# Testing the Market Integration in Regional Cantaloupe and Melon Markets between the U.S. and Mexico: An Application of Error Correction Model

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**Abstract:**

This paper examines the integration between U.S. and Mexican cantaloupe and watermelon prices using cointegration and error correction model approach. Price relationships are examined in one period and two subperiods: 1996-2006, pre major tariff removal under NAFTA (1996-2002), post major tariff removal under NAFTA (2003-2006). Empirical results indicate long term relationships exist between the price series. Prices are found to be first-difference stationary and cointegrated during all three time periods. Cointegration analysis shows significant post-2002 improvement in market integration, particularly in the speed at which the market adjusts to departures from its long-run equilibrium. The major tariff removal in 2002 increased the market integration of cantaloupe and watermelon markets in the United States and Mexico.

*Keywords*: cointegration, error correction model, Johansen test, market cointegration.

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## INTRODUCTION

In the past three decades, the North American agricultural markets have become much more integrated (USDA, 2005). It is generally accepted that NAFTA intensified the integration process over the last 12 years (Rosson, 2005; Zahniser, 2006). Although the agricultural markets are more closely integrated, the level of integration varies across sectors and over time (Doan et al., 2005; Hahn et al., 2005).

Market integration is an important issue as it affects economic growth, induces structural changes, alters the location of economic activity, and bears upon the viability of small and large agricultural enterprises(Vollrath and Hallahan, 2006)). It is a topic of particular concern to policy makers striving to maximizing economic opportunities and minimizing potential economic conflicts. Consumers benefit from integration as well. Goods available for purchase are at the lowest possibly prices. It is therefore very important to study market integration.

In this study, we focus specifically on regional cantaloupe and watermelon markets in the United States and Mexico and examine the extent to which these markets exhibit cross-border spatial integration based upon the price transmission of shocks across national boundary. The primary objective of this study is to determine the impact of the major tariff removal of the cantaloupe and watermelon trade between the United States and Mexico on the level of market integration using a cointegration and error correction approach. The reminder of the paper is organized as the following. First, a brief overview of the cantaloupe and watermelon markets in the United States and Mexico is provided. Next, data collection and estimating methods are discussed. Then cointegration was tested and the error correction model (ECM) is estimated. Finally, the results are presented and implications of the results are discussed.

## AN OVERVIEW OF THE U.S. AND MEXICAN CANTALOUPE AND MELON SECTORS

The United States is a net importer of *cantaloupe*. During the 1990's, U.S. cantaloupe imports have averaged 24% of supply. Almost all cantaloupe imports enter the United States between November and June. During this period, Mexico is a major supplier. In 2000, Mexico accounted for 27 percent of U.S. cantaloupe imports and was the only source of these imports during June and July (ERS, USDA). U.S. cantaloupe imports from Mexico generally have increased since NAFTA's implementation. Between 1993 and 2000, Mexican cantaloupe exports to the United States increased 99 percent.

Since NAFTA's implementation in 1994, Mexico has supplied 92 percent of U.S. *watermelon* imports. In 2000, U.S. watermelon imports from Mexico equaled 107,821 metric tons, with a value of $48 million. Between 1993 and 2000, U.S. imports of Mexican watermelon increased 122 percent in volume. However, very little U.S. watermelons are exported to Mexico, generally less than 1 percent of the U.S. crop (Zahniser, 2001).

Prior to NAFTA, the United States and Mexico levied various seasonal tariff rates on cantaloupe and watermelon imports. The United States, for example, imposed tariffs varying from 15% to 35%. Under NAFTA, the United States is phasing out its tariff on Mexican cantaloupes and watermelons and Mexico is matching or exceeding the pace of the U.S. phasing-out of its tariffs. The major tariff was eliminated at the end of 2002.

*Cantaloupe*

Prior to 1995, the United States levied a general tariff of 20 percent on cantaloupe during the period of August 1 to September 15 and 35 percent during the rest of the year. However, from the mid-1980's through 1992, the United States frequently exempted fresh cantaloupe imported between January 1 and May 15 from the applicable general tariff. Under URAA, the United States gradually reduced its general tariffs on cantaloupe to 12.8 percent for August 1 to September 15 and to 29.8 percent during the rest of the year. These reductions occurred over the 6-year period that ended on January 1, 2001.

Under NAFTA, the United Sates is phasing out its tariff on Mexican cantaloupes imported during the period from August 1 to September 15. This transition is occurring over the 9-year period that ends on January 1, 2003. The tariffs for May 16 to July 31 and September 16 to November 30 are being gradually eliminated over the 14-year period that ends on January 1, 2008. The tariff for December 1 to May 15 was immediately eliminated on January 1 1994.

