The relationship between spatial price transmission and geographical distance: the case of Brazil

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Abstract— **The objectives of this research are to investigate the influence of geographical distance on the cointegration relationship in order to increase knowledge on the issue, and to indentify its role in Brazilian agricultural 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 cointegration coefficient and geographical distance relationship is calculated by means of an OLS regression, taking into account the quality of roads and the proximity to a border or port. The effect of the distance depends on the product. In the case of rice markets, there is a weak, negative and significant relation. Concerning soybeans, the relationship is not significant. After allowing for the inclusion of breaks in the long run, the results remain unvaried. In addition, the region and a better access to export points are the main variables in the definition of the prices.**

Keywords— **cointegration, price transmission, geographical distance, structural breaks, rice, soybeans, Brazil.**

JEL: C32, Q11, Q13

I. 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 [1] The principal idea around this is bore 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 [2]. 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).

However 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. [1] observed a negative relationship between distance and the co-integration coefficient in the rice markets of Bangladesh. When looking at the rice markets in Nepal, Sanogo [3] found i 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 effect is emphasized, or access to wholesale markets, in the reduction of transaction costs and the improvement integration [4]. Likewise, Rapsomanikis and Karfakis [5] 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 [6] 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 on this topic. Moreover, the difference of the effect among the 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 in a market whose characteristics are connected to distance. The most important differences between the sectors are the distinctiveness of the geographical location: natural resources and infrastructure. It is not a unique agricultural sector in Brazil. The deep differences between the regions give us a division with many sides where it is possible to find small family production and large scale production with high technologies and organization [7]. Moreover the regions differ in the grade of specialization and in the influence over the

behavior of the market. For example, the main producers of soya are located in the central region, where the state of Mato Grosso has particular importance. In 2005 it was responsible for 35% of the national production [8].

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. In 2005 it was the second largest producer of soybeans [9]. Likewise, Brazil is also a very important net consumer. In 2005 the country, which is the most populated in Latin-America, was the 10th highest consumer of rice and the 3rd of soybeans [9].

Furthermore, the products in which Brazil plays a main role are the base of the diets for the majority of the population in developing countries. Moreover, Brazil is anticipating a high possibility of increased production. In 2005, of the 350 millions of suitable hectares available for agriculture just around 44% were used for planting [8]. According to the current President Luiz Inacio Lula da Silva, Brazil has the suitable conditions to become the next granary of the world [10]. All of these facts hence translate into an agricultural development with a preoccupation for both developed and developing countries. In order to be able to effectively create growth and progress in the agricultural sector of Brazil, it is necessary to look deeply at the relationship of the markets, especially those of primary products.

The objectives of this research are to investigate the influence of geographical distance on the cointegration relationship in order to increase knowledge surrounding this issue, and to indentify its role in the Brazilian agricultural 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 a 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 inclusion of seasonal and breaks dummies. The cointegration coefficient and geographical distance relation is calculated by means of an OLS regression, taking into account the quality of the roads and the proximity to a border or port.

Section 2 and 3 give an overview of agriculture in Brazil and the markets of the crops included. Section 4 describes the estimation methods. The data characteristics are presented in section 5, the hypothesis in Section 6 and the results are given in section 7. Section 8 concludes with final remarks.

II. OVERVIEW OF THE BRAZILIAN AGRICULTURAL MARKET

In the past 25 years the Brazilian economic reforms have had a decisive role in the definition of the actual agricultural conditions. The implementation of stabilization plans in the 1990's reduced the influence of the government, thus increasing private participation, and changed the distribution of resources, and altered the share of market of each state. Furthermore, in order to fight against the threat of hyperinflation crucial measures were adopted, such as trade liberalization, deregulation of agricultural markets, and changes in rural credit and support price policies [11].

The sudden and deep effects of some of these measures within the agricultural markets made them worth mentioning. First, in 1990 the non-tariff barriers were removed abruptly. Furthermore in this year credit experienced a strong reduction. Shortly thereafter, in 1991, the MERCOSUR agreement was signed, eliminating the tariffs of imports from Argentina and Uruguay, two stronger competitors of the Brazilian markets. Another important event was the interruption of the support price policy between 1990 and 1991 and its reactivation throughout the period of 1992 and 1995. In 1994 the so-called "Real Plan" was started. It increased both the land and other non financial asset prices. It faced a peak in December of 1994. The result of the plan's successfulness was an increase in the attractiveness of financial assets. Therefore in 1995 a severe financial crisis affected the agricultural sector as the prices for both land and the agricultural commodities fell abruptly. 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 [12].

A. Principal characteristics which affect the relationships between the 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. Due to this fact, the government has given more amenities to the producers in these regions, for example access to financial support, training and technologies. This has lead to integration with international markets, increasing the exports, and thus the sensitivity to external changes. Annex 1 shows the geographical location of the states in Brazil.

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, similar to Mato Grosso, need to transport their products more than 1000 km, while they also need to import essential inputs to be productive [13]. 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. Santos is the most significant and is located in the state of São Paulo; it is also a vital center for the export of soybeans. The second, Itajaí in Santa Catarina, is a central point for the maize trade. Finally, Rio Grande is essential for the commerce of rice, soybeans and maize [14].

Related to the trade of products with the neighboring countries, the accessibility to the check point of the border is also essential for the behavior of the markets. In 2005, 98% of rice and 99% of soya and its derived products imports came from Argentina, Uruguay or Paraguay [15]. Therefore, the southern states have more border check points for the transportation of products. In Río Grande do Sul, with borders to both Argentina and Uruguay, 43% of the check points for loading are located, followed by Parana with 23% [16].

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 [17].

III. PRINCIPAL CHARACTERISTICS OF THE MARKETS AND PREVIOUS PRICE TRANSMISSION WORKS

The most important factor shared by the two markets included in this investigation is the seasonality of the crop cultivation. The changes in climate have an important influence on the supply and the prices' behaviors. The description of this seasonality is included in Annex 2. The other important characteristics are more specific to each of the market, and they are described in the following subsections.

