Título: Towards a better assessment of soybean supply elasticities in Brazil

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Resumo

Um importante debate que está ocorrendo atualmente é se a expansão da soja no Centro-Oeste brasileiro tem sido ou não um dos responsáveis pelo aumento do Desmatamento na Amazônia. A idéia central é se a expansão da soja tem ocorrido nas áreas que antes eram destinados a pastagem, ou se de fato ela tem tomado local da floresta. O presente trabalho aplica o Método dos Momentos Generalizados a uma estrutura de dados em painel, para estimar a elasticidade preço de oferta da soja, assim como sua elasticidade de substituição com o gado. Os resultados mostram que, embora haja uma alta elasticidade de substituição entre gado e soja, ela esta bastante reduzida nas áreas próximas da Amazônia. Esse trabalho mostra também uma variação significativa da elasticidade preço da oferta da soja nas diferentes macro-regiões brasileiras, sugerindo impactos regionais contrastantes duma possível elevação do preço da soja com a liberalização dos mercados internacionais.

Palavra Chave : Soja, oferta, elasticidade preço, Brasil, dados em painel

Abstract

An important debate exists on whether soybean is responsible for putting more pressure on the Amazon forest or if it allows land use intensification through the recuperation of degraded pasture. Estimating regional soybean supply elasticity permit us analyzing the tread liberalization impact on Brazilian soybean plantation and deforesting. Appling a panel data estimation technique we found huge substitution supply elasticity between soybean and beef in Brazil, however the elasticity was quite smaller in the regions near to Amazon Forest. The results show also that soybean supply elasticities is quite different between the different Brazilian macro regions, suggesting contrasted regional impacts of an increase of soybean international price following trade liberalization.

Keywords : soybean, supply elasticity, Brazil, panel data

JEL : Q11, C23, F18

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Towards a better assessment of soybean supply elasticities in Brazil

1. Introduction

Brazil is one of the leaders in regional and multilateral trade negotiations, and particularly offensive on agricultural issues. Indeed one of the obvious comparative advantages of the country relies on its huge land and natural resources reserves, already partly responsible today of the competitiveness of some major agri-chains such as livestock, soybean or sugar. The expected price and export demand increase following possible larger market access in developed and developing countries may have very large economic impacts for the country.

However, in a large country as Brazil, the possible responses to market access increase and their impacts will probably strongly differs from one region to another. Indeed as stated by Thery (2005), the dynamism of the Brazilian agriculture is constantly reorganizing the national territory, however several agricultural commodities are concentrated in some specific regions.

This paper will focus on soybean, one of the major Brazilian agricultural commodities that could benefit from trade liberalization. It is based on a study aimed at estimating a soybean supply function for Brazil, and particularly its own price and cross price elasticity. Because of a strong differentiation of the regional distribution of soybean expansion in Brazil and of data limitations, an original methodology has been developed and regional elasticities have been produced.

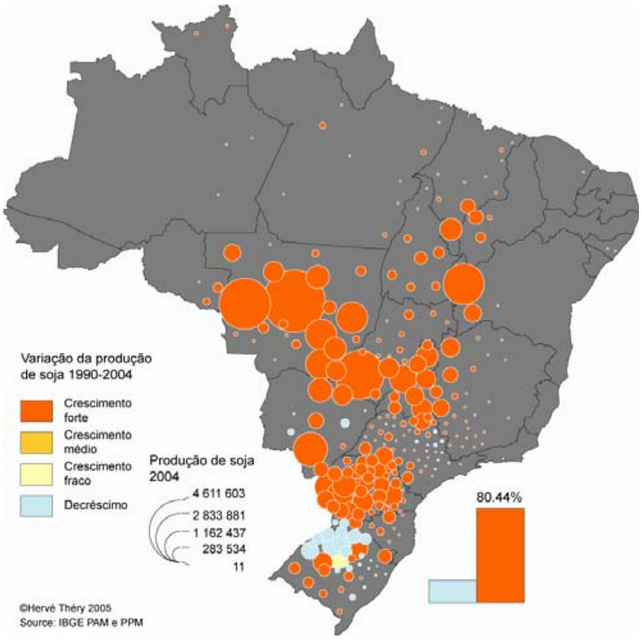
The paper will first present some apparent determinant of soybean expansion during the last fifteen years in Brazil (section 2). Then the database and the methodology will be detailed (section 3). The results will be presented at the national and the regional levels (Section 4) and then the conclusion (section. 5).