Prior to 1994, Mexico levied a 20-percent tariff on imported cantaloupe. Upon NAFTA's implementation, Mexico immediately eliminated its tariffs on U.S. cantaloupe for December 1 to May 15 and for August 1 to September 15. The tariffs for the rest of the year are being gradually eliminated over the 9-year period that end son January 1, 2003.

*Watermelon*

Prior to 1995, the United States levied a general tariff of 20 percent on watermelons. Under URAA, the United States gradually decreased the tariff for

December 1 to March 31 to 9 percent and the tariff for the rest of the year to 17 percent. These reductions occurred over the 6-year period that ended on January 1, 2001.

Under NAFTA, the tariff for the main U.S. production period (May 1 to September 30) is being phased out over the 9-year period that ends on January 1, 2003. The tariff for the rest of the year was removed immediately on January 1, 1994. For the May-September period, the United States introduced a TRQ (tariff rate quota), initially set at 54,400 metric tons for 1994. The quota grows 3 percent over the 9-year transition period and then is eliminated altogether. Over-quota imports from Mexico are subject to the lower of the MFN (most favored nation) rate in place on July 1, 1991, or the current MFN rate.

Before NAFTA, Mexico levied a 20-percent tariff on watermelons. With NAFTA, this tariff is limited to the same period (May 1 to September 30) as the U.S. tariff. The Mexican tariff is to be phased out over the 9-year period that ends on January 1, 2003.

## DATA AND METHODOLOGY

The data used in this study are monthly prices for the period from January 1996 to July 2006. The specific data series for the United States are extracted and complied from various issues of Vegetable and Melons Outlook, which are available at Economic Research Service of the United States Department of Agriculture (ERS/USDA). Mexican prices are collected from the Agriculture & Rural Development Ministry (SAGAR). All U.S. prices are quoted in pounds and converted to equivalent kilogram amounts. All Mexican prices are quoted in Mexican Peso and converted to equivalent U.S. dollar amount with the monthly exchange rate obtained from USDA. All prices are then deflated into real terms.

For the representation of a time series data in an Error Correction Model, cointegration is a necessary and sufficient condition. Prior to testing for cointegration, the price series are first tested for their order of integration, since a necessary condition for cointegration is that the series are integrated of the same order. The augmented Dickey-Fuller (ADF) test is used to test for the order of integration. To test unit root, the ADF test is based on the following regression equation:

$$\Delta Z_{it} = \beta Z + \sum_{i=1}^{m} \delta_i \Delta Z_{i,t-1} + \varepsilon_t \qquad (1)$$

Where

$\Delta$ = the first-difference operator

$\varepsilon$ = a stationary error term.

Table 1 presents the results of ADF unit root tests for each variable. Lag length for the ADF equation is determined using the Aikaike information criterion (AIC) criterion. Unit root cannot be rejected for the level of all the variables at the 5% significance level. The unit root hypothesis is rejected for all variables when they are expressed as first differences at the same significance level. It is reasonable to conclude that price series are integrated of order one or I(1).

Having confirmed that the price data are first-differenced stationary, the analysis is proceed with the cointegration tests using Johansen's maximum likelihood procedure. The Johansen cointegration method used in this study is a multivariate generalization of the Engle-Granger method. The Johansen method was designed to overcome several defects in the Engle-Granger method. Under Johansen's approach, the following systems of vector autoregressive equations are estimated:

$$\Delta P_t = \theta_{0t} + \sum_{i=1}^{k-1} \Gamma_{0i} \Delta P_{t-1} + \eta_{0t} \ , \tag{2}$$

$$P_{t-k} = \theta_{1t} + \sum_{i=1}^{k-1} \Gamma_{1i} \Delta P_{t-1} + \eta_{1t} \ , \tag{3}$$

where $P_t$ is a vector of p time-ordered prices, $\eta_t$ is a p-dimensional vector of random errors, $\Delta$ is the first difference operator, and $\theta$ is the intercept, and $\Gamma$ is p-dimensional vectors and matrices of coefficients to be estimated. The vectors of random errors, $\eta_{0t}$ and $\eta_{1t}$, are then used to construct two likelihood ratio test statistics that are used to determine the number of unique cointegrating vectors in $P_t$. The first test statistics, known as the trace test, evaluates the null hypothesis that there are at most r cointegrating vectors and is represented by

