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PRICE TRANSMISSION IN CANADIAN FRESH FRUIT MARKET: A TIME SERIES ANALYSIS

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Abstract:

Price transmission in vertically linked agri-food markets received considerable attention in recent years. An attempt is made in this article to investigating the nature of price transmission in the Canadian apple and orange markets. Monthly import and retail prices of apples and oranges in Canada from 1996 to 2017 are used to examine the direction, speed, and magnitude of price transmission in two fresh fruits market employing cointegration and error correction modelling. The results reveal that for each commodity, there is only one long-run relationship between the upstream and downstream prices. In each case, import price influences the price at the retail level. Our results also demonstrate that there is asymmetric price transmission for apples in Canada. The margin is corrected more rapidly when it is squeezed than when the margin is expanded.

Keywords: Price transmission, asymmetric, apples, oranges, error-correction modelling, Canada.
JEL Codes: Q130, Q170, F140

1. Introduction

The latest Food Guide of Canada attaches significant importance to fresh fruits and vegetables as part of a healthful diet. Fresh fruits and vegetables contain nutrients including vitamins A and C, potassium, and magnesium, which provide many health benefits (Health Canada 2019). Since older adults, in general, are at heightened risk of cardiovascular diseases, as more Canadians get into the ripe age, increased consumption of fruits and vegetables would have many desirable social outcomes. During the last fifteen years, there has been a sustained increase in health concerns and consciousness in developed countries. However, these appear to be rather slow in Canada compared to those in the EU as fresh fruit consumption in Canada increased only marginally in the New Millennium (Statistics Canada 2015).

Apples and oranges are the two most important fresh fruits consumed in Canada (Statistics Canada 2016). These fruits are available in all supermarkets and have a relatively long shelf life compared to other fruits such as banana or strawberries. While apples are produced in several provinces, demand always outpaced domestic production. Canada became a large net importer of apples over time. However, for oranges consumed in this country, Canada depends entirely on imports. In the past, both apples and oranges were imported primarily from the United States. The sources of imports are becoming more diverse since the New Millennium.

Due to rapid changes in production, processing, trade and retail sectors of the food industry, issues related to price transmission in vertically linked agri-food commodity markets have attracted significant research interest in the New Millennium. Many studies have demonstrated that an increase in producer price causes consumer price to rise more fully and faster than when producer price falls (Griffith & Piggott 1994; von Cramon-Taubadel 1998; Peltzman 2000; Acosta & Valdes 2014). The magnitude and speed with which price is transmitted between upstream and downstream levels of a market can have significant impacts on welfare distribution among market participants as well as on the competitiveness of the market (Meyer & von Cramon-Taubadel (2004); Acosta & Valdes 2014). The extent and dynamics of price adjustments in the food chain are key indicators of the economic behaviour of various participants in the value chain and the overall functioning of the market (Lloyd 2017). Price transmission analysis often shed new insights into the changing behavior of various market participants in the food value chain and its implications for the distribution of surpluses among different market participants. Therefore, the results of price transmission between upstream and downstream segments of a market can inform policy choices to improve outcomes of the relevant market in the future.

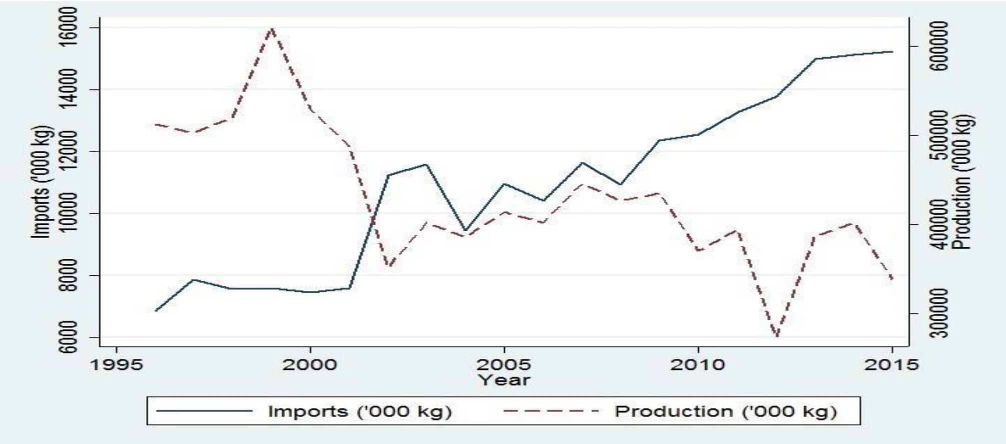
Despite significant economic and political interests in agricultural price transmission in many countries, little work has been done on price transmissions in major fruit markets in Canada. Two previous studies on red delicious apples in the United States revealed asymmetric price responses, where the authors concluded that consumers bear the burden of increasing input costs (Schertz Willett et al. 1997; Hansmire & Willett 1993). A more recent study on vertical price transmission in the apple market in Slovenia found similar results (Hassouneh et al. 2015). Pick et al. (1990) found that there is asymmetric price transmission in the short run for Navel oranges in selected regional markets in the United States.

