Evidence of non-linear price transmission between maize markets in Mexico and the US

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Abstract

The present work provides evidence that non linear co-integration between Mexico and the US maize prices exists, at country and regional level. The models suggest that Mexican prices adjust at changes in US prices. Despite asymmetry was statistically rejected, it is likely that it might occur for thriving parameters different that zero in the error correction term. The results suggest on which way the research might be improved in order to assess such co-integration relationship accurately.

Keywords: **co-integration, asymmetric price transmission, vector error correction model, error correction term, loading parameter, Mexico, US, maize.**

JEL: C32, Q11, Q13

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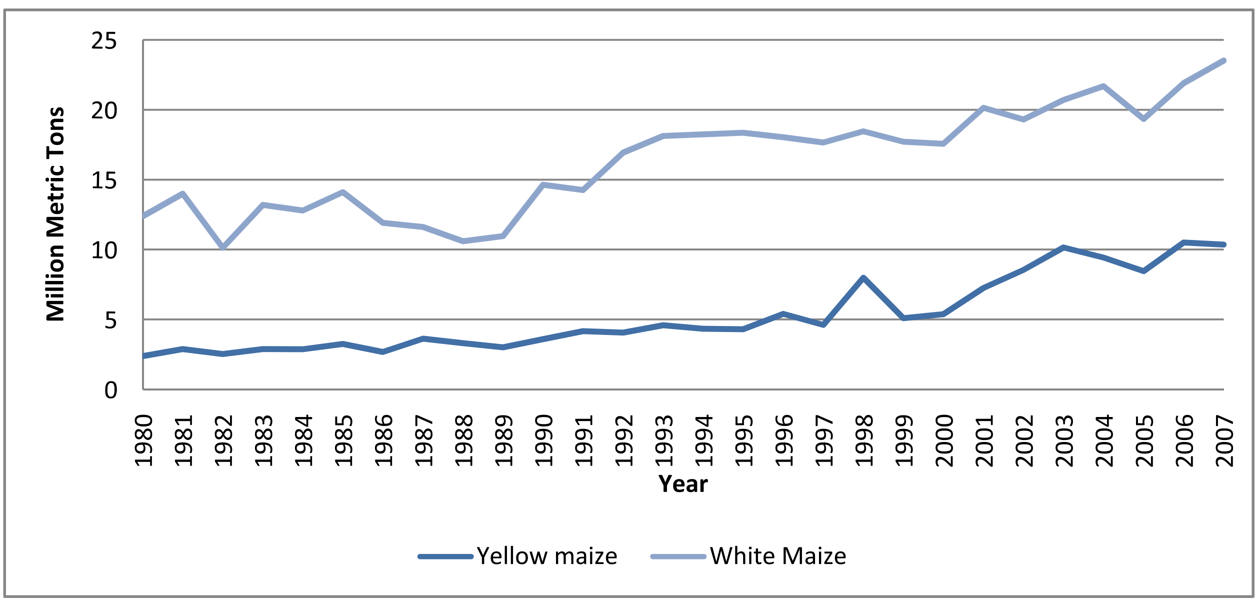
1. Introduction and motivation

Maize is the most important agricultural product in Mexico; it occupies the largest share of cropped area and is the main component of the Mexicans' diet. From the 80's maize imports grew in Mexico in order to satisfy domestic demand, this caused a shift on the Mexican maize market toward an integration with international markets, mainly the US. Today maize imports and exports are exempted from any tariff or quota between Mexico and the US.

Unlike other countries were maize production is regionalized, in Mexico it is spread all over the territory, as for that the production systems differ broadly. For example Fiess & Lederman (2004) distinguish two maize production systems in Mexico: high input (wealthy farmers) and low input (poor farmers). The two major Maize varieties cropped in Mexico are white and yellow, being white maize the most important with over 70% of the total production.

Figure 1. Evolution of maize production in Mexico



Source: SAGARPA

The performance of maize production in Mexico has been shaped by a set of complex events including: the disappearance of the National Company of People´s Subsistence (CONASUPO), a state company that controlled the domestic market for several crops; the shift of land devoted to maize to other crops (fruits and vegetables); the abandonment of land; subsidies; and meteorological phenomena in some cases. Furthermore imports show to be more relevant for the Mexican domestic supply. Over the period 2000-2006, the volume of imports from the US equalled roughly 23% of total domestic maize production (73% of yellow maize production). This highlights Mexico´s dependency on maize imports, mainly yellow maize. Despite both varieties differs on their usage, under some circumstances they are substitutes. Given the high amount of yellow maize imports from the US, one might expect to find co-integration between maize yellow US prices and white maize prices in Mexico. Furthermore, the US yellow maize price is used as the reference price for calculating subsidies to maize producers in Mexico.

There is a strong controversy regarding the effects of maize imports on Mexican production. It is often argued that imports from US have negatively influenced domestic prices and destroyed domestic production systems. Fanjul & Fraser (2003) argue that maize producers' prices in Mexico have fallen due to increasing imports and dumping; this argument is strongly supported by other authors such as Calva (1996), and Vega & Moreno (2007). Furthermore, it is argued that emigration from rural into urban areas and the US was enhanced by income reduction, which was mainly based on maize production (Ritcher et.al., 2005; Yunez-Naude 1998).

Some authors have tried to measure the price relation for maize in Mexico and the US. Fiess & Lederman (2004) found prices in Mexico and the US to be co-integrated (Johansen Test approach); nonetheless other authors such as Araujo-Enciso (2008) & Motamed et.al (2008), have found that the estimated Vector Error Correction Model (VECM) are weak to assert for market integration. Plausible reasons for that is the use of a linear approach. The aim of this paper is to fill the gap in the literature and to test whether US maize prices have an impact on the Mexican maize prices, and to study the study of this impact using time series econometric techniques.

2. Methods

Maize is traded between Mexico and the US under a set of variables, observable and unobservable, that shape the performance of prices. Under many circumstances prices are the unique source of information for markets; therefore the linkage between markets might be measured them.