2. Soybean expansion during the last 15 years in Brazil

The soybean planted area in Brazil has known a tremendous growth from around 250 000 hectares in 1960 to 16,3 millions hectares in 2004. Such expansion started in the South of the country, mainly in the States of Rio Grande do Sul and Parana during the 1960s, then continued through some states of the Centre-West (Minas Gerais, Goias and Mato Grosso do Sul) during the 1970s and the 1980s, and finally from 1990 until now, through the Northern of the *Cerrado*[2] region (Mato Grosso particularly, Northern part of the State of Tocantins and Maranhão, Southern Part of the Para State), at the frontier with the Amazon basin (Bertrand and al. 2004 - see Map 1.).

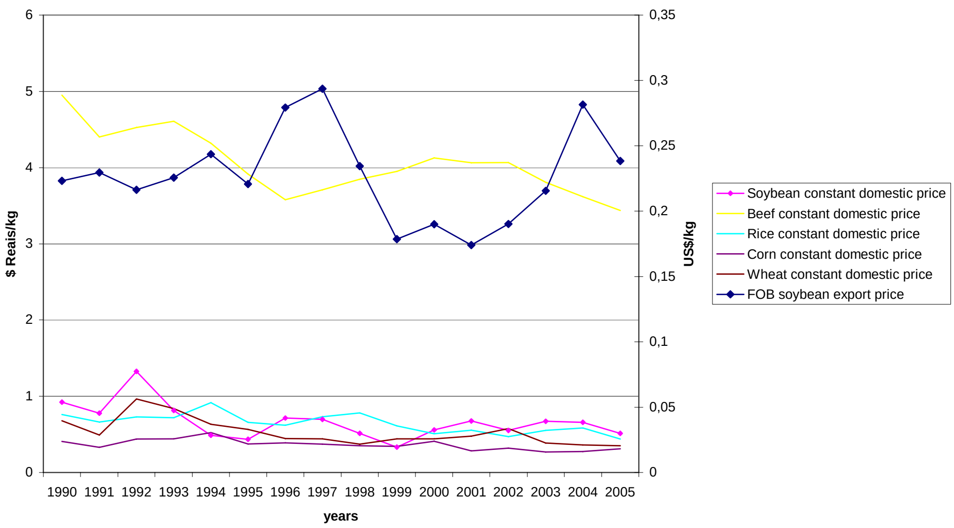
[2] For the graph exposed in the report, most of the Cerrado region pertains to the Centro Oeste macro region.

Map 1 : The expansion of soybean production in Brazil during the 1990s (Source Thery 2005)



In front of such an expansion particularly during the last 15 years, the first possible determinants coming in mind are exports or domestic output prices or the relative price of soybean vs. others agricultural products. However, such prices have not clearly favored soybean expansion as shown in Graph 1, so other determinants have to be invoked and, amongst them, regional land price, public research and exchange rates are possible good candidates (Bertrand and al. 2004).

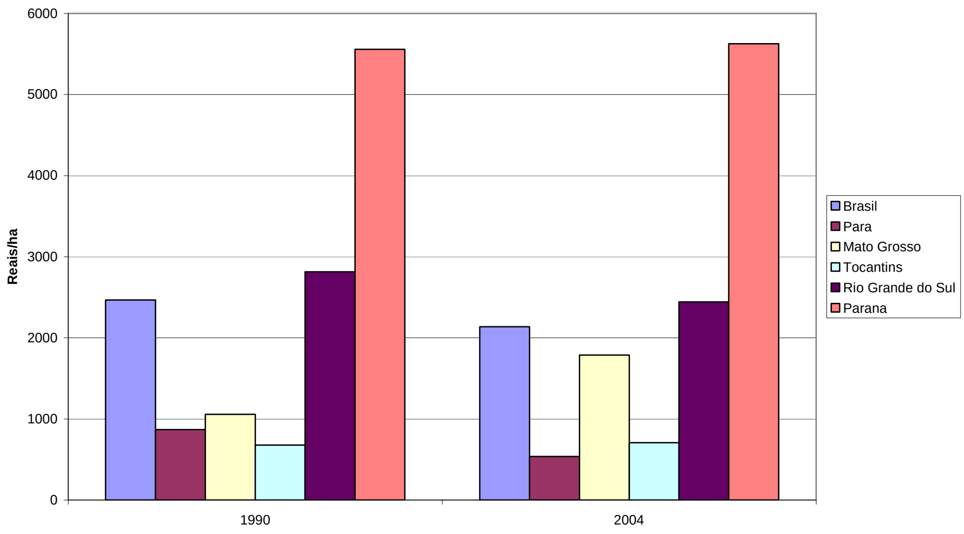
Graph 1 : Soybean, rice, wheat, corn and prices - 1990- 2005



