (significant and insignificant) in the twelve months lags model. Based on significant coefficients for pass through, return over cash costs decreases to 11.49 (44.43 percent), 6.11 (59.77 percent), 14.87 (27.10 percent), 27.92 (26.13 percent) and 8.5 (71.56 percent) for study

[4] Cash costs have been calculated as total costs minus costs related to labour and management , land investment and building depreciation and investment.

crops respectively, while without considering the significance of the estimates, it decreases to -13.69 (166.19 percent), -16.30 (207.3 percent), 1.74 (91.47 percent), -3.82 (110.10 percent) and 5.55 (81.43 percent). As it can be observed, a ten percent appreciation of the Canadian dollar has considerable effect on return per acre for the study crops mostly because of high degree of ERPT for outputs and low degree of ERPT for inputs.

Table 18: Farm Return Changes per acre as a result of Ten percent Appreciation of $CDN

Time Period	Commodity									
	Wheat		Barley		Oats		Corn		Soybean	
	Sig.	Insig.	Sig.	Insig.	Sig.	Insig.	Sig.	Insig.	Sig.	Insig.
First Month	0.83	-2.95	0.83	-1.27	-9.70	-9.37	1.28	-3.76	-6.27	-6.15
Second Month	2.35	-0.68	2.35	-3.64	2.35	2.78	3.76	-3.10	-7.66	-7.19
Third Month	0.00	-9.19	0.00	-3.06	0.00	-8.05	-11.75	-12.27	7.66	7.21
Fourth Month	-13.38	-13.38	1.03	-3.05	1.03	1.03	1.70	1.70	-10.09	-10.09
Fifth Month			-14.98	-14.98						
Total Effect	-10.19	-26.22	-10.76	-26.01	-6.32	-13.61	-5.01	-17.43	-16.35	-16.21
Net Return (Before Shock)	-0.07	-0.07	-5.56	-5.56	-0.35	-0.35	-19.46	-19.46	-11.97	-11.97
Net Return (After Shock)	-10.26	-26.29	-16.32	-31.57	-6.67	-13.96	-24.47	-36.89	-28.31	-28.17
Return over Cash Costs (Before Shock)	20.68	20.68	15.19	15.19	20.40	20.40	37.80	37.80	29.89	29.89
Return over Cash Costs (After Shock)	10.49	-5.54	4.43	-10.82	14.08	6.79	32.79	20.37	13.54	13.68
Changes in Return over Gross Revenue (%)	6.22		7.11		4.07		1.53		6.80	

1- Sig. means calculations are based on significant coefficients for pass through in base model.
2- Insig. means calculations are based on significant and insignificant coefficients for pass through in base model.
3- Return calculations for wheat, barley, and oats are based on price, yield and production costs in Sskatchewan in 2007 while for corn and soybean, calculations are based on price, yield and production costs in Manitoba in 2007.

Table 19: Farm Return Changes per acre as a result of Ten percent Appreciation of $CDN

Time Period	Commodity									
	Wheat		Barley		Oats		Corn		Soybean	
	Sig.	Insig.	Sig.	Insig.	Sig.	Insig.	Sig.	Insig.	Sig.	Insig.
First Month	0.80	-4.83	0.80	3.50	-5.39	-4.94	1.24	-4.93	-7.01	-6.88
Second Month	2.03	-0.00	2.03	-4.55	2.03	-3.41	3.25	-3.90	-6.65	-6.14
Third Month	0.00	-10.13	0.00	-9.07	0.00	-1.20	0.00	-9.27	9.34	8.97
Fourth Month	-12.30	-12.11	0.95	-3.54	0.95	-9.71	1.58	2.22	-9.46	-9.46
Fifth Month	0.00	2.76	0.00	-14.07	0.00	2.37	0.00	-7.19	0.00	-5.05
Sixth Month	0.00	-7.26	0.00	-2.75	0.00	-6.28	0.00	7.53	-11.26	-10.92
Seventh Month	0.00	-11.29	25.11	25.61	0.00	13.19	-16.32	-15.53	0.00	-2.32
Eighth Month	0.00	-0.74	0.00	2.47	0.00	-6.96	0.00	-1.12	0.00	3.08
Ninth Month	0.00	3.29	-21.63	-22.25	0.00	3.48	0.00	-1.30	0.00	-3.50
Tenth Month	0.00	-0.47	0.00	1.98	0.00	-8.88	0.00	-8.94	0.00	0.92
Eleventh Month	0.00	3.73	-16.64	-16.21	0.00	2.36	0.00	-0.92	11.97	12.82
Twelfth Month	0.65	1.10	0.65	7.28	0.65	5.14	1.00	10.02	-7.90	-8.06
Thirteenth Month	-0.37	1.61	-0.37	0.11	-3.78	-3.82	-0.58	-8.29	-0.42	2.19
Total Effect	-9.19	-34.37	-9.08	-31.49	-5.53	-18.66	-9.83	-41.62	-21.39	-24.34
Net Return (Before Shock)	-0.07	-0.07	-5.56	-5.56	-0.35	-0.35	-19.46	-19.46	-11.97	-11.97
Net Return (After Shock)	-9.26	-34.44	-14.64	-37.05	-5.88	-19.01	-29.28	-61.08	-33.36	-36.31
Return over Cash Costs (Before Shock)	20.68	20.68	15.19	15.19	20.40	20.40	37.80	37.80	29.89	29.89
Return over Cash Costs (After Shock)	11.49	-13.69	6.11	-16.30	14.87	1.74	27.92	-3.82	8.5	5.55
Changes in Return over Gross Revenue (%)	5.61		-6.00		3.56		-3.02		8.90	

