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Measuring spatial transmission of white maize prices between South Africa and Mozambique: An asymmetric error correction model approach

ALEJANDRO ACOSTA [1]

Department of Agricultural Economics and Rural Development, Georg-August Universität Gottingen, Göttingen, Germany

Abstract

Over the last decade, Mozambique has experienced drastic increases in food prices, with serious implications for households' real income. A deeper understanding of how food prices are spatially transmitted from global to domestic markets is thus fundamental for designing policy measures to reduce poverty and food insecurity. This study assesses the spatial transmission of white maize prices between South Africa and Mozambique using an asymmetric error correction model to estimate the speed and symmetry with which prices are being transmitted from the international to the domestic market. The study found that although the transmission of white maize prices from South Africa and Mozambique is co-integrated in the long run, it is not co-integrated in the short run, and that the transmission of these prices is asymmetric depending on whether the international price increases or decreases. The study suggests that some of the barriers that currently constrain a more efficient price transmission are related to the presence of a highly prohibitive import tariff and the structure of a value added tax.

Keywords: price transmission; market integration; asymmetric error correction model

JEL codes: Q110; Q130

Lors des dix dernières années, le Mozambique a vu les prix des denrées alimentaires augmenter de manière drastique, causant de graves implications sur le revenu réel des ménages. Il est par conséquent fondamental de mieux comprendre comment les prix des denrées alimentaires sont transmis spatialement, des marchés mondiaux aux marchés nationaux, pour concevoir des mesures politiques visant à réduire la pauvreté et l'insécurité alimentaire. Cet article évalue la transmission spatiale des prix du maïs blanc entre l'Afrique du Sud et le Mozambique en utilisant un modèle à correction d'erreurs asymétrique pour estimer la rapidité et la symétrie avec lesquelles les prix sont transmis depuis les marchés mondiaux vers les marchés nationaux. L'étude a montré que, bien que la transmission des prix du maïs blanc entre l'Afrique du Sud et le Mozambique soit cointégrée sur le long terme, celle-ci ne l'est pas sur le court terme, et que la transmission de ces prix est asymétrique selon que le prix international augmente ou diminue. L'étude suggère que quelques-unes des barrières qui entravent actuellement une transmission des prix plus efficace sont liées à la

[1] Correspondence: alejandroacostaavila@gmail.com

présence d'un tarif douanier à l'importation hautement prohibitif et à la structure de la taxe sur la valeur ajoutée.

Mots-clés : *transmission du prix ; intégration du marché ; modèle à correction d'erreurs asymétrique*

1. Introduction

Over the last decade, the world has experienced drastic increases in food prices, with serious implications for households' food security, especially for those in developing countries. In comparison to 2006, the FAO food price index rose by 25% in 2007, 57% in 2008 and nearly 80% in 2011. This has been described as the longest and largest surge in global commodity prices in over a century (OECD/FAO, 2010). Among the factors that have contributed to this phenomenon are the sudden rise in energy prices, population and income growth, under-investment in agriculture, variability in weather conditions and the speculative behavior of various actors (Chirwa, 2009).

It is likely that the increase in food prices has had different effects in different countries and socio-economic groups. On the one hand, the increase in food prices may have benefited net exporting countries that reacted rapidly; on the other, it may have negatively affected developing countries that are net importers, causing their terms of trade to deteriorate and reducing the real income of food buyers (Okello, 2009). A deeper understanding of how food prices are spatially transmitted from global to domestic markets is thus fundamental for designing policy measures to reduce poverty and food insecurity (Schroeder & Hayenga, 1987; Alemu & Van Schalkwyk, 2009).

Spatial price transmission is an issue that has been widely analyzed in the context of the 'law of one price', which assumes that if two markets are linked by trade in an efficient market, the movement of prices in one market will be equalized with the movement in the other in the long run, while allowing for deviations in the short run (Margarido et al., 2007). A proportional increase in the international price will therefore lead to an equally proportional increase in the domestic price, at all points in time, assuming the markets are perfectly integrated (Mundlak & Larson, 1992). In this context, 'spatial price transmission' means the process and degree to which markets for homogeneous commodities at spatially separated locations share long-run market information (McNew, 1996; Amikuzuno, 2009).