Source : IBGE www.ibge.com.br

The *Cerrado* region, where most of the soybean expansion has occurred during the last 15 years, has been colonized during this period by migrants first essentially from the Southern part of the country then from closer states. The huge availability of land and low land prices have been the first determinants of such migration, as farmers could sell a property of 150 - 200 hectares in the South and acquire 800 to 1000 hectares in the States of the *Cerrados* region (Bertrand and al. 2004). Of course, in the meantime, this has led to an increase of land prices in the region but, the differential still persists (see graph 2), and, somewhere, it has reinforced the migration dynamic, attracting actors more interested by land speculation in a region where land rights and land property are not clearly defined. The low land prices in the *Cerrado* region is one of the main reason for which soybean is more competitive than in United States or in Argentine, even if such competitiveness is partially offset by higher transport costs to maritime ports (Bertrand and al. 2004). The Brazilian Program to improve roads in the region is aimed at lowering this constraint in the future.

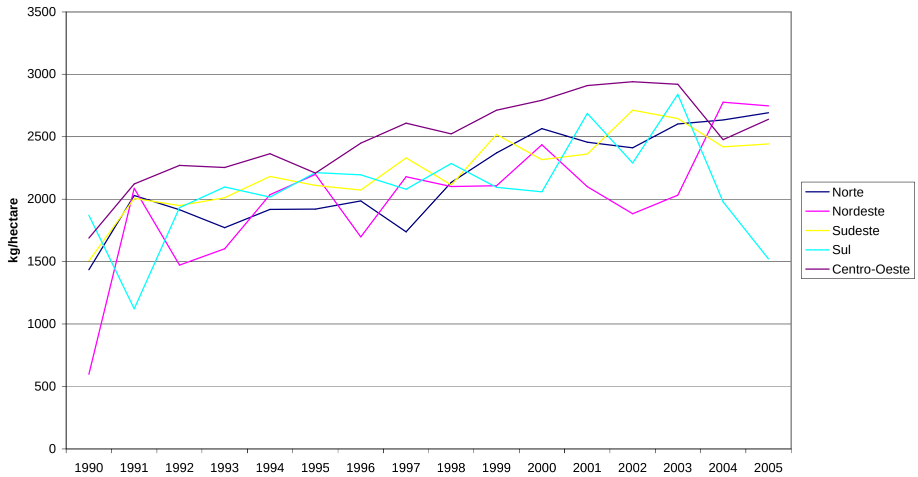
Graph 2 : Land prices (pasture) 1990 and 2004 ($Reais 2004)



Source : fgvdados.com.br

Public research has also been an important vector of soybean expansion, since it has allowed the development of the culture in a region that was not adapted to former soybean varieties and agricultural technologies. Since the end of the 1970s, genetic research has allowed producing a variety adapted to the Cerrado regions, and several techniques have been developed to improve soils fertility. Such results led to yield improvements in all Brazilian States. However, the highest yield increase has occurred in the Cerrados region (see Graph 3). From the same graph, one can observed a sharp yield decrease during the last two years, essentially linked to phytosanitary problems, leading farmers to reduce planted areas.

Graph 3 : Soybean Yield in Brazil 1990-2005



Source : IBGE, PAM

Source : www.ibge.com.br

During the years 2000, between 40 % and 60 % of soybean grain production value came from exportation to the international markets. This estimation does not account for soybean oil export income. So exchange rate matters. Until the last years, the Brazilian real low rate has clearly favored exportations. The contrary occurred during 2004-2005, because of the US$ decrease, leading to reduce international selling and explaining, together with yield decrease, the current diminution of planted areas. Compared to other countries, the impact of exchange rate may be partially offset by the large size of the domestic market.

In term of substitution/complementarities with other agricultural activities, one can expect substitution with beef, since a significant share of soybean plantation are established on former pasture land, as well as on natural vegetation. Substitution may be observed with rice also, as the soybean production and marketing chains presents several advantages when compared to the rice's one. For corn, the expect result is less clear because of the possibility to make a double harvest soybean / corn, with a small harvest of corn, during the same year (Bertrand and al. 2004).

