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The relationship between trade and price volatility in the Mexican and US maize markets

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Abstract

The supply of maize in the Mexican market depends to a large extent from the US imports which represent a large share of the domestic consumption. Furthermore imports exhibit a seasonal pattern, and peaks are often found close to low levels of domestic production and stocks. The present research suggests that there is a link between imports and prices volatility. Below a threshold value, imports and volatility are not related, but beyond the threshold it is volatility the variable driving imports. From the results one can argue that imports have served as a measure to stabilize prices when the domestic supply is scarce.

Keywords: Volatility, Maize, Imports, Mexico

JEL classification: Q11, Q17.

1. INTRODUCTION

Albeit price variation has been a characteristic of the agricultural markets, the dramatic increases for many commodities during the 2007-2008 food crisis has made researchers, policy makers, NGO's and other stakeholders to pay attention to the issue. The discussion in the academia has not only been centred on the consequences of high volatility, but also in the causes for it.

Unlike other type of goods, agricultural commodities are demand inelastic, thus large changes in the prices lead to short changes in the demand; on the contrary agricultural commodities prices are quite sensible to shocks in the supply (Gilbert, 2006), thus weather shocks have a large impact on prices performance (Gilbert & Morgan, 2011). The current literature offers several explanations for volatility and variables affecting it. For instance Balkome (2011) and Tothova (2011) summarizes some factors which are likely to affect volatility such as past volatility, trends, yields, stock levels, weather, speculation, policy, exchange rates, oil and energy prices, investment, interest rate and structural change. Those factors and their relation with volatility have been studied more in detail by other authors, being much of the research done between volatility and biofuel linkages. Recent research suggests that there is evidence that the increasing amount of agricultural goods devoted to the produce biofuel, i.e. maize and rapeseed has created a link between energy and food prices. For instance Baffes (2001), Busse et.al (2011), Du et.al (2011), and Ji & Fan (2011) found that for some agricultural commodities the relationship between agricultural goods and energy prices has increased in the last years. The problem is not such a link itself, it is rather that energy markets exhibit higher volatilities than other commodities (Plourde & Watkins, 1998), thus volatility spillovers are passed through the agricultural markets. Other research has centred on how policy

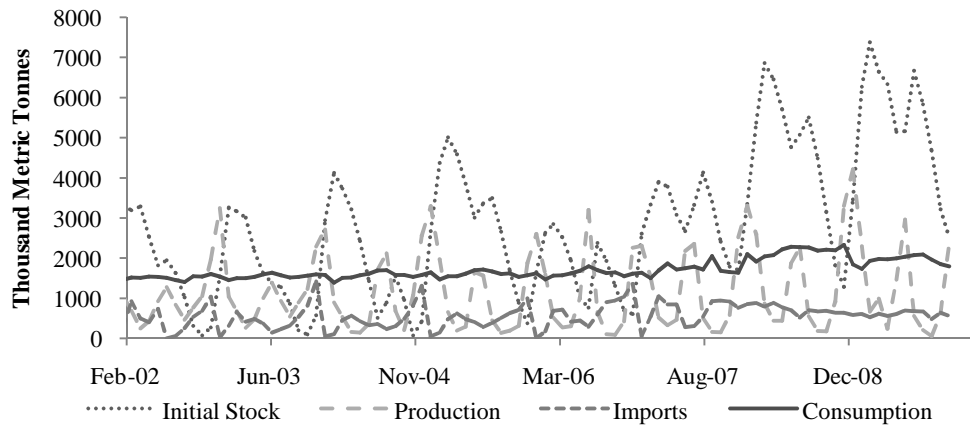
instruments serve to prevent excessive volatility. Specifically in the European case O'Connor & Keane (2011) and Velazquez (2011) argue that the current CAP instruments which have served to stabilize prices should be revised and improved; this should be done properly in order to avoid volatility peaks in international markets. Concerning developing countries, policy instruments to ensure price stabilization have been the reduction of the tariffs and custom fees (Demeke et.al, 2011), which has lead to an increase in trade. This exposure to international markets, although might serve to alleviate high prices and volatility, exposes regional markets in developing countries to international shocks. Using information from the international markets Stigler & Prakash (2011) found that volatility is linked to low levels of stocks. Indeed for many developing countries such stocks depend on imports. From this perspective trade might serve to understand volatility in the agricultural markets. To the knowledge of the author no study had found empirical evidence that relates trade and volatility. Knowing if international trade serves either to alleviate or increase volatility can serve to implement the adequate policies. The question turns more interesting when one of the markets is a developing country with an open economy, for instance Mexico.

