RELATIONSHIP BETWEEN SPATIAL PRICE TRANSMISSION AND GEOGRAPHICAL DISTANCE IN BRAZIL

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Paper prepared for presentation at the EAAE 2011 Congress
Change and Uncertainty
Challenges for Agriculture,
Food and Natural Resources

August 30 to September 2, 2011
ETH Zurich, Zurich, Switzerland

Abstract – The price transmission between markets is often interpreted as providing insights into the market's infrastructure efficiency and transaction costs. Thus, finding a possible explanation for the degree of integration has become an issue of special interest. Recent researchers have pointed out the distance between markets as one of the possible factors. However, the distance is closely related with other elements, such as road quality and the proximity to an export point, which affect transport costs, opportunity costs and thus the integration. Therefore, what the most important factor is when determining the relationship among markets remains unclear. The cointegration framework, OLS and principal component regressions are applied in order to investigate the influence of geographical distance on the cointegration relationship between Brazil`s rice markets. In response to changes of the agricultural policies during the period of investigation, the presence of multiple structural breaks in the long run equation is allowed. The results point out a weak, negative and significant relation between distance and the elasticity of cointegration. Moreover, the region in which the market is located and a better access to export points are the main variables which defined the strength of the price transmission.

Keywords— ***cointegration, price transmission, geographical distance, structural breaks, principal component regression, rice, Brazil.***

1. Introduction

Spatial market integration refers to co-movements of prices and, more generally, to the smooth transmission of price signals and information across spatially separate markets (Goletti & other, 1995). The principal idea around this is upheld by the Law of One Price, which argues that the prices of the same product in two spatially separate markets would differ just in the transactions costs (Enke, 1951, cited by Rapsomanikis & others, 2003). The degree to which market shocks are transmitted across spatially-distinct markets has long been considered to be an important indicator of the performance of the market. The basis is that linkages are often interpreted as providing insights into the market´s infrastructure efficiency and the transaction costs (infrastructure issues such as road systems, market development, transportation, etc).

Nevertheless, the variables which affect the grade of integration have not yet been specified. Recent researchers have pointed out the distance between markets as one of the possible factors. Goletti et al. (1995) observed a negative relationship between distance and the co-integration coefficient in the rice markets of Bangladesh. When looking at the rice markets of Nepal, Sanogo (2008) found a positive relationship between price differentials, road distances and transport costs, as well as a lack of cointegration in the insolated markets. In another investigation regarding Peruvian markets, distance and geographical differences were identified as important factors affecting spatial integration. In the same investigation road density as a key affect is emphasized, or access to wholesale markets, in the reduction of transaction costs and the improvement integration (Escobal & Vásquez, 2005). Likewise, Rapsomanikis and Karfakis (2004) maintain that distance and transfer costs determine the price received by farmers. Literature to date has highlighted the narrow link between transaction costs and distance, and thus with the cointegration. In the case of Mozambican maize markets, Alemu & Biacuana (2006) establish that the transaction costs, using threshold values as an approach, are correlated positively with distance and inversely with the condition of the roads. Nevertheless, there are only a few investigations of this topic and the difference of the effect of geographical distance, road quality and other factors which affect the transaction costs has not been explored profoundly.

Brazil, one of the largest countries in the world, allows for an opportunity to examine this issue. The most important differences between the sectors are the distinctiveness of the geographical location, natural resources and infrastructure. It is not possible to discuss of an exclusive agricultural sector in Brazil. The deep differences between the regions provide a division with many aspects whereby it is possible to find small family farms and large scale production with high technologies and organization (Guilhoto & others, 2007). Moreover, the regions differ in the grade of specialization and in the influence over the behavior of the market. In the case of rice, production is concentrated in Rio Grande do Sul, where in 2005 the harvest was around 46% of the national production (MAPA).