3. Methodology

3.1. Available data

The collection of most of the data linked to the agricultural sector in Brazil is made by IBGE, the Brazilian Statistics Institute (www.ibge.com.br). Two main database sources could have been used for this study: the Agricultural Census, realized every five years since 1970, which contains several detailed information (production volume, farming structures, areas etc…) and the Municipal Agricultural Production Survey, realized yearly since 1990 only, which contains data limited to planted and harvested areas, production volume and yield, and production value (producer price level). The main problem with the Agricultural Census is that the last available year is 1995-1996 and that, for several regions, data collection suffered various bottlenecks. Thus, the second database has been used, even if it does not contain very long term series (only 15 years).

For prices data (beef price, land price and labor prices, inflation rate), the data from the foundation Getulio Vargas have been used (www.fgvdados.com.br). They are usually mensal and nominal, available at the national and the states levels, so some computations have been made to get annual constant prices for each Brazilian state.

For export FOB prices, the data comes from SECEX, the Secretary of Foreign Trade (www.aliceweb.desenvolvimento.gov.br), that computes yearly export volume and export values for each Brazilian imported and/or exported products. These data are also available at the States Level which allows having an estimation of each state export prices and share (% of the state production).

3.2. Supply function

Following Sadoulet and Janvry (1995), the estimation of supply response equation face two central problems: First, the observed prices are market prices after the production has occurred. Second, the observed quantities may differ from the desired ones because of the adjustment lags in the reallocation of variables factors. In this paper, we will apply the Nerlove model to estimate supply elasticity. This model was developed to handle these two dynamic processes (Nerlove, 1956, 1958).

The soybean supply elasticity was thus estimated following Nerlove (1958) adaptive expectation model. The agriculture supply function is described below:

$$X_t^* = a + b\, P_{Xt}^e \qquad (1)$$

Where, X_t^* is the ideal balanced production of product X at time t and P_{xt}^e is the commodity X price expectation (P_{xt}) at moment *t-1*. Price expectation are formed using adaptative expectation. Defining

0< γ <1 the adapted price coefficient :

$$P_{xt}^e - P_{xt-1}^e = \gamma\left(P_{xt-1} - P_{xt-1}^e\right) \Rightarrow P_{xt}^e = \gamma P_{xt-1} - (1-\gamma)P_{xt-1}^e$$

$$\therefore$$

$$P_{xt}^e = \sum (1-\gamma) P_{xt-1}^e \qquad (2)$$

Substituting (2) in (1)

$$X_t = \frac{a}{\gamma} + \frac{b}{\gamma} P_{x,t-1} + (1-\gamma) X_{t-1} \qquad (3)$$

Therefore, b is the long term (LT) price supply elasticity and b/γ is the short term (ST) price supply elasticity.

On the other hand, it is reasonable to assume that the adjustment of agricultural production is time consuming. Therefore, a time lag is introduced between agricultural production dynamic and prices. The variable X_{t-1} in (3) is trying to catch such effect.

To complete the supply model, we have proceeded like Griliches (1957) and included in (3) inputs demand (Z_t) and a random component (v_t).

$$X_t = \frac{a}{\gamma} + \frac{b}{\gamma} P_{x,t-1} + (1-\gamma) X_{t-1} + Z_t + v_t \qquad (4)$$

3. 3. Estimation using Panel Data

Sadoulet and Janvry (1995, cap 4) suggest that the supply function and first order conditions can be estimated simultaneously using observed price variables either time series data or pooling of cross-section. However the time series shows little variability in fixed factor unless the series is very long. When the series is not long the panel data is necessary.

As was mentioned in the last section, Brazil is a large country and the soybean planted area is not spatially homogeneous i.e. there are a lot of regional characteristics influencing supply, that change between states but are fixed on time. These features need to be controlled in the regression model to avoid biases of the estimated coefficients. The supply response of soybean in Brazil was estimated by Barbosa (1986) using rational expectation techniques. The original contribution of this paper is to work with panel data and to estimate the soybean supply elasticity controlling for fixed effect.