The previous weak findings of co-integration between maize markets in Mexico and the US, does not necessarily implies no market integration; for instance the assumption of a linear relationship might cause misleading results. The following research is based on the so called Vector Error Correction Model, which considers a linear relationship, and the Asymmetric Price Transmission analysis which allow for a certain type of non-linearity.

2.1 Linear error correction

The approach followed for the first analysis is to use a standard linear vector error correction model (VECM). The endogenous variables are the logarithm of the maize prices for Mexico and the US, denoted as $\mathrm{LogP}_t^{\mathrm{MX}}$ and $\mathrm{LogP}_t^{\mathrm{US}}$ respectively. The linear VECM is:

$$\Delta LogP_t = \Pi LogP_{t-1} + \Gamma_1 \Delta \mathrm{LogP}_{t-1} + \cdots + \Gamma_{k-1} \Delta \mathrm{LogP}_{k-t-1} + \mu + \varepsilon_t \qquad (1)$$

Where Π is a matrix with a rank value of *r*, it goes from *0* to *p*, and denotes the number of long-run relationships. Matrix Π can be decomposed into:

$$\Pi = \alpha\beta' \qquad (2),$$

Being $\boldsymbol{\beta}$ a matrix containing all the long-run relationships parameters, and $\boldsymbol{\alpha}$ the short-run adjustment coefficient or loading factors.

Two variables are said to be co-integrated if they are of order one (I (1)), and they have a linear combination I(0). The Augmented Dicked-Fuller Test (ADF) is used to determine the order of the series, being the null hypothesis a Unit Root (I (1)), versus the alternative of a stationary process (I(0)). . In order to perform the ADF is necessary to include the number of lagged variables, which is selected following the Akaike Info (AIC), and/or Hannan-Quinn (HQC), and/or Schwarz (SC) criterions.

The following step is to test for co-integration between the series. The Johancen Trace (JTT) approach serves for determining the co-integration rank *r*. It tests for the null hypothesis of exactly *r* positive eigenvalues, versus the null hypothesis of more positive *r* eigenvalues. As in the ADF, it is necessary to include the lagged variables following one or more of the three criterions below.

A limitation of the present model is the basic assumption of a unique loading factor among the two variables. For instance some circumstances might cause non linearity behaviour on the model. On the present studies it is considered the so called Asymmetric Price Transmission (APT) as an alternative to improve the results.

2.2 Asymmetric error correction.

When price transmission differs between a positive or negative value on the deviations from the equilibrium, an asymmetric behaviour or process is present (Meyer & v.Cramon-Tabaudel, 2004: 581). Such behaviour might occur either in the long-run equilibrium or the short run adjustment. Following Meyer & v.Cramon-Tabaudel (2004), the model for Asymmetric Price Transmission (APT) in the short run has the following form:

$$\Delta \mathrm{LogP}_t^A = c + \sum_{j=1}^{K} \beta \Delta \mathrm{LogP}_{t-j+1}^B + \phi^+ \mathrm{ECT}_{t-1}^+ + \phi^- \mathrm{ECT}_{t-1}^- + \gamma_t \qquad (3)$$

Were the error correction term (ECT) or long-run equilibrium is first estimated as a simple linear autoregressive (VAR) form with zero lags:

$$\mathrm{LogP}_t^A = c + \beta \mathrm{LogP}_t^B + u \qquad (4)$$

being *u* the deviation between the prices, which is corrected in the short run by the loading factors. Rearranging (4) is obtained:

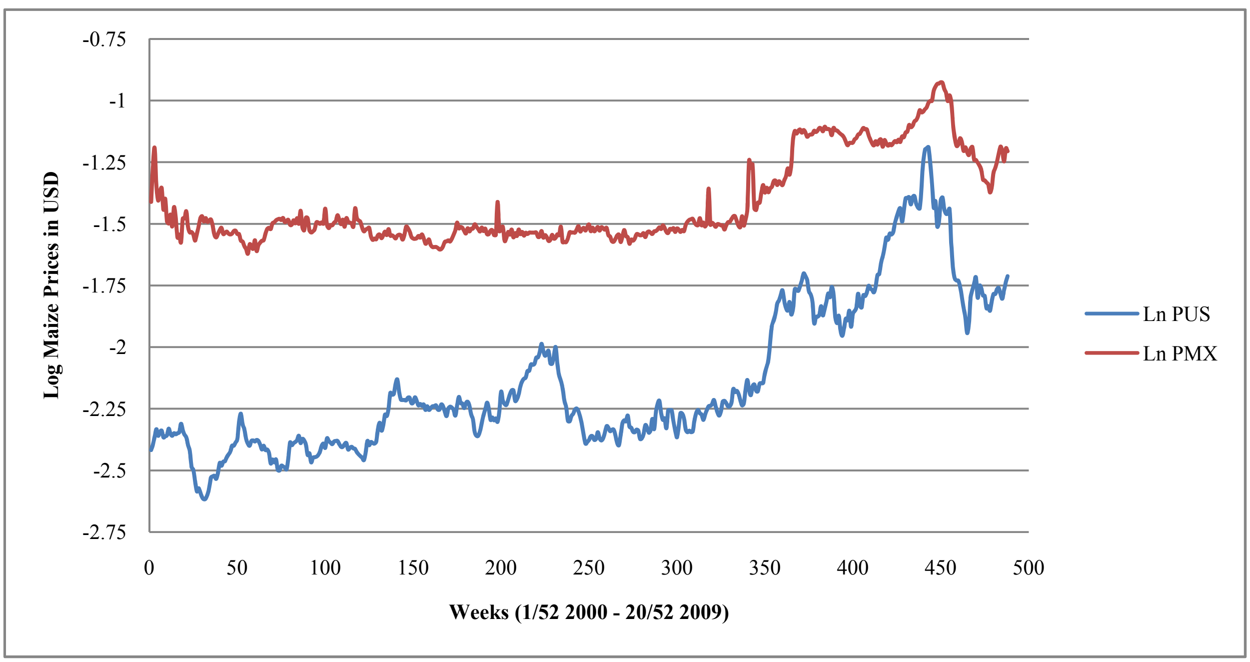
$$\mathrm{ECT} = \mathrm{LogP}_t^A - c - \beta \mathrm{LogP}_t^B = u \qquad (5)$$

Therefore splitting *u* into its positive and negative values is equivalent to separate the ECT. In that regard by doing so is possible to estimate ATP as in equation (3). Although the approach followed by the ATP is different from the VECM, the assumptions of non-stationary (ADF test) and co-integration (JTT approach) must be hold for the pair of series.