Brazil is also a main participant in the global market of crops. It is one of the biggest exporters of agricultural products, especially grains. Around 4.6% (2006) of the net world agricultural exports are from Brazil (FAOSTAT). Likewise, Brazil is also a very important net consumer. In 2005 the country was the 10^{th} highest consumer of rice (FAOSTAT). Furthermore, products in which plays a main role are the base of the diets for the majority of the population in developing countries and its agricultural sector is anticipating a high possibility of increased production. In 2005 of the 350 million hectares available suitable for agricultural production, just around 44% were used for planting (MAPA). All of these factors hence translate into an agricultural development with a preoccupation for both developed and developing countries.

The objectives of this research are to investigate the influence of geographical distance on the cointegration relationship and isolate the effect from the impact of a set of possible influential variables in order to increase knowledge surrounding this issue and to indentify its role in Brazilian rice markets. With this intention, the cointegration framework is applied allowing for the presence of multiple structural breaks in the long run equation. The inclusion of breaks is in response to the multiple changes of the agricultural system during the period of investigation. The spatial integration is calculated between each market pair. The multinomial analysis is not included as carrying out the analyses with many states turned out to be computationally unmanageable, particularly due to the low degrees of freedom resulting from the inclusion of seasonal and breaks dummies. The relation between the cointegration coefficient and geographical distance is calculated by an OLS regression. Principal component regression is included with the purpose being to face the problem of multicolinearity appearing with the inclusion of the set of selected variables which are closely associated with the distance and have a possible effect on the cointegration.

Section 2 and 3 provide an overview of agriculture in Brazil and the rice markets. Section 4 describes the estimation methods. The data characteristics are presented in section 5 and the results are given in section 6. Section 7 concludes with final remarks.

2. Overview of the Brazilian agricultural market

Over the past 25 years the Brazilian economic reforms have had a decisive role in defining the actual agricultural conditions. The implementation of stabilization plans in the 1990's reduced the influence of the government, increasing private participation and changing the distribution of resources and altering the share of market covert for each state (Guanziroli, 1999).

The sudden and deep effects of some of these measures on the agricultural markets make them worth mentioning. First-off, in 1990 the non-tariff barriers were abruptly removed. Shortly thereafter, in 1991, the MERCOSUR agreement was signed, eliminating the tariffs of imports from Argentina and Uruguay, two stronger competitors and suppliers of Brazil. Another important event was the so-called "Real Plan" in 1994. It increased both the land and other non-financial asset prices which faced a peak in December of 1994. Perhaps the most important event during this period occurred in January 1999 when the Brazilian currency was allowed to float freely and depreciated by 50%, allowing for the resumption of some of the domestic products (Helfand & Castro, 2001).

Characteristics which affect the relationships between Brazilian markets

Firstly, one of the most important differences between the markets is the characteristics of the geographical location natural resources and infrastructure. This has given a comparative advantage to the states located in the middle-east, south east and southern part of the country.

Another critical factor of the agricultural development in Brazil has been transportation, which includes the quality of the roads and the accessibility to a port and check point at the border. Those farming in the Cerrano land in the center of Brazil need to transport their products more than 1000 km, while they also need to import essential inputs to be productive (Flaskerund, 2003). There are around 30 main ports distributed along the coasts and the principal rivers of Brazil. However, the three largest ones are responsible for 57% of the loading and unloading. One of them, Rio Grande, is essential for the commerce of rice, soybeans and maize (Ministério dos Transportes, 2010).

Regarding road quality, the high transportation costs affect producers' profitability with scheduled infrastructure improvements still outpaced by potential growth in production. An example is the case of soybeans, which are transported to market and exported mainly via roadway, with slow progress being made in multimodal transport systems. The record 2009/10 harvest has seen truck rates increase by 25-50%, as demand outstripped supply, accounting for 50% of the value of soybeans in the center-west region (Zimmerman 2010).

3. Price transmission investigations and principal characteristics of rice markets

In Latin America Brazil is the biggest producer of rice and in 10th place for per-capita consumption (371 Kcal/capita/day) (FAOSTAT). It is also a net importer, one of the most important in the world, absorbing around 5% of total world exports. In 2005 98% of rice and its derived product came from Argentina, Uruguay or Paraguay. However, the bigger proportion of consumption is provided by national production.