1- Sig. means calculations are based on significant coefficients for pass through in twelve months lag model.
2- Insig. means calculations are based on significant and insignificant coefficients for pass through in twelve months lag model.

9 Policy Implications

The results of this analysis have several policy implications. The lack of complete ERPT indicates relative prices, production decisions and farm income are impacted by changes in exchange rates. Large increases the value of the Canadian vs. the US dollar have large short-term negative impacts on farm income which become somewhat muted over time. These impacts on the agricultural sector should be included as considerations in the development of macro economic and monetary policy of Canada.

The potential impacts of exchange rate changes on relative prices and farm income suggest that agricultural producers need to be able to anticipate the risks associated with exchange rate changes and develop risk management strategies. Some of the strategies would include hedging, marketing and procurement strategies to mitigate the financial risk associated with exchange rate volatility. The public sector may play a role in the development and extension of these tools for producers.

The lack of ERPT can be symptomatic of the lack of arbitrage opportunities and of the presence of market power in the agricultural sector. For those inputs and output with slow or limited ERPT, there is a need to further explore the reasons for limited ERTP. When these are identified , there may be need for policy action to reduce barriers to trade or to take measures to enhance the competitiveness of the sector. A lack of ERPT also suggests that investment in better provision of price information may be warranted, in part to better measure ERPT but also to identify opportunities for arbitrage between the markets.

10 Summary and Conclusions

This study investigates the effects of the exchange rate movements on the price behaviour of thirteen agricultural outputs (wheat, barley, oats, corn, soybeans, potatoes, calves, cattle, hogs, lamb, sheep, eggs and turkey) and four inputs (fertilizer, agricultural chemicals, fuel, and farm machinery) in the U.S. and Canadian markets by examining the empirical validity of the Law of One Price (LOP).

After a brief introduction, Section 2 provided an overview of the existing empirical studies which are closely related to the LOP in the U.S. and Canadian agricultural trade markets. The theoretical framework to analyze the exchange rate effects on prices and production was presented in Section 3. Appreciation of Canadian dollar would decrease farm output prices, but its impact on supply also depends on input price changes. Considering that some inputs are not traded, and that traded inputs do not exhibit complete exchange rate pass-through, supply would be determined by a combination of factors including the elasticity of the supply curve, the share of traded inputs costs in total production costs and the demand elasticity for these inputs. In Section 4, econometric models for testing the LOP were developed based on Carter et al's paper (1990). After a brief explanation about the data, their sources and the study period in Section 5, the estimation results for major tradable outputs and inputs in short run (three months lags), intermediate run (six months lags) and medium run (twelve months lags) models as well as the base model, in which the lag length of independent variable is determined based on AIC, were presented in Section 6.

In Section 7, the empirical analysis was extended to consider the stationary properties of the time series used in estimation. Long run rates of pass-through were estimated using a co-integration approach. In general, the statistical tests conducted in this study supported the LOP for farm outputs (wheat, barley, corn, oats, soybeans, calves and hogs) but not for tradable farm inputs (fertilizer, agricultural chemicals and farm machinery). The aggregation problem related to the price indexes and government regulations were discussed as the reasonable explanations for low rates of pass-through for agricultural inputs. Then, based on exchange rate pass-through estimations, the impacts of exchange rate movements on farm return were evaluated in Section 8. Based on the estimated coefficients for pass through in the base model, return over cash costs per acre decreases as a result of a ten percent appreciation of the Canadian dollar from 20.68 to -5.54 (126.78 percent) for wheat, from 15.19 to -10.82 (171.23 percent) for barley, from 20.40 to 6.79 (66.71 percent) for oats, from 37.80 to 20.37 (46.11 percent) for corn and from 29.89 to 13.65 (54.33 percent) for soybeans. The changes in return over gross revenue are between 1.53 and 7.11 percent depending on the degree of pass-through for each output, the share of tradable inputs in total production costs, and their respective pass-through rates. Finally, policy recommendations were discussed.