2. MAIZE PRODUCTION IN MEXICO

For Mexico one of the most, if not the most, important agricultural commodity is maize. Between 1996 and 2006, 51% of the agricultural land in Mexico was used for producing maize, it accounted for 7.6% of the total agricultural production volume and 30% of the total agricultural production value (Galarza, 2011). The importance of the maize is not only from the production/supply side perspective, but from the consumer perspective as well. In rural areas for 2006 on average 5.9% of the total expenditures are made on cereals (Urzúa, 2008), from which maize represents more than 50%. Another important consumer of maize is the feed industry which share of the total domestic demand is 50%. Nevertheless feed industry and human consumption require different types of maize; for human consumption the main product is white maize, for the feed industry the main product is yellow maize. From the labour markets perspective maize is also important. For 2005 it was required more than 20 millions of workers for producing maize (Galarza, 2011). Also in the same year the maize processing industry occupied nearly 150,000 workers. Indeed maize production value is close to one percent of the national GDP.

Despite being in the top five maize producers in the world, Mexico is also in the top maize importers in the world; being most of the imports from the neighbour US. Indeed yellow maize accounts for more than 90% of maize imports in Mexico. Figure 1 shows the development of monthly production, stocks, imports and demand for maize between 2002 and 2009.

Figure 1. Development of monthly maize stocks, production, imports and demand for the period 2002-2009



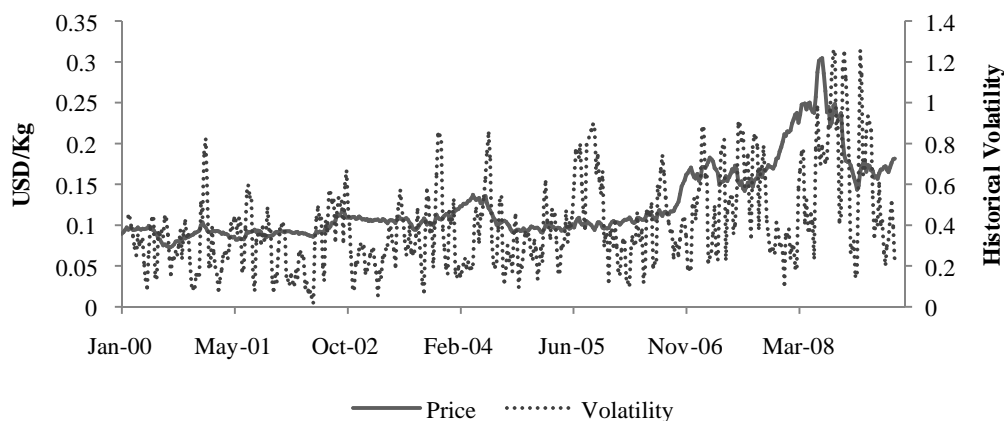
Source: Own elaboration with data from the Mexican Ministry of Agriculture

For the period 2002-2009 imports represented 48% of the domestic production, 33% of the domestic demand, and 20% of the initial stocks. Being the imports from the US relevant for the domestic supply in the Mexican market, one can expect that the volatility of the US markets prices will influence volatility in the Mexican markets prices.

3. VOLATILITY AND TRADE IN THE MEXICAN AND US MAIZE MARKETS

The agricultural commodities prices, as many other commodities, are characterized by price fluctuations which if big lead to periods of high volatility. In 2007-2008 the so called food crises was characterized by large increases in food prices, having as a consequence high volatility periods. The maize markets were exposed to such crises as well as Figure 2 shows.

Figure 2. Prices in USD per kilogram and four-week period volatility for yellow maize at the Louisiana Gulf port (Period January 2000 – May 2009)