3. Data

The Mexican Ministry of Agriculture (SAGARPA) publishes annual average rural prices at the national and regional levels starting from 1980. However, 27 years (observations) is insufficient for carrying out a co-integration analysis. Fiess & Lederman (2004) and Araujo-Enciso (2008) generated monthly prices from these annual series using monthly deflators; however, this method is clearly fraught with difficulties. An alternative is to use consumer level maize prices, collected by the Ministry of Economy (SNIIM). The main concern with such data is that is that consumer prices might differ from processor or producer prices on their performance. Nevertheless, since the data is gathered on a weekly basis at several sales points in the country, from a statistical point of view it might be rich in information. The US maize prices are export prices free on board at the Louisiana Gulf port reported on a weekly basis obtained from the USDA. The data covers the period from the 1st week of 2000 until the 20th week of 2009 (488 observations). The prices are transformed to logarithms in order to interpret the estimated parameters as elasticities.

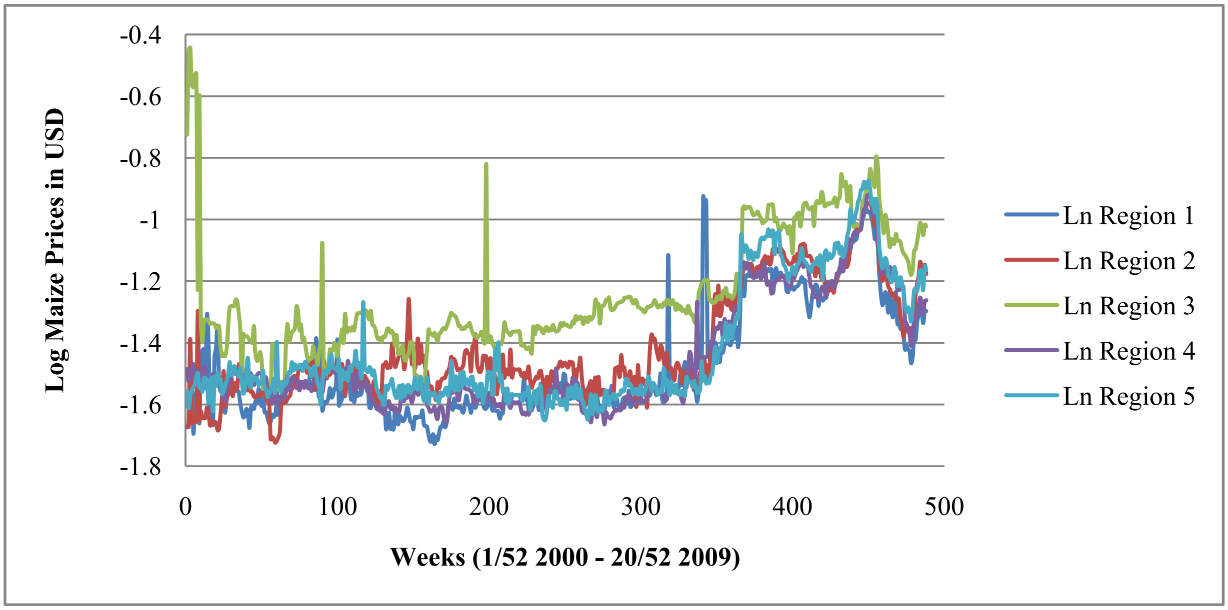
Figure 2. Logarithms of the weekly maize prices Mexico and US



Source: USDA and SNIIM. Prices for Mexico were converted to USD using the weekly average exchange rate from Banxico

Figure 2 shows the aggregated prices at country level for Mexico, and prices for USA. The Mexican average price is gotten from the figures in the thirty two states that compromise the country. As the Mexican Ministry of Agriculture classifies the thirty two states in five geographical regions, the aggregated prices for the five regions were calculated as well (Figure 4).

Figure 3. Logarithms of the weekly maize prices in Mexico by region (2000 week 1 - 2007 week 26)



Source: Prices for were converted to USD using the weekly average exchange rate from Banxico

As Figure 3 shows the performance of the prices among regions is quite different in some periods of time. The major concern of this is that data aggregation leads to loss of information and misleading results in the price transmission analysis as showed by V.Cramon-Taubadel (2006). On that regard, the use of regional data might offer a more reliable result than country level data.

4. Data analysis and results

Results for the ADF test shows that all the times series, except prices for Region III, were unitary root process, either with or without a constant and /or trend (Appendix B). As the estimated models consist on bivariate analysis for each of the six Mexican prices series with the maize prices in the US, for each pair it was performed the JTT (Appendix C). The results exhibit co-integration for all of them except for Regions IV and V, with and without trend. Despite this results it was decided to perform the VECM analysis, its results are shown in Table 1.