To the best of our knowledge, no attempt has been made in the past to investigate price transmission in the apple and orange markets in Canada. The primary objective of this paper is to bridge this gap by focusing on price transmission in apple and orange markets in Canada. Apples and oranges are the two most important fresh fruits consumed in Canada throughout the year. Many changes occurred at import and retail levels since the New Millennium. Increased competition at the trade sector due to growing globalization led to reduction in the number of fruit importers and distributors. Mergers in the retail sector of the food market reduced the number of retailers. In some cases, the retail supermarkets are vertically integrated through the distributer. While there are adjustment costs or menu costs at the retail level, the reduction in the number of retailers and importers and their possible vertical integration may have also created a complex market power issue. Asymmetric price transmission between border and retail level, if exists, may also imply that changes in market information do not flow readily to consumers at the retail level. Thus, concentrations at the distribution and retail sectors may have altered the pricing practices and may have compromised consumers benefits from a competitive market system Meyer and von Cramon-Taubadel, 2004). In this paper, we investigate the nature, direction, and speed of price transmission between import and retail prices in the context of a vertically linked market for the selected commodities. The degree with which shocks are transmitted between these two levels will, hopefully, enable us to have a better understanding of the overall functioning of these two fruits market in Canada.

The remainder of the paper is organized as follows. Section 2 describes background information on the Canadian apple and orange markets. Section 3 presents the empirical framework used for price transmission analysis and describes the data and the sources. Section four discusses the empirical results and their implications. The final section highlights the key results and concludes the paper.

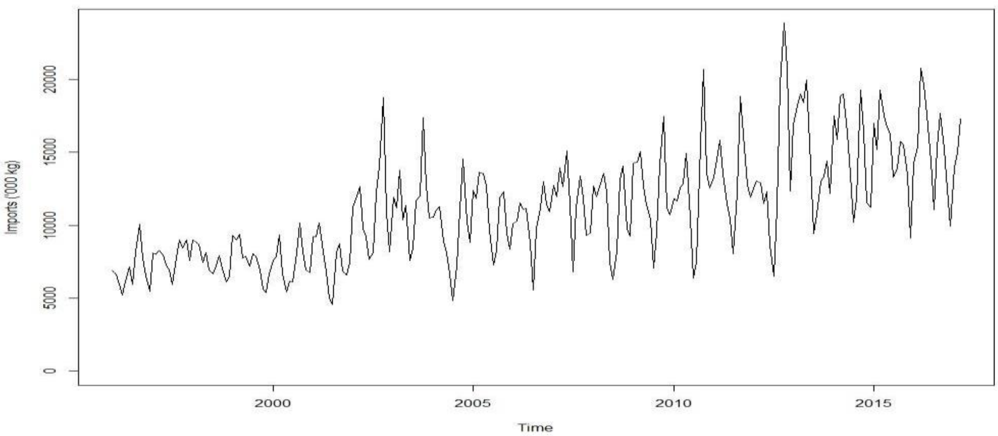
2. The Apple and Orange Markets in Canada

Over the last two decades, Canadian apple production has been steadily declining, while imports from abroad have increased. The United States is Canada's largest supplier of fresh apples at 79%, with the majority coming from Washington State. Chile and New Zealand are distant second and third, representing 13% and 4% of Canada's total fresh apple imports respectively (Agriculture and Agri-Food Canada 2010). Since about 80 percent of imports come from the United States, we decided to examine fresh apples imported from the U.S. to Canada in this study. Figure 1 illustrates the trends of imports and production in the Canadian apple industry. As domestic production of apples in Canada declined from over 600 million kilograms in late 1990s to around 350 million kilograms in 2015, imports of fresh apples from the United States increased steadily from 6 million kilograms in late 1990s to over 160 million kilograms in recent years.



Source: Authors' prepared using data from Statistics Canada.

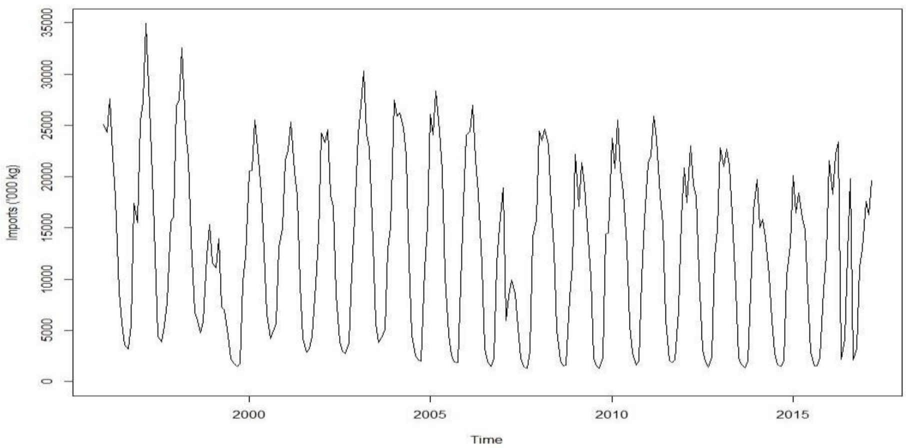
Figure 1. Canadian Production of Apples and Imports from U.S., 1996-2015



Source: Authors' prepared with data from Statistics Canada.

