Market Integration in the North American Onion Markets: An Empirical Analysis Using Panel Data

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Abstract

This study investigates the level of market integration in the North American Onion Markets. A two-sample period analysis shows an increase in the speed of price convergence overtime, suggesting deeper market integration as NAFTA was fully implemented. Further analysis showed that U.S.-Canadian markets have experienced deeper market integration compared with U.S.-Mexican markets as well as Canadian-Mexican markets.

Key words: market integration, onion markets, panel data, price convergence.

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INTRODUCTION

In the past three decades, the North American agricultural markets have become much more integrated (USDA, 2005). A number of factors have been attributable to this event, including the rapid pace of technological change, Mexico joining the GATT in 1986, shifts in domestic farm policies, the Canada-U.S. Free Trade Agreement (CUSTA), the North American Free Trade Agreement (NAFTA), and multilateral trade negotiations (Vollrath, 2005). Many attribute NAFTA to intensifying the integration process through the establishment of common antitrust and regulatory procedures, harmonization of product standards, and increased coordination of domestic farm market and macroeconomic policies, among others (Rosson, 2005; Zahniser, 2006). All of these factors have deepened market integration and enhanced market efficiency and growth within North America.

Although the North American agricultural markets are more closely integrated, the level of integration varies across sectors and over time (Doan *et al*., 2005; Hahn *et al*., 2005). Differential tariff phasing-out periods and remaining trade disputes are two of many factors contributing to this. Tariff elimination for U.S.-Canada trade concluded on January 1, 1998, but the two countries retain the option to apply temporary safeguards on bilateral trade in selected fruits, vegetables, and flowers until 2008. Numerous trade restrictions between the United States and Mexico and between Canada and Mexico were eliminated immediately upon NAFTA's implementation, while others were phased out over periods of 5 to 15 years. Disputes concerning sugar and sweetener trade have left many formidable trade barriers in place, creating lag of market integration in this sector (Zahniser, 2006).

Market integration as in the NAFTA region is an important issue because it has important implications for economic welfare (Robertson, 2004). Market integration gives countries the advantages of competition and consumers can purchase goods at the lowest possible prices. The U.S. consumers, for example, have enjoyed the benefits of lower cost fruits and vegetables as a result of integration between Mexican and U.S. markets (Knutson and Ochoa, 2004). Information of spatial market integration also facilitates firms to deploy resources more efficiently to provide gains from trade. Based on the information of the extent of market integration, government can formulate policies of providing infrastructure and information regulatory services to avoid market exploitation.

Given the implications of market integration and the fact that it varies across sectors and over time, this paper aims to empirically investigate the level of market integration in the North American onion markets. Furthermore, this paper also attempts to measure whether market integration in the onion markets changes over time. This study focuses exclusively on the onion markets because onions are one of the most traded vegetables within the NAFTA region. Furthermore, the availability on commodity and variety based price data may help controlling for the aggregation effects that can impact convergence estimates. In fact, empirical results reveal that aggregation over onion variety underestimate price convergence. Another feature of this study is the use of panel data analysis. This approach is argued to give advantages over the conventional method that uses bilateral price relationships as an indicator of market integration. For example, panel data analysis provides more observations and accounts for the variation across individuals which improve estimation efficiency. Furthermore, the use of panel data analysis is also argued to improve the power of unit root tests.

MEASURING MARKET INTEGRATION: THE ONION MARKETS

There are different ways to measure market integration, one of which is based on the economic law of one price (LOP) (Moodley *et al*., 2000). According to LOP, markets are considered spatially integrated for a specific good if a causal relationship between prices in different spatial markets can be measured. Market integration means that a measurable long-run relationship exists between spatially separated prices for the same good. Thus, even when prices might temporarily deviate from each other in the short-run, the differentials should eventually converge in the long-run. The speed of price convergence indicates the degree of market integration.

Measure of market integration in this study is based on the convergence equation and the estimation procedure is based on the work of Levin, Lin, and Chu (2002, thereafter the LLC test) and Im, Pesaran, and Shin (1997, 2003, thereafter IPS test) on unit root tests with panel data. The two procedures are used because they are more powerful than the conventional unit root tests, or at least they improve the power of unit root tests. This is because the two procedures provide a larger number of data points and use the variation across individuals which improve estimation efficiency. For example, the fixed effect model captures market fixed effects that account for non-time dependence, transportation costs, and unobserved quality differences (Goldberg and Verboven, 2005). The presence of market fixed effects in the estimation also suggests the relative version of the LOP, which has advantages over the absolute LOP that assumes transaction costs vary proportionately over time. A practical consideration of using these procedures is also proposed by Levin *et al* (2002) that for panel of moderate size (between 10 to 250 individuals with 25-250 observation per individual) the current procedures are more relevant than other procedures.