The term panel data refers to the pooling of observation on a cross-section of 13 States over 15 years. Following Behrman (1968) the agriculture planting area is used as a proxy of production. The empirical representation of equation (4) is described below

$$\begin{aligned} \ln area_{ikt} &= \beta_0 + \beta_1 \ln(area)_{ik,t-1} + \beta_2 \ln(soy\ \ price)_{ikt-1} + \phi_j \ln(substitute\ price)_{jkt-1} \\ &\quad + \varphi_m \ln(input)_{mkt-n} + v_{ikt} \end{aligned} \qquad (5)$$

Where k (1,…, *13*) denoting the Brazilian States with soy bean plantation and T (1,…, 15) denoting available years, we will assume that v_{kt} follows a one-way error component model

$$v_{kt} = \mu_k + u_{kt} \qquad (6)$$

with μ_k denotes the unobservable individual-specific effect, u_{kt} denotes the remainder disturbance, $\mu_k \approx IID(0, \sigma_\mu^2)$ and $u_{kt} \approx IID(0, \sigma_u^2)$. Substituting (6) in (5):

$$\begin{aligned} \ln area_{ikt} &= \beta_0 + \beta_1 \ln(area)_{ik,t-1} + \beta_2 \ln(soy\ \ price)_{ikt-1} + \phi_j \ln(substitute\ price)_{jkt-1} \\ &\quad + \varphi_m \ln(input)_{mkt-n} + \mu_k + u_{ikt} \end{aligned} \qquad (7)$$

Panel data suggests that states are heterogeneous and that it is possible to control this. Soybean supply is modelled as a function of the lagged planted area, soybean own lagged price, substitute products lagged prices, and others input prices that vary with state and time. However, a lot of variables affecting soybean supply may be time-invariant (μ_k) as, for example, land quality, climate, kind of soil, sun exposition, etc. These variables change among States but they are not expected to change much over time. When time-invariant (μ_k) variables are omitted in the model, the estimated coefficient are biased.

Another advantage of panel data is that they allow the researcher to better understand adjustments dynamic. These dynamic relationships are characterized by the presence of a lagged dependent variable among independent variables as described in equation (7).

The dynamic panel data regression described in (7) presents two sources of persistence over time (see, Baltagi (2005)): Autocorrelation due to the presence of lagged dependent variables among regressors and individual effects characterizing the heterogeneity among states. Since the $ln(area)_{kt}$ is a function of μ_k, it immediately follows that $ln(area)_{kt-1}$ is also a function of μ_k. Therefore $ln(area)_{kt-1}$ is correlated with error term. This is enough to turn Ordinary Last Square (OLS) estimator biased and inconsistent even though u_{kt} are not serially correlated. To solve this problem, one option could be to apply the fixed effect estimator (FE) that wipes out μ_k. However, a fundamental identification condition for this model to be estimated by FE is the strict exogeneity of explanatory variables, which is not satisfied because $ln(area)_{kt-1}$ is correlated with u_{kt-1} by construction. Therefore for a panel where T is fixed, the FE estimator is biased and inconsistent[3].

An alternative to wiping out the fixed effect is the first difference (FD) transformation. In this case, correlation between the predetermined explanatory variables and the remaining error is easier to handle (see, Baltagi (2005), cap. 8). Taking (3) first differences:

$$\begin{aligned}\Delta \ln area_{ikt} &= \beta_0 + \beta_1 \Delta \ln(area)_{ik,t-1} + \beta_2 \Delta \ln(soy\ \ price)_{ikt-1} + \delta_j \Delta \ln(substitute\ \ price)_{jkt-1} \\ &+ \theta_m \Delta \ln(input)_{mkt-n} + \Delta u_{ikt}\end{aligned} \tag{8}$$

The first differences get rid of the μ_k and, in practice, this allows to use past, present and future values of the strictly exogenous variables to build instruments for the lagged dependent variables and other non exogenous variables, once the permanent effect has been cancelled after differentiation (Anderson and Hsiao (1981)).

Anderson and Hsiao (1981) suggested instrumental variable (IV) estimation method to estimate the first differentiating model. However, Arellano and Bond (1991) argue that this method leads to consistent but not necessarily efficient estimates of the parameter because it does not make use of all the available moment conditions. Therefore, they proposed a generalized method of moments (GMM) procedure that is more efficient than IV. In this paper, we have used the Arellano and Bond (1991) technique to estimate our dynamic panel model found in (8).

3. Results

3.1. National level

Equation (8) describes the soybean planted area as a function of four sets of variables: the planted area lagged; the soybean price lagged, two soybean substitute products price lagged (corn and beef); and two input variables (salary, and land price). Usually, farmers are buying land at time *t-1* to plant at time *t*. Therefore, we are assuming that farmer does not only consider the current land price but also the land price of the last year.

[3] However, it is worth emphasizing that only if $T \rightarrow \propto$ the FE is consistent for the dynamic error component model (see Nickell (1981)), unfortunately in our data base T is fixed and short.