Figure 2. Canadian Imports of Apples from U.S., 1996-2017

The precipitous decline in Canadian apple production can be attributed to frequently changing weather patterns and to changes in relative prices. The rising Canadian dollar may also have made American apples cheaper to purchase in Canada. In addition, there has been a change in consumer trends reflecting a 10% increase in fresh apple consumption by Canadians over the past five years (Agriculture and Agri-Food Canada 2010). Figure 2 shows the level of apple imports from the U.S. over a twenty-year period, indicating a clear upward trend. This is likely due to the rise in healthy living education that encourages people to eat healthier and include fresh fruits and vegetables in their diets. An increase in demand for fresh apples may have increased the amount of fresh apple imports.



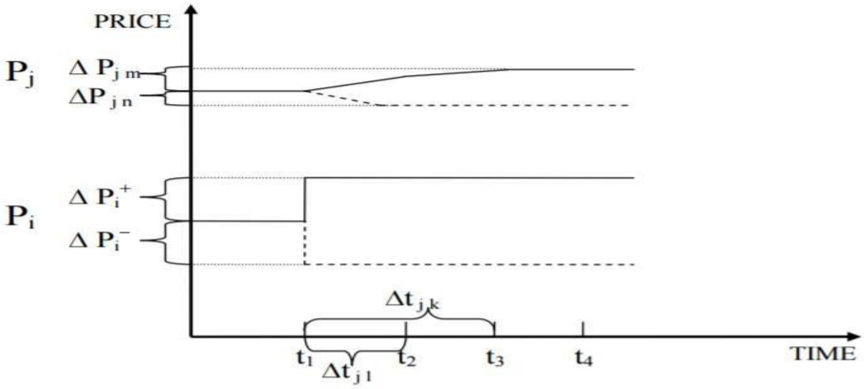
Source: Authors' prepared with data from Statistics Canada.

Figure 3. Canadian Imports of Oranges from U.S., 1996-2017

The United States is also the top exporter of oranges to Canada. The import levels of fresh oranges are illustrated in Figure 3. Orange imports from the United States are influenced by seasonality as import levels are low in the Summer months and high in the Winter months. This could be due to availability of large amounts of local fruits during the Summer, causing a low demand for oranges during this season. Finally, orange imports from the United States appear to have declined over time as imports from other sources became relatively more cost-effective over time.

3. Empirical Methods and Data

To maintain comparability between two fruits considered in study, we concentrate on price transmission between wholesale and retail levels for both apples and oranges. Figure 4 shows shock adjustment down the marketing chain. A price increase at one level has not been fully transmitted up through the supply chain even after several periods. Similarly, in the case of a negative shock, the dotted line shows that the decrease in producer price does not lead to an equivalent change in retail price. These two episodes describe the nature of asymmetric price transmission in fruit markets.



Source: Adapted from Vavra and Goodwin (2005).

Figure 4. Illustration of an Asymmetric Vertical Price Transmission (Two Levels)

It is widely known that many economic time series contain non-stationarity and classical regression analysis can produce erroneous results if this data feature is ignored. To overcome this issue, our price transmission analysis begins with a determination of the univariate property of the price variables. While there are several alternative approaches to determine unit roots, we decided to use the most widely used test, the Augmented Dickey-Fuller test for this purpose. To determine if the price is a random walk with an intercept and a trend or not, we employed the following three regressions. This approach is very similar to the approach used by many others including Acosta and Valdes (2014).

$$\Delta Y_t = \alpha_0 + \gamma Y_{t-i} + \alpha_2 t + \sum_{i=2}^{p} \beta_i \Delta Y_{t-i+1} + \epsilon_t \quad (1)$$

$$\Delta Y_t = \alpha_0 + \gamma Y_{t-i} + \sum_{i=2}^{p} \beta_i \Delta Y_{t-i+1} + \epsilon_t \quad (2)$$

$$\Delta Y_t = \gamma Y_{t-i} + \sum_{i=2}^{p} \beta_i \Delta Y_{t-i+1} + \epsilon_t \quad (3)$$

where α_0, α_2, γ and β_i are the coefficients, t is the time trend variable and ϵ_t is the error term. Equation (1) represents the unrestricted model which includes a constant and a trend variable. Equation (2) has a constant but no trend, and equation (3) represents a random walk model without an intercept and the trend.

After determining the correct model to use, we can assess whether the series contains a unit root or not. As the reliability of the ADF test is highly dependent on the number of lags used, it is important to use the appropriate number of lags. To find the appropriate number of lags for the ADF test, we used Akaike's information criterion (AIC). The null hypothesis of the ADF test states that non-stationarity exists in the series. A rejection of the null suggests that the series is, in fact, stationary. If a price series is nonstationary in its level form but the first-difference price series is found to be stationary, then the price series is said to have a unit root or it is integrated of degree 1.