Table 1. Estimated long-run equilibrium (ECT) from the VECM

		Model 1 $LogP^{MX}$	Model 2 $LogP^{MX\ I}$	Model 3 $LogP^{MX\ II}$	Model 4 $LogP^{MX\ III}$	Model 5 $LogP^{MX\ IV}$	Model 6 $LogP^{MX\ V}$
$LogP^{US}$	β_1	-0.565***	-0.509***	-0.526***	-0.515***	-0.593***	-0.631***
	test statistics	-9.393	-9.586	-9.684	-7.889	-7.021	-7.943
	$\sigma_{\beta 1}$	0.06	0.053	0.054	0.065	0.084	0.079
Constant	*c*	0.215*	0.382**	0.287**	0.16	0.183	0.069
	test statistics	1.656	3.329	2.442	1.134	1.005	0.402
	$\sigma_{\beta 1}$	0.13	0.115	0.117	0.141	0.182	0.172

Source: own estimations using J-multi software. Prices for Mexico are normalized to one

The results suggest that prices in the US share a common long run relationship with prices in Mexico at country and regional level since the estimated parameters are significant. The estimated β's, values less than one, are interpreted as Mexican prices being greater than US prices.

Table 2. Estimated loading parameters from the VECM

Model	Variable	Loading Parameters		
		α	*test statistics*	$\sigma_{\beta 1}$
Model 1	$\Delta LogP^{MX}$	-0.061***	-4.198	0.015
	$\Delta LogP^{US}$	0.033**	2.160	0.015
Model 2	$\Delta LogP^{MX\_I}$	-0.159***	-5.910	0.027
	$\Delta LogP^{US}$	0.012	0.874	0.014
Model 3	$\Delta LogP^{MX\_II}$	-0.096***	-4.161	0.023
	$\Delta LogP^{US}$	0.042**	2.600	0.016
Model 4	$\Delta LogP^{MX\_III}$	-0.141***	-6.532	0.022
	$\Delta LogP^{US}$	0.021**	2.067	0.01
Model 5	$\Delta LogP^{MX\_IV}$	-0.040***	-3.233	0.012
	$\Delta LogP^{US}$	0.022	1.536	0.014
Model 6	$\Delta LogP^{MX\_V}$	-0.057***	-3.511	0.016
	$\Delta LogP^{US}$	0.023*	1.657	0.014

Source: own estimations using Jmulti software

The loading parameters and trend results (Table 2) suggest that prices for Mexico at country and regional level adjust to the equilibrium, while US prices in some cases do not adjust. With such evidence it might be plausible to say that US prices to some extend are exogenous and not determined by prices in Mexico.

With prices in Mexico as endogenous variable, and price in the US as exogenous variables, it is estimated the long run equilibrium with a VAR model. The results exhibit again prices in the US to be statistically significant, and that prices in Mexico are higher than in the US (Table 3).

Table 3. Estimated long-run equilibrium with VAR

		Model 1 $LogP^{MX}$	Model 2 $LogP^{MX\_I}$	Model 3 $LogP^{MX\_II}$	Model 4 $LogP^{MX\_III}$	Model 5 $LogP^{MX\_IV}$	Model 6 $LogP^{MX\_V}$
$LogP^{US}$	β_1	0.495***	0.49***	0.497***	0.444***	0.502***	0.554***
	test statistics	38.821	32.434	39.27	21.297	36.711	38.855
	$\sigma_{\beta 1}$	0.013	0.015	0.013	0.021	0.014	0.014
Constant	*c*	-0.358***	-0.425***	-0.352***	-0.297***	-0.38***	-0.241***
	test statistics	-13.018	-13.015	-12.897	-6.595	-12.859	-7.823
	$\sigma_{\beta 1}$	0.028	0.033	0.027	0.045	0.03	0.031

Source: own estimations using Jmulti software

In order to estimate the ATP, the residuals from the VAR models are split on positive and negative value. Using the model from equation (3), the new estimation shows the following (Table 4).

Table 4. Estimated loading parameters from the APT

	Variable	ECT^{+}		ECT^{-}	
		Φ^{+}	*Test statistic*	Φ^{-}	*Test statistic*
Model 1'	$\Delta LogP^{MX}$	-0.086***	-4.207	-0.037*	-1.654
Model 2'	$\Delta LogP^{MX\_I}$	-0.217***	-6.185	-0.083**	-2.07
Model 3'	$\Delta LogP^{MX\_II}$	-0.095***	-2.98	-0.098***	-3.051
Model 4'	$\Delta LogP^{MX\_III}$	-0.193***	-7.319	-0.038	-1.015
Model 5'	$\Delta LogP^{MX\_IV}$	-0.047***	-2.615	-0.035*	-1.937
Model 6'	$\Delta LogP^{MX\_V}$	-0.056**	-2.484	-0.061**	-2.475

Source: own estimations using Jmulti software

It is noticeable that the positive adjustment is always significant, while the negative adjustment is not. With such results it is not possible to assert that there is or not asymmetry. For that it was performed an F test comparing the restricted model (VECM) with the unrestricted (APT). The null hypothesis states as "positive and negative adjustments are equal and jointly significant" (Table 5).

Table 5. F-tests for asymmetry

Models compared	*Test Statistics*	*5 % Critical F*
Model 1'(ATP) vs Model 1 (VECM)	2.51	3.84
Model 2'(ATP) vs Model2 (VECM)	6.39**	3.84
Model 3'(ATP) vs Model 3 (VECM)	0.17	3.84
Model 4'(ATP) vs Model 4 (VECM)	10.67**	3.84
Model 5'(ATP) vs Model 5 (VECM)	0.02	3.84
Model 6'(ATP) vs Model 6 (VECM)	-0.30	3.84

Source: own estimations

The results suggest the presence of asymmetries for Models 2 and 4; nonetheless for Model 4, due the fact that the negative adjustment is not significant (Table 4) also the asymmetry is rejected.

5. Discussion

The results from the VECM and VAR/APT suggest that there is co-integration between maize markets in Mexico and the US. Nonetheless some issues should be regarded with more attention before drawing any conclusion.