As mentioned, the international market is important to determine the soybean supply. Therefore, we have use the exchange rate (R$/U$) and export share as control variables. We are assuming that farmers decide the size of the area to be planted in soybean after observing the lagged exchange rates.

The first difference of equation (7) was estimated using GMM technique. We used all possible $ln(area)_{kt-1}$ lagged and future as the instrument for $\Delta ln(area)_{kt-1}$ (Arellano and Bond (1991), others regressors are supposed exogenous. The one-step model was estimated (table 1A in annex). The over identification Sargan test and the second order no autocorrelation was accept by 5%. However the Sargan test is not valid in presence of heteroscedasticity. To check for heteroscedasticity, an equation (9) first difference was estimated again and heteroscedasticity was corrected using the matrix of White (table 1). Comparing the estimated coefficients in table 1A and table 1 shows that the standard error is larger in table 1A, this is an indication of heteroscedasticity.

To solve this problem, Arellano and Bond (1991) suggested to estimate the model in two-steps. In the two-step analysis (table 2A in annex), once more the over identification Sargan test and the second order no autocorrelation were accept by 5%. In this situation, Arellano and Bond (1991) recommend using the one-step results with robust standard errors for inference on coefficients (table 1).

Two models have been estimated. In model I, we used the FOB soybean price lagged (U$) (*ln(soyfob)*); in the model II we worked with the Brazilian soybean producer price lagged (R$) (*ln(p_soy)*).

Analyzing the estimated coefficients in both models (table 1), we observed that most coefficients are significant and have expected signs. In models I and II the exchange rate first lagged coefficients are positive and significant, reflecting that the lower the Brazilian real the larger the soybean planted area. However the exchange rate second lagged coefficient is negative and significant. It may be, because farmers are expecting an appreciation of the real after two years of low values. As expected the export participation coefficients are positive and significant in both model. Observing input coefficients, only land price is significant in model I.

Beef and corn coefficients are negative, which means that they are soybean substitute products. Beef price appears to have more impact than corn price on the size of the area planted in soybean for two reasons. First, because the beef price lagged coefficients are higher than corn coefficients, second because the corn price lagged coefficient is different from zero only in the model II whereas beef price lagged is important in both models.

The soybean price lagged coefficients are positive and significant in both models. The soybean price lagged coefficients are higher in model I than in model II which confirms that international markets are important determinants of the size of the soybean planted area.

Table 1: Soybean Supply estimation
(Dependent variable is planted area)

	(I)	(II)
Constant	0.049	0.030
	(0.014)**	(0.008)**

lnarea (t-1)	0.754	0.788
	(0.044)**	(0.044)**
lnp_soy(t-1)		0.195
		(0.042)**
lnp_soyfob(t-1)	0.288	
	(0.093)**	
lnp_beef(t-1)	-0.328	-0.280
	(0.145)*	(0.110)*
lnp_corn(t-1)	-0.051	-0.123
	(0.050)	(0.033)**
Lnwage	-0.033	0.003
	(0.036)	(0.030)
lnp_land	0.134	0.029
	(0.063)*	(0.060)
lnp_land(t-1)	-0.083	-0.030
	(0.039)*	(0.033)
ln_exenge(t-1)	0.053	0.076
	(0.014)**	(0.009)**
ln_exenge(t-2)	-0.073	-0.066
	(0.017)**	(0.012)**
ln%fob(t-1)	0.013	0.017
	(0.005)*	(0.006)**
No autocorrelation order 1	-1.71 (0.086)	-1.72 (0.086)
No autocorrelation order 2	0.12 (0.90)	0.76 (0.44)
Observations	120	120
Number of est	12	12

Obs.: Robust standard errors in parentheses, * significant at 5%

Using the estimated coefficients in models I and II, it is possible to calculate the own and cross price supply elasticities for both models. The short supply elasticity is the price lagged estimated coefficient, and the long term elasticity is calculated admitting that in the long term *(t) = (t-1) (see table 2).*

In the long term, in model II, the soybean own price elasticity is smaller than in model I, however the difference is small, and in both cases, we can consider that soybean supply is price elastic. In both models, beef is an important soybean substitute with cross price elasticity higher than one. On the other hand, analyzing the cross price elasticitity with corn, it appears quite inelastic. This may partially reflect that in some cases corn can also be a secondary crop after soybean, as stated in part 1, and such complementarity may partially offset the substitution effect.

Table 2: Own price and cross price supply elasticities.