Depending on the environment in which markets operate, two prices can be related in many different ways, adjusting completely or partially, slowly or instantaneously, or in a linear or nonlinear manner (Ihle et al., 2009). According to Rapsomanikis et al. (2003), the notion of price transmission can be better understood as being based on three main components: co-movement of adjustment, speed of adjustment and asymmetry of response. 'Co-movement of adjustment' means that a change in the price of an agricultural commodity in one market is reflected in the price change of the commodity in other markets at all points in time, 'speed of adjustment' means the rate at which changes in prices in one market are transmitted to other markets, and 'asymmetry of response' means the process in which transmission differs according to whether prices are increasing or decreasing (Prakash, 1999; Balcombe & Morrison, 2002; Rapsomanikis et al., 2003; Meyer & von Cramon-Taubadel, 2004).

The literature on spatial price transmission has identified three main types of barrier that constrain the transmission of prices from one market to another: transaction costs, trade policy mechanisms and imperfect competition. If transaction costs are prohibitively high (often because of poor infrastructure, high transport costs and deficient communication services), price changes will be transmitted only partially or not at all (Abdulai, 2000; Conforti, 2004). Trade policy mechanisms such as import tariffs, tariff rate quotas, export subsidies and exchange rate policies can isolate domestic markets and obstruct the transmission of international price signals (Rapsomanikis et al., 2003; Conforti, 2004). Imperfect competition, due to the concentration of market power of different actors in the supply chain, may result in higher price differences, hindering the full transmission of price signals (Abdulai, 2000; Rapsomanikis et al., 2003).

The purpose of this research is twofold: first to discover whether the white maize prices from South Africa's export market and Mozambique's main domestic market are spatially co-integrated, and second to assess the speed and symmetry of the price transmission. The rest of this paper is organized as follows. Section 2 describes the structure of the white maize market in Mozambique, Section 3 introduces the econometric methods used to analyze the spatial price transmission, Section 4 describes the data, Section 5 discusses the main results, Section 6 offers policy recommendations, and Section 7 concludes.

2. Structure of the white maize market in Mozambique

In Mozambique the agricultural sector is dominated by the production of white maize, the staple food and principal cash crop. Its production is divided into three main regions: North, Center and South.[2] The white maize produced in the North supplies northern cities such as Nampula and also flows to neighboring countries such as Tanzania and Malawi. The Center, being the zone with the best agro-ecological conditions, has the highest production levels. Maize from this area goes to the city of Beira and an important share to Zambia and Zimbabwe. In the South, the driest zone of the country, most of the maize is consumed directly at the household level. Any negative balance in the local markets is filled by white maize from the central provinces. In Maputo, the capital city, the white maize used for domestic consumption comes from the Center, while demand from industrial processes is met by imports from South Africa (Tostao & Wade Brorsen, 2005).

2.1 Production

White maize production in Mozambique remains highly dependent on the rainfall regime, and there are seasonal patterns that affect prices. The high production period occurs during the post harvest season, between May and October. In contrast, the low production period occurs during the wet season from November to March, just before the first harvest, when family food stocks have run out and there are not yet harvestable crops in their fields to replenish them. This lean season is known as the 'hunger gap'.

The production of white maize in Mozambique is dominated by small producers. As Table 1 shows, 78% of agricultural households cultivate white maize as their main crop, and the average national production of white maize in 2008 was approximately 1.17 million tons

[2] In this paper the South is defined as the provinces of Maputo, Gaza and Inhambane, the Center as Sofala, Manica and Tete, and the North as Zambezia, Nampula, Cabo Delgado and Niassa.

(TIA, 2009). Tschirley and Abdula (2007) note that only a small proportion of households sell their maize, and that the quantity sold by those who do sell is between 100 and 200 kg.