A. Rice

In Latin America Brazil is the biggest producer of rice and in 10th place for per-capita consumption (371 Kcal/capita/day) [9]. It is also a net importer (Figure 1), absorbing around 5% of the total of world´s exports. Its imports principally come from Uruguay, Argentina and Paraguay. The investigation carried out by Wanderac et al. [18] points out that of the three different cultivation systems of rice (irrigated lowland rice, upland aerobic rice and deep water rice), in Brazil the production is done by irrigated lowland rice and aerobic rice, while only the first one is being exported. They found that Brazil has no comparative advantage in the production of rice, and that its share in the world market depends on the structural changes in the international conditions.

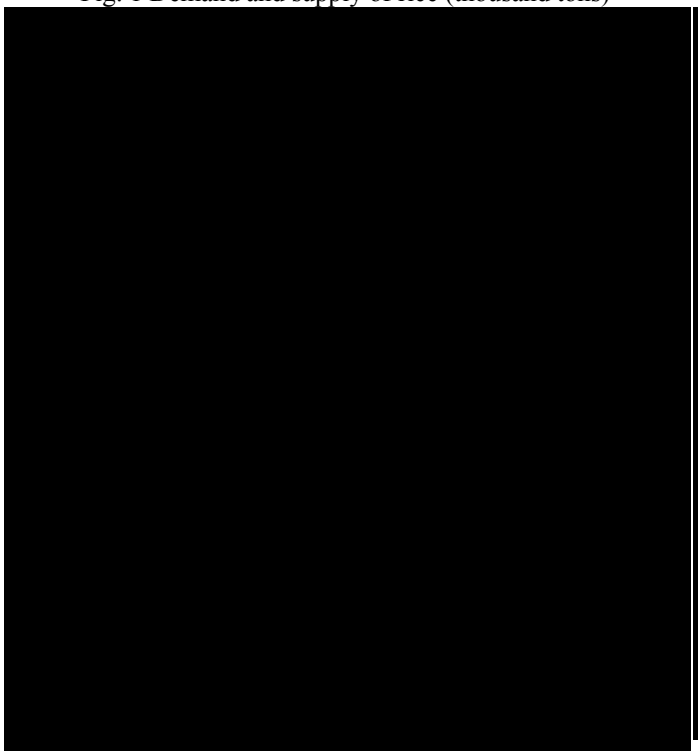
The bigger producer of rice in Brazil is the state of Rio Grande do Sul, where in 2005 the harvest was around 46% of the national production [8]. In this state the main characteristics of production are the large size of the farms (around 200 ha) and the high level of technologies used [19]. However, the whole southern region (Annex 1) has a central role in this market, despite the fact that in the other two states, Santa Catarina and Paraná, production takes place on small farms with an average size of 10ha [19]. The states of Mato Grosso (17% of production), Pará (5%) and Maranhão (5%) are significant producers as well, although they are not located in the South [8].

Río Grande do Sul is also the principal supplier of the two biggest consumer centers located in the South-East and North-East of the country. It and the state of São Paulo, as the principal core of consumers, have an enormous influence on the formation of prices [20].

Concerning price transmission, Dutoit et al. [21] found that Brazil´s rice market shows a strong relationship with the FOB prices of Argentina and

Uruguay, which is due to the fact that they are the principal source of imports. They also found that the relationship is stronger in the reselling markets than in the producer markets. For their part Gonzales and Helfand used a multivariate system. They 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. However, they establish that the Southern part is the least interdependent in the country; which they attribute it to the difference in quality, with rice from the South being superior. Regarding distance, they found that the distance between Sao Pablo and the others states has an effect on the long run equilibrium and speed of the adjustment [22].

Fig. 1 Demand and supply of rice (thousand tons)



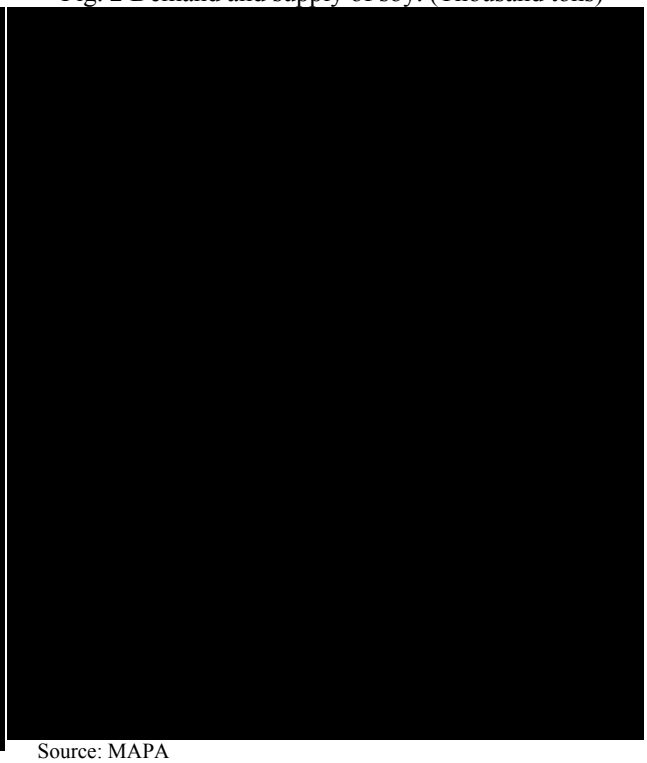
Source: MAPA

B. Soybeans

Brazil is the second largest producer of soy in the world, after the USA, but with a higher growth rate of 28% (2001-2005) [8].It is also one of the three most important exporters, together with Argentina and the USA. The principal market for its exports is the elaboration of supplement for animal feeding. Therefore the price of soy is related to the movements of the animal breeding markets, especially those located in China and the EU [23], the first being its primary export destination and the second its principal competitor.

In recent years both the production and exports have been increasing (Figure 2). This can be explained by the availability and quality of resources in some areas of Brazil, and the new technologies used to increase productivity. Actually the main producing state is Mato Grosso (35%), whose governor is Blairo Maggi, president of "Grupo Maggi", which is considered the largest producer of soy in Brazil. In this state industrial production on big farms dominates; which use high technologies for cultivation and harvest [23]. Mato Grosso is followed in importance by the others states located in the center of the country: Paraná, Goiás, Mato Grosso do Sul and Minas Gerais [8].

