

Full Length Research Paper

Exports and market power of the soybean processing industry in Brazil between 1980 and 2010

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The objective of this research was to identify whether the majors of the soybean production chain in Brazil have conditions to design their market power and capture part of the economic surplus farmers? In this context, based on the analysis of price elasticity, drawn from the postulates of neoclassical microeconomic theory, it was found that exports of soybeans and soybean meal are inelastic to price. Therefore, companies are able to exercise their market power, mainly because they are protected by barriers to entry. In contrast, exports of soybean oil are price elastic and therefore, the soybean industry tends to seek profit on transactions with farmers to improve their competitiveness in the soybean oil segment. As a result, the Brazilian government should use mechanisms of economic policy to foster competition in the market.

Key words: Soybean supply chain, agribusiness, market structure, export function, price elasticity.

INTRODUCTION

Given the economic importance, social significance and contribution to the national and international food security, the soybean (*Glycine max* (L.) Merr.) production chain is one of the most important in Brazil's agribusiness. Explanation for this includes the development of new technologies resulting from public and private investments, which have revolutionized the management practices for soybean cultivation (Giordano, 1999; Brum, 2002; Rezende et al., 2003; Embrapa, 2004). On the other hand, this process of development resulted in the constitution of oligopolies and oligopsony (Lima, 2012; Costa and Santana, 2014), such as the segment of transgenic seeds (Costa and Santana, 2013),

agricultural machinery, fertilizers and pesticides (Costa, 2012).

Thus, trade relationships between farmers and the agricultural inputs industries as well as the processing agroindustry began to take place in an imperfect market environment, which leaves farmers with no choice but to buy inputs from oligopolistic companies and market their production in an oligopsonized market structure (Wesz Junior, 2011; Sedyama et al., 2013).

While soybean culture may contribute to the development of many regions located in areas of livestock farming in Brazil. The possibility of losing competitiveness as a result of market failures should be

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evaluated. Thus, the present research aimed to examine the importance of variables such as exchange rate, income and price, because about 48% of soybeans, 52% of soybean meal and 23% of soybean oil of the country's production of the soy complex are for the export market (Abiove, 2011).

Given this, the key issue of the present research is to find out whether the companies that determine governance in the supply chain can use their dominant position to exercise their market power by capturing the economic surplus from soybean farmers. The analysis, based on instrumental neoclassical microeconomics begins with the econometric estimation of a function of exports to the markets of soybeans, soybean meal, and soybean oil.

Existence and exercise of market power

The neoclassical economics theory has legitimated the concept that the free enterprise of firms and consumers lead the economy to an efficient allocation of resources, mainly by the first theorem of the Welfare Economics: "any general competitive equilibrium, regardless of the initial allocation of resources, maximize the well being of society" (Pareto, 1988: 13). In this context, the hypotheses devised by Smith (1988) and Ricardo (1988) that the free enterprise market is capable of leading the economic system to an improved allocation of resources was confirmed by Pareto (1998).

However, the theoretical assumptions of economic rationality, information domain and free entry and exit of suppliers and buyers, which features efficient competition, cannot be seen in all market sectors. In this context, Miller (1981) demonstrates that the exercise of market power is related to the ability of the industry to set market prices for factors and products above the marginal cost. In general, this practice is directly related to conditions involving: 1) price elasticity of demand; 2) number of competitors; 3) degree of competition among firms.

In the same line, Possas (1996: 4) identified that "the exercise of market power via price implies a demand with elasticity sufficiently low so that a price rise (and reduction of quantity) will result in increased profits – without which the strategy of price increase would not make sense" (author's translation). Pindyck and Rubinfeld (2007) also demonstrated that the smaller the number of firms competing in the market, the greater the oligopoly; the lower the competition between firms, the greater their ability to raise profits by price manipulation.

Possas (1996) and Pindyck and Rubinfeld (2007) found that the degree of product substitutability and income are also important elements, because the greater the possibility of substitution the higher the price elasticity and the lower the ability of setting prices. By analogy, the more inelastic the farmers' supply the greater their risk of

exposure to the market power of agro-industrial corporations. Such issues are important because the exercise of market power leads to the loss of economic efficiency and, above all, to the transfer of part of the consumers' surplus (or producers' surplus) to a select group of leading companies (Ferguson and Ferguson, 1994; Possas, 1996, 2002; Pindyck and Rubinfeld, 2007). As a result, it has been consolidated in the field of economic and legal sciences; the notion that markets must be subject to the establishment of regulations (legal norms) and political instruments to assure competition.