Once it is determined that the relevant prices contain unit roots, the cointegration analysis can proceed. We decided to employ the Johansen cointegration analysis in this research to determine if there is a stable long-run relationship between the price variables and if it is unique or not. As an alternative to the Johansen cointegration analysis, the Engle-Granger cointegration approach could have been used in this study. Although it is easier to implement, it does not determine the number of cointegrating equations as precisely as Johansen's approach does. Secondly, the Engle-Granger approach relies on the residuals obtained from the first-step regression. Therefore, any error from the first step could carry forward to the second step, making the results of the test less reliable. Finally, Johansen's approach enables us to detect more than one cointegrating relationship in the data. These considerations motivated us to use the Johansen's cointegration analysis in this paper [1].

The basic model employed in Johansen's cointegration analysis for two prices can be represented by the following vector error correction model (VECM):

$$[\Delta\Delta PPA,t\ ] = [\alpha\alpha A]\ (P_{A,-1} - constant - \beta P) + \sum R[\gamma\gamma AABA,,ii\gamma\gamma ABBB,,ii]$$
$$[\Delta\Delta PPAB,,tt--ii] + [\epsilon\epsilon BA,,tt] \quad (4)$$

$B,-1\ i=1\ B,t\ \ B$

where Δ is the first difference operator, t represents time and i is the number of lagged values of the variables included on the right-hand side and ϵ_A and ϵ_B are the error terms. While the parameter to be estimated from the bivariate VEC model are α, β, and γ, the key parameters for the purpose of price transmission analysis are α and β. The long-run cointegrated relationship between the two prices are contained in β. If the model is estimated with log transformed prices, then β would represent the long-run elasticity of price transmission. The term, $(P_{A,-1} - constant - \beta P_{B,t-1})$, represents the long-run equilibrium relationship between the two prices. If the two prices are in equilibrium at each data point, this term will be a null vector; if not, the values will be different from zero. In general, some of the values of this term will deviate from the long-run equilibrium condition. Since the price variables are cointegrated, the system will correct the errors and approach the long-run equilibrium (Johansen 1995; Juselius 2006).

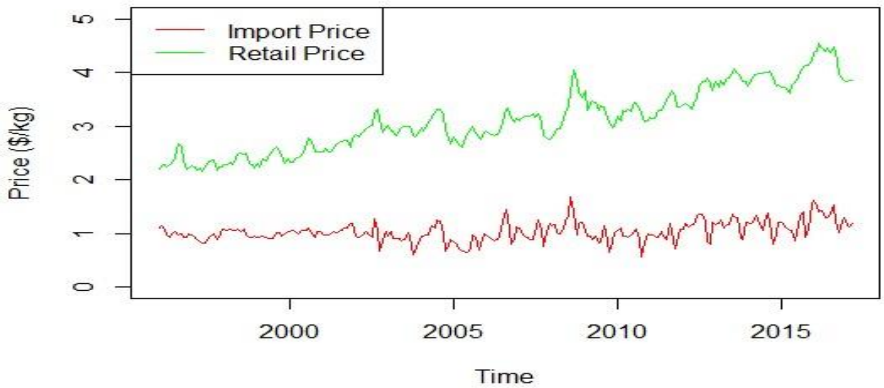
The adjustment parameter, α, measures how rapidly prices respond to correct deviations from the long-run equilibrium. In particular, α_A measures the proportion of any deviation from the equilibrium in last period is corrected by a change in P_A in the current period. Similarly, α_B measures the proportion of any deviation from equilibrium in the previous period will be corrected by a change in P_B.

In the VEC model of two prices, α_A should be less than zero and α_B should be greater than zero to ensure that P and P_B both respond to correct the disequilibrium rather than amplifying it. Moreover, the magnitude of α_A and α_B each should be smaller than one in absolute value and their combined magnitude should not be greater than one (Greb et al. 2013; Jamora & Cramon-Taubadel 2017). The relative magnitudes of α_A and α reveal the extent to which the task of correcting disequilibrium is shared between P_A and P_B. This could also lead to an important economic interpretation. If, for example, P_A is an import price and P_B is the domestic price and if the country in question is a small importing country, then α_A is likely to be insignificant and α_B would be significant. This would also substantiate that the causality runs from the import to the domestic market.

Under Johansen's maximum likelihood cointegration approach, two tests are used to test the rank of a matrix, Π, which is a product of α and β. These tests are known as the maximum eigenvalue test and the trace test (see Johansen (1995) for details). In the context of the price transmission analysis presented in this paper, if both tests reveal that the rank of Π is equal to $n - 1$, then the prices in question are cointegrated. To estimate the elasticity of price transmission in the short-run, we estimated an error correction model using the long-run relationship estimated in the first step as a constraint. The error correction model we used is as follows:

$$\Delta P_{A,} = \beta_0 + \beta_1 \Delta P_{B,t} + \beta_2 ECT_{t-1} + \beta_3 \Delta P_{B,t-1} + \beta_4 \Delta P_{A,t-1} + \epsilon_t \quad (5)$$

where ECT_{t-1} is the vector lagged residuals of the long-run regression from the first step and β represents the elasticity of price transmission in the short-run[2]. This error correction model implicitly assumes that the speed of price adjustment is the same irrespective of rising or falling prices in P_B. However, this may not be the case as demonstrated by Peltzman (2000). An empirical verification of this issue for the relationship for prices of apples and oranges leads us into the analysis of asymmetric price transmission.