Following Wei and Parsey (1995) and Solakoglu and Goodwin (2005), this study uses relative prices with New York as the benchmark city. New York is chosen because it represents an onion market that has more international and local price quotes than any other markets in the United States. For example, prices for all onions originating from Mexico and Canada are quoted in New York Markets but not in other markets like Chicago and Philadelphia. Furthermore, prices quoted in New York exhibit the least variability among the ten markets (Table 1). A possible criticism of this approach is that the convergence results are sensitive to the choice of the benchmark city (Wei and Parsley, 1995; Cecchetti et al, 2002; Goldberg and Verboven, 2005). To address this criticism, this study adopts Dallas as an alternative benchmark city. The results were not substantially different from the results with New York as the benchmark city (Table 2).

The LLC test for the North American onion market is carried out by estimating the following equation:

$$(1) \qquad \Delta P_{i,t} = \alpha_{i,k} + \beta_i P_{i,t-1} + \sum_{l=1}^{L_i} \partial_l \Delta P_{i,t-l} + \varepsilon_{i,t}$$

Where $P_{i,t}$ is the log-difference in the price of onion in city *i* relative to benchmark city at time *t*, and Δ is the first difference operator. The lag structure *l* is determined on a variety basis as in a univariate augmented Dicky-Fuller test to account for possible serial correlation. The lag length of *l* is decided based on Bayesian Information Criteria (BIC). Since this study also considers onion variety differences, equation (1) needs to be modified accordingly. The subscripts consist of three components: *i*, *k*, and *t;* which denote market (city), variety (red, white, and yellow), and time, respectively. The primary interest is the coefficient on the lagged log of price differences, β_i which represents the speed of convergence. Under the null of no convergence, β_i is equal to zero for all *i*, suggesting that a shock to $P_{i,t}$ is permanent. That is the LLC test specifies the null hypothesis of H_0 against the alternative hypothesis of H_a as:

$$Ho: \beta_1 = \beta_2 = ... = \beta_N = \beta = 0$$

$$Ha: \beta_1 = \beta_2 = ... = \beta_N = \beta < 0 .$$

To conduct the LLC test, several steps are performed. First, the cross-sectional averages are subtracted from the data to remove the influences of time effects. That is $\overline{P_t} = \frac{1}{N} \sum_i^N P_{it}$. Second, the first difference of relative prices ($\Delta P_{i,t}$) is regressed on its lagged values for each city. Denote the residuals as $\hat{e}_{i,t}$. Third, the lag of relative prices ($P_{i,t-1}$) is regressed on the same variables in the second step to obtain $\hat{v}_{i,t-1}$, the residuals of this regression. Fourth, the residuals $\hat{e}_{i,t}$ are regressed on $\hat{v}_{i,t-1}$ without a constant. The standard error obtained from this regression is then used to normalize $\hat{e}_{i,t}$ and $\hat{v}_{i,t-1}$ for controlling heterogeneity across individuals. Finally, the panel OLS of the normalized residuals is run to obtain the β estimates. That is:

(2) $$\tilde{e}_{it} = \beta \tilde{v}_{i,t-1} + \tilde{\varepsilon}_{it} .$$

Levin *et al* show that under the null hypothesis $H_o : \beta = 0$, the regression t-statistic (t_β) has a standard normal limiting distribution. To obtain a standard normal distribution, Levin *et al* propose to adjust the *t-statistic* (denoted as *t-bar*) using the ratio of long-run and short-run standard deviations (see Levin *et al*, 2003 for detail procedure).

The major limitation of the LLC tests is that β_i is the same for all observations. To relax this assumption, Im *et al* (2002) propose an extension of the LLC procedure by allowing β_i to differ across groups. Therefore, IPS tests the null hypothesis $H_0 : \beta_i = 0$ against the alternative that $H_0 : \beta_i < 0$ for at least one i. Similar to LLC, the *t-statistics* for the IPS can be converted into a standard normal distribution, denoted by *w-tbar*.