	I		**II**	
	LT	**ST**	**LT**	**ST**
soybean	1.171	0.288	0.920	0.195
beef	-1.333	-0.328	-1.321	-0.280
corn	-0.207	-0.051	-0.580	-0.123

4.2. Regional Analysis

As stated in part 1, soybean production started in the South of Brazil, particularly in two states, Rio Grande do Sul and Parana, and then grew progressively in the Northern direction, until the Amazon boarders in the 1990s. So we can separate two different macroregions : the traditional and older one, in the South and Southeast States, where in some cases the planted area is decreasing, and the new and dynamic one, in the Center-West and *Cerrado* regions..

Our sample was divided in two parts. Region 1 is the South and Southeast and includes the States of Minas Gerais, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul. Region 2 is the Centre – West and *Cerrado,* and includes the States of Rondônia, Tocantins, Piaui, Mato Grosso, Matogrosso do Sul and Goiais.

Table 3 displays the two models results (model 1 for Region 1 and model 2 for region 2). For both models, equation (8) was estimated using GMM technique with robust standard errors for inference on coefficients. The Brazilian soybean price lagged was chosen, instead of international prices.

Once more the planted area lagged and soybean price lagged coefficients are significant and have the expected signs. Beef and corn are both soybean substitutes, but in region 2 the beef price lagged coefficient is not different from zero.

For input coefficient, wage and land price lagged are significant only in the South and Southeast region, which may reflect that land price increase in the Southern Brazil compare with Center and Northern States push soybean to the North. Exchange rate coefficients are significant in both models and present the expected sign, whereas export participation is significant only for the Center-West and *Cerrado* region.

Table 3: Soybean Supply estimation Regions 1 and 2
(Dependent variable is planted area)

	(I)	(II)
Constant	0.021	0.046
	(0.012)	(0.012)**
lnarea (t-1)	0.694	0.813
	(0.086)**	(0.039)**
lnp_soy(t-1)	0.124	0.291
	(0.036)**	(0.039)**
lnp_beef(t-1)	-0.287	-0.112
	(0.072)**	(0.197)
lnp_corn(t-1)	-0.141	-0.057
	(0.041)**	(0.025)*
Lnwage	0.017	0.023
	(0.009)	(0.078)
lnp_land	0.094	-0.068
	(0.053)	(0.075)
lnp_land(t-1)	-0.082	0.014
	(0.028)**	(0.051)
Ln_exenge(t-1)	0.078	0.082

	(0.022)**	(0.021)**
Ln_exenge(t-2)	-0.062	-0.083
	(0.027)*	(0.019)**
Ln%fob(t-1)	-0.004	0.041
	(0.010)	(0.020)*
No autocorrelation order 1	-1.39 (0.165)	-2.13 (0.03)
No autocorrelation order 2	0.51 (0.610)	0.30 (0.76)
Observations	57	52
Number of est	5	5

The regions 1 and 2 long and short term own and cross price elasticity are found in table 4. For own price elasticity, a clear difference appears between region 1 and region 2 : the long term soybean supply is elastic in the Center-West region (model II) but inelastic in the South-Southeast region (model I), which was quite expected when one looks at the soybean expansion regional dynamic during the last 15 years.

In both models, corn and beef appears as soybean substitutes. The relationship between corn and soybean remains inelastic in both regions, as in the national model. On the other hand, the long term absolute values of cross price elasticities between soybean and beef are also inferiors to 1 in both regions but very closed to one in the South-Southeast. The fact that the beef price lagged coefficient is not significant in region II may reflect the large difference of profitability between cattle ranching and soybean in the Center – West region (soybean is much more profitable than cattle ranching). Moreover, as stated in Bertrand and al. (2004), farmers arriving in the Center-West are usually former soybean producers from the South-Southeast, with a particular skill for this agricultural activity and not for cattle ranching.

Table 4: Own price and cross price supply elasticities
in Regions 1 (South – Southeast) and 2 (Center-West - *Cerrado*).

	I		**II**	
	LT	**ST**	**LT**	**ST**
soybean	0.405	0.124	1.556	0.291
Beef	-0.938	-0.287	-0.599	-0.112
Corn	-0.461	-0.141	-0.305	-0.057

4. Conclusions and discussion

Estimating regional soybean supply elasticity shows that the agrichain possible response to trade liberalization will be quite contrasted between the South – South East and the Center West –*Cerrados* regions. It is clear that any international price increase will probably speed up the expansion of soybean in the *Cerrados,* as it occurred during the last 15 years, unless new determinants appears to restrain this movement.