Source: Authors' prepared using data from Statistics Canada.

Figure 5. Monthly Data of Apple İmport and Retail Prices ($/kg) in Canada from January 1996 to March 2017

To investigate the presence of asymmetric price transmission, we followed Granger and Lee (1989), and modified the error correction model as follows:

$$\Delta PA, = \beta 0 + \beta 1 \Delta PB,t + \beta 2{+}ECTt{+}{-}1 + \beta 2{-}ECTt{-}{-}1 + \beta 3 \Delta PB,t{-}1 + \beta 4 \Delta PA,t{-}1 + \epsilon t \quad (6)$$

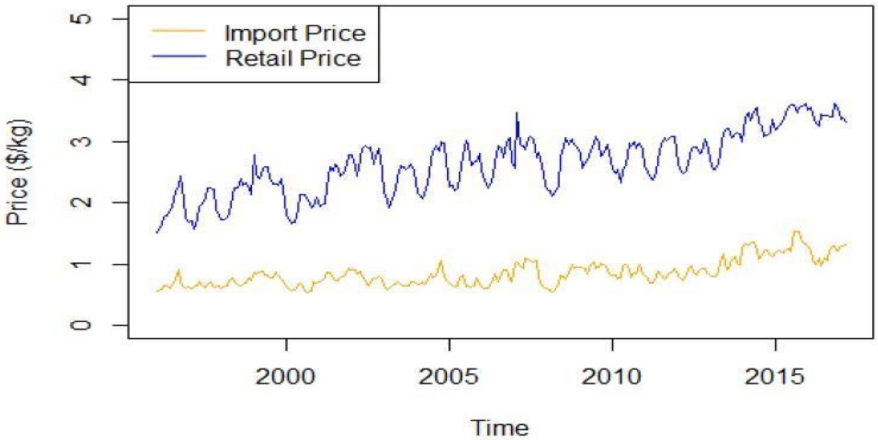
where $ECT = ECT^{+} + ECT^{-}$; β_2^{+} captures the speed of adjustment when P_B is rising while β_2^{-} captures the speed of adjustment when P_A when P_B is falling. All variables and the remaining coefficients are defined as above. The presence of asymmetric price transmission can now be examined by testing the following hypothesis.

$$H_0: \beta_2^{+} = \beta_2^{-}$$

This test reveals if the coefficients of ECT^{+} and ECT^{-} are statistically different from each other. The speed of asymmetric price transmission can also be tested by examining the estimated coefficients of ECT^{+} and ECT^{-}. In particular, when the coefficient of ECT^{+} is greater in absolute value than ECT^{-}, it indicates that P_A reacts faster when P_B increases than when it falls.

We used monthly data from January 1996 to March 2017 (255 observations) to estimate the bivariate VEC model presented in the previous section and to determine the direction as well as the magnitude of price transmission between the import prices and the retail prices of apples and oranges in Canada.

All empirical results have been estimated using STATA 14.0 (2015). It is important to note that different varieties of apples and oranges are imported from the United States and from other countries and are sold in retail outlets in Canada. While it would have been ideal to estimate price relationships between these two levels for each type of apple and oranges and evaluate price transmission of the same quality of apple or orange, it was not possible because of the unavailability of retail prices for different varieties of apples and oranges in Canada. Therefore, the average retail prices and the unit import prices likely reflect different qualities of apples and oranges. This could have an unknown effect on the estimated price transmission elasticities. Assuming that the mix of the varieties or qualities of apples and orange imported in Canada mimic the mix of the qualities of apples and oranges sold in supermarkets, this would not pose a serious issue for the estimated price transmission elasticities.



Source: Authors' prepared using data from Statistics Canada.

Figure 6. Monthly Data of Orange İmport and Retail Prices ($/kg) in Canada from January 1996 to March 2017

Table 1. Summary Statistics of Import Price (IP), Retail Price (RP) and Marketing Margin of Apples and Oranges in Canada

Fruits	Variables	Observ.	Mean	Median	Std. Dev.	Min.	Max.
Apples	IP	255	1.034	1.015	0.181	0.562	1.690
	RP	255	3.113	3.060	0.596	2.160	4.530
	Margin	255	2.080	2.053	0.525	1.087	3.199
	IP	255	0.852	0.801	0.214	0.543	1.543
Oranges	RP	255	2.639	2.630	0.503	1.500	3.620
	Margin	255	1.788	1.818	0.346	0.931	2.479

Source: Authors' calculation.

Table 1 describes the summary statistics of the data. The import price (IP) represents prices of apple and orange imports from the United States to Canada and were obtained from Statistics Canada's Canadian International Merchandise Trade Database (Figure 5). Retail price (RP) is the average price of apples and oranges in food supermarkets across Canada, and were obtained from Statistics Canada, Table 326-0012 (Figure 6). All prices are given in Canadian dollar per kilogram. To gain additional insights about fresh apple and orange markets in Canada, we computed the marketing margin between import and retail prices for both fruits. While both margins have been growing over time during the study period, the margins for apples and oranges were very similar between 1996 and 2009. After 2009, however, the margin for apples increased and continues to be higher than the margin for oranges.