Table 1: White maize production in Mozambique

Year	2002	2003	2004	2005	2006	2007	2008
Percentage of households that cultivate white maize	81	81	79	79	79	74	78
Average country production of white maize in thousands of tons	1.20	1.14	1.18	0.94	1.42	1.13	1.17
Percentage of households that sold their production	26	23	NA	22	22	20	18

Source: TIA (2009)

2.2 Consumption

In Mozambique nearly all the white maize produced by smallholders (who make up 99% of agricultural producers) is consumed internally at the household level. Only 18% is sold to the market (TIA, 2009). When aggregated across the country, white maize and its derivates constitute about 15% of households' total expenditure allocated to cereals, with some variations between urban (10%) and rural areas (16%) (Corniza, 2008).

Transport is one of the main factors that constrain integration between areas of production and consumption in Mozambique. Moving grain from the northern and central provinces to the south is difficult and costly due to poor infrastructure and long distances. For example, the distance from Lichinga in the northern region to Maputo is over 1800 km. An additional problem is the Zambezi River, which is impossible to cross during the rainy season, disconnecting the north from the rest of the country (Tostao & Wade Brorsen, 2005; Corniza, 2008).

2.3 Milling industry

Tschirley and Abdula (2007) identify three types of maize miller in Mozambique: households that grow their own maize and pound it manually to create maize flour, small-scale millers who provide services to producers who bring grain to be milled, and industrial millers, who purchase grain, process it and sell the maize flour to wholesalers and retailers. CIM (Compannia Industrial da Matola) is the largest milling industry in the South, followed by Merec Industries, SMC and Inacio de Sousa. CIM and Merec control over 70% of the market for industrial maize flour in the South and the Center and 100% of the market in Maputo.

2.4 Trade

South Africa has been Mozambique's main trading partner for decades. South African products account for nearly 40% of Mozambique's total imports and are primarily comprised of white maize, cereals, flour and animal feed pellets. Conversely, Mozambique accounts for 20% of South Africa's imports, mainly nickel and cotton. (Corniza, 2008)

As Table 2 shows, in recent years South Africa has become the main supplier of white maize grain and an important supplier of maize flour to Mozambique. In 2009 imports of white maize grain from South Africa accounted for 99% of Mozambique's total white maize imports and 78% of the country's maize flour was imported from South Africa.

Table 2: Imports of white maize into Mozambique

Year	World imports		South African imports		Value of SA imports
	USD(000)	Tons	USD(000)	Tons	%
			Maize grain (HS code:1005)		
2005	8,904	47,520	8,339	44,926	94
2006	20,046	107,524	15,736	84,906	78
2007	8,100	47,168	4,963	28,362	61
2008	20,299	N/A	20,221	N/A	100
2009	26,000	N/A	25,675	N/A	99
			Maize flour (HS code: 110220)		
2005	995	2,026	971	1,978	98
2006	1,296	2,639	1,294	2,636	100
2007	3,522	7,300	850	1,761	24
2008	3,274	5,721	2,291	4,003	70
2009	3,789	5,626	2,961	4,396	78

Source: Author based on UNCOMTRADE database (2010)

3. Econometric methods

Many of the econometric models for analyzing spatial price transmission are based on the log-linear regression model (1) used by Mundlak and Larson (1992) to assess the relationship between international and domestic prices:

$$p_{it} = \alpha + \beta p_{it}^{*} + \gamma e_t + \varepsilon_{it^*} \tag{1}$$

Ardeni (1989) has argued that many of the previous studies conducted in the area of market integration and price transmission were unreliable, and that most of the evidence presented to support the assumption that commodity prices are co-integrated in the long run was flawed and affected by spurious regressions, non-stationary series[3] or the inappropriate use of first differences. In order to address these econometric shortcomings, error correction models (ECMs) have gained importance in assessing price dynamics between one commodity in different markets, allowing for the use of non-stationary variables and its intuitively appealing interpretation (Meyer, 2004).