The LLC approach provides estimates of speed convergence, which is indicated by estimates of β and their corresponding half-life estimates. Therefore, it is possible to evaluate whether the speed of convergence in prices change over time. In order to do so, the data are split into two periods: from 1998 to 2002 (Period 1) and from 2003 to 2006 (Period 2). The two periods are chosen because the data show that since 2003, onion tariffs have been completely removed under NAFTA agreements. This will enable us to test whether the speed of convergence changes during the two periods. Higher speed of convergence in the later period implies that market integration increases.

DATA

This study utilizes monthly data for the period of 1998 to 2006 covering 10 markets within the NAFTA countries. The 10 markets are Mexico City and Monterrey for Mexico; Quebec and Toronto for Canada; and Chicago, Dallas, Los Angeles, New York, Philadelphia, and Seattle for the United States. Mexico City and Monterrey are chosen because of the availability of the data. The Agricultural Marketing Service (AMS) of the United States Department of Agriculture (USDA) publishes minimum and maximum monthly onion prices in these two markets. This study uses the average of these two prices. Similar reason is applied for Quebec and Toronto markets. The 6 markets of the United States are chosen to represent all markets in the United States considering the geographic location between the United States and Mexico and the United States and Canada. Furthermore, onion prices originating from Mexico and Canada are mostly quoted in these 6 markets. Similar to the Mexican prices, U.S. and Canadian market prices are the average of minimum and maximum prices in each market published by AMS of USDA. It is also important to note that prices for U.S. markets are average prices of onions originated from the United States. Therefore, any onion prices quoted in U.S. markets originated from non-U.S. territory were excluded. A similar approach is used for Canadian and Mexican markets.

Data on prices are available by variety: red, white, and yellow. Reported prices are usually in different units (25 pounds bag, 40 pounds bag, kg, etc). Prices are converted into pound units. The aggregate prices were calculated by taking the average of red, white, and yellow onion prices. Both aggregate and variety based prices are used to estimate price convergence. It should be noted that not all prices by variety are available in each market. In instance where they were available, they did not cover the whole period. For variety based price analysis, therefore, this study uses only prices that span from 1998 to 2006. Furthermore, price convergence for each onion variety is estimated. For this reason, this study may be the first that analyzes market integration in disaggregated data.

Summary statistics of the data are presented in table 1. For the period of 1998 to 2006, average onion prices quoted in Dallas was the highest ($0.31 per lb); while the average onion price in Mexico City was the lowest ($0.18 per lb). One should note, however, that Mexico City’s prices have the highest coefficient of variation, which indicates the highest variation of the ten markets. It is also shown in Table 1 that average prices in period 2 were higher than in period 1, with the exception of Mexico City. The greatest increase in prices from period 1 to period 2 occurred in Montreal, from $0.21 per lb to $0.42 per lb.

Table 1 also displays average prices of onions by variety in the ten markets observed. Red onion prices were the highest with an average of $0.39 per lb in the period of study; nonetheless, they had the least variability as shown by the coefficient of variation. Yellow onion prices, on the other hand, were the lowest with an average of $0.23 per lb.

Table1. Summary Statistics of the Sample Data: Average Onion Prices[a]

Market/variety	1998-2006			1998-2002			2003-2006		
	Avg.	Std.	CV	Avg.	Std.	CV	Avg.	Std.	CV
Chicago	0.30	0.06	0.20	0.29	0.05	0.17	0.32	0.06	0.19
Dallas	0.31	0.07	0.23	0.29	0.05	0.17	0.36	0.06	0.17
Los Angeles	0.26	0.06	0.23	0.25	0.06	0.24	0.27	0.06	0.22
Mexico City	0.18	0.09	0.50	0.19	0.10	0.53	0.17	0.07	0.41
Monterrey	0.27	0.10	0.37	0.27	0.10	0.37	0.29	0.09	0.31
Montreal	0.29	0.13	0.45	0.21	0.06	0.29	0.42	0.11	0.26
New York	0.29	0.04	0.14	0.28	0.04	0.14	0.31	0.04	0.13
Philadelphia	0.28	0.05	0.18	0.27	0.04	0.15	0.29	0.04	0.14
Seattle	0.25	0.07	0.28	0.23	0.06	0.26	0.28	0.13	0.46
Toronto	0.19	0.04	0.21	0.18	0.02	0.11	0.22	0.05	0.23
Red	0.39	0.11	0.28	0.37	0.11	0.30	0.41	0.11	0.27
White	0.35	0.16	0.46	0.33	0.11	0.33	0.38	0.19	0.50
Yellow	0.23	0.10	0.43	0.21	0.09	0.43	0.26	0.11	0.42

[a]Market prices are average prices of red, white, and yellow onions quoted in designated markets (US dollar per pound); red, white, and yellow prices are average prices in all markets; CV is the coefficient of variation, calculated as average prices divided by their standard deviations.