The bigger producer of rice in Brazil is the state of Rio Grande do Sul, where in 2005 the harvest was around 46% of national production (MAPA). The states of Mato Grosso (17% of production), Pará (5%) and Maranhão (5%) are significant producers as well (MAPA).

Río Grande do Sul is also the principal supplier of the biggest consumer center located in the south-east of the country. It and the state of São Paulo, representing the principle core of consumers, have an enormous influence on the formation of prices (dos Santos, 2005).

Concerning price transmission, Dutoit et al. (2009) found that rice market shows a strong relationship with the FOB prices of Argentina and Uruguay. They also found that the relationship is stronger in the reselling markets than in the producer markets. For their part Gonzales and Helfand, using a multivariate system, affirm that rice is traded extensively within the country and underscore the centrality of the southeast, specifically Sao Paulo and Minas Geradis, in the adjustment process and the long run equilibrium. Regarding distance, they found that the distance between Sao Pablo and the other states have an effect on the long run equilibrium and the speed of adjustment (Gonzáles & Helfand, 2001).

4. Methodology

The investigation is divided into two parts: first the cointegration analysis is given and second the relation between the coefficients of the long /short run and the distance of the markets is calculated.

Using the methodology proposed by Engle and Granger (1987) cointegration is used to test the existence of non spurious long run equilibrium between each market pair (Kirchgässner and Wolters, 2007). First, and once the order of the series is determined, the long run equilibrium is calculated using the following equation:

$$P_t^y = \beta_0 + \beta_1 P_t^x + \lambda t + \mu_t \qquad (1)$$

Where P_t^y is the dependent variable P_t^x the independent variable (both are the log of the prices), β_0 the coefficient related to the intercept, t the trend and μ is the error term. In equation (1) we do the assumption that P_t^x influences P_t^y, which means that market X is the leader in the relationship and market Y is the follower. In order to determine the role of the markets, the Granger Causality test (Granger, 1969) including the modification suggested by (Dolado & Luetkepohl, 1996) is employed. The cases selected fulfill the notion that P_t^x is causal of P_t^y but not on the contrary.

Thereafter, different tests are used to prove the stationarity of the error term (μ), in which case *y* and *x* are cointegrated (ADF, Phillips-Perron, ERS and Schmidt-Phillips) (Pfaff, 2006).

Until this point we know between which pairs of markets cointegration exists. Furthermore, in view that the variables are the logs of the prices, β_1 can be interpreted like elasticity. For the short run analysis of the relations it is applied the following Error Correction Model (ECM):

$$\Delta P_t^y = \alpha_y ECT + \sum_{j=1}^{n_x} \Gamma_j^y \Delta P_{t-j}^y + \sum_{j=1}^{n_y} \Gamma_j^x \Delta P_{i-j}^x + \alpha_0 + \alpha_1 t + \delta_i D_i + \varepsilon_t^y \quad \text{(2a)}$$

$$\Delta P_t^x = \alpha_x ECT + \sum_{j=1}^{m_x} \Phi_j^y \Delta P_{t-j}^y + \sum_{j=1}^{m_y} \Phi_j^x \Delta P_{t-j}^x + \alpha_0 + \alpha_1 t + \delta_i D_i + \varepsilon_t^x \quad \text{(2b)}$$

where the error correction term (ECT) is defined as the error (μ) of the long run equation described in (1). α_i represents the adjustment of prices on the left hand side to the deviations from the long run equilibrium. Γ_j and Φ_j are the short term parameters associated with lagged price changes. D_i are seasonal dummy variables where *i* can be from 1 to 12. When α_y is significant and α_x is not, any deviation from the long run relationship will cause an adjustment in P_t^y but not in P_t^x.