While the likelihood of exerting the dominant power varies according to price elasticity and that a significant part of the Brazilian production of soybeans, soybean meal and soybean oil is destined to the international market, the analysis of the possibility of market power via prices was performed according to the econometric estimation of the trade flow.

The trade flow model studies was conducted by Goldstein and Khan (1978), Dornbusch and Fischer (1994), Castro and Cavalcanti (1997), Cavalcanti and Ribeiro (1998), Onunkwo and Epperson (1999), Zini Júnior, (1995), Barros et al. (2002) and Santana (2002), who defined that the trade balance (difference between exports and imports) is a variable that is explained mainly by the real exchange rate, domestic income and the rest of the world's income.

In this sense, "the trade balance depends positively on the real exchange rate and on the income of the rest of the world and negatively on the domestic income" (author's translation) (Zini Júnior, 1995: 138); the real exchange rate tends to interfere directly with the trade balance because it causes relative changes in currency expenditures for the purchase of goods (Krugman and Obstfeld, 2010: 307); the domestic income should make up the model because it is directly related to domestic consumers' expenditures so that rises in this variable tend to result in increased outlays, including imports; and the increased international income tends to impact domestic exports. On the other hand, the price variable is directly related to changes in the consumers' purchasing power (microeconomic concept of income effect) and consumption decisions (microeconomic concept of substitution effect), widely studied and described in the work by Varian (2006) and in the main microeconomics textbooks.

MATERIALS AND METHODS

The Multiple Linear Regression (MLR) was used to estimate the econometric equations. As a technique, "the regression analysis is the most important econometric method" (author's translation) (Santana, 2003), because it allows to identify the effects that some variables exert on others.

In this case, in which data are from historical series, the Augmented Dickey-Fuller (ADF) test was used to identify the degree of the series integration and stationarity. According to Gujarati (2006), the ADF test consists of estimating a regression such as:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^m \alpha_i \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

Where: ε_t is a pure blank series, and $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, etc., α and β are the parameters.

Thus, first the stationarity hypothesis was tested in level, without intercept and trend component. Subsequently, the stationarity hypothesis was assessed with intercept and trend component. Tests for serial autocorrelation and heteroscedasticity were not performed because the equations were calculated by the Generalized Method of Moments (GMM), considered robust to correct automatically these problems, if any (Hansen, 1982). The importance of the tools in the GMM estimation was assessed by the J-statistics introduced by Hansen. From time series the econometric models were adjusted for analysis of the markets of soybeans (Equation 2), soybean meal (Equation 3) and soybean oil (Equation 4):

$$QTXG_t = \alpha_0 + \beta_1 PXG_t + \beta_2 (PXG_t)^2 + \beta_3 PXF_{t-1} + \beta_4 PXO_t + \beta_5 REXCHANGE_t + \beta_6 GDPBR_t + \beta_7 PIBAS_t + \varepsilon_{gt} \quad (2)$$

$$QTXF_t = \alpha_0 + \beta_1 PXF_t + \beta_2 (PXF_t)^2 + \beta_3 PXG_t + \beta_4 PXO_t + \beta_5 (REXCHANGE_t)^2 + \beta_6 GDPBR_t + \beta_7 GDPAS_t + \varepsilon_{ft} \quad (3)$$

$$QTXO_t = \alpha_0 + \beta_1 PWSOYOIL_t + \beta_2 REXCHANGE_t + \beta_3 GDPBR_t + \beta_4 GDPEU_t + \beta_5 PWPALMOIL_t + \beta_6 PWCANOLAOL_t + \beta_7 PWSUNFLOWEROIL_t + \varepsilon_{ot} \quad (4)$$

Where:

Endogenous variables

$QTXG_t$: Total exports (10³ kg) of soybeans from 1980 to 2010.

$QTXF_t$: Total exports (10³ kg) of soybean meal from 1980 to 2010.

$QTXO_t$: Total exports (10³ kg) of soybean oil from 1980 to 2010.