Fig. 2 Demand and supply of soy. (Thousand tons)



Source: MAPA

In view of the importance of soy to the Brazilian agricultural development, there are a considerable number of cointegration analyses for this market. Vieira et al. [24] found a strong cointegration between the prices of Brazil and Chicago (a long run coefficient equaling 83%). It is worthwhile to mention that in the analysis they included the presence of two structural breaks, one in 1996, the year of the exoneration of exports, and the second one in 1999, because of the transformation of the exchange regime; nevertheless

the results did change in a significant way. Something similar was found by Matheus and Silvestre [25], the difference being that they compared the prices of Maringá (important sub-state of Paraná) with the prices of USA solely. When concluding, they first mention the existence of a long run relationship and, secondly, that the changes in the external price are transmitted slowly to the internal prices. Another investigation conducted by Margarido et al. [26] analyzed the long run relationship between Brazil, the EU and US markets, concluding that Brazil is more affected by variations in the Rotterdam prices than in US prices. They also affirm that Brazil can be seen as a price taker, even though it is an important producer and exporter of soybeans. Balcome et al.[27], which use thresholds in the co integration analysis, included soya as one of the products in their study. It is noteworthy that soya presented the smaller threshold, while the speed of the adjustment is quiet different between the within and out-of-threshold as well.

In a domestic analysis Pinheiro and Carvalho [28], using the Johansen´s cointegration test and the vector error correction model, determined that the changes in prices which occurred in Rio Grande do Sul are almost fully transmitted to the soy bean prices in Paraná and Mato Grosso. Nevertheless there is no relationship between in prices Mato Grosso and Paraná.

IV. 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 [29] cointegration is used to test the existence of non spurious long run equilibrium between each market pair [30]. First, and once the order of the series is determined, the long run equilibrium is calculated using the following equation:

$$y_t = \beta_0 + \beta_1 x_t + \lambda t + \mu_t \qquad (1)$$

Where y_t is the dependent variable x_t the independent variable (both corresponding to the log of the prices), β_0 the coefficient related to the intercept, t the trend, μ is the error term, and the rest are unknown coefficients.

Thereafter, different tests are used to prove the stationarity of the error term (μ), in which case *y* and *x* are cointegrated. Among them are the ADF test with adjusted critical values, the significant number of lags is calculated by computing the Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC) and the Fixed criterion. The other unit root tests applied are the Phillips-Perron Test, ERS-Test (P-test) and Schmidt-Phillips (SP) test [31].

Until this point it is known that price transmission exists between each pair of markets and the cointegration coefficient (β_1). Furthermore, in view that the variables are the logs of the prices, β_1 can be interpreted like the elasticity. Only the short run analysis of the relation remains; with this aim the Johansen [32] method is applied to estimate the following Vector Error Correction Model (VECM):

$$\Delta Py_t = \alpha_y ECT + \sum_{j=1}^{n_x} \Gamma_{yj} \Delta Py_{t-j} + \sum_{j=1}^{n_y} \Gamma_{yj} \Delta Px_{t-j} + \alpha_0 + \alpha_1 t + \delta_i D_i + \varepsilon_{yt} \qquad (2a)$$

$$\Delta Px_t = \alpha_x ECT + \sum_{j=1}^{m_x} \Phi_{yj} \Delta Py_{t-j} + \sum_{j=1}^{m_y} \Phi_{yj} \Delta Px_{t-j} + \alpha_0 + \alpha_1 t + \delta_i D_i + \varepsilon_{xt} \qquad (2b)$$

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_{ij} and Φ_{yj} are the short term parameters associated with lagged price changes, the optimal number of lags corresponded to the maximum number among AIC, HQ, SC and the FPE criterion. The selection between constants, trends, both or none was made in the base of the ratio test. D_i are seasonal dummy variables where *i* can be from 1 to 12, they are included if the month related is statistically significant at explaining the behavior of y_t. When α_y is significant and α_x is not, any deviation from the long run relationship will cause an adjustment in *Py* but not in *Px*. In this case we can say that (2a) corresponds to the "follower market", because in each case *Py* is the price which is adjusting. It is for the reason that the order in which *y* and *x* are selected gives a t value of α_y always higher than α_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, the omission of this situation might provoke bias in the results. In order to find evidences of structural breaks, first it is applied to

the long run equation the Empirical Fluctuation Process (RE test) suggested by Kuan and Horn [33] In the case of having indications of instability, the procedure suggested by Bai and Perron [34], modified using the significant values proposed by Kejriwal and Perron [35], is applied to identify the number and the period of structural breaks. Once the periods of the possible breaks is located, they are included in the long run equation using the three possible long run equation suggested by Gregory and Hansen [36], which considered the idea of cointegration allowing for structural breaks.

Model II. With level shift:

$$y_t = \beta_0^1 + \beta_0^i \psi^i{}_{t\tau} + \beta_1^1 x_t + \mu_t \quad (3a)$$

Model III. With level shift and trend:

$$y_t = \beta_0^1 + \beta_0^i \psi^i{}_{t\tau} + \beta_1^1 x_t + \delta t + \mu_t \quad (3b)$$

Model IV. Regime Shift:

$$y_t = \beta_0^1 + \beta_0^i \psi^i{}_{t\tau} + \beta_1^1 x_t + \beta_1^i \psi^i{}_{t\tau} x_t + \delta t + \mu_t \quad (3c)$$

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. Where 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 more significantly describes the behavior of y_t is selected

Continuing with the analysis, the stationarity of the new error term is tested using the same indicators which have been mentioned before. After that the VECM is applied again.

The methodology described above is carried out on the two products (rice and soybeans) and each pair of Brazilian markets, each case giving as a result the long run elasticities ($\beta_1(1,)$ $\beta_1 1^{\wedge}1$ and $[[(\beta]$ $_1 1^{\wedge}1 + \beta]$ $_1 1^{\wedge}i$)), and the short run adjustment coefficient ($\alpha_1 y$ and $\alpha_1 y$ break) . On the basis of this, for each product six equations are calculated where the independent variable is the distance and the dependent variables are:

1. β_1 calculated in the long run equation (1).
2. α_y (Follower market) this is the adjustment coefficient of the first equation of the VECM (2a).
3. β_1^1 associated to the first break calculated
4. Beta of the Transition period which is:
   a. $[\beta_1^1 + \beta_1^2)$ when there are two significant breaks.
   b. $[(((\beta_1 1^{\wedge}1 + \beta]$ $_1 1^{\wedge}2) + [(\beta_1 1^{\wedge}1 + \beta]$ $_1 1^{\wedge}3))/2$) in the cases with three breaks
   c. there is not when one break is significant.
5. Beta of the last period. Corresponds to the last beta calculated.
6. α_y break which is the adjustment coefficient of the equation of the VECM which included the ECT of the break long run equation.