In some cases the long run equilibrium is held over some period of time, and then shifts to a new long run relationship. Given the information expounded in the previous chapter, in the 1990's Brazil experienced an intense period of adjustments, hence the omission of this situation could provoke bias in the results. In order to find evidences of structural breaks, the Empirical Fluctuation Process (RE test) long run equation suggested by Kuan and Hornik (1995) is first applied. In the case of having indications of instability, the procedure suggested by Bai and Perron (1998), modified using the significant values proposed by Kejriwal and Perron (2008), is applied to identify the number and the period of structural breaks. Once the periods of the possible breaks are located, they are included in the long run equation using the three possible long run equations suggested by Gregory and Hansen (1996), which considered the idea of cointegration allowing for structural breaks.

Model II. With level shift: $$P_t^y = \beta_0^1 + \beta_0^i \psi^i{}_{t\tau} + \beta_1^1 P_t^x + \mu_t \quad \text{(3a)}$$

Model III. With level shift and trend: $$P_t^y = \beta_0^1 + \beta_0^i \psi^i{}_{t\tau} + \beta_1^1 P_t^x + \delta t + \mu_t \quad \text{(3b)}$$

Model IV. Regime Shift: $$P_t^y = \beta_0^1 + \beta_0^i \psi^i{}_{t\tau} + \beta_1^1 P_t^x + \beta_1^i \psi^i{}_{t\tau} P_t^x + \delta t + \mu_t \quad \text{(3c)}$$

It is defined: $$\psi^i{}_{t\tau} = \begin{cases} 0 & if \quad \tau^i \le [n\tau], \\ 1 & if \quad \tau^i > [n\tau] \end{cases}$$

Where the parameter $\tau \in (0,1)$ denotes the timing of the change point, and $[\ ]$ denotes integer part, i corresponds to the break and can be from 1 to 3. β_0^1 corresponds to the intercept before the shift and β_0^2 represents the change in the intercept at the time of the shift. β_1^1 designates the cointegration slope coefficients before the regime shift, and β_1^i corresponds to the change in the slope. The model which (minimum AIC) describes the behavior of P_t^y more significantly is selected. Once again the stationarity of the new error terms is tested using the same indicators mentioned above and the ECM is applied.

The methodology described is carried out over each pair of Brazilian rice markets, giving as a result the elasticities of cointegration ($\beta_{1,}$ β_1^1 and $(\beta_1^1+\beta_1^i)$), and the short run adjustment coefficient (α_y and α_y $break$). Thus, using a simple OLS analysis, six equations are calculated where the independent variable is distance (km) and the dependent variable is: 1) β_1 calculated in the long run equation (1). 2) α_y (Follower market) the adjustment coefficient of the first equation of the ECM (2a). 3) β_1^1 the elasticity of the initial period of investigation, before the first break. 4) Beta of the transition period[1]. 5) Beta of the last period or the elasticity after the last break. 6) α_y break the adjustment coefficient of the ECM allowing for breaks in the long run.

One of the aims of this paper is to isolate the effect of distance on other factors that have an influence on the cointegration relation. Considering the information presented in sections 2 and 3, the following characteristics are identified as important: the access to export points (ports and check points at the border), the quality of the roads, the region in which production is located, and the importance of the state as a producer or consumer. Thus, each variable is taken as an independent variable and, using OLS, is regressed individually against every one of the six dependent variables defined above. The variables which have a significant t-value are included in a set of independent variables which explain the elasticity and the adjustment. However, these variables are closely related with each other and thus the possible presence of multicollinearity could provoke bias in the results. As a consequence, the Principal Component Regression methodology is applied (Mevik B. & R. Wehrens, 2007) (Jolliffe, 2002). It is a method for combating multicollinearity and results in estimations and predictions which are better that ordinary least squares (Ramzan & Inayat Khan, 2010).