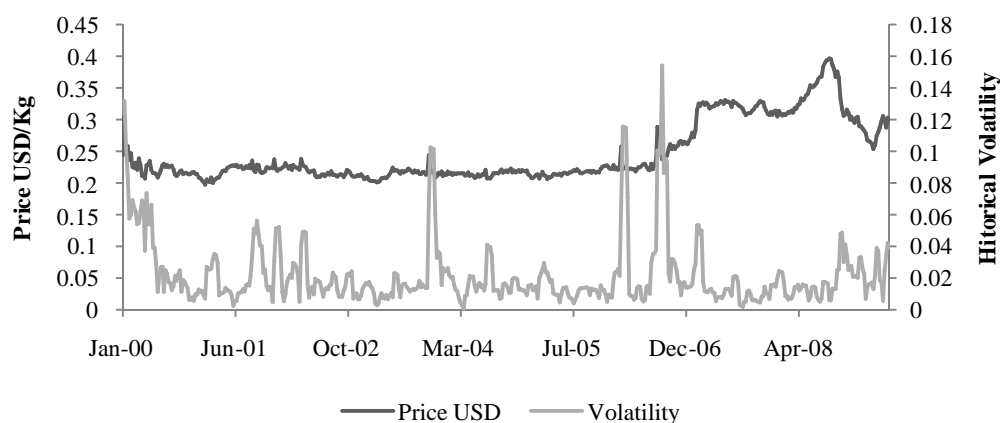


Source: Own elaboration with data from the USDA

Thus from figure 2 it is clear that the increases in maize prices in 2008 are also linked to the highest volatility values; nevertheless other periods of high fluctuations before the food crisis can be observed. The question is to what extent the volatility in the US markets affect the prices in Mexico.

In theory, perfectly cointegrated markets in equilibrium exhibit the same volatility as their changes over the time are proportionally the same. Although in the long run markets should reach equilibrium, in the short run it can be violated. Nevertheless arbitrage brings markets to the equilibrium. In the case of Mexican and US maize markets the violations of its equilibrium relationship are corrected by means of the trade among them. Thus as trade occurs prices in the markets adjust following the same path, hence exhibiting similar volatility. Figure 3 shows the historical volatility for the Mexican maize markets.

Figure 3. Maize prices and four-week period historical volatility in Mexico (Period January 2000 – May 2009)

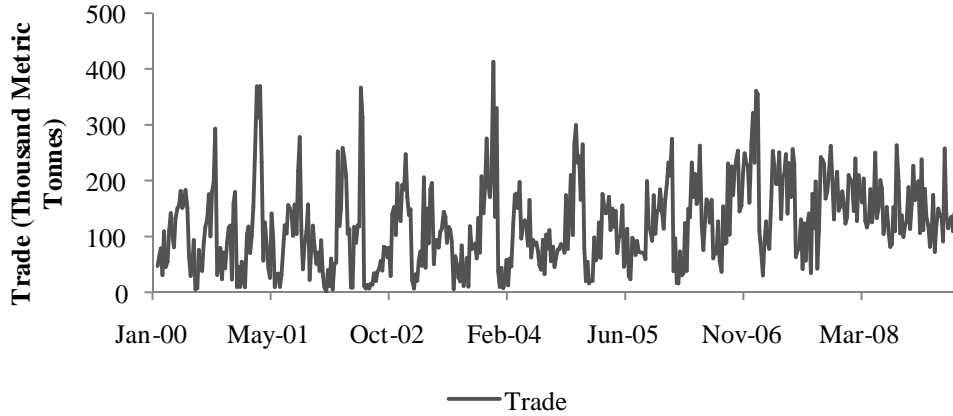


Source: Own elaboration with data from the Mexican Ministry of Economy

From Figure 3 one can see that Mexican markets are characterized by larger fluctuations than in the US. This is perhaps linked to the production systems in both countries. For instance in Mexico a large share of the domestic supply comes from small farmers (non-irrigation production) which depend on the weather conditions. Thus by comparing figures 2 and 3 one can observe that volatility in Mexico and the US is quite different. This outcome is closely related to the markets cointegration. For instance Araujo-Enciso (2011) found Mexican markets to have mixed degrees of cointegration with the US markets ranging from 0.27 to 0.93, with a value close to 0.5 at national level. An approach suggested to evaluate the relationship between volatility spillovers was suggested by Zhao & Goodwin (2011); their approach is to find volatility spillovers with a VAR model rather than with the typical GARCH models. Their research is done for soybeans and maize markets, for which there is evidence of spillovers. Nevertheless both products are likely to have a strong cointegration, for instance Marsh (2007) considers an effect on the maize prices by the soybeans supply in the livestock and poultry industries; also Zhang et al (2009) found Granger causality between soybean and maize prices.

As it was mentioned before, the evidence of cointegrated prices between Mexico and the US is not strong, hence an analysis of volatility spillover is not really promising. Instead of doing that an alternative approach is to evaluate the impact of imports on the volatility by means of a VAR model. Figure 4 depicts the maize imports from the US on a weekly basis.