The independent variable distance is analyzed using two measures: the km and the duration in hours of a journey.

One of the aims of this paper is to isolate the effect of distance on other factors that have an influence in the cointegration relation. In the basis of 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 of the product. Thus, for each one of these characteristics the Log Ratio is used in order to prove whether its contribution to explain the dependent variable is significant in which case it is included in the equation. Details of the variables are included in Annex 5.

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

V. DATA BASE

The state prices of rice and soy 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, that is, rice that has only been cut from the plant, with the husk, i.e, without any transformation.

All prices are monthly data and are in dollars per ton. The time span for the majority of Brazilian series starts in February 1990 and ends in January 2006 (Annex 3). The variables are used in their logarithmic form. Missing values were filled using an imputation algorithm proposed by King et al. [37] and the corresponding R-package AMELIA II, developed by Honaker et al. [38] 1000 imputations for each missing value were performed and its most likely values were estimated using Parzen's [39] nonparametric mode estimator. Figures 4 and 5 in Annex 4 show the price data available for each product for the different Brazilian states.

The distance has been calculated using the information of Google maps which uses the road distance to calculate the number of kilometers and the time needed. The location and information of the most important ports have been made available by 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. A detail of the variables is included in the Annex 5.

VI. HYPOTHESIS

Given the characteristics of the two markets, the following hypotheses and expectations are derived. Firstly, considering the results of previous researches and the rises in the cost of transportation with an increase in distance, a negative relationship is expected between distance and long/short run coefficients.

Secondly, in view of the fact that the agricultural sector experienced strong and quick policy changes, it is expected that the long run equations of most of the market pairs present at least one statistically significant structural break. Moreover, it is anticipated that most cases present a break during the beginning of the application of the reforms (1990/92), and afterwards a depreciation of the currency (1999).

Likewise, it is also expected that if the quality of the roads is good the lower transportation costs make easier trade possible. However, if the states have an important number of paved roads, it could be taken as an indicator of the interest of the government and private producers to have better trading possibilities, including a closer connection with international markets.

The production of the commodities under investigation is highly concentrated in some specific states. Therefore, it is also expected that these states have an important influence in the behavior of the other states, and thus in price transmission indicators. Furthermore, it is feasible that the larger consuming states have a main role in the definition of the prices.

In addition, the regions of the South, South East and Middle West have better indicators of production, consumption, inversion, financing and ability to access export points. It is expected that these regions will have more influence on the formation of prices.

Finally, the effects of the ability to access a port or a check point are expected to be negative on the cointegration coefficients. If the cost of the opportunity to export is high, the market could prefer to supply internal markets and to purchase from national producers.

VII. 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). In the first place the ADF test is applied, since it allows for any assumption about the behavior of the variables, it is calculated including: intercept, trend, or both. In view of the critics against the ADF Test, Phillips-Perron Test, ERS-Test or P-test, and Structural Break Zivot-Andrews test is also included. The trend and the intercept are included in the cases in which they are significant. In some cases the results are not consistent for all the tests, the final results corresponded to the solution point out for at least three of the five indicators. 24 of the 25 rice prices and all of the soybeans prices (10 variables) are non-stationary (Annex 3). It is important to mention that the first difference of all variables are I(0).

In the case of rice, of the 276 market pairs analyzed 249 (90.2%) are cointegrated with values of β_1 distributed between 0.27 (Mato Grosso do Sul and Rio

Grande do Norte) and 1.14 (Goias and Rio de Janeiro). There are 259 (93.8%) equations which present significant structural breaks and 241 are cointegrated. The cases which have may any break in the long run equation are linked with the state of Tocantins whose data start in 1998.

Regarding soybeans, 45 equations are calculated and 37(82.2%) present signs of cointegration. The elasticities have a minimum of 0.5 (Mato Grosso and Tocantis) and a maximum of 1.03 (Mato Grosso and Parana). The presence of breaks is found in 40 cases (88%) and all of them are cointegrated. In this case the states which appear in three of the five relations without breaks are Mato Grosso du Sul and Parana, both of them principal producers which export a major part of their production.

Table 1 shows the expected negative significant relationships between the distance and the elasticity of cointegration. Likewise the adjustment coefficient is negative and significant. However, the coefficients are small, as much of the distance is in km as in hours.

Additionally, the results reveal that the ability of access to an export port is a main issue. Regarding the number of ports, concerning the variables *followerPort24* and *LeaderPort12h/24h* the outcome is according to the expectations, as a bigger quantity of closer ports is associated with a lower β_1.

The region is also central factor affecting the relationship of the rice markets. The North East is the region with the smallest long run relationships. This is in conflict with the fact that Maranhão is an important rice producer. However, the high demand of rice of Maranhão is hardly supplied by what can be offered, and hence in some periods it is also necessary to import. Furthermore, for a market located in the most important production area, the South, when it is the leader the coefficient adjustment is the smallest. It could be an indicator that this region is more affected by the international changes.

It is also worthy to note that when the leader is from the Middle West the long run relationship is the strongest, and when it is the follower the adjustment is the slowest. In most of the cases when the Middle West states are the followers the relationship is with the Southern markets, which are net exporters. On the other hand, when they are leaders the relationship is between them and the net importers in the North.

Another notable factor is the importance of the states as a producer. It is significant and positive as much for the long run as for the short run adjustment. The factor has insignificant coefficients when it is associated to the leader. Nonetheless the importance of being consumers and the extension of the paved roads linked to the leader has a positive effect in the short run.