First the principal component analysis is applied; the possible eigenvalues of the matrix of bivariate correlations between each pair of the explanatory variables in descending order is estimated: $\lambda 1, \lambda 2, \ldots, \lambda n$; $j = 1, 2, \ldots, k$. Simultaneously the corresponding eigenvectors (written as row vectors) are $\mathbf{C}j = (c1j, c2j, \ldots, ckj)$. The n principal components $Z1, Z2, \ldots, Zk$ are given by $Z_{j=} \sum_{i=1}^{n} C_{ij} X_i$; $j = 1, 2, \ldots, k$ and $i = 1, 2, \ldots, k$. Where X_i are the independent variables (matrix notation as Z=CX). Z_j are linear functions of the standardized explanatory variables with the covariance matrix $V = \text{diag}(\lambda 1, \lambda 2, \ldots, \lambda k)$

Second the normal OLS equation is applied:

$$y^{\iota} = \theta_0^{\iota} + \sum_{i=1}^{k} \theta_i^{\iota} X_i + \mu \quad (4)$$

where y_{ι} $\iota = 1,2, \ldots, 6$ and correspond to each one of our dependent variables. It is written in terms of standardized variables as:

$$y^{\iota} = \sum_{i=1}^{k} \theta'^{\iota}_i X_i \quad (5)$$

then, because C is orthogonal, the equation (5) is equivalent to

$$y^{\iota} = \sum_{i=1}^{k} \gamma_i^{\iota} Z_i \quad (6)$$

[1] The average between: the elasticity in the second period (after the first and before the second break) and the elasticity in the third period (after the second and before the third break).

where the θ_i and γ_i are related as:

$\gamma^i = \sum_{i=1}^{k} c_{ij}\theta''^i_i$ (7.1) $\theta''^i_j = \sum_{i=1}^{k} c_{ji}\,\gamma^i_i$ (7.2)

However, if we include all the *Zj* principal components in the equation (6), the extra information given by the multicollinearity of the variables is not removed. Because of that the least important principal components are eliminated, thus much more stable estimates of θ^i_i can be obtained. First the leave-one-out cross-validation of the root squared error of prediction (RMSEP) is used (Mevik B. & H. Cederkvis, 2004).

All of the econometric analyses were carried out using the free access program R.

5. Data base

The markets prices of rice have been provided by the Economic Commission for Latin America and the Caribbean of Chile (ECLAC), and are from the Regional Council of Agricultural Cooperation. The type of rice considered is paddy rice. The time span starts in February 1990 and ends in January 2006. All prices are monthly data in dollars per ton. The variables are used in their logarithmic form. Missing values represent 2% of the data base. They were filled using an imputation algorithm proposed by King et al. (2001) and the corresponding R-package AMELIA II, developed by Honaker et al. (2009). 1000 imputations for each missing value were performed and its most likely values were estimated using Parzen's (1962) nonparametric mode estimator.

The distance has been calculated using Google maps information which provides the road distance in kilometers. The location and information of the most important ports are from the Ministry of Transport of Brazil and the number of check points at the border by Port Authorities. Brazil's National Department of Transport Infrastructure has provided information on the quality of the roads. Finally, the importance of the states as producers or consumers has been given by the Brazilian Institute of Geography and Statistics (Annex).

6. *Results*

In order to begin the cointegration analysis, it is necessary to indentify the integration order of the series. It is possible to calculate the long run equilibrium only between such pairs of prices of which both series are I(1) and whose firsts differences are I(0). With the purpose of not making assumptions about the behavior of the variables, the ADF test is applied including as much intercept as a trend or both. In view of the critics against the ADF Test; the Phillips-Perron Test, ERS-Test or P-test, and Structural Break Zivot-Andrews test are also included. For some variables the tests are not equal and the final result corresponds to the solution point for at least three of the five indicators. There are 25 prices, 24 are non-stationary and the first difference for each variable is I(0).

Before the estimation of the Granger Causality test, 183 market pairs are selected, 137 (74.9%) of them are cointegrated. In addition, there are 177 equations which present significant structural breaks and all of them are cointegrated. Table 1 shows the distribution of the periods in which the relations present significant structural breaks. There is a clear concentration of the first break between 1991 and 1992, shortly after the entry into MERCOSUR. The second break presents a higher dispersion which could be associated with the fact that the policy changes were not applied in all of Brazil at the same time. Finally, the last break happens mostly after the liberalization of the currency. In view of these results, we expect that the initial β, reflects the behavior of the market before the application of the reforms and the β of the last period reflects the situation after the reforms. The β transition represent the period in which the policy changes were being implemented.