Figure 4. Mexican yellow maize imports (Period January 2000 – May 2009)



Source: Own elaboration with data from the USDA

The weekly maize imports serve to capture seasonality changes in the supply, which are assumed to be one plausible source of volatility in the Mexican maize markets.

4. METHODS AND RESULTS

4.1. Methods

Let considered a Vector Autoregressive Model (VAR) of order p whit K endogenous variables $y = (y_1, y_2, \dots, y_K)$. The VAR(p) process is defined as

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + \epsilon_t \quad (1)$$

where A_i are $(K \times K)$ coefficient matrices for $i = 1, \dots, p$ and ϵ_t is a K -dimensional white noise process.

For instance one can consider the vector $y_t = (p_t, i_t)$, with p_t denoting the maize prices volatility in the Mexico, and i_t the maize imports between Mexico and the US at national level. Such a model would serve to understand a linear relationship between volatility and trade. Nevertheless one can consider a non-linear approach such as the so called Threshold Vector Autoregressive Model (TVAR). The TVAR(p) process can be written as

$$y_t = \begin{cases} A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + \epsilon_t & \text{if } y_{t-1} > \tau \\ A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + \epsilon_t & \text{if } y_{t-1} \leq \tau \end{cases} \quad (2)$$

where \leq is the selected lagged value for the threshold variable, is the threshold value and the superscripts U and L denote the upper and lower regimes respectively. The idea behind a threshold model is to consider different relationships between the variables depending on a threshold value.

In order to estimate a TVAR model one needs to set up a variable which will serve as the threshold which for this research are the imports. The reason is that imports are a source of shifts on the supply, nonetheless they are not the unique source as domestic production and stocks also play a role, hence it is only when the imports are beyond a certain threshold value that the shift in the supply becomes large enough to cause fluctuations in prices (volatility).

The selection of a TVAR versus a VAR can be done by using the sup-LR statistics proposed by Lo & Zivot (2001) which can be written as

$$= \Sigma - \Sigma \quad (3)$$

where Σ and Σ denote the estimated residual covariance matrix from the restricted (linear) and unrestricted (threshold) models respectively. The previous test can be extended to test models with more than one threshold, for instance two threshold and three regimes. Three criterions are done in order to select the number of lags: Akaike Info Criterion (AIC), Hannan-Quinn Criterion (HQC) and the Schwarz Criterion (SC). The selected value is the one that serves to estimate the most parsimonious model.

The analyses consist on pair-wise models for the volatility data in the five regions in Mexico and at national level, and the maize imports.

4.2. Criterion results

The first step consists on determining the number of lags to include in the models. Table 1 summarizes the results of the three criterions for the six models.

Table 1: Lags to include suggested by the criterions results for the six VAR models

Criterion	Lags
AIC	9
HQC	9
SC	5

Source: own elaboration

The results suggest that in order to estimate the most parsimonious model the choice is 5 lags for all the models.

4.3. Testing for linear and threshold models results

In order to test if the model is linear or non-linear first one has to select the threshold variable, which on this set up is the imports variable, nevertheless as the model includes five lags one has to select which of the lags is the threshold. The imports used on the analysis have a delivery time of 30 days; hence one expects that the shock in the supply will occur with 30 days of delay, which in weeks is approximately four. Nonetheless that is the delivery time at the port of entry. There is also a time for carrying out the maize to the final destination which has to be accounted for. Following this idea the lagged selected for the threshold was of five weeks, which is also the maximum number of lags considered for the models.

After selecting the threshold variable one has to test for the threshold models, for doing so it is used the Lo & Zivot (2001) test implemented in the tsDyn package. Testing threshold models consider more than one null hypothesis. The following sets of hypothesis are tested: the null H_0^1 :linearity versus the alternative H_a^1 : one threshold with two regimes; the H_0^2 :linearity versus the alternative H_a^2 : two thresholds with three regimes; and the null H_0^3 : one threshold with two regimes versus the alternative H_a^3 : two thresholds with three regimes. The results are summarized in table 2. For all the test 250 bootstraps were performed to get the distribution.