EMPIRICAL RESULTS

Table 2 shows the panel unit root tests based on LLC and IPS for three different periods and four different specifications. Specifications 1 and 2 use relative prices with New York and Dallas as the base, respectively. The two specifications were estimated under the assumption of homogeneity in variety, *i.e.* prices were the average prices of red, white, and yellow onions. Specifications 3 and 4 are similar to the first two specifications; but they consider variety differences. Furthermore, each specification was estimated considering fixed effects only and both fixed effects and time trend.

The estimated of speed of convergence as indicated by β and its half-lives are also presented in table 2. One should note that the estimated β is based on LLC only since the IPS approach does not provide such estimates. The half-lives, representing the time required for the quantity to decay to half of its initial value, are calculated as $-\ln(2)/\ln(1+\beta)$ (See Goldberg and Verboven, 2005). The critical values for *t* and *t-bar* statistics are given in Levin and Lin (1992) and Im *et al* (2003), respectively. *t-star* and *w-tbar* are distributed standard normal under the null hypothesis of nonstationarity. The reported *p-values* are for the *t-star* (LLC) and *w-tbar* (IPS).

As shown in table 2, all point estimates of β are negative as expected and all are significant at 1 percent significance level. Therefore, it is concluded that the LLC and IPS tests reject the null hypothesis of unit roots regardless of the specification or the sample period. This suggests significant relative price convergence for onion in the North American region as represented by the ten markets under study. Since the main interest of this study is on the convergence level and hence the integration level, the next discussion

Table 2. Panel Unit Root Tests for North American Onion Markets

Specification/ Period	Levin-Lin-Chu (LLC)					Im-Pesaran-Shin (IPS)		
	β	*t*	*t-star*	*p-val*	*Half-life*	*t-bar*	*w-tbar*	*p-val*
Specification 1: New York Base, Variety not included								
Fixed effects								
1998 - 2006	-0.25	-12.6	-9.29	0.00	2.41	-4.43	-10.1	0.00
1998 - 2002	-0.28	-10.5	-7.56	0.00	2.11	-3.61	-7.19	0.00
2003 - 2006	-0.33	-9.38	-5.64	0.00	1.73	-3.09	-5.36	0.00
Fixed effects and time trend								
1998 - 2006	-0.31	-14.1	-12.3	0.00	1.87	-4.76	-9.99	0.00
1998 - 2002	-0.32	-11.5	-8.42	0.00	1.80	-3.83	-6.26	0.00
2003 - 2006	-0.38	-10.4	-5.73	0.00	1.45	-3.36	-4.44	0.00
Specification 2: Dallas Base, Variety not included								
Fixed effects								
1998 - 2006	-0.26	-13.4	-10.3	0.00	2.30	-4.69	-11.0	0.00
1998 - 2002	-0.30	-11.6	-8.77	0.00	1.94	-3.92	-8.26	0.00
2003 - 2006	-0.34	-9.66	-5.58	0.00	1.67	-3.15	-5.54	0.00
Fixed effects and time trend								
1998 - 2006	-0.32	-14.9	-13.5	0.00	1.80	-4.97	-10.8	0.00
1998 - 2002	-0.34	-12.6	-9.74	0.00	1.67	-4.14	-7.41	0.00
2003 - 2006	-0.38	-10.7	-5.54	0.00	1.45	-3.42	-5.54	0.00
Specification 3: New York base, Variety included								
Fixed effects								
1998 - 2006	-0.36	-20.7	-16.9	0.00	1.55	-5.45	-20.4	0.00
1998 - 2002	-0.39	-16.8	-12.5	0.00	1.40	-4.35	-14.6	0.00
2003 - 2006	-0.41	-14.1	-9.96	0.00	1.31	-3.61	-10.6	0.00
Fixed effects and time trend								
1998 - 2006	-0.41	-22.4	-22.0	0.00	1.31	-5.77	-20.7	0.00
1998 - 2002	-0.42	-17.6	-12.7	0.00	1.27	-4.49	-13.1	0.00
2003 - 2006	-0.48	-15.6	-10.2	0.00	1.06	-4.00	-10.2	0.00
Specification 4: Dallas base, Variety included								
Fixed effects								
1998 - 2006	-0.30	-18.7	-13.9	0.00	1.94	-4.85	-17.3	0.00
1998 - 2002	-0.31	-14.6	-9.89	0.00	1.87	-3.72	-11.3	0.00
2003 - 2006	-0.35	-12.8	-7.35	0.00	1.61	-3.37	-9.39	0.00
Fixed effects and time trend								
1998 - 2006	-0.34	-20.0	-17.8	0.00	1.67	-5.16	-17.2	0.00
1998 - 2002	-0.36	-16.1	-10.7	0.00	1.55	-4.07	-10.7	0.00
2003 - 2006	-0.40	-13.8	-6.87	0.00	1.36	-3.59	-7.94	0.00