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \ , \tag{4}$$

where $\hat{\lambda}_i$ denotes that p-r smallest canonical correlations of $\eta_{0t}$ with respect to $\eta_{1t}$ and T is the number of observations. The second maximum likelihood ratio test, known as the maximal Eigen value test, evaluates the null hypothesis that there are exactly r cointegrating vectors in $P_t$ and is given by

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \tag{5}$$

Because ln(1) = 0, the expression $\ln(1 - \hat{\lambda}_{r+1})$ will be equal to zero if the prices are not cointegrated. The further the estimated characteristic roots are from zero, the larger the $\lambda_{trace}$ and $\lambda_{\max}$ statistics.

**Table 1. Unit room test results using augmented Dickey-Fuller tests**

| | ADF test statistics | |
|---|---|---|
| Variables | Levels | First Difference |
| USPC | -0.8051 | -11.9574* |
| USPW | -1.3036 | -15.0388* |
| MEPC | -0.7692 | -8.38758* |
| MEPW | -0.3803 | -12.8115* |

* Indicates rejection of null hypothesis of non stationarity or unit roots at 5% significance level. Critical value is -2.98.
USPC = U.S. Cantaloupe price ($/kg)
USPW = U.S. watermelon price ($/kg)
MEPC = Mexico cantaloupe price ($/kg)
MEPW = Mexico watermelon price ($/kg)

## ESTIMATION AND RESULTS

Before estimating the error correction model, it is very important to determine the position of the constant term because the asymptotic distribution of the test for cointegration changes depending on the assumptions regarding constant term. In this study, the position of the constant term is determined following the test developed by Johansen (1992). The test results indicate the necessity of incorporating an intercept in the cointegrating vector.

As shown in table 2 and table 3, both trace tests and eigenvalue reject the null hypothesis of no cointegrating vectors at 5% and/or 10% significance level, but these statistical tests fail to reject one or fewer cointegrating vectors at the same significance level for the entire time period from 1996 to 2006. For the two sub-periods of each product, before and after 2002 when the major tariffs for melon and cantaloupe were eliminated, same conclusions are drawn except for the cantaloupe price prior 2002. Both trace test and eigenvalue fail to reject the hypothesis of no cointegrating vectors at 5% and 10% significance level.

**Table 2. Trace test and maximum eigenvalue on number of cointegrating vectors, r, for the entire series from 1996 to 2006**

| Variables | Null hypothesis | Trace statistics | 95% critical value | Maximum eigenvalue statistics | 95% critical value |
|---|---|---|---|---|---|
| USPC and MEPC | r = 0 | 24.67 | 19.99 | 15.31 | 15.67 |
| | r ≤ 1 | 9.36* | 9.13 | 9.36* | 9.24 |
| USPW and MEPW | r = 0 | 46.74 | 19.99 | 39.30 | 15.67 |
| | r ≤ 1 | 7.44 | 9.13 | 7.44 | 9.24 |

* Fail to reject the null hypothesis at 1% significance level.

**Table 3. Trace test and maximum eigenvalue on number of cointegrating vectors, r, for pre- and post-2002**

| Variables | Sub periods | Null hypothesis | Trace statistics | 95% critical value | Maximum eigenvalue statistics | 95% critical value |
|---|---|---|---|---|---|---|
| USPC and MEPC | 96:1 to 02:12 | r = 0 | 16.69 | 19.99 | 9.30 | 15.67 |
| | | r ≤ 1 | 7.39 | 9.13 | 7.39 | 9.24 |
| | 03:1 to 06:7 | r = 0 | 22.20 | 19.99 | 18.34 | 15.67 |
| | | r ≤ 1 | 3.85 | 9.13 | 3.85 | 9.24 |
| USPW and MEPW | 96:1 to 02:12 | r = 0 | 31.47 | 19.99 | 25.05 | 15.67 |
| | | r ≤ 1 | 6.42 | 9.13 | 6.42 | 9.24 |
| | 03:1 to 06:7 | r = 0 | 41.54 | 19.99 | 31.83 | 15.67 |
| | | r ≤ 1 | 9.71* | 9.13 | 9.71* | 9.24 |

* Fail to reject the null hypothesis at 1% significance level.

Therefore, it is reasonable to conclude that cantaloupe price and watermelon prices in the United States and Mexico are cointegrated throughout the entire period. Watermelon prices are cointegrated pre- and post-2002 and so does cantaloupe prices after 2002. Although no statistical evidence shows cointegration of cantaloupe prices before 2002, the results presents strong evidence of market integration for post-2002 cantaloupe prices between the United States and Mexico.