Table 2: P-values for the Lo & Zivot (2011) test

Threshold variable	Hypotheses	P-value
	H_0^1 vs. H_a^1	0.02
	H_0^2 vs. H_a^2	0.01
	H_0^3 vs. H_a^3	0.10

Source: own elaboration

Following the results the model to estimate is a TVAR(5) with one threshold and two regimes

4.4. Estimations from the TVAR model

The estimation is done using the package tsDyn implemented in R by Dinarzo et al (2011). The estimated threshold value is $\tau = 252.66$. The percentage of observations in the lower regime is 94.8, and 5.2 for the upper regime. The estimated coefficients are summarized in Table 3.

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Table 3: Estimated parameters from the TVAR(5) model

Variables	Lower Regime		Upper Regime	
Intercept	0.0354	31.3763	0.0925	-113.4385
	(0.0096)***	(7.7721)***	(0.1715)	(139.3942)
	1.0182	-30.2241	0.4694	-2072.3451
	(0.0437)***	(35.5191)	(0.5671)	(461.0869)***
	-0.00002	0.4884	-0.0002	1.2725
	(6.3e-05)	(0.0511)***	(0.0005)	(0.4177)**
	-0.1817	80.8839	0.1784	1722.7369
	(0.0596)**	(48.4743)	(0.6641)	(539.8975)**
	-0.000082	0.2326	-0.0001	-0.2603
	(6.1e-05)	(0.0496)***	(0.0002)	(0.1754)
	0.1652	-57.1883	-0.0604	-799.1242
	(0.0601)**	(48.8404)	(0.6789)	(551.9462)
	0.0000036	0.0679	-0.0002	0.2958
	(6.2e-05)	(0.0503)	(0.0002)	(0.1923)
	-0.4976	11.4253	-0.1282	1789.8152
	(0.0597)***	(48.5445)	(0.5826)	(473.6871)***
	-0.00005	-0.01	0.0008	0.1266
	(5.9e-05)	(0.0482)	(0.0003)*	(0.2576)
	0.3339	29.9835	0.0839	-1536.6734
	(0.0424)***	(34.4909)	(0.4947)	(402.2132)***
	0.000056	-0.0586	-0.0002	-0.0952
	(5.5e-05)	(0.0447)	(0.0003)	(0.2345)

Source: own elaboration

Note: standard errors are in parentheses, ***, **, and * denote the significance levels at 1%, 5% and 10% respectively.

The results suggest that in the Lower Regime, where most of the observations belong, the lagged terms of the volatility do not have an effect on the imports, on the same way the lagged terms of imports do not have an effect on the volatility. Therefore in the lower regime, both variables are unrelated. Nevertheless in the Upper Regime, which accounts for nearly five percent of the observations, the lagged terms of the volatility have a significant impact on trade, on the contrary only one lagged term of the imports has a significant impact on volatility at 10% level. Hence one can conclude that when the amount of trade is lower than 252.66 thousand metric tonnes, the variables volatility and trade do not have an effect each on other, nevertheless when the trade amounts goes beyond the lagged terms of the volatility drive the performance of the imports. This is to some extent contrary to what was assumed, one could assume that imports by means of shifts on the supply curve causes prices to fluctuate, hence causing volatility. Nonetheless the fact that volatility is driven imports is plausible. The figure 1 shows that between 2002 and 2007, peaks on the amount of imports are close to low levels of stock and low level of production. On this regard one can argue that low production and low stocks shifts the supply down causing prices to fluctuate (increase), as a measure to alleviate such a

fluctuation and in order to stabilize prices imports increase. Following this idea, on average, exposure of the Mexican markets to the world markets by means of trade (imports) seems to have served as tool not only to drop the domestic prices, but also to stabilize them when production and stocks levels are low.

The measurement of impact of the volatility on imports cannot be analyzed by simply looking at individual estimated coefficients; it has to be done by looking at the impulse response functions which is left for future research.

Besides it could be interesting to perform the analysis not only with imports, but also with the stocks and production variables. Nonetheless there is data limitation, as for those two later variables the data frequency is in months. Hence the time horizon of the analysis should be extended in order to allow estimating a TVAR model with monthly data.

5. CONCLUDING REMARKS

The maize imports of maize in Mexico from the US have served as a tool to stabilize prices. Import peaks are often found close to low levels of production and stocks, hence when the low supply causes prices to fluctuate, the imports increase. Furthermore such mechanism is not frequently observed as it accounts roughly five percentage of the observations.

Further research has to be done by including more variables affecting the supply, additionally the impulse response functions can provide a better understanding on how imports and volatility are related.

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