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APPENDIX

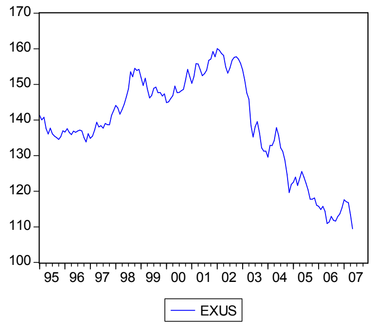

Figure 1: The Nominal Exchange Rate between Canada and the U.S.

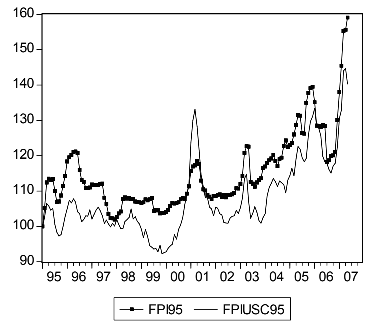

Figure 2: Price Index for Fertilizer in Canada (FPI95) and U.S. (FPIUSC95), 1995=100

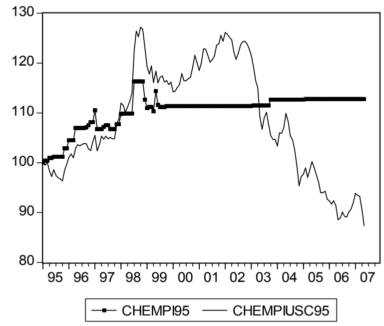

Figure 3: Price Index for Agricultural Chemicals in Canada and U.S. , 1995=100

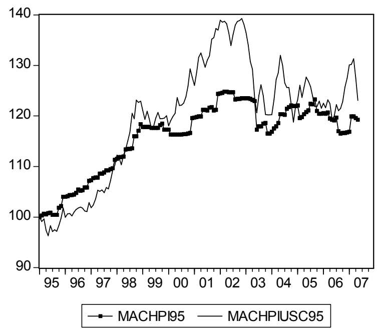

Figure 4: Price Index for Farm Machinery in Canada and U.S. , 1995=100

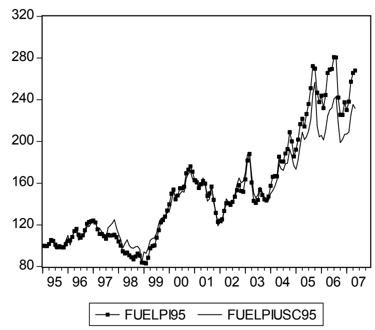

Figure 5: Price Index for Fuel in Canada and U.S. , 1995=100

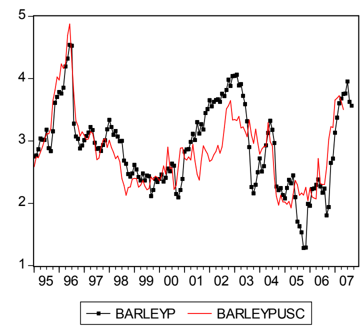

Figure 7: Barley Price in Canada and U.S. in Canadian Dollar

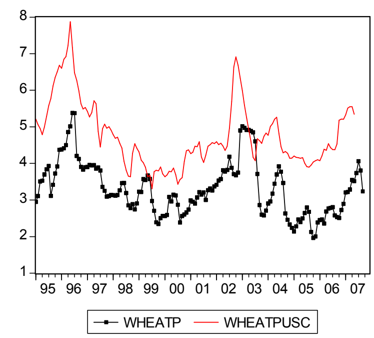

Figure 6: Wheat Price in Canada and U.S. in Canadian Dollar

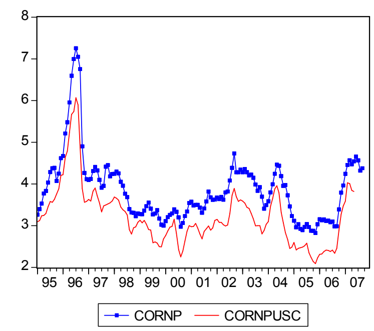

Figure 8: Corn Price in Canada and U.S. in Canadian Dollar

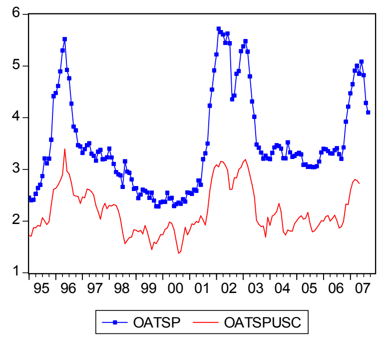