Note: Onion variety includes red, white, and yellow onions. *t star* and *w-tbar* are distributed standard normal.

will focus on the point estimates of β . This discussion is important and meaningful since the test results decisively suggest the existence of price convergence across all markets.

First, consider specifications 1 and 2 that do not include onion variety in the model. The results clearly suggest that the estimated speed of convergence for New York were not substantially different from those for Dallas for the three different sample periods. For the full sample period, for example, estimates of speed of convergence were found to be -0.25 when New York was the benchmark city and -0.26 when Dallas was the benchmark city, giving half-lives of 2.41 and 2.30 months, respectively. The results also show that relative price convergence across cities is faster in period 2. Furthermore, as one would expect, allowing for a trend in the model increases the magnitudes of the β estimates, and in turn, reduces the estimated half-lives.

Second, when onion variety is considered in the model, the results changed markedly. There are two important points in this case. First, higher magnitudes of the β estimates were obtained in all cases as compared with the results that did not account for variety differences, suggesting a faster price convergence across cities and varieties. As shown in table 2 that estimates of half-lives are less than two months, regardless of the specification and the sample period. Second, this study also found that estimates of β are higher in magnitude when New York is the benchmark city than when Dallas is the benchmark city. This indicates that price convergence is faster in the former case than the latter case. Observed estimates of half-lives where New York is the benchmark city are less than those when Dallas as the benchmark city. Clearly, this finding suggests the importance of variety differences in price convergence analysis, particularly in onion markets.

The fact that variety differences does matter is shown by average prices across onion variety. As displayed in Table 1, average prices by onion variety show substantial differences with red onion the highest, followed by white and yellow onions. A further investigation of the data also indicates that substantial differences in average prices across varieties and markets (not reported) are revealed. On the other hand, why the results where New York as the benchmark city gave a faster price convergence could be explained by the fact that New York market is the largest among the ten markets under study; in the sense that New York market quotes the most onion prices, both domestically and internationally. Therefore, higher interaction among different onion prices in both variety and sources may induce faster price convergence as competition increases[†].

Having obtained evidence that the speed of convergence increases when variety is considered in the model, the models were estimated for each onion variety. The results are discussed in the following section.

Table 3 presents panel unit root tests for onions by variety for fixed effects. As shown, the LLC and IPS tests reject the null hypothesis of unit root for each case which suggests the existence of price convergence in the onion markets. In general, the results based on New York and Dallas benchmark cities gave close estimates of speed of convergence. The two base estimates also show similar pattern in the estimates of convergence level between the first and the second periods.

The results for the full sample period indicate that the speed of convergence for red onion is faster than both white and yellow onions. The half-life for red onion is estimated to be approximately 1.73 months for New York benchmark and 1.80 month for

[†] Armed with this finding, we also estimated the models using Los Angeles as an alternative benchmark city. The results show slower price convergence compared with the results when New York is the benchmark city.