Exogenous and instrumental variables

PXG_t : Average export price (USD/metric ton) of soybeans (USD of 2010; FOB, Brazil).

PXG_t^2 : squared PXG_t .

PXF_t : Average export price (USD/ metric ton) of soybean meal (USD of 2010, FOB, Brazil).

PXF_{t-1} : PXF_t lagged over one period

PXF_t^2 : Squared PXF_t ;

PXO_t : Average export price (USD/ metric ton) of soybean oil (USD of 2010, FOB, Brazil).

$REXCHANGE_t$: Real exchange rate: $REXCHANGE_t = NEXCHANGE_t (P_t^*/P_t)$, where

$NEXCHANGE$ is the BRL/USD nominal exchange rate, P_t^* is the consumer price index in the USA and P_t is the general price index – domestic supply, Brazil;

$GDPBR_t$: Real Gross Domestic Product *per capita* in Brazil in year t , calculated according to the Purchasing Power Parity;

$GDPAS_t$: Real Gross Domestic Product *per capita* in ASEAN5 in

year t , calculated according to the Purchasing Power Parity and used to represent the income of the Asian continent as a whole;

$GDPEU_t$: Real Gross Domestic Product *per capita* in the European Union in year t , calculated according to the Purchasing Power Parity.

$PWSOYOIL_t$: Average price of world exports of soybean oil in USD/metric ton in 2010, obtained by the quotient between the exported value in USD/ metric ton and the amount exported in 10³ kg by all countries.

$PWPALMOIL_t$: Average price of world exports of palm oil in USD/metric ton in 2010, obtained by the quotient between the exported value in USD and the amount exported in metric ton by all countries.

$PWCANOLAOL_t$: Average price of world exports of canola oil in USD/metric ton in 2010, obtained by the quotient between the exported value in USD and the amount exported in metric ton by all countries.

$PWSUNFLOWEROIL_t$: Average price of world exports of sunflower oil in USD/metric ton in 2010, obtained by the quotient between the exported value in USD and the amount exported in 10³ kg by all countries.

Parameters

α_i is the general intercept value of the equation; β_i are the parameters to be estimated.

Error term

ε_{it} is the random error term of the equation i (soybeans, meal and oil).

It is expected that the parameters β relating to the price variables of the products present negative sign as a function of income. Similarly, in cross relationships between the exported amount of goods x and the price of goods y , it is expected a positive sign for parameter β , indicating, for example, that a rise in the export price of soybeans tends to stimulate Brazilian exports of soybean meal, *ceteris paribus*. The parameter sign for the real exchange rate variable must be positive, indicating that exports tend to increase to the extent that the exchange rate suffers depreciations, *ceteris paribus*, as emphasized by Dornbusch and Fischer (1994), Zini Júnior (1995) and Santana (2002). Finally, the principles of the trade flow model point to inverse relationships between exports and domestic income and constant relationships between exports and external income.

For a better detailing of the market of edible oils and analysis of the existence of long-term integration between the diverse types of oil supply, the Johansen's co-integration test was performed, methodologically detailed by Johansen (1988). According to Santana (2003: 432), "the co-integration equation can be interpreted as the long-term relationships between variables" (author's translation). Thus, the set of time series $PWSOYOIL$;

$PWPALMOIL$; $PWCANOLAOL$; $PWSUNFLOWEROIL$ was submitted to the co-integration analysis to confirm the existence of long-term linear combination.

RESULTS

The markets for soybeans, soybean meal and oil were

Table 1. Regression to explain export of soybeans from Brazil.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-27.961.859.00	5.640.624.00	-4.9572	0.0001
PXG	-36.113.72	17.888.78	-2.0188	0.0559
PXG ²	40.87	19.47	2.0997	0.0474
PXF ₋₁	22.055.86	5.205.36	4.2371	0.0003
PXO	-2.350.87	856.25	-2.7455	0.0118
REXCHANGE	2.902.130.00	432.684.90	6.7072	0
GDPBR	2.527.05	1.284.22	1.9677	0.0618
GDPAS	5.206.33	2.123.76	2.4514	0.0226
R-squared	0.9754	Mean dependent variable		10.280.953.00
Adjusted R-squared	0.9676	S.D. dependent variable		9.430.533.00
S.E. of regression	1.696.636	Sum squared residual		6.33E+13
Durbin-Watson statistic	1.4432	J-statistic		1.51
Instrument rank	9	Prob(J-statistic)		0.22

examined according to independent, single-equation econometric models.