The long run equilibrium estimated on the VECM and VAR suggest that either at country or regional level prices for Mexico share a common trend with US prices. Nonetheless it is unexpected that VECM suggest US prices also adjust to changes in the Mexican prices. Such event might be quite debatable; despite the fact that Mexico is the destination for 15% of the US maize total exports; the force that drives US maize prices is more likely to be the international market rather than solely the Mexican market. For instance co-integration between both markets might have a non-linear performance. Furthermore as the estimated VECM is bivariate, it neglects the interaction among the five Mexican regions; therefore it is not possible to conclude that the adjustments measured are definitive. Regardless of the previous outcome is important to stress that the VECM suggest that both markets are integrated, either at regional or country level. As for that changes in the US prices will pass to the Mexican counterpart. The evidence for such argument is that adjustment parameters for prices changes in Mexico are significant, even using a level of confidence of one percent; furthermore the speed of adjustment for Mexican prices seems to be greater than adjustments in the US. In that regard the previous assumption of Mexican maize prices being affected or determined by the US markets might be suggested.

The APT results exhibit a weak evidence for asymmetry, only Model 2 can account for real asymmetry. These might be explained on the basis of the estimated VAR. From Table 3 is possible to see the high values of the t-statistics; such values exhibit estimation problems on the parameters, which although not biased might be misleading. Other possible limitation of the asymmetry might deal with the thriving parameter, which for the present research is not estimated but established as zero. There is the necessity to explore if asymmetries occur with other values; on this regard the approach of Goetz & v.Cramon-Taubadel (2008) following Gonzalo & Pitarakis (2006) might be used to estimate a thriving parameter, furthermore such methodology allows for asymmetry in the ECT estimation as well.

Regarding the models in general, there is a main concern; they do not assume any structural break. Such assumption is clearly unrealistic given the results of the stability tests (Appendix E) which shows that both, the VECM and the ECT (VAR), are unstable. Such outcome stresses again the importance of accounting for some non-linearity in the long and short run equilibrium in order to improve the results.

Another limitation of the results has to do with data aggregation. As prices either at country level and regional level are the average of regional prices, the assumption of constant aggregation must be hold in order to get reliable results (v.Cramon-Tabaudel et.al; 2006). Unfortunately for the data the cross sectional aggregation is not constant (Appendix F) therefore to some extend the average prices might not represent the performance of all the states compromising the Regions. As data aggregation causes loses of information, an alternative is modelling with the so called generalized autoregressive conditional heteroskedasticity (GARCH) models, which might capture volatility; nonetheless if the loss is concerning positive and negative changes of two prices averaging, the best option is the use of non-aggregated data. A possible approach to follow is at a first stage measure the co-integration for the markets within the regions, if the estimated parameter of the ECT is equal to one, following the law of the one price (LOP), is possible to take the average of those integrated markets as the regional price; those markets not integrating should be left out.

A final word of caution has to be made regarding the present study. Despite the maize prices used here are at consumer level, maize is not consumed as a grain but as a processed good, mainly as "Tortilla". Indeed more than 50% of the Mexican maize production is devoted for the "Tortilla" industry (Galarza, 2005: 57). Weather such increases might have either a positive or negative effect on the consumers depends on the price transmission from maize to tortilla. The elasticities derived from the previous models might provide some insight of the effects at producers and processors levels, but not for consumers.

6. Conclusion

The present work provides a first insight on the way future research should develop in order to fill the gap in the current literature for maize markets co-integration between Mexico and the US. The relationship among US prices and Mexican prices at different levels is hard to capture by a simple linear model. The results exhibits that there is strong evidence that maize market in Mexico and the US are integrated, and that prices share a common relationship. An accurate measure of such relationship and its dynamics can be drawn with the help of advanced techniques such as thresholds, structural breaks, smoothness, or conditional heteroskedasticity. The advantage of such techniques lays on its non-linear nature.

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Appendix A. Acronyms

ADF. Augmented Dicked-Fuller Test

AIC. Akaike Info Criteria

ATP. Asymmetric Price Transmission

Banxico. Central Bank of Mexico

BLS. U.S. Berau of Labor Statistics.

CONASUPO. National Company of People´s Subsistence

ECT. Error Correction Term

HQC. Hannan-Quinn Criteria

JTT. Johancen Trace Test

NAFTA. North American Free Trade agreement

OLS. Ordinary Least Squares

SAGARPA. Mexican Ministry of Agriculture, Livestock, Rural Development, Fishery and Nourishment

SC. Schwarz Criteria

SNIIM. National System of Markets Information of the Mexican Ministry of Economy.

USDA. United States Department of Agriculture.

VECM. Vector Error correction Model.

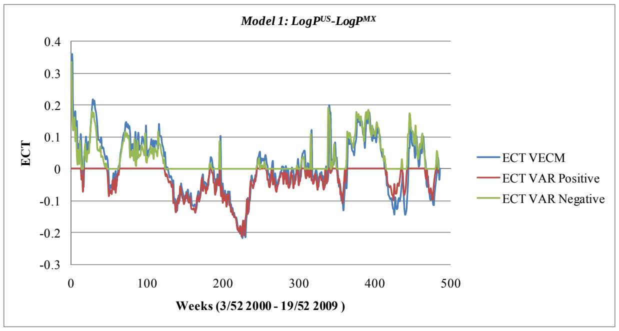
Appendix B. Unit root test results: Augmented Dicked-Fuller Test