However, these market integration approaches often ignore the important role played by transaction costs (Balcombe et al., 2007), which may result in a neutral band within which markets are well integrated even though prices are not directly linked (Goodwin & Piggott, 2001). To tackle this issue, Alemu and Biacuna (2006) have found the use of a threshold vector ECM to be more robust than previous approaches to incorporate the effects of transaction costs, showing that in Mozambique thresholds play a significant role in determining maize price dynamics between domestic provincial markets.

[3] Non-stationarity makes classical asymptotic theory inapplicable – invalidating the regular estimating process.

Nevertheless, a major shortcoming of threshold vector ECMs is that they are based on the assumption that transaction costs are constant (Meyer, 2004). Previous studies (Penzhorn & Arndt, 2002; Tostao & Wade Brorsen, 2005; Cirera & Arndt, 2006; Tschirley & Abdula, 2007) have found that Mozambique's white maize market has been characterized by high transaction costs that change constantly, depending on the level of the import duty, transport costs, road quality, the cost of working capital, storage capacity and the availability of marketing infrastructure.

The fact that the white maize trade between South Africa and Mozambique is characterized by a market scenario where transaction costs are unlikely to be constant provides strong justification for exploring the use of an asymmetric ECM as an alternative to conducting a spatial price transmission analysis.

Meyer and von Cramon-Taubadel (2004) group the approaches to analyzing asymmetric price transmission into pre-co-integration and co-integration models. Pre-co-integration models are based on Houck's (1977) segmentation of price variables into positive and negative components. Houck's model can be written as:

$$\Delta y_t = \alpha_0 + \alpha_1 \Delta x_t^+ + \alpha_2 \Delta x_t^- + \varepsilon_t \qquad (2)$$

where Δx^+ and Δx^- are positive and negative changes, α are coefficients and t is the current period. The problem with Houck's approach is that it is based on simple VAR (vector autoregressive) models in first differences, which is often a cause of spurious results in the presence of non-stationary time series (Meyer & von Cramon-Taubadel & Meyer, 2004).

A first attempt at testing for asymmetric price transmission using co-integration techniques was made by von Cramon-Taubaldel and Fahlbusch (1994), who used an ECM and proposed segmenting the error correction term into positive and negative components (Acquah & Dadzie, 2010). Following this approach, we estimate equation (3) by regressing Y on X to obtain an estimate of Z by taking the residuals from the regression. We then estimate equation (4) by regressing ΔY_t on ΔX_{t-1} plus the equilibrium errors represented by z_{t-1}:

$$y_t = \alpha + \beta x_t + z_t \qquad (3)$$

$$\Delta y_t = \beta_0 \Delta x_{t-1} - B_1 z_{t-1} \qquad (4)$$

Equation (4) can be represented as a basic structure of an ECM (5) where β captures the short-term effects of X in the prior period and on Y in the current period and ϕ captures the rate at which the system Y adjusts to the equilibrium state after a shock; in other words, the error correction term (ECT).

$$\Delta Y_t = \alpha + \beta \Delta x_{t-1} - \phi ECT_{t-1} + \varepsilon_t \quad (5)$$

Finally, we use an asymmetric ECM (6) to test for asymmetric price transmission. Thus we split the error correction term into positive and negative deviation from long-run equilibrium.

$$\Delta y_t = \alpha + \beta \Delta x_{t-1} - \phi ECT_{t-1}^{+} + \phi ECT_{t-1}^{-} + \varepsilon_t \quad (6)$$

The splitting of the ECT into positive and negative components and the use of an F-test allow us to discover whether the speed at which prices are transmitted differs, depending on whether price transmission is symmetric or asymmetric (von Cramon-Taubadel, 1998).