One of them could be the growing concern of the possible negative impact of soybean expansion on the Amazon forest. Indeed, an important debate exists on whether soybean is responsible for putting more pressure on the Amazon forest or if it allows land use intensification through the recuperation of degraded pasture. On the one hand, Brandão and al. (2005) argue that soybean is planted mainly on degraded pasture and do not affect deforestation. On the other hand, the Forest Working Group of the Brazilian Forum of NGOs and Social movements for Environment and Development (FBOMS) has conducted a rapid analysis for the Brazilian Ministry of Agriculture, showing some correlation between soybean expansion and deforestation, particularly in Matto Grosso, mainly through the delocalization of ranching activities up to the Amazon frontiers. Probably both studies are right to some extent.

Our results at the national level suggest that beef and soybean are highly substitutes (cross price elasticity of – 1,33) and thus that cattle pasture can easily be replaced by soybean plantation. However, contrasting the results between older soybean production basins (South and Southeast) and new soybean frontiers (Center-West) suggests that, in the Amazon Border (Center – West), the substitution between cattle ranching and soybean is reduced (cross price elasticity of -0.599). This suggests that pressure on the Amazon forest may be even stronger with soybean trade liberalization.

Several soybean international firms, under strong NGOs pressure, have recently decided to put a moratorium on the buying of soybean from recently deforested areas in Brazil during two years. The Brazilian industry itself is engaged in negotiation with the civil society to establish criteria to promote sustainable and responsible soybean production. One of them, particularly important in the Amazon to conciliate the expansion of agriculture and environment preservation, is the respect of the legal reserve (80 % of the property in the Amazon Biome and 65 % in the *Cerrado* Biome). Still at the beginning, such movements will probably affect the Brazilian response to increase market access, as well as it long term impacts.

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ANNEX

Table 1A: One-step Soybean Supply estimation
(Dependent variable is planted area)

	(I)	(II)
Constant	0.049	0.030
	(0.009)**	(0.008)**
lnarea (t-1)	0.754	0.788
	(0.043)**	(0.043)**
lnp_soy(t-1)		0.195
		(0.039)**
lnp_soyfob(t-1)	0.288	
	(0.072)**	
lnp_beef(t-1)	-0.328	-0.280
	(0.159)*	(0.157)
lnp_corn(t-1)	-0.051	-0.123
	(0.059)	(0.061)*
Lnwage	-0.033	0.003
	(0.046)	(0.045)
lnp_land	0.134	0.029
	(0.055)*	(0.060)
lnp_land(t-1)	-0.083	-0.030
	(0.054)	(0.053)
ln_exenge(t-1)	0.053	0.076
	(0.023)*	(0.023)**
ln_exenge(t-2)	-0.073	-0.066
	(0.020)**	(0.020)**
ln%fob(t-1)	0.013	0.017
	(0.008)	(0.008)*
Sargan Chi2 (89) =	108.46 (0.08)	103.46 (0.14)
No autocorrelation order 1	-3.97 (0.000)	-3.87 (0.000)
No autocorrelation order 2	0.61 (0.84)	0.08 (0.935)
Observations	120	120
Number of est	12	12

Table 1B: Two-step Soybean Supply estimation
(Dependent variable is planted area)

	(I)	(II)
Constant	0.089	0.149
	(0.043)*	(0.064)*
lnarea (t-1)	0.175	-0.601
	(0.224)	(0.502)
lnp_soy(t-1)		-0.208
		(0.140)
lnp_soyfob(t-1)	0.385	
	(0.131)**	
lnp_beef(t-1)	-0.238	-2.155
	(0.480)	(0.719)**
lnp_corn(t-1)	-0.218	0.807
	(0.183)	(0.366)*
lnwage	0.045	-0.374
	(0.302)	(0.401)
lnp_land	0.119	0.008
	(0.270)	(0.311)
lnp_land(t-1)	-0.097	0.545
	(0.248)	(0.382)
ln_exenge(t-1)	0.114	-0.159
	(0.069)	(0.128)
ln_exenge(t-2)	-0.117	0.011
	(0.036)**	(0.043)
ln%fob(t-1)	0.016	0.278
	(0.007)*	(0.105)**
Sargan Chi2 (89) =	1.72	0.07
	(1.00)	(1.00)
No autocorrelation order 1	0.16	-0.73
	(0.87)	(0.406)
No autocorrelation order 2	1.46	-1.42
	(0.144)	(0.15)
Observations	120	120
Number of est	12	12