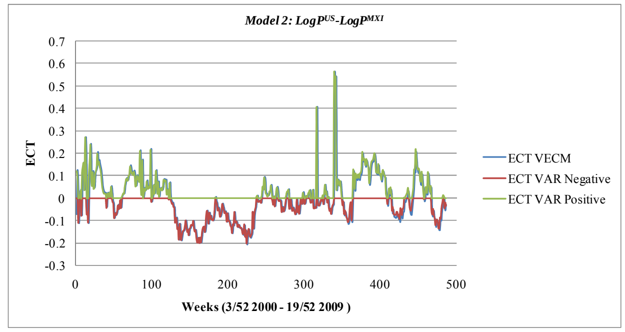
Variable	Constant	Trend	Criterion	Lags	Test Statistics	Critical value
$LogP^{US}$	No	No	AIC, HQC, SC	1	-0.9542	-1.94
	Yes	No	AIC, HQC, SC	1	-1.1559	-2.86
	Yes	Yes	AIC, HQC, SC	1	-2.569	-3.41
$LogP^{MX}$	No	No	AIC, HQC	4	-0.5277	-1.94
	Yes	No	AIC	4	-0.9586	-2.86
	Yes	Yes	AIC	4	-2.5126	-3.41
$LogP^{MXI}$	No	No	AIK, HQC	6	-0.6562	-1.94
	Yes	No	AIK, HQC	6	-1.5289	-2.86
	Yes	Yes	AIC	6	-2.5229	-3.41
$LogP^{MXII}$	No	No	AIC	7	-0.5792	-1.94
	Yes	No	AIC	7	-1.4127	-2.86
	Yes	Yes	AIC	7	-3.3358	-3.41
$LogP^{MXIII}$	No	No	AIC, HQC	3	-0.0309	-1.94
	Yes	No	AIC, HQC	3	-3.9758	-2.86
	Yes	Yes	AIC, HQC	3	-7.407	-3.41
$LogP^{MXIV}$	No	No	AIC, HQC, SC	1	-0.6637	-1.94
	Yes	No	AIC, HQC, SC	1	-1.1661	-2.86
	Yes	Yes	AIC, HQC, SC	1	-2.0621	-3.41
$LogP^{MXV}$	No	No	HQC	2	-0.9446	-1.94
	Yes	No	AIC, HQC	2	-1.1246	-2.86
	Yes	Yes	AIC, HQC	2	-1.8952	-3.41

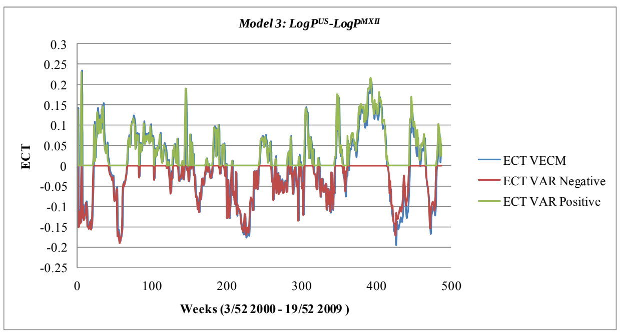
Appendix C. Co-Integration test results: Johancen Trace test

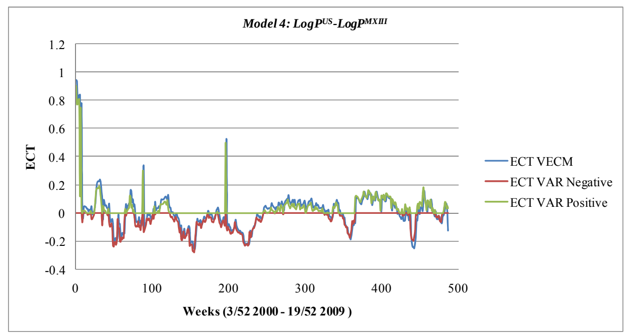
	Constant	Trend	Criterion	Lags	Ho	Statistics	Critical value 5%	Critical value 10%
$LogP^{US}$-$LogP^{MXI}$	Yes	No	AIC, HQC, SC	2	r=0	36.62	20.16	17.98
			AIC, HQC, SC	2	r=1	1.96	9.14	7.60
	Yes	Yes	AIC, HQC, SC	2	r=0	41.10	25.73	23.32
			AIC, HQC, SC	2	r=1	6.46	12.45	10.68
$LogP^{US}$-$LogP^{MXII}$	Yes	No	AIC, HQC, SC	2	r=0	26.21	20.16	17.98
			AIC, HQC, SC	2	r=1	2.08	9.14	7.60
	Yes	Yes	AIC, HQC, SC	2	r=0	29.56	25.73	23.32
			AIC, HQC, SC	2	r=1	5.45	12.45	10.68
$LogP^{US}$-$LogP^{MXIII}$	Yes	No	AIC, HQC	3	r=0	54.51	20.16	17.98
			AIC, HQC	3	r=1	1.25	9.14	7.60
	Yes	Yes	AIC, HQC	3	r=0	67.77	25.73	23.32
			AIC, HQC	3	r=1	7.04	12.45	10.68
$LogP^{US}$-$LogP^{MXIV}$	Yes	No	AIC, HQC, SC	2	r=0	14.89	20.16	17.98
			AIC, HQC, SC	2	r=1	1.50	9.14	7.60
	Yes	Yes	AIC, HQC, SC	2	r=0	19.80	25.73	23.32
			AIC, HQC, SC	2	r=1	4.16	12.45	10.68
$LogP^{US}$-$LogP^{MXV}$	Yes	No	HQC, SC	2	r=0	17.59	20.16	17.98
			HQC, SC	2	r=1	1.76	9.14	7.60
	Yes	Yes	AIC, HQC, SC	2	r=0	22.99	25.73	23.32
			AIC, HQC, SC	2	r=1	3.98	12.45	10.68
$LogP^{US}$-$LogP^{MX}$	Yes	No	AIC, HQC, SC	2	r=0	23.21	20.16	17.98
			AIC, HQC, SC	2	r=1	1.17	9.14	7.60
	Yes	Yes	AIC, HQC, SC	2	r=0	28.79	25.73	23.32
			AIC, HQC, SC	2	r=1	6.82	12.45	10.68

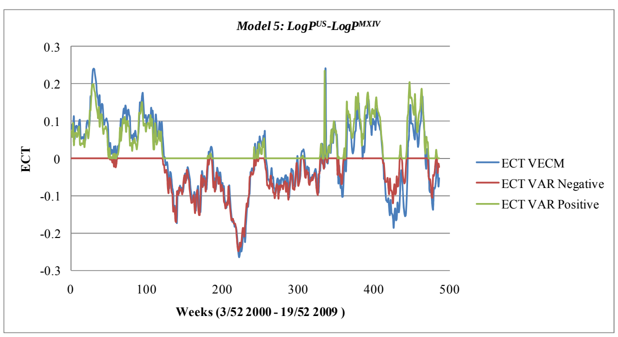
Appendix D. Estimated Error Correction Term (ECT) from the Vector Error Correction Model (VECM) and the Vector Autoregressive Model (VAR)/Asymmetric Price Transmission (APT) split in positive and negative values.