Table 1. Results of rice market without break

Independent Variables		β_1				ABS(α_y)			
		km		time		km		time	
distance		-5,0E-05	***	-4,1E-03	***	-1,3E-05	***	-1,0E-03	***
FollowerReg	MiddleWest					0,186	***	0,186	***
	North	0,154	***	0,152	***	0,313	***	0,311	***
	NorthEast	-0,090	***	-0,094	***	0,266	***	0,264	***
	South	0,067	**	0,064	**	0,219	***	0,217	***
	SouthEast	-0,012		-0,014		0,205	***	0,203	***
FollowerPort1h	yes	0,042	**	0,042	***	-0,071	***	-0,071	***
FollowerPort24h	<=9	0,672	***	0,676	***	0,000		0,000	
	9 <=12	0,760	***	0,762	***	0,068	***	0,068	***
	more than 12	0,671	***	0,673	***	-0,015		-0,015	
FollowerPortRIOGRANDE									
FollowerCheckPoint	yes								
FollowerPavState									
FollowerPrinProd	yes	0,057	*	0,058	*	0,045	***	0,044	***
FollowerConsumption									
LeaderReg	MiddleWest								
	North	-0,015		-0,015		0,074	***	0,074	***
	NorthEast	-0,462	***	-0,462	***	-0,098	***	-0,097	***
	South	-0,242	***	-0,242	***	-0,129	***	-0,128	***
	SouthEast	-0,120	**	-0,120	**	-0,112	***	-0,111	***
LeaderPort12h	<=3								
	3 <= 6	0,132	***	0,131	***	0,089	***	0,088	***
	6 <=10	-0,088	***	-0,087	***	-0,060	***	-0,060	***
LeaderPort24h	<=9								
	9 <=12	0,325	***	0,323	***				
	more than 12	-0,172	***	-0,171	***				
LeaderPortRIOGRANDE		0,000	***	0,000	***				
Leader5thport		0,000	***	0,000	***				
LeaderCheckPoint									
LeaderPavState						0,001	***	0,001	***
LeaderPrinProd	yes								
LeaderConsumption						0,002	***	0,002	***
Only distance		**-1,0E-04**	***	**-3,5E-03**	***	**-1,3E-05**	***	**-1,0E-03**	***

The equations have not an intercept coefficient
Source: Own Elaboration

In the soybean market, as Table 2 shows, the distance is not significant as much for β_1 as it is for α_y. Furthermore, the coefficients are smaller and the adjustment presents a sign opposite to the expectations. It could be associated with the fact that almost 50% of the production of soybeans in Brazil is for exportation. Moreover, accordingly with the researchers mentioned in section 3, the soybean market has a narrow link with the international prices.

The region again results as an important factor. Mato Grosso, the most important producer, is located in region of Middle West. This region presents the superior elasticity and adjustment coefficient when the state is the leader, whereas the South has the bigger coefficients in the case of the follower. On the other hand, the states with low production, the North and South East, also have lower indicators. Nevertheless, the difference between the regions is less in contrast with the rice results.

Table 2 shows that in order to have a short approach, a road connected to an export point is significant. The elasticity is affected by the distance to

the closer port and the adjustment is influenced only by the variable *followercheckpoint*. It could be in agreement with the fact that a main part of the exports are done by ship, whereas most of the imports are from the neighboring countries.

A state than classified as an important producer and a follower market has a lesser α_y, but if it is a leader this indicator is bigger, even so for the leader the difference is small.

Table 2. Result Soybean Market without break

Independent Variables		β_1		ABS(α_y)	
		km	time	km	time
distance		-2,6E-07	-2,7E-05	4,6E-06	3,1E-04
FollowerReg	MiddleWest	1,005 ***	1,005 ***		
	North	0,593 ***	0,593 ***	-0,377 ***	-0,377 ***
	South	1,090 ***	1,090 ***	0,132 **	0,131 **
	SouthEast	1,072 ***	1,072 ***	-0,213 ***	-0,213 ***
FollowerPort1h	yes				
FollowerCloserport		0,000 ***	0,000 ***		
FollowerCheckPoint	yes			-0,152 ***	-0,152 ***
FollowerPavState		0,000 **	0,000 **		
FollowerPrinProd	yes			-0,130 **	-0,131 **
LeaderReg	MiddleWest				
	South	-0,135 ***	-0,134 ***	-0,026	-0,026
	SouthEast	-0,138 ***	-0,138 ***	-0,071 *	-0,071 *
LeaderCloserport		0,000 ***	0,000 ***		
LeaderCheckPoint	Yes				
LeaderPavState					
LeaderPrinProd	Yes			0,589 ***	0,590 ***
	Not			0,514 ***	0,515 ***
Only distance		**-1,1E-05**	**-9,5E-04**	**-3,4E-05**	**-3,5E-03**

The equations have not an intercept coefficient
Source: Own Elaboration

The results of the break analysis are more closely connected with the year of the breaks. Table 3 shows a clear concentration for the first break in 1992 for rice, short after the entry into MERCOSUR. The second break is principally distributed between 1994 and 1998, which is also the period in which the "Real Plan" started. Finally, the last break appears to happen after the liberalization of the currency. The soybean market appears to be affected when the currency was allowed to float and later in the year 2003.

Table 3. Years with significant structural breaks

Year	Rice			Soybean		
	Break1	Break2	Break3	Break1	Break2	Break3
1991	35					
1992	120	6		5		
1993	30	14		1		
1994	32	37	7	5		
1995	15	37	12	1		
1996	5	34	6	0		
1997	3	9	6	0		
1998	0	31	17	2	2	
1999	4	18	2	19	2	
2000	5	22	15	4	0	
2001	9	16	31	2	8	
2002	0	14	30	1	6	
2003	1	8	43	0	13	9
2004	0	1	6	0	0	3
Total	***259***	***247***	***175***	***40***	***31***	***12***

Source: Own Elaboration

The analysis of the long run allowing for breaks is presented in Tables 4 and 5. It is expected that the β_1^1 will reflect the behavior of the market before the application of the reforms and β the last break after the reforms. The β transition reflects those cases in which the reforms have affected the markets with more than one unexpected important event; the period is extended until the markets find a new long run relationship again after all the policy and economic changes.

As before, the elasticity and the speed of the adjustment in the case of rice is affected weakly, positively and significantly by the distance; it is true without considering the break (Table 4).

Regarding the follower states, those located in the Southern region are moving from the least cointegrated in the first period to the more cointegrated after the reforms. This could be explained by the new programs of support given to the small-scale farmers in the South, with the main aim being to improve the possibility of familial and smaller farms to participate in national and international markets. The production in the South is mostly characterized by family farms. On the other hand, the indicators in the Northern region have lost position in comparison with the rest of the country. It is worthy to note that before the first break a group, formed by the North and Middle West, have elasticities closer to one, while the other three regions are around 0.5. Such behavior disappears in the second and third periods. Contrary to the followers, in the first two periods the leading states in the South have the highest elasticity and after the last break they leave their leadership to the states in the North and North East.