Table 4 shows the long-run price transmission elasticities implied in the cointegrating vector. For Watermelon, the price transmission elasticity increased from 0.12 to 2.14 from prior-2002 to post-2002 period, suggesting that market integration significantly increased after the removal of the major tariff for both the United States and Mexico in 2002. During the entire time from 1996 to 2006, however, the price transmission elasticity is only 0.23. Since the cantaloupe data series were tested not cointegrated before 2002, no long-run price transmission elasticity was calculated and reported. The price transmission elasticity is -1.85 and 0.85 for the post-2002 period and the entire time period, respectively. This also suggests a dramatic improvement of market integration in cantaloupe sector after the tariff removal in 2002.

**Table 4. Long-run price transmission elasticities for the entire period and two sub-periods (maximum likelihood estimates of restricted cointegrating relations)**

| | 1996:1 to 2006:7 | | 1996:1 to 2002:12 | | 2003:1 to 2006:7 | |
|---|---|---|---|---|---|---|
| Variables | Cantaloupe | Melon | Cantaloupe | Melon | Cantaloupe | Melon |
| USPC | 1.00 | | - | | 1.00 | |
| MEPC | -0.8474 | | - | | -1.8458 | |
| USPW | | 1.00 | | 1.00 | | 1.00 |
| MEPW | | -0.2313 | | -0.1201 | | -2.1438 |

A very important finding is the statistical significance of the error correction or disequilibria term in corresponding cantaloupe and watermelon equations for different periods shown in table 5 and table 6. This suggests that U.S. and Mexican prices tend to always return to their long-run equilibrium relationships from any deviations in their normal relationships. However, a higher value for the speed of adjustment coefficient during post-2002 period for both cantaloupe and watermelon suggests that the time taken to return to long-run equilibrium is faster during post-2002 than pre-2002 period. Overall, the cointegration results clearly demonstrates that, while integration between U.S. and Mexico cantaloupe and melon markets began to increased after NAFTA in 1996, the removal of major tariffs in 2002 further speed up market integration.

**Table 5. Ordinary least squares estimates of U.S. and Mexican cantaloupe and melon prices using ECM for the entire period and sub-periods**

| Dependent | 1996:1 to 2006:7 | | 1996:1 to 2002:12 | | 2003:1 to 2006:7 | |
|---|---|---|---|---|---|---|
| Variables | ΔUSPC | ΔUSPW | ΔUSPC | ΔUSPW | ΔUSPC | ΔUSPW |
| Intercept | -0.0014 | -0.0012 | | -0.0021 | -0.0002 | 0.0005 |
| | (0.16) | (0.16) | | (0.18) | (0.02) | (0.03) |
| ΔUSPC(-1) | -0.5257 | | | | -0.3925 | |
| | (8.08) | | | | (3.27) | |
| ΔMEPC(-1) | 0.5570 | | | | 0.4116 | |
| | (5.35) | | | | (1.97) | |
| ΔUSPW(-1) | | -0.4446 | | -0.4075 | | -0.4363 |
| | | (6.43) | | (4.42) | | (3.88) |
| ΔMEPW(-1) | | 0.8397 | | 0.8624 | | 0.9307 |
| | | (5.29) | | (4.62) | | (2.67) |
| ECM(-1) | 0.7983 | 0.4649 | | 0.3642 | | 0.6579 |
| | (*9.89*) | (*5.98*) | | (*3.61*) | | (*4.45*) |

Numbers in parentheses are the absolute values of *t*-ratios.

## CONCLUSIONS

This study examines dynamics of the U.S. and Mexican cantaloupe and melon prices using a cointegration and error correction approach. Price relationships are investigated to determine if policy changes in 2002 impacted the degree of integration as measured by prices between the markets of the two countries. The overall results suggest that the U.S. and Mexican cantaloupe and melon prices are cointegrated in a way that they return to their long-run equilibrium from short-term exogenous shocks.

The results also provide evidence of improved market integration during the post-2002 period relative to pre-2002 period. Further investigation reveals that the removal of major tariffs in cantaloupe and melon markets has clearly increased market integrations between the two countries. The U.S. and Mexican cantaloupe and watermelon markets are more closely connected. This implies a quicker adjustment and transmission of price shocks in both spatial and temporal terms. The improved market integration after 2002 may imply that future trade policies in altering cantaloupe and melon prices might have similar effects in either country.

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