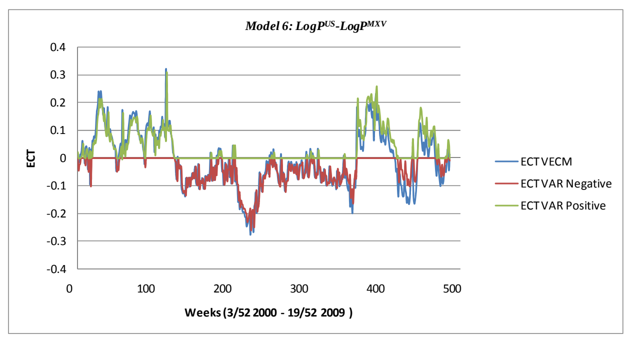




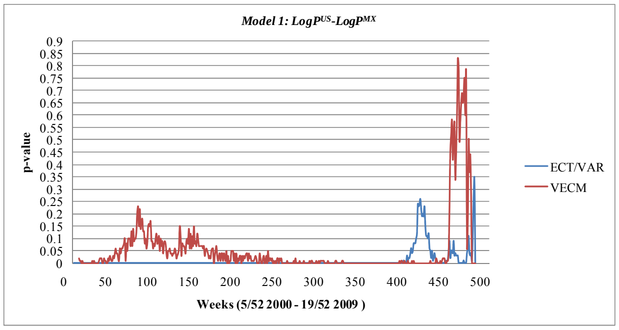


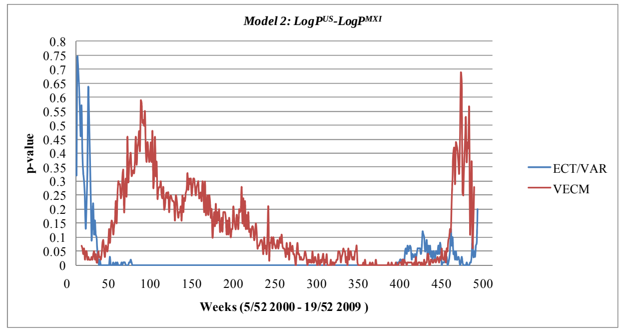


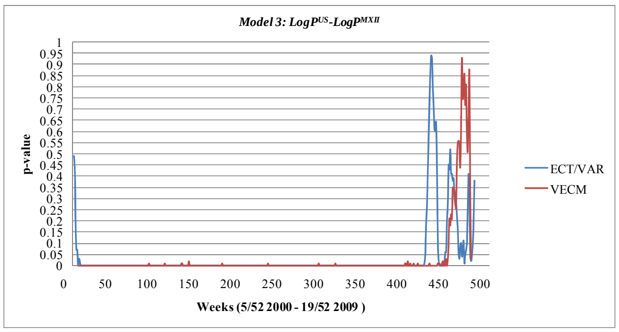


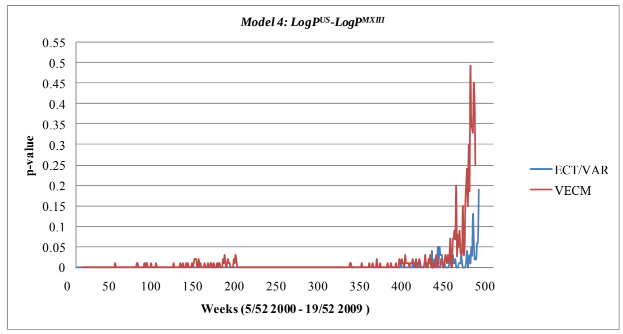


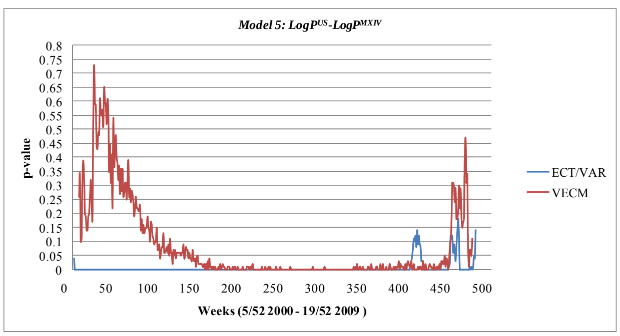
Appendix E. Stability tests for the long run equilibrium (ECT/VAR) and the VECM