4. Empirical Results and Discussion

Figure 6 shows the monthly data of apple import and retail prices in Canada from January 1996 to March 2017. Non-stationary data are unpredictable and cannot be forecasted. To determine the presence of unit root non-stationarity in prices, the Augmented Dickey-Fuller test was conducted.

A model specification procedure is conducted to identify the equation that best fits the data for the ADF test. The results presented in Table 2 show that the best fit model used for unit root test for the retail prices of apples include an intercept and a linear time trend[3]. For apple import prices, however, the best fit model includes neither an intercept nor a time trend. The best fit model for testing unit roots for both retail and import prices of oranges includes an intercept and a time trend (Table 2).

Table 2. Specification of Appropriate Price Equations for Unit Root Tests

	Models	p	α_0	α_2	γ	β_{t-p}
Apples	$\Delta IP_t = \gamma IP_{t-i} + \sum_{i=2}^{p} \beta_i \Delta IP_{t-i+1} + \epsilon_t$	11	-	-	0.002 (0.58)	-0.96 (0.082)
	$\Delta RP_t = \alpha_0 + \alpha_2 t + \gamma RP_{t-i} + \sum_{i=2}^{p} \beta_i \Delta RP_{t-i+1} + \epsilon_t$	11	0.349* (0.100)	0.001* (0.000)	-0.161* (0.048)	0.190* (0.073)
Oranges	$\Delta IP_t = \alpha_0 + \alpha_2 t + \gamma IP_{t-i} + \sum_{i=2}^{p} \beta_i \Delta IP_{t-i+1} + \epsilon_t$	12	0.089* (0.029)	0.0004* (0.000)	-0.157* (0.049)	0.142** (0.07)
	$\Delta RP_t = \alpha_0 + \alpha_2 t + \gamma RP_{t-i} + \sum_{i=2}^{p} \beta_i \Delta RP_{t-i+1} + \epsilon_t$	11	0.387* (0.122)	0.001* (0.000)	-0.193* (0.063)	0.138*** (0.082)

Source: Authors' calculation.

Note: Standard errors are in parentheses. *, **, and *** indicate significance at 1%, 5% and 10% respectively.

The results of unit root tests for all price series are presented in Table 3. These results demonstrate that all price series are non-stationary in level form but become stationary after differencing once.

Therefore, all prices are integrated of order one. Since both import and retail prices are I(1) processes, we need to determine if there is cointegration or a long-run relationship between these two prices. To test for cointegration, the number of lags must be specified. The AIC method is used to choose the level of optimum lags and it reveals that three lags are optimum for the apple prices.

Table 3. Results of Augmented Dickey-Fuller Test

	Variable	Level Form	Lags	Critical Value (5%)	First-Differenced	Lags	Critical Value (5%)
Apples	IP RP	0.242 -3.399	11 11	-3.431 -3.431	-11.003** -10.400**	4 1	-2.880 -2.880
Oranges	IP RP	-3.222 -3.078	12 11	-3.431 -3.431	-8.169** -11.222**	4 1	-2.880 -2.880

Source: Authors' calculations

Note: ** indicates significance at 5% level. Source: Authors' calculation

Table 4. Results of Johansen's Multivariate Cointegration Analysis

	Null Hypothesis	λ-max test	95% λ-max	Trace Stat	Trace test (95%)	Eigenvalue
Apples	r = 0 r = 1	30.025** 3.328	14.07 3.76	33.353** 3.328	15.41 3.76	0.131 0.012
Oranges	r = 0 r = 1	24.837** 5.683	14.07 3.76	30.521** 5.683	15.41 3.76	0.094 0.022

Source: Authors' calculations

Note: Adjustment matrix for apples: $\alpha = (-0.54, 0)$; Normalized cointegrating vector for apples (RP, IP, constant): $\beta = (1.00, -0.38, 0.40)$; Adjustment matrix for oranges: $\alpha = (-0.12, 0.12)$; Normalized cointegrating vector for oranges (RP, IP, constant): $\beta = (1.00, -1.24, -1.37)$

The results of cointegration analysis for both apple and orange markets are presented in Table 4. Both the trace test and the maximum eigenvalue test demonstrate that there is only one cointegrated long-run relationship between the two prices in the Canadian apple and orange markets. The estimated coefficients of the long-run relationship between retail and import prices for apples demonstrate that the import price is exogenous, and it influences the retail price of apples in Canada. The long-run price transmission elasticity is 0.38. Thus, only a fraction of the change in import price is transmitted to the retail level. The normalized cointegrating vector for the orange market reveals that the long-run price transmission elasticity is 1.24, which is almost four times larger than in the apple market. The estimated loading vectors for both apple and orange markets are consistent with their theoretical properties as indicated earlier; the coefficient for retail price (α) is negative and less than one in absolute value, while that for the import price is positive and less than one. The sum of α_A and α_B is less than one (0.54 for apples and 0.24 for oranges). Finally, in the apple market, the retail price adjusts to correct disequilibrium caused by any external shock and moves the system back towards the steady state long-run relationship. In the orange market, however, both retail price and import price adjust almost equally to correct disequilibrium and bring the system back to the long-run relationship (Table 4).