Figure 9: Oats Price in Canada and U.S. in Canadian Dollar

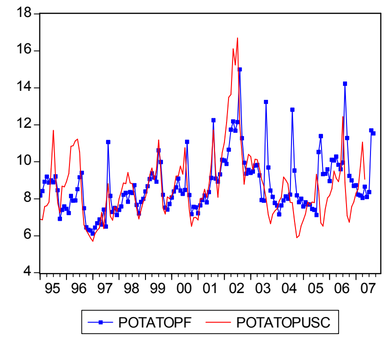

Figure 11: Potato Price in Canada and U.S. in Canadian Dollar

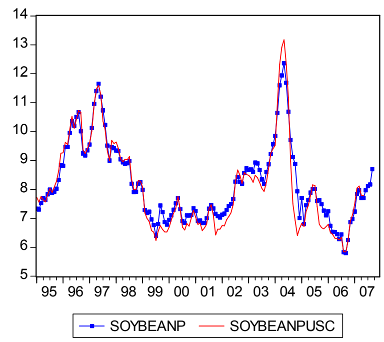

Figure 10: Soybean Price in Canada and U.S. in Canadian Dollar

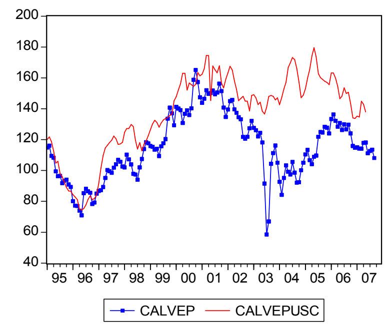

Figure 12: Calve Price in Canada and U.S. in Canadian Dollar

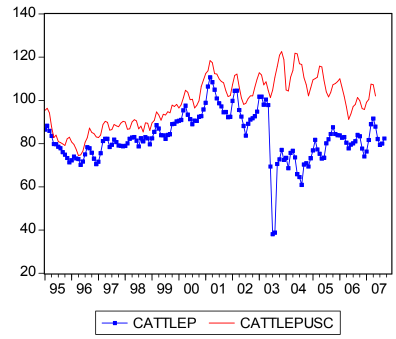

Figure 13: Cattle Price in Canada and U.S. in Canadian Dollar

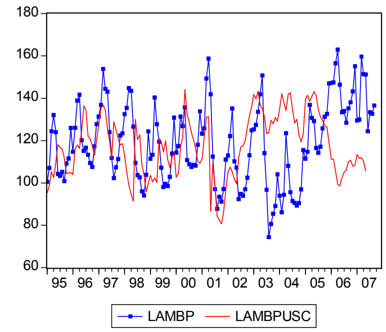

Figure 15: Lamb Price in Canada and U.S. in Canadian Dollar

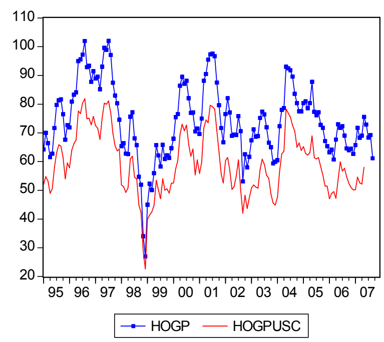

Figure 14: Hog Price in Canada and U.S. in Canadian Dollar

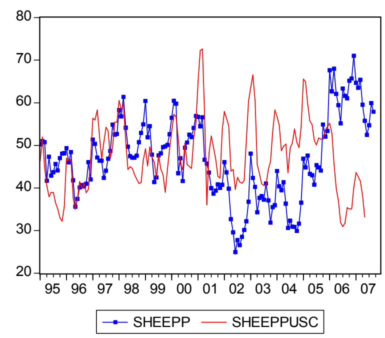

Figure 16: Sheep Price in Canada and U.S. in Canadian Dollar

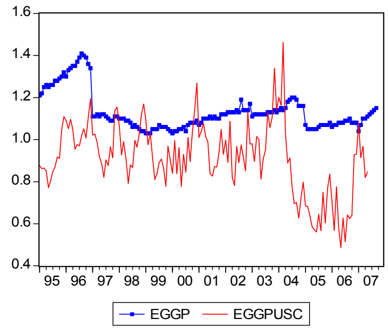

Figure 17: Egg Price in Canada and U.S. in Canadian Dollar

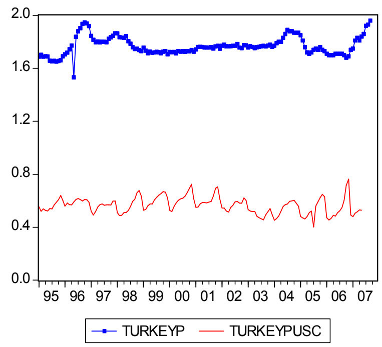

Figure 18: Turkey Price in Canada and U.S. in Canadian Dollar