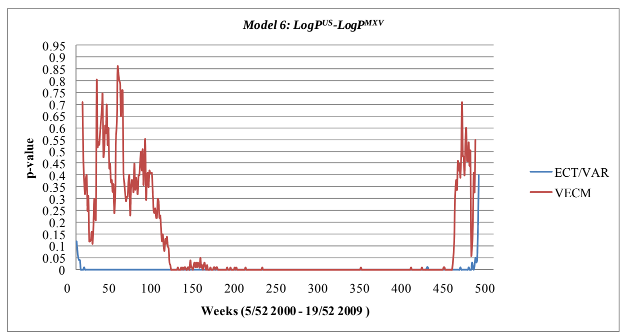




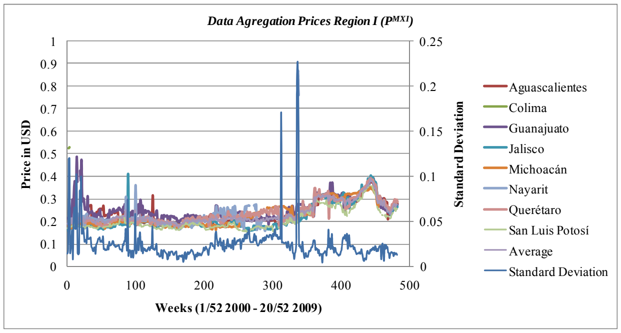


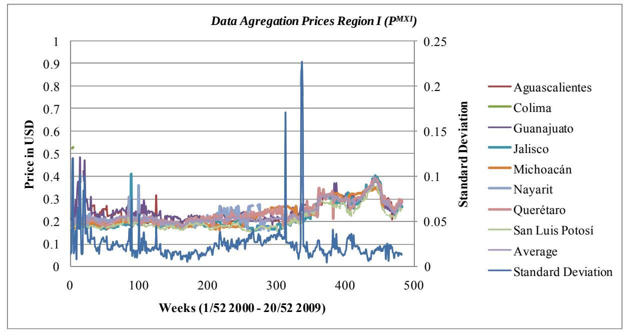


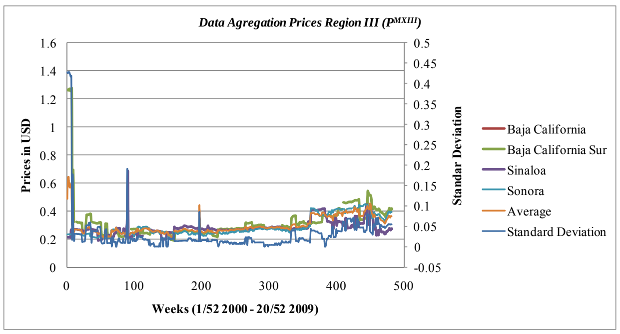


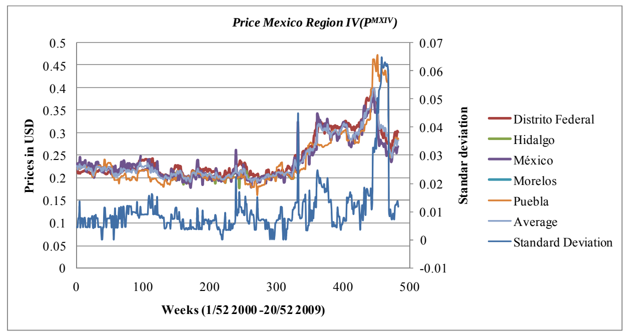


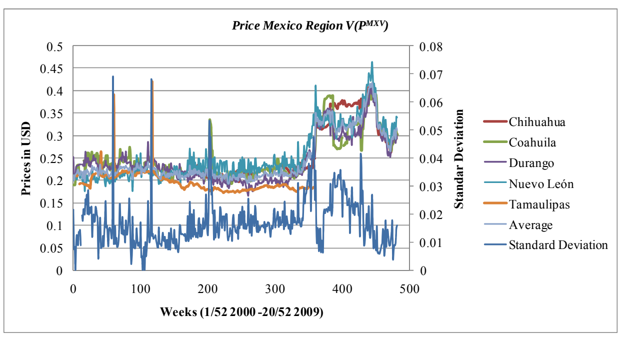
Appendix F. Cross-sectional data aggregation for calculating the average regional prices











Appendix E. Descriptive statistics of the prices series

Region	Variable	Mean	Min	Max	Standard Deviation
Region I	$P^{MX\ I}$	0.233436	0.177525	0.394806	0.047012
	$LogP^{MX\ I}$	-1.472630	-1.728640	-0.929362	0.182679
	$\Delta LogP^{MX\ I}$	0.000764	-0.498360	0.565100	0.062081
Region II	$P^{MX\ II}$	0.247339	0.178377	0.393163	0.046624
	$LogP^{MX\ II}$	-1.413630	-1.723860	-0.933531	0.175514
	$\Delta LogP^{MX\ II}$	0.001021	-0.353978	0.357573	0.045809
Region III	$P^{MX\ III}$	0.293320	0.207142	0.642614	0.065026
	$LogP^{MX\ III}$	-1.246090	-1.574350	-0.442211	0.196975
	$\Delta LogP^{MX\ III}$	-0.000611	-0.729380	0.632768	0.077808
Region IV	$P^{MX\ IV}$	0.238138	0.189239	0.400493	0.047241
	$LogP^{MX\ IV}$	-1.452320	-1.664750	-0.915060	0.180416
	$\Delta LogP^{MX\ IV}$	0.000458	-0.212727	0.251179	0.026766
Region V	$P^{MX\ V}$	0.245684	0.191933	0.417436	0.053752
	$LogP^{MX\ V}$	-1.424700	-1.650610	-0.873624	0.196265
	$\Delta LogP^{MX\ V}$	0.000807	-0.214443	0.244306	0.038054
Mexico country level	P^{MX}	0.246581	0.197613	0.396189	0.047441
	$LogP^{MX}$	-1.416440	-1.621450	-0.925865	0.175431
	$\Delta LogP^{MX}$	0.000422	-0.178157	0.200119	0.029819
US	P^{US}	0.124393	0.073032	0.304528	0.045003
	$LogP^{US}$	-2.137400	-2.616860	-1.188990	0.308191
	$\Delta LogP^{US}$	0.001448	-0.143548	0.111435	0.030886

Appendix F. Regions within Mexico

Region	States	Region	States
1- West	Aguascalientes	3 -Northwest	Baja California
	Colima		Baja California Sur
	Guanajuato		Sinaloa
	Jalisco		Sonora
	Michoacán	4 -Centre	Distrito Federal
	Nayarit		Hidalgo
	Querétaro		México
	San Luis Potosí		Morelos
	Zacatecas		Puebla
2 -South	Campeche	5 - Northeast	Tlaxcala
	Chiapas		Chihuahua
	Guerrero		Coahuila
	Oaxaca		Durango
	Quintana Roo		Nuevo León
	Tabasco		Tamaulipas
	Veracruz		
	Yucatán		