Concerning the distance to port, the variables leader and follower *porth24* are significant and behave as expected, a number of accessible ports greater than 12 means a higher long run coefficient. In addition, the results point out a significant and positive relationship of the factors distance to the closer port and *porth1*, and the long run coefficient. The first one is in agreement with the expectation of the second and third periods; that is, a superior distance means a stronger relationship. However, porth1 differs in comparison to its anticipated conduct, as having a port close to the state provokes a stronger cointegration. Even so, these variables are not important for explaining the behavior in all the three periods, being more important in the first period and less important in the second. A similar outcome occurs with *checkpoint* which is significant before and after the reforms.

The last column in Table 4 corresponds to the adjustment coefficient. Compared with Table 1, the region and the consumption of the leading market state are the two variables which are maintained in the analysis. The first one indicates that the Middle West is the region with the slower adjustment, while the North and North East have the faster adjustment. Another difference surges, the outcome of the follower market characteristics: *checkpoint, pavstate and consumption*. However, the three variables show signs of the coefficients which oppose the expectations. A possible reason is that a follower state with a high consumption and a long extension of paved roads is an important price taker market, with characteristics which can hence increase the incentives of financial activity. This however requires a comparison of the differences in the distributions and commerce structures between the followers and leaders, which are issues out of the main aims of this document.

Table 4. Result Rice Market with break

Independent Variables		β_1[1]	β Transition	β last break	ABS(α_y)
distance (km)		-8,7E-05 ***	-3,7E-05 **	-9,2E-05 ***	-2,2E-05 ***
FollowerReg	MiddleWest	1,153 ***			0,008
	North	1,370 ***	0,167 *	-0,372 **	0,354 ***
	NorthEast	0,583 ***	-0,261 **	-0,026	0,414 ***
	South	0,514 **	-0,174	0,635 *	0,399 ***
	SouthEast	0,748 ***	-0,003	0,188	0,364 ***
FollowerCloserport		-0,001 ***	0,000 **	0,001 *	0,000 ***
FollowerPort1h	yes	0,124		0,287 **	
FollowerPort24	<=9		0,203	1,034 ***	
	9<=12	0,383 ***	0,477 ***	0,428	
	more than 12	-0,195 **	0,317 **	0,369	
FollowerCheckPoint	yes			-0,409 ***	-0,074 ***
FollowerPavState					-0,006 ***
FollowerConsumption					-0,003 ***
FollowerPrinProd	yes	0,159 *			
LeaderReg	MiddleWest				
	North	-0,144	-0,448 ***	0,541 ***	0,122 ***
	NorthEast	-0,197 *	-0,559 ***	0,256 ***	0,059 **
	South	0,470 ***	0,251 ***	0,053	0,031 *
	SouthEast	0,062	0,092 *	-0,160 *	0,039 *
LeaderCloserport	yes	0,000 **			
LeaderPort1h	yes	0,248 ***			-0,044 **
LeaderPort24	<=9				
	<=12	-0,021	0,284 ***	0,570 ***	
	more than 12	-0,176 ***	-0,197 ***	-0,231 ***	
LeaderCheckPoint	yes	-0,414 ***			
LeaderPavState		-0,001 *		0,002 **	0,006 ***
LeaderConsumption				-0,007 ***	
LeaderPrinProd	yes	-0,317 ***			
LeaderPort RIOGRANDE	yes		0,000 ***		
Only distance		-9,7E-05 ***	-3,9E-05 ***	-1,1E-04 ***	-1,3E-05 *

The equations have not an intercept coefficient
Source: Own Elaboration

Table 5 presents the results of the soybean market allowing for structural breaks. The distance is once again not significant and close to zero. The variable *followerreg* is significant in the South in the first period.. During the transition and after the reforms, the coefficient is negative and significant to the North. It is necessary to analyze this result cautiously, due to the small number of observations associated with the Northern region. However, it is clear that the region becomes an issue after the reforms. Regarding *LeaderReg*, the region Middle West stands out with the largest cointegration in the first period, an intermediate value in the second and the smallest in the last period. It is also in accordance with to the increase in the dependency of this sector with the internationals markets. This is also in agreement with the results of the export point accessibility in the equation. Before the reforms, the close distance of the follower market is significant, but after the characteristics of the leader are the important subjects.

Concerning the speed of adjustment, the fastest follower region is the North but the coefficient is not significant. Instead, the South East has the smallest and significant indicator.

Table 5.Results Soybean market with break

Independent Variables		β_1[1]	β Transition	β last break	α_y
distance km		5,1E-05	-1,1E-04	-4,4E-05	-3,6E-05
FollowerReg	MiddleWest			0,785 ***	
	North	0,017	-0,671 ***	-0,435 *	0,040
	South	0,182 **	0,120	0,883 ***	-0,036
	SouthEast	-0,153	0,129	0,829	-0,240 *
FollowerPort1h	yes				
FollowerCloserport					0,000
FollowerCheckPoint	yes	0,979 ***	-0,465		0,935 ***
	not	0,715 ***	-0,354		0,799 ***
FollowerPavState					
FollowerPrinProd					-0,092
LeaderReg	MiddleWest				
	North	-0,236 *	0,365	0,738 ***	-0,415 ***
	South	-0,187 *	-0,037	0,005	0,172 **
	SouthEast	-0,241 **	1,033 ***	0,041	-0,055
LeaderPort1h	yes		-0,647 ***	-0,026	
LeaderCheckPoint	yes		1,012 ***	0,094	-0,127
LeaderPavState			0,011 ***		-0,001
LeaderPrinProd	yes			-0,151	
Only distance		-4,3E-05	-2,2E-04	-1,9E-04 **	-1,3E-04 **

The equations do not have an intercept coefficient
Source: Own Elaboration

VIII. CONCLUSION

Two states which have a long distance between them would face higher transportation costs and hence more troublesome 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, there are other factors which influence the cointegration as well. For instance the quality roads, the intrinsic attributes of the located region and the ability to access an export point. The main objective of this document has been to isolate the effect of distance on the cointegration relationship from the influence of the other variables.. The possibility of using Brazil has been a key advantage. This is because of the importance of transportation for the trading of products, the difference between the sectors and finally its importance among the internationals market.