Table 3. Panel Unit Root Tests for Relative Onion Prices with New York as the Benchmark City: By Variety and fixed Effects

Variety/Period	Levin-Lin-Chu (LLC)					Im-Pesaran-Shin (IPS)		
	β	*t*	*t-star*	*p-val*	*Half-life*	*t-bar*	*w-tbar*	*p-val*
				Benchmark: New York				
Red Onions								
1998 - 2006	-0.33	-10.8	-8.24	0.00	1.73	-5.27	-10.6	0.00
1998 - 2002	-0.36	-8.85	-6.41	0.00	1.55	-4.13	-7.31	0.00
2003 - 2006	-0.33	-6.89	-3.78	0.00	1.73	-3.51	-5.53	0.00
White Onions								
1998 - 2006	-0.25	-10.0	-6.77	0.00	2.41	-4.28	-8.48	0.00
1998 - 2002	-0.28	-8.20	-5.54	0.00	2.11	-3.59	-6.30	0.00
2003 - 2006	-0.28	-6.37	-3.29	0.00	2.11	-2.57	-3.15	0.00
Yellow Onions								
1998 - 2006	-0.30	-11.2	-8.58	0.00	1.94	-4.77	-9.97	0.00
1998 - 2002	-0.32	-8.91	-6.46	0.00	1.80	-3.71	-6.66	0.00
2003 - 2006	-0.36	-7.92	-5.34	0.00	1.55	-3.39	-5.64	0.00
				Benchmark: Dallas				
Red Onions								
1998 - 2006	-0.32	-10.6	-7.40	0.00	1.80	-5.05	-10.0	0.00
1998 - 2002	-0.34	-8.48	-5.89	0.00	1.67	-3.91	-6.71	0.00
2003 - 2006	-0.33	-6.85	-3.79	0.00	1.73	-3.22	-4.73	0.00
White Onions								
1998 - 2006	-0.29	-10.8	-7.24	0.00	2.02	-4.96	-10.5	0.00
1998 - 2002	-0.31	-8.77	-6.16	0.00	1.86	-4.04	-7.64	0.00
2003 - 2006	-0.28	-6.64	-3.67	0.00	2.11	-3.33	-3.82	0.00
Yellow Onions								
1998 - 2006	-0.30	-11.2	-8.87	0.00	1.94	-4.73	-9.85	0.00
1998 - 2002	-0.34	-9.13	-6.79	0.00	1.67	-3.70	-6.64	0.00
2003 - 2006	-0.36	-7.94	-5.49	0.00	1.55	-3.32	-5.41	0.00

Note: Onion variety includes red, white, and yellow onions. *t star* and *w-tbar* are distributed standard normal.

Dallas benchmark. When comparing the speed of convergence between period 1 and period 2 for the three varieties, interesting results were revealed. For both red and white onions, the convergence is slower in period 2 or at least the same (white onion with New

York benchmark). Conversely, the price convergence in period 2 for yellow onions is faster than in period 1. A possible explanation for this finding is related to the markets that are included in estimation. In the yellow onions, two markets in Mexico (Mexico City and Monterrey) were not included in panel because prices were not quoted in these markets. In the case of red and white onions, on the other hand, at least one market in Mexico was included in panel analysis. Based on these results, it is argued that Mexican markets may have had an impact in the integration process. The integration process in the North American onion markets is faster or higher if Mexican markets were not included in the analysis. Because of this finding the models of convergence equations were estimated using the data that include markets in only two countries. This approach may also be viewed as bilateral price relationship.

Table 4 displays estimates of speed of convergence with three different scenarios related to which countries are included in the model: U.S. and Canadian markets, U.S. and Mexican markets, and Mexican and Canadian markets. Comparing the three scenarios, the results show that the magnitudes of the β estimates within the U.S.-Canadian markets are the highest, followed by the U.S.-Mexican markets and Mexican-Canadian markets. All are statistically significant at one percent level. Therefore, it is argued that onion markets within the U.S.-Canadian markets experienced a deeper integration level compared with both the Canadian-Mexican and U.S.-Mexican. These results are not very surprising given that the United States and Canada have historically engaged longer trade agreements compared with the United States-Mexico or Canada-Mexico. The country's characteristics may also explain why such differences occur. Economically, for instance, the United and Canada are much more similar than Mexico.

The results also show that price convergence in the second period is faster in all cases and the inclusion of time trend in the model increased the speed of convergence as expected.