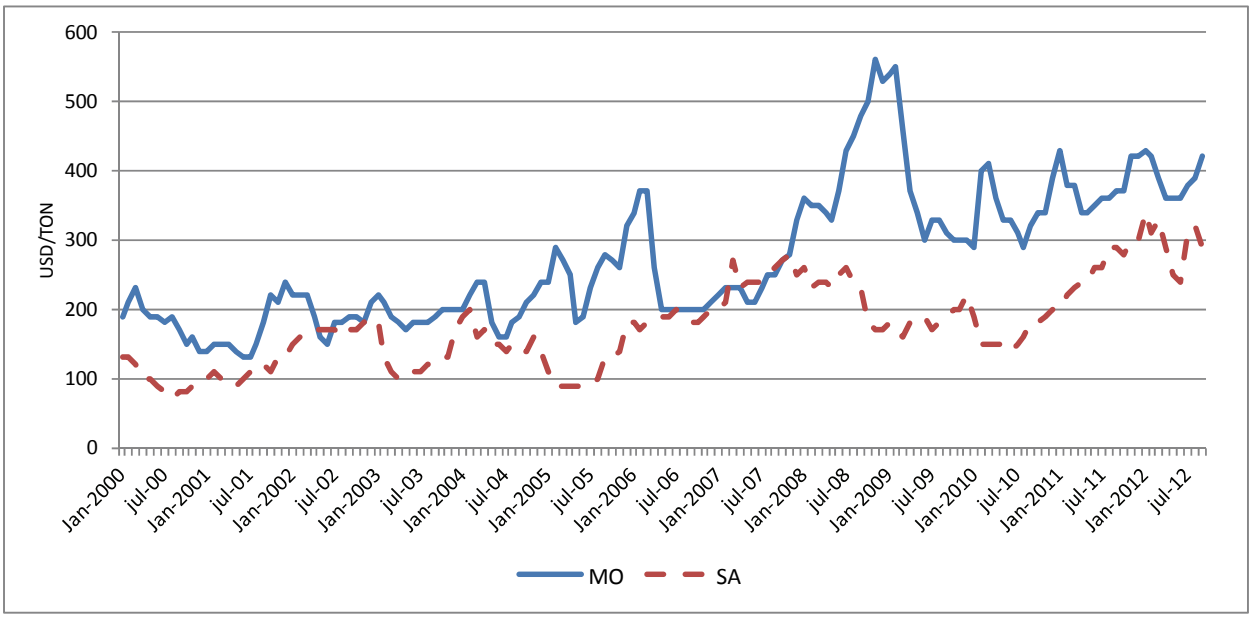
4. Data

The spatial price transmission analysis was conducted using 144 monthly wholesalers' white maize price observations over the period 2000 (01) to 2011 (12) from Mozambique and South Africa. Taking into consideration that Mozambique is a net importer of white maize and South Africa a net exporter, and that most imports of white maize into Mozambique come from South Africa, we used Maputo as an indicator of the domestic market and Gauteng, South Africa's main exporter market, as an indicator of the international market. For Mozambique, we used the data reported by the Agricultural Market Information System (SIMA, 2012) of the Ministry of Agriculture, which publishes monthly information on white maize wholesaler prices for several locations. For South Africa, we used the white maize wholesaler data reported by the Agricultural Market Division of the South African Futures Exchange (SAFEX, 2012).

5. Results and discussion

As always, it is good practice to plot the time series while searching for potential outliers, trends, structural breaks and the general characteristics of the data generating process. Thus, the white maize prices time series from South Africa and Mozambique were plotted and analyzed descriptively. The plot of the South African white maize export price (SA) and Mozambique white maize domestic price (MO) at the wholesale level (Figure 1) shows that, with the exception of a few months in 2002 and 2007, the domestic price of white maize in Mozambique was higher in general terms than the export price of white maize in South Africa. This suggests that throughout the period under study, domestic wholesale prices were generally above international wholesale prices. On the other hand, the plot also shows that the movements of white maize prices in South Africa and Mozambique are quite independent, suggesting weak price transmission from the export market in South Africa to the domestic market in Mozambique.