The most important conclusion which can be draw here is that the effect of distance depends of the product analyzed. In case of the rice markets, as we expected, there is a negative and significant relationship, although it is weak. In the case of soybeans, the relationship is not significant. After allowing for the inclusion of breaks in the long run, the results remain unvaried.

Another point worthy of noting is that in only a few of the cases the long run cointegration relationship does not have a structural change in the slope. The period in which a break occurs is clearer in the case of rice than in soybeans. For rice the first change takes place around the beginning of the application of the reforms (1990/92), the second one corresponds to the period between 1994 and 1998 when the "Real Plan" started, and the last break occurs after the liberalization of the currency in 1999. In the case of the soybean market, the first changes are located in most of the cases around 1999.

In addition, in the case of Brazil the region is a main variable in the definition of the prices. The analysis without a break for the South, the most important producer of rice, presents smaller coefficients of adjustment. However, when the strong changes in time are taken into account, the result is not the same in each period. When the south has the follower position, the elasticity is increasing over the period from before the reforms to after the reforms. The opposite is true for the leader markets, for which the beta coefficient is decreasing. It could be associated with the effort of the

government to improve the efficiency of the small farms (in most cases followers), and the increase of the national dependency on the international markets.

The number of ports near the state has an effect on the elasticity and the adjustment. Moreover, having at least one check point at the border is associated with a lower speed of adjustment. Better access to the export point provokes a diminution in the cointegration relationship. This could be explained by a better connection with the international market, as well as the national. In order to go further with this result, it is recommended that the international prices be included in the analysis, thus to be able to compare the distance to an export point with the national and international price transmission.

Finally, it is recommended to use other non-linear approximation in order to account for all of the costs of transportation. In some cases, even if the markets are closed, the cost of transportation is very high, because of the natural barrier between them. One possibility could be to use a Threshold analysis.

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ANNEX 1: Distribution of the States of Brazil

Fig.3. Regions of Brazil

ANNEX 2: Seasonality in the products

Table 6. Sowing seasonality and harvest time of rice, maize and soybeans

	Rice	Maize		Soybean
		First Season	Second Season	
January	sowing time	harvest	sowing time	harvest
February	harvest	harvest	harvest	harvest
March	harvest	harvest		harvest
April	harvest	harvest		harvest
May	harvest	harvest		harvest
June		harvest		
July			harvest	
August		sowing time	harvest	
September		sowing time	harvest	sowing time
October	sowing time	sowing time		sowing time
November	peak of the sowing	peak of the sowing		peak of the sowing
December	peak of the sowing	sowing time		sowing time

sowing time	harvest
peak of the sowing	peak of harvest

Source: CONAB, 2009

ANNEX 3: Characteristics of the series of prices

Table 7. States and periods included in the investigation

Source: Own Elaboration.