As the estimated loading vector for the orange market revealed no conclusive direction of price transmission, we decided to employ Granger causality analysis to determine the direction of price transmission. The results presented in Table 5 demonstrate that import price has stronger influences on retail price in both markets. Thus, retail price is used as the dependent variable to display the long-run cointegrated relationship and to estimate the error-correction model for each fruit. We estimate two symmetric and two asymmetric error correction models for each market, one without and the other with centred seasonal dummy variables to investigate if seasonality matters in price transmission in markets for apples and oranges. The results presented in Table 6 reveal that price transmission elasticities are smaller in the short-run for both apples and oranges than their respective long-run counterparts. The coefficients of the ECT_{t-1} are negative and statistically significant, which indicate that the speed at which prices in each model return to respective equilibrium path is rather slow in the short-run. While the speed of adjustment is slow, our results suggest that a change in import price in the current month will have a larger effect on retail prices in the next month.

Table 5. Direction of Price Transmission in Apple and Orange Markets in Canada

Apple Model	**Orange Model**
$RP = 1.344 + 1.711IP + \varepsilon t$ (0.185) (0.177)	$RP = 0.976 + 1.953IP + \varepsilon t$ (0.072) (0.082)
$IP = 0.541 + 0.158RP + \varepsilon t$ (0.052) (0.016)	$IP = -0.083 + 0.354RP + \varepsilon t$ (0.040) (0.015)

Source: Authors' calculation.
Note: Standard errors are in parentheses.

Table 6. Symmetric and Asymmetric Error Corrected Price Transmission Models for Fruits in Canada

	Apples		Oranges	
	Symmetric ECM	Asymmetric ECM	Symmetric ECM	Asymmetric ECM
Constant	0.00191 (0.00196)	0.0207* (0.0053)	0.00146 (0.00349)	0.0536* (0.0114)
ΔIP_t	0.0670* (0.0127)	0.0787* (0.0124)	0.182* (0.0400)	0.185* (0.0402)
ECT_{t-1}	-0.0278** (0.0117)	--	-0.196* (0.0368)	--
ECT^{+}_{t-1}	--	-0.104* (0.0226)	--	-0.221* (0.0391)
ECT^{-}_{t-1}	-	-0.111* (0.0243)	--	-0.223* (0.0397)
ΔRP_{t-1}	0.0937 (0.0629)	0.101 (0.0619)	0.144 (0.0781)	0.154** (0.0767)
ΔIP_{t-1}	0.0740* (0.0135)	0.0511* (0.0142)	0.219* (0.0565)	0.205* (0.0562)
R^2 Adjusted R^2	0.228 0.216	0.268 0.253	0.359 0.348	0.367 0.354
F-statistics Durbin's h-stat JB Normality test z-score $(\sum ECT^{+}_{t-1} = \sum ECT^{-}_{t-1})$	19.66* 3.17 20.65* --	20.45* 1.70 14.08* 3.88*	27.62* 12.24* 135.05* --	22.45* 11.61* 136.7* 1.87***

Source: Authors' calculations
Note: Standard errors are in parentheses. *, ** and *** indicate significance at 1%, 5% and 10% respectively.

Finally, to examine the presence of asymmetric price transmission in the markets for apples and oranges in Canada, we estimated equation 4 and the results are also presented in table 6. The results show that the coefficients of ECT^{+} and ECT^{-} are both significant at 10%. An F-test of the null hypothesis of symmetry ($\beta_2^{+} = \beta_2^{-}$) is rejected for both markets. Thus, the results demonstrate that there is asymmetric price transmission in both apple and orange markets in Canada.

Table 7. Error Corrected Price Transmission Models for Fruits with Seasonality in Canada

	Apples		**Oranges**	
	Symmetric ECM	**Asymmetric ECM**	**Symmetric ECM**	**Asymmetric ECM**
Constant	0.00218 (0.00175)	0.0189* (0.00489)	0.00178 (0.00316)	0.0442* (0.0110)
ΔIPt	0.00523 (0.0184)	0.0105 (0.0184)	0.147* (0.0416)	0.151* (0.0422)
ECTt-1	-0.0228* (0.0107)	--	-0.158* (0.0352)	--
ECT+t-1	--	0.0944* (0.0220)	--	0.181* (0.0371)
ECT-t-1	--	-0.101* (0.0235)	--	0.183* (0.0376)
ΔRPt-1	-0.0449 (0.0637)	-0.0408 (0.0633)	-0.0366 (0.0727)	-0.0266 (0.0716)
ΔIPt-1	0.0665* (0.0124)	0.0463* (0.0134)	0.262* (0.0576)	0.250* (0.0575)
April	--	--	0.0387* (0.0097)	0.0373* (0.0099)
May	0.0226* (0.0051)	0.0224* (0.0051)	0.0548* ((0.0104)	0.0533* (0.0106)
June	0.0204* (0.0051)	0.0220* (0.0049)	0.0577* (0.0116)	0.0568* (0.0117)
July	0.0296* (0.0052)	0.0313* (0.0050)	0.0608 (0.0129)	0.0607* (0.0128)
August	0.0268* (0.0075)	0.0283* (0.0074)	0.0649* (0.0120)	0.0655* (0.0124)
October	-0.0410* (0.0112)	-0.0359* (0.0112)	--	--
R^2 Adjusted R^2	0.396 0.374	0.429 0.406	0.490 0.471	0.496 0.475
F-statistic Durbin's h-stat z score ($\sum ECT_{t-1}^{+} = \sum$ JB Normality test - $ECTt$−−1)	18.48* 1.80 6.75** --	20.88* 0.39 3.15 3.89*	27.18* 6.95* 108.87* --	24.61* 5.78* 136.7* 1.76***

Source: Authors' calculation.