Table 1
Period of significant structural breaks (number of relations)

Period	First Break	Second Break1	Last Break2
1991-1992	***96***	2	0
1993-1994	53	***27***	13
1995-1996	8	***48***	14
1997-1998	2	24	22
1999-2000	9	19	22
2001-2002	8	9	***63***
2003-2004	1	0	***39***
Total	***177***	***129***	***173***

[i] The second one in the relations with 3 breaks.
[ii] The last break in the cases with at least 2 breaks.
Source: Own Elaboration

Table 2 displays the principal results of the OLS analysis. First, the elasticity of cointegration shows a significant and negative relation with the distance. This is true with and without break, with the exception of the transition period. Moreover, the relation is weak an increment in the distance of 100 km decreases the elasticity of cointegration by 1% before the first break and by 1.67% after the last break. Second, the adjustment of the follower market to the equilibrium (α_y) is not significantly related with the distance.

Table 2
OLS: Distance and Cointegration

	WITHOUT BREAK		*WITH BREAK*			
	β^{i}	α_y^{i}	β initial [i]	β transition[i]	β last period[i]	α_y^{i}
Intercept	0,90 ***	-23,56 ***	93,84 ***	65,69 ***	103,31 ***	-30,96 ***
distance in 100 km	-0,004 ***	0,08	-1,00 ***	0,18	-1,67 ***	-0,12
R2 Adj	0,12	0,01	0,12	0,00	0,12	0,00
F	19,10	2,44	25,60	0,67	25,80	1,36
Normality	yes	not	not	not	not	not
Heterocedasticity	not	not	yes	not	yes	not
Autocorrelación	yes	not	not	yes	not	not

[i] Represent the percentage effects.
Source: Own Elaboration

The next results correspond to the principal component regression. They confirm the negative relation between the distance and the elasticity, which is again weak and bigger after the last break (Table 3). The second finding is the low relation between the variables and the beta in the transition period. Two considerations are important, first it corresponds to continuous and dissimilar changes, and, second the cases with three structural breaks have four different periods, thus the β transition corresponds to the average of the second and third periods.

Regarding the access to an export point (Table 3), the distance to the closest port is the most important factor after the last break, with a negative relation so much for the follower market as for the leader market. Furthermore, the variable *ports at 12 hours* shows that more than 6 is associated with a diminution in the elasticity and between 1 and 6 ports represent an increase. Moreover, the existence of a *check point* at the border lost its importance from the initial period to the last one, when it is small and negative. These findings mean that those markets closer to an export point have a higher connection with the internal sector. This is unexpected because selling on the national markets is associated with lower transport costs than selling on international markets for a producer closer to an export point. However, according to Gries et al. (2009), the transport costs to an export point is an important factor, but it is only one component of distance that affects the optimal location of an exporter producer. They argue that a port is used to be part of an economic center or agglomeration, and the wages and the price of land decline as one move away from the center. Considering the existence of many aspects which change the effect of the distance to an export point in the elasticity, we recommend going deeper on this point in a further investigation.

Concerning the region, the effect is stronger before than after the reform (Table 3). It could be related with the appearance, due to the changes in the economy; of new variables which are now important in order to define the cointegration relation. The South Eastern region has the best elasticity in the initial and the last period, with only the last column of Table 3 being an exception. São Paulo is located in this region, and is the principal core of consumers with an enormous influence on the formation of prices. The main producer markets in the South have one of the lower elasticities except for the follower market in the last period. It could be associated with a stronger relation of this region with the international markets than with the national markets. It is important to mention that in the relations in which the main producer, Rio Grande do Sul, is included, it is the leader market. Regarding the North, compared with the Middle Western region (base region in the regression), it has a weaker cointegration before the policy changes, while in the last period the contrary occurs. The opposite is true in the North Eastern region, which also has the lower cointegration coefficient in the last period. Maranhão, located in this region, is an important rice producer although most of the production is consumed inside the state, and in some periods it is also necessary to import. An increase in the trade with international suppliers can explain the low cointegration.