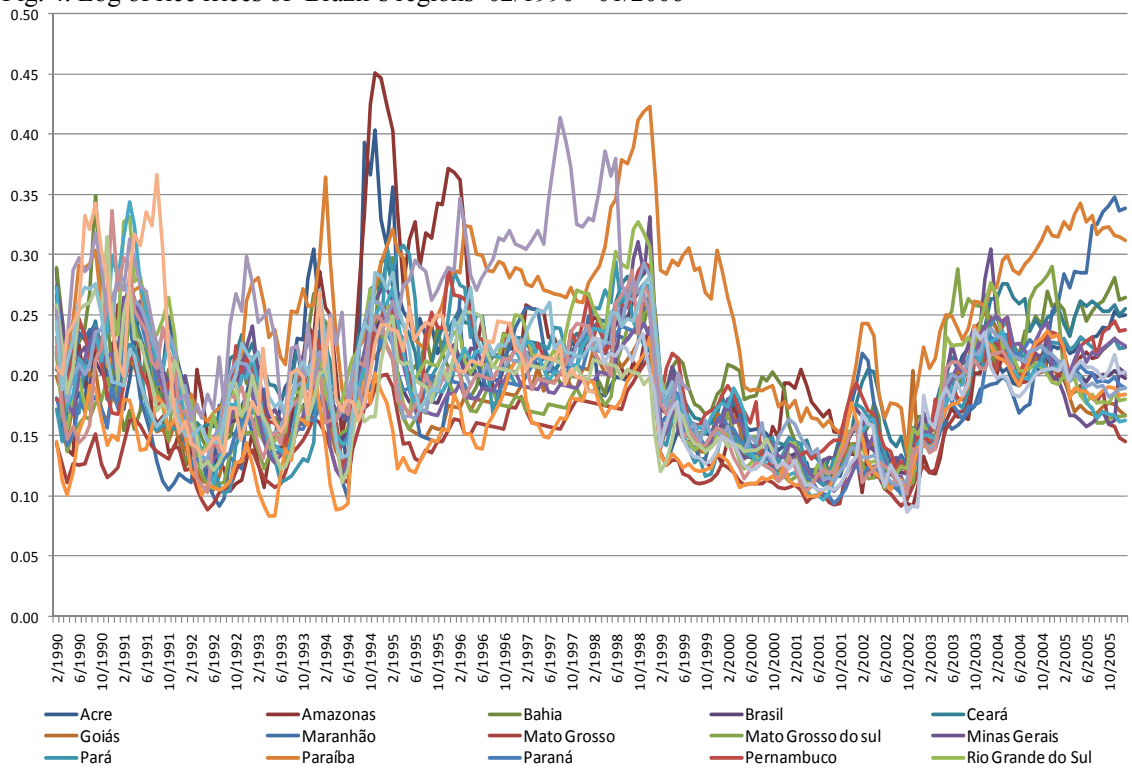
Table 8. Unit Root Test

REGION	MAIZE	SOYBEAN	RICE	REGION	MAIZE	SOYBEAN	RICE
			Brazil				
Acre	I(1)		I(1)/I(0)	Paraiba	I(0)		I(1)/I(0)
Amapa	I(1)			Parana	I(0)	I(1)	I(1)
Amazonas	I(1)		I(1)	Pernambuco	I(1)/I(0)		I(1)/I(0)
Bahia	I(1)		I(1)/I(0)	Piaui	I(1)/I(0)		I(1)/I(0)
Brasil (DF)	I(1)/I(0)	I(1)	I(1)	Rio de Janeiro	I(1)/I(0)		I(1)/I(0)
Ceara	I(0)		I(1)	Rio Grande do Norte	I(1)/I(0)		I(1)
Espirito Santo	I(0)		I(1)/I(0)	Rio Grande do Sul	I(1)/I(0)	I(1)	I(1)
Goias	I(0)	I(1)	I(1)/I(0)	Rondonia	I(0)		I(0)
Maranhão	I(1)/I(0)		I(1)	Roraima	I(1)/I(0)		I(1)
Mato Grosso	I(1)/I(0)	I(1)	I(1)/I(0)	Santa Catarina	I(0)	I(1)/I(0)	I(1)
Mato Grosso do Sul	I(0)	I(1)/I(0)	I(1)/I(0)	Sao paulo	I(0)	I(1)/I(0)	I(1)
Minas Gerais	I(1)/I(0)	I(1)/I(0)	I(1)	Sergipe	I(1)/I(0)		I(1)
Para	I(1)		I(1)/I(0)	Tocantins	I(1)	I(1)/I(0)	I(1)

Source: Own Elaboration.

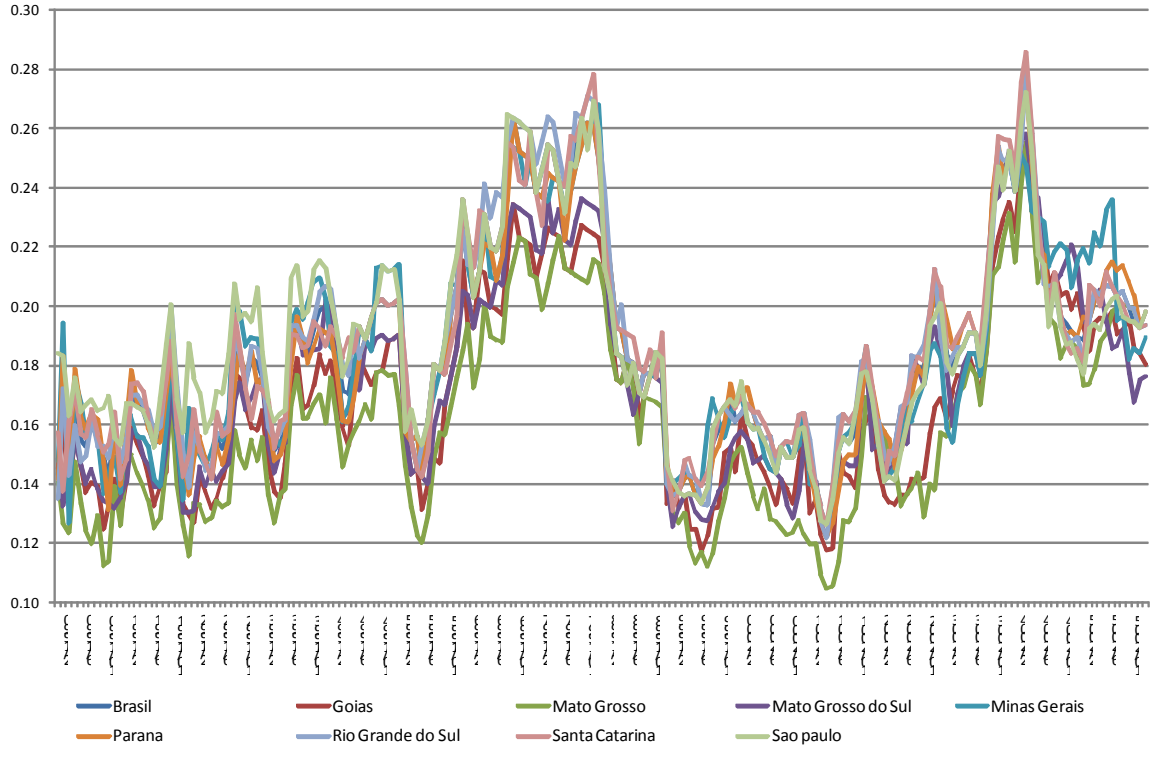
ANNEX 4: Graphics of Prices

Fig. 4. Log of rice rrices of Brazil´s regions 02/1990 - 01/2006



Source: Data ECLAC Chile

Fig. 5. Log of soyban prices of Brazil´s states. 02/1990 - 01/2006



Source: Data ECLAC Chile

ANNEX 5: Independent Variables

Table 9. Independent Variables

Variables	***Categories***	***Source***	***Abbreviation***	
Distance Km	Continuous variable	Google Maps	*km*	
Time Hours	Continuous variable	Google Maps	*time*	
			Follower market [1]	***Leader Market*** [2]
Regions	1. Middle East 2. North 3. Northeast 4. South 5. Southeast		FollowerReg	LeaderReg
There is at least one port at 1 hour	dummy variable	Google maps and ANTAQ	FollowerPort1h	LeaderPort1h
Number of port which are at least 12 hours	at least 3 more than 3 and least or equal that 6 more than 6	Google maps and ANTAQ	FollowerPort12h	LeaderPort12h
Number of port which are at least 24hours	at least 9 more than 9 and least or equal that 12 more than 10	Google maps and ANTAQ	FollowerPort24h	LeaderPort24h
Distance closer port	Continuous variable	Google maps and ANTAQ	FollowerCloserport	LeaderCloserport
Distance to the 5th closer port	Continuous variable	Google maps and ANTAQ	FollowerCloserport	LeaderCloserport
Distance to the most important port	Maize and Rice: Port Rio Grande Soybean: Port Santos	Google maps and ANTAQ	FollowerPort SANTOS/ RIOGRANDE	LeaderPort SANTOS/ RIOGRANDE
There is a Check Point at the border	dummy variable	ANTT	FollowerCheckPoint	LeaderCheckPoint
Extension in km of Paved Road per 1000 Km2	State	Ministério Transpote	FollowerPavState	LeaderPavState
The state correspond to a one of the principal producers.	dummy variable	IBGE b.	FollowerPrinProd	LeaderPrinProd
Consumption (per capita annual (kg))	dummy variable	IBGE a.	FollowerConsumption	LeaderConsumption

[1] Variables related to the state which have a significant and higher t value in the short run adjustment.
[2] Variables related to the state which have the smaller t value in the short run adjustment.
Source: Own Elaboration. Data: ANTT [16], ANTAQ [40], IBGE [41]