Figure 1: White maize nominal price trends in South Africa and Mozambique



Source: Author

The price of white maize in Mozambique reveals a clear upward trend since 2000, with a remarkable increase between April 2007 and February 2009 before falling sharply in March 2009. The same trend is not very evident in the white maize prices for South Africa, which reveals a higher volatility. Swings in white maize prices are not a new phenomenon in Mozambique. Figure 1 shows that apart from the surge in white maize prices during 2007/2009, hikes also occurred in 2000, 2002, 2005 and 2006. Most of these increments were related to climate shocks in the form of droughts and floods that periodically affect the country.

As is widely known, regressions involving non-stationary time series[4] will produce spurious results that show a significant relationship between variables that are not correlated. Therefore, in order to determine whether the time series contained a unit root or not, we used an augmented Dickey Fuller test. The optimal number of lags was determined using the Schwarz criterion information criteria. The outputs of the unit root tests (Table 3) indicate that for both variables there is insufficient evidence to reject the null hypothesis of unit roots at the 5% level, suggesting that all the series are non-stationary processes and integrated of the same order.

Table 3: Unit root test

Variable	Test	Lags	$Ho: \gamma = 0$	Lags	$Ho: \Delta\gamma = 0$	t-stats critical values at 5% level
MO	ADF	1	-2.12	0	-7.88	-2.86
SA	ADF	0	-0.73	0	-10.24	-2.86

[4] A non-stationary I(1) process has a non-reverting mean and an infinite variance, while a time series is stationary I(0) if it has a finite mean and a variance that does not depend on time.

Given that all the time series analyzed are non-stationary I(1) processes, and taking into account co-integration theory, which states that two or more non-stationary series are long-term co-integrated if both series are integrated of the same order and their linear combination yields a disturbance term that is stationary, we follow Johansen's (1991) approach to test for long-run co-integration. The results of the Johansen test (Table 4) indicate that there is strong evidence to reject the null hypothesis of no co-integration between South African and Mozambique white maize prices, suggesting that a long-run co-integration relationship exists between international and domestic prices.

Table 4: Johansen trace test

Variables	Lags	Ro	LR	P-value	t-stats critical values at 1% level
MO -SA	2	0	27.79	0.02	25.73
		1	7.58	0.29	12.53

Taking into account the previous results, we specify a two-step single equation ECM to assess the short-term dynamics of the relationship between the two price series. This model allows us to capture the short-term effect that a shock in the independent variables has on the dependant variable, and the speed at which the system will adjust to the new equilibrium after the shock. The output of the ECM (7) indicates that while the coefficient (-0.09) of the error correction term ϕ is significant at the 5% level (-3.51), the coefficient (-0.11) of the short-term parameter β is not (-0.78). This output suggests that white maize export prices from South Africa are transmitted in the long term, but not in the short term, to Mozambique's main domestic market. In fact, the model shows that the time it takes for white maize prices in Mozambique to return to an equilibrium after a shock in the South African white maize export market is about 11 months.

$$\Delta MO_t = \underset{(0.51)}{1.14} + \underset{(3.85)}{0.29}\,\Delta MO^{*}_{t-1} - \underset{(-0.78)}{0.11}\,\Delta SA_{t-1} - \underset{(-3.51)}{0.09}\,ECT^{*} \tag{7}$$

Finally, we construct an asymmetric ECM (8) to assess whether there are significant differences in the speed of adjustment in Mozambique when prices in South Africa increase or decrease, in other words whether price transmission is symmetric or asymmetric.

$$\Delta MO_t = \underset{(1.41)}{5.06} - \underset{(3.91)}{0.302^{*}}\,\Delta MO_{t-1} - \underset{(-0.79)}{0.117}\,\Delta SA_{t-1} - \underset{(-3.36)}{0.139^{*}}\,ECT^{+} - \underset{-0.19}{0.013}\,ECT^{-} \tag{8}$$

The output of the asymmetric ECM suggests that price increases in the South African white maize export market tend to be transmitted faster than decreases, showing that it takes about seven months for the domestic market in Mozambique to adjust to the new equilibrium when prices increase, and about 11 months when they decrease. This result makes sense from an

economic standpoint, since there are clear incentives for importers to react faster to shocks that squeeze their margins than to shocks that stretch it.