Table 3
Principal Component Regression: Elasticity of Cointegration

Variables	β[i]		β initial[i]		β transition[i]		β last period[i]	
Intercept	76,08		96,70		75,09		181,62	
distance (100km)	-0,24		-0,72		0,19		-1,22	
	X	*Y*	*X*	*Y*	*X*	*Y*	*X*	*Y*
Distance to the Closest Port (100km)	0,71	-1,80	0,50				-2,21	-3,04
Port 12h- 1 to 5	0,21	-10,86	0,83	-6,08	0,00	0,00	0,17	0,12
Port 12h- 6 to 10	-1,69	10,92	4,85	-4,58	0,00	0,00	-0,07	-0,19
Distance to the Principal Port: *RIO GRANDE* (100km)		0,30	-0,05	-0,11	-0,41			-1,11
CheckPoint- yes	-5,08	4,38	-10,05	5,25	0,01	0,00	-0,13	-0,10
Regions- North	2,68	-12,89	-2,23	-8,66	-0,01	0,00	0,09	0,05
Regions- NorthEast	0,20	1,86	1,30	1,44	0,00	0,00	-0,18	-0,07
Regions- South	-3,03	-3,32	-6,71	-1,33	0,01	0,00	-0,03	0,06
Regions- SouthEast	-0,01	3,90	9,54	2,43	0,00	0,00	0,09	0,03
Federal´s Roads (km per each 1000 km^2)	0,15					-0,03	-0,35	0,06
State´s Roads (km per each 1000 km2)	0,15				0,13	-0,22	0,22	-0,23
Municipal´s Roads (km per each 1000 km2)		0,09	-0,54	-0,38				
Consumption		0,24		0,15			-0,88	
Population Density	-0,04						0,01	
Principal Producer- yes	-3,59	-0,43	-5,86	0,42	0,01	0,00	0,01	0,04
# components	*18,00*		*11,00*		*3,00*		*10,00*	
% variance explaind-X	*100,00*		*99,99*		*85,77*		*99,99*	
% variance explaind-Y	*56,19*		*30,53*		*17,57*		*34,83*	
RMSEP adjCV	*0,10*		*28,74*		*29,71*		*46,53*	

[i] Represent the percentage effects.
X= Leader Market Y= Follower Market
Source: Own Elaboration

The relation with the quality of the roads is presented in Table 3. In the initial period the amount of the municipality's paved roads has an influence on the cointegration, while in the last period the federal and state roads are the important ones. However, the sign of the coefficient is against the expected behavior, an increment in the number of km of paved road by 1000km^2 is related with a diminution in the elasticity.

The consumption of rice and the population density are approximations of the importance of the state as a consumer. The first variable has a positive impact for the followers market in the initial time but a negative for the leaders in the last period (Table 3). It could be connected to the increases in the import facilities of the main purchasing states. The followers are less important as a destination of the production, while the leader consumers can import a bigger part of their purchases from internationals markets. The last variable *principal producer* shows a significant impact in the first period. In addition, in the third period the impact is lower and the sign implicates that the principal producer has a better connection with the rest of the markets.

Further within the analysis we have the results of the adjustment coefficient. Table 4 demonstrates the weak impact of the distance in the adjustment to the equilibrium, but it is essential to remember that it has not been significant in the OLS regression.

The inclusions of the breaks in the long run give as a result a weakening in the impact of the selected variables (table 4). This is probably due to the effect of new factors which increased their importance after the applications of the reforms, such as, perhaps, the concentration of the land and the production. The Gini index of land rose 1.9% from 1995/1996 to 2006, with a final value of 0.872 points (IBGE).

The most important influence is shown by the variable *Closer port* with a negative impact of 2.48%. This means that the followers markets near a port have the faster adjustment to the equilibrium.