Notes: Monthly dummy variables are centred. Standard errors are in parentheses. *, ** and *** indicate significance at 1%, 5% and 10% respectively.

To investigate if seasonality matters for vertical price transmission in the Canadian apple and orange markets, we estimated equations 5 and 6 with monthly seasonal dummy variables. The results are presented in table 7. The inclusion of seasonal dummy variables improves the overall goodness of fit of both models as reflected in the adjusted R^2 values. Moreover, the residuals from the estimated apple model are now normally distributed and contain no serial correlation. While the residuals of the orange market improve slightly on both dimensions, they are still not free from serial correlation and non-normality. Seasonality matters for both fruit markets in Canada. While the speed of adjustment is reduced with the incorporation of seasonality, the asymmetric price transmission results for the apple market become sharper. The asymmetry in price transmission for the orange market is now significant at 10%. Thus, price transmission in the Canadian apple and orange market is characterized by asymmetry.

What do these results tell us intuitively? Without seasonality, it takes 9.5 months for the prices to return to their equilibrium values after an increase in margin but only 8.9 months after a decrease or squeeze in margin. When seasonality is included in the analysis, the speed of adjustment drops. Consequently, the margin expansion phase lasts for almost 11 months while the margin squeeze phase lasts for only 10 months. The corresponding results for the orange market with seasonality are about 6 months for margin expansion and about 5.5 months for margin squeeze phases. A direct implication of these results is that the benefits of a price drop reach the final consumers only partially and slowly over time. These results are broadly consistent with the findings of von Cramon-Taubadel 1998; Peltzman 2000; Acosta & Valdes 2014. The results are also consistent with those of Schertz et al. 1997; Hansmire & Willett 1993 and Pick et al. (1990). As there has been no major change in policy during the study period, the asymmetric price transmission in apple and orange markets may be due to increased concentration in both upstream and downstream segments of each market and increased adjustment costs in retail distributions. This is an important topic for future research.

5. Concluding Remarks

Price transmission in vertically linked agri-food commodity markets have attracted significant research interest since the mid-1990s. While many agri-food commodity markets in various countries have been investigated, vast majority of the applications focus on grain and livestock commodities and reveal the nature of price transmission in the United States or in the European Union. Only a few studies have focused on the market for fruits and even fewer on price transmission in the apple and orange markets. This study aims to improve our understanding of vertical price relationships in the Canadian apple and orange markets.

We used monthly data from January 1996 to March 2017 and employed cointegration analysis and error-correction modelling to estimate long-run and short-run price transmission elasticities between import and retail prices for the Canadian apple and orange markets. Our key findings are as follows. First, the import price and the retail price are both characterized by unit root non-stationarity. This is true for both apple and orange markets. In each market, both prices are integrated and have a stable long-run relationship. Import prices influence retail prices in each market in the long-run. This is expected because Canada is a small importer for both apples and oranges. The long-run price transmission elasticity is much larger for the orange market than for the apple market. However, in each market, the long-run price transmission elasticity is larger than its short-run counterpart.

Secondly, we find that there is asymmetric price transmission between the import and retail prices. While this is true for both apple and orange markets in Canada, the asymmetric price transmission results are stronger for the apple market. The speed of price adjustment is rather slow in the short-run to correct any disequilibrium. However, it is relatively faster for the orange market than for the apple market. Moreover, significant seasonality influences price relationships in the Canadian apple and orange markets.

Finally, our empirical results suggest that traders may have enjoyed margin expansion opportunities in the apple market slightly longer than similar opportunities in the orange market in Canada. This may partly explain why the margin for apples increased faster than that of oranges in Canada since 2009. While the speed of adjustment is slow, the time difference between margin expansion and contraction phases return to the steady state equilibrium is not more than a month. This may be reflective of the competitive trading environment between Canada and the United States. Future research could focus on price transmission in other commodities and develop a framework to investigate the nature and the drivers of asymmetric price transmission in vertically linked fresh fruit and other agri-food markets in Canada.

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[1] We did, however, use the Granger causality test in this study to determine the direction of price transmission. If this test yields inconclusive results, the alternative is to run regressions on both price series. The regression with the greater coefficient would be considered to be the correct model, and that dependent variable will be chosen accordingly for the next step.
[2] While we obtain the elasticity of price transmission in the short-run and the speed of adjustment, little is revealed about the presence of asymmetric price transmission in the commodity market from this regression.
[3] This is determined by examining the coefficients associated with the constant and trend parameter, which are statistically significant. This means that adding these two variables to the equation will significantly improve the explanatory power of the restricted model (Acosta & Valdes 2014).