These findings accord with a previous market integration analysis of white maize in Mozambique (Alemu & Van Schalkwyk, 2009) that shows that it takes between four and 11 months for domestic prices to adjust to a new equilibrium after a market shock has been introduced, and with recent studies from the FAO and the OECD (FAO, 2009; OECD/FAO, 2010) that have found strong statistical evidence for long-run co-movement of domestic white maize prices in southern African countries.

6. Policy recommendations

The issue of spatial market integration of white maize between domestic markets has been a subject of several studies over the last 10 years in Mozambique (Penzhorn & Arndt, 2002; Tostao & Wade Brorsen, 2005; Alemu & Biacuana, 2006; Cirera & Arndt, 2006; Tschirley & Abdula, 2007; Alemu & Van Schalkwyk, 2009). However, not many of these analyses have focused on assessing the level of spatial market integration between domestic and international markets.

The spatial market integration of white maize prices between South Africa and Mozambique is an issue of major importance because southern Mozambique is a maize deficit region, and therefore efficient trade between these two countries has important food security policy implications. The results of the stochastic analysis in this study show that white maize prices from South Africa and Mozambique are co-integrated strongly in the long run but weakly in the short term: it takes about seven months for domestic markets in Mozambique to adjust to the new equilibrium when international prices increase and about 11 months when they decrease.

In 1980, Mozambique joined SADC (the Southern African Development Community), which aims to stimulate free trade of agricultural commodities among its member countries. Nevertheless, some sensitive commodities, such as white maize, were exempt from the negotiation and Mozambique was permitted to apply tariffs based on the sensitivity of certain commodities (Corniza, 2008). In this regard, Mozambique applies an import tariff of 2.5% to all white maize grain imports and a 20% tariff to all maize flour imports. In addition to the 2.5% tariff, Mozambique also applies a 17% value added tax (VAT) to white maize grain. Government regulations indicate that VAT that is applied to the imported white maize that is processed into maize flour is entirely reimbursed to the importer within three months. However, if the grain imported is processed only on a small scale or sold in retail markets, the VAT is not reimbursed (Tschirley & Abdula, 2007).

We believe that one of the main factors that is constraining a more efficient transmission of white maize prices from South Africa to Mozambique is the presence of this highly prohibitive import duty and the structure of the VAT. The study by Tschirley and Abdula (2007) on the impact of the VAT on maize imports shows that with VAT being charged it is often not profitable to import maize grain from South Africa to be sold in Mozambique. In addition, the VAT is not generating any additional income to the government of Mozambique, since most maize imports are used to make maize flour, resulting in the tax being reimbursed afterwards.

A first step toward increasing price transmission between international and domestic markets will therefore be to accelerate the elimination of the 2.5% import duty (already scheduled for 2015) and to phase out the 17% VAT on white maize grain. The removal of the import duty is a fundamental necessity for a more efficient maize trade system between these two countries. However, this mechanism cannot be applied independently: it needs to be accompanied by a national policy for the sustainable development of the white maize sector that coordinates and harmonizes policy mechanisms to motivate the development of a more competitive white maize grain market in Mozambique.

7. Conclusions

The main objectives of this research were to discover whether white maize prices in South Africa and Mozambique are spatially co-integrated, and to assess the speed and symmetry with which prices are being transmitted from the international to the domestic market.

The results of our econometric analyses show that although South African and Mozambican white maize prices are co-integrated in the long run, they are not co-integrated in the short run, and that the transmission of price signals between South Africa and Mozambique is asymmetric depending on whether international prices increase or decrease, with domestic prices taking about 11 months to adjust to a new equilibrium when international prices decrease, but only seven months when international prices increase.

The study suggests that two of the barriers preventing a more efficient price transmission from the international to the domestic market are the presence of a highly prohibitive import tariff and the structure of the VAT. The elimination of the 2.5% import duty and the phasing out of the 17% VAT are therefore recommended as a first measure to increase the transmission of white maize prices between South Africa and Mozambique.

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