Table 4. Panel Unit Root Tests for Relative Onion Prices: Variety and Markets

Specification/	Levin-Lin-Chu (LLC)					Im-Pesaran-Shin (IPS)		
Period	β	*t*	*t-star*	*p-val*	*Half-life*	*t-bar*	*w-tbar*	*p-val*
U.S. and Canadian Markets								
Fixed effects								
1998 - 2006	-0.40	-20.6	-17.7	0.00	1.36	-5.52	-19.1	0.00
1998 - 2002	-0.42	-16.4	-12.8	0.00	1.27	-4.33	-13.3	0.00
2003 - 2006	-0.46	-14.2	-10.6	0.00	1.12	-3.65	-10.0	0.00
Fixed effects and time trend								
1998 - 2006	-0.45	-22.3	-23.2	0.00	1.16	-5.78	-19.2	0.00
1998 - 2002	-0.46	-17.4	-13.1	0.00	1.12	-4.50	-12.1	0.00
2003 - 2006	-0.54	-15.9	-11.1	0.00	0.89	-4.07	-9.76	0.00
U.S. and Mexican Markets								
Fixed effects								
1998 - 2006	-0.37	-19.9	-16.3	0.00	1.50	-5.53	-19.7	0.00
1998 - 2002	-0.40	-16.3	-12.2	0.00	1.36	-4.45	-14.3	0.00
2003 - 2006	-0.40	-13.2	-9.32	0.00	1.36	-3.59	-9.99	0.00
Fixed effects and time trend								
1998 - 2006	-0.41	-21.4	-21.1	0.00	1.31	-5.84	-20.1	0.00
1998 - 2002	-0.43	-16.8	-12.2	0.00	1.23	-4.56	-12.7	0.00
2003 - 2006	-0.47	-14.7	-9.54	0.00	1.09	-4.00	-9.66	0.00
Mexican and Canadian Markets								
Fixed effects								
1998 - 2006	-0.26	-8.69	-5.87	0.00	2.30	-4.45	-7.59	0.00
1998 - 2002	-0.31	-7.41	-5.08	0.00	1.87	-3.79	-5.84	0.00
2003 - 2006	-0.32	-6.29	-4.00	0.00	1.80	-3.04	-3.86	0.00
Fixed effects and time trend								
1998 - 2006	-0.32	-9.74	-6.88	0.00	1.80	-5.00	-8.14	0.00
1998 - 2002	-0.32	-7.59	-5.01	0.00	1.80	-3.83	-4.68	0.00
2003 - 2006	-0.36	-6.79	-3.69	0.00	1.55	-3.29	-3.13	0.00

Note: *t star* and *w-tbar* are distributed standard normal.

SUMMARY AND CONCLUSSIONS

The degree of market integration in the North American onion markets is assessed using a panel data analysis. The analysis addresses two important questions: 1) Are onion markets within the NAFTA region integrated? and 2) Is the level of integration changing over time or deepening? The level of integration is analyzed using price convergence equations. Furthermore, the analysis also considers variety differences in the model.

Empirical investigation of market integration in this study is based on price convergence equation in a panel data setting. The Levin, Lin, and Chu (2005) (LLC) and IM, Pesaran, and Shin (2003) (IPS) unit root tests on panel data are used to test the existence as well as the change in the level of market integration. Rejection of the null hypothesis indicates the presence of market integration. The estimates provide the speed of price convergence, and hence market integration. The change in the level of market integration is observed trough estimating the model in two different sample periods. Faster price convergence in the latter period suggests faster and deeper market integration.

Statistical results show that both LLC and IPS tests indicate significant price convergence in the North American onion markets, with an estimated half-life greater than two months if variety was not considered and less than two months otherwise. Furthermore, this study also found that including variety in the panel analysis gave faster price convergence when New York is the benchmark than when Dallas is the benchmark. Therefore, it is argued that variety differences are important in analyzing market integration. The results for sub-samples show that price convergence in period 2 is faster than in period, suggesting deeper market integration in the latter period after NAFTA was fully implemented.

The results based on each onion variety show marked differences. Red onions have the highest convergence level, followed by white and yellow onions with estimates of half-lives of less than two months in all cases. Furthermore, the results for sub-samples show that red and white onions experienced slower price convergence level in the second period. On the other hand, empirical estimates revealed faster price convergence for yellow onions in period 2. These results are best explained by the fact that panel analysis for yellow onions did not include Mexican markets; whereas panel analysis for red and white onions included Mexican markets. In fact, further analysis based on two country market basis supports that U.S.-Canadian markets have deeper market integration compared with U.S.-Mexican markets as well as Canadian-Mexican markets. The long history of U.S.-Canada trade agreements and open borders and transportation ties seem to contribute to these findings.

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