Table 4
Principal Component Regression. Adjustment Coefficient

Variable	α_y without break[i]		α_y with break[i]	
Intercept	-21,13		-29,52	
distance (100km)	0,04		-0,12	
	X-Lider	*Y-Follower*	*X-Lider*	*Y-Follower*
Distance to the Closest Port (100km)	-1,36			-2,48
Port 12h- 1 to 5	0,55	0,95	0,00	0,10
Port 12h- 6 to 10	0,66	1,94	0,01	-0,17
Distance to the Principal Port: *RIO GRANDE* (100km)				
CheckPoint- yes	0,22	2,23	-0,05	-0,15
Regions- North	-0,83	-1,84	0,02	0,12
Regions- NorthEast	-0,33	-0,05	0,01	-0,09
Regions- South	0,61	1,72	-0,04	0,01
Regions- SouthEast	0,68	-0,11	0,03	0,01
Federal´s Roads (km per each 1000 km^2)		-0,09		0,03
State´s Roads (km per each 1000 km2)				
Municipal´s Roads (km per each 1000 km2)				
Consumption		0,12		0,18
Population Density				
Principal Producer- yes	0,48	0,31	-0,04	0,07
# components	*9*		*4*	
% variance explaind-X	*99,89*		*99,55*	
% variance explaind-Y	*41,02*		*38,79*	
RMSEP adjCV	*5,977*		*12,31*	

[i]Represent the percentage effects.
Source: Own Elaboration

7. Conclusions

Two states which have an extensive distance between them would face high transport costs and hence more troubles to trade with each other. This is the idea behind the consideration of distance as a factor which affects the price transmission between two spatially separate markets. However, this idea omits other factors apart from distance which also influences the decision to trade, affecting the opportunity costs, the transport costs and thus the cointegration. For instance, the quality of the roads, the intrinsic attributes of the located region and the ability to access an export point are other relevant factors. It is really a question of how far the two markets are, or is where the markets are and what their trading facilities are more important? In order to explore this question, the main objective of the research has been to isolate the effect of distance on the cointegration relationship from the impact of a set of possible influential variables. This topic is even more important for an agricultural market such as that of Brazil, because of the long distance required for many producers to reach other markets, the deep differences between the regions, etc., making Brazil an interesting and important case. In view of that, the investigation has been oriented to the rice market of this country.

The results indicate that there is a negative and significant relationship between distance and the elasticity of cointegration, although it is weak. Regarding the adjustment coefficient, the relation is also weak but not significant.

Considering the policy reforms, changes in the elasticity in the period of investigation are permitted. The majority of the relations have at least two structural changes, hence dividing the time in three periods: before, during and after the reforms. The first change takes place around the beginning of the application of the reforms (1990/92) and the last break occurs after the liberalization of the currency in 1999. The results of the period of transition or during the reforms indicate an almost null influence of the variables in the elasticity. This is associated firstly to the fact that the time of the second break has a high distribution among the relations, and secondly to the unequal implementation of the reforms between the regions. Furthermore, the effect of the variables in the cointegration coefficient in the last period is lower than in the first one. Issues which are possibly related with the increase of the importance of new factors, like the power market, for example, could be an explanation for this.

Regarding the variables, *distance to an export point* is the most important variable which defines the elasticity and the adjustment coefficient. So much so that the distance to port as to check point have a negative and significant influence. The causes of this effect are not clear, thus it is suggested to investigate this point further. The region is also an important factor; the most cointegrated markets are in the South Eastern region, where São Paulo is located.

Finally, it is worthy to highlight the changes in the impact between the first and the last period which suggest that, even if the rice is not principally produced for international markets, these have an effect on the cointegration. Moreover, this effect appears more important after the reforms than before. Therefore, it is recommended to go deeper into this topic, including the effect of the international prices as well as the direction and amount of the import and export quantities of each state.

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ANNEX

Table 5
Independent Variables

Variables	Description	Variables	Description
Regions	1. Middle East	Distance to the most important port (Port Rio Grande)	100 km
	2. North	There is a Check Point at the border	1=yes
	3. Northeast	Extension in km of Paved Road per 1000 Km^2	Federal
	4. South		State
	5. Southeast		Municipal
Number of port which are at least 12 hours	0	Consumption	per capita annual (kg)
	1-5		
	6-10	It is a principal producer	1=yes
Distance to the closest port	100 km	Population Density	Continuous variable