Exports and market power in the soybeans market

The results of the Augmented Dickey-Fuller (ADF) test show that all time series are integrated of order one I (1). The analysis of the exports and the likelihood of an existing market power were made by the estimation of Equation (2). The instrumental matrix that aggregated the direct effects of PXG, PXG2, PXFt-1, PXO, REXCHANGE, GDPBR and GDPAS and the indirect effects of PXF2 calculated both the standard deviation and covariance.

One of the GMM characteristics is the choice of coefficients in such a way that the residues are orthogonal to the instruments used. In the case under study, the P-value (J Statistics) of 0.219 confirms the orthogonality of the tools.

The probability value and t-statistics confirm that all estimated parameters are statistically different from zero: GDPBR at 10%, PXG and GDPAS at 5% and PXF and REXCHANGE at 1%, as can be seen in Table 1.

The adjusted R² value of the regression indicates that 96.76% of the changes in the exported amount of soybeans are explained by the set of exogenous and instrumental variables, that is, by the variables that represent the export price for soybeans, the real exchange rate and the domestic and international income.

The coefficient of price elasticity of soybean exports at the level of 0.1955 (Equation 5) indicates that the price variations of soybeans have little influence on the amount exported of the same product.

$$E_{p_g} = \frac{dQ}{dP} \cdot \frac{\bar{P}_x}{\bar{Q}_x} = (b + 2c\bar{P}_x) \cdot \frac{\bar{P}_x}{\bar{Q}_x} = -36.113,72 + 2 \cdot 40,87 \cdot 374,81 \cdot \frac{374,81}{10.280.953} = -0,1955 \tag{5}$$

In this context, for every 10% rise in the export price of soybeans, a decrease of 1.96% is expected in the amount exported, *ceteris paribus*. Similarly, price reductions in soybeans tend not to stimulate exportation of this product. This is because soy is a basic, non-perishable raw material, difficult to replace because its protein is the only one available in the plant kingdom that has high quality and is easily digestible by the human body, as pointed by Hughes et al. (2011).

Moreover, the governance structure of the supply chain and the market power of the firms that are part of the soybean processing industry can help explain the price inelasticity of this commodity, once part of its exports is made between companies controlled by the same group. In this marketing paradigm, price increases or decreases tend not to change significantly the amount traded. Such price inelasticity results in greater submission of the soybean farmers to the domain of the processing industries and reinforces the theories postulated by Ferguson and Ferguson (1994), Possas (1996) and Pindyck and Rubinfeld (2007). It also indicates the possibility of the exercise of market power via prices by companies such as Bunge S.A., Cargill Agrícola S.A. and other corporations leading the sector.

The coefficient of cross-price elasticity of soybeans supply in relation to the price of soybean meal ($E_{Q_g P_f}$) presented a positive sign, indicating that the increased price of soybean meal tends to result in increased exports of soybeans. So, a 10% rise in the price of soybean meal lagged behind by one period tends to result in an increase of 6.78% in the amount of exports of soybeans, *ceteris paribus*, as can be seen in (6).

$$E_{Q_g P_f} = \beta_3 \frac{\overline{PXF}_{-1}}{\overline{QTXG}} = 22.055,86 \frac{316,05}{10.280.953} = 0,6780 \tag{6}$$

Economic rationality indicates in the analysis of supply

that price increases of soybean meal would tend to result in decreased exports of soybeans because the profits maximization would be achieved with soybean meal exports. However, soybeans trade is predominantly intra-industry and intra-firm, so that exoneration of Brazilian exports and the incidence of *ad valorem* duties on soybean meal imports lead the companies to maximize profits by producing meal in plants outside the country. The cross-price elasticity of soybeans supply in relation to the export price of soybean oil ($E_{Q_g P_o}$) was calculated by Equation 7 and the coefficient was at the level of -0.175.

$$E_{Q_g P_o} = \beta_4 \frac{\overline{PXO}}{\overline{QTXG}} = -2.350,865 \frac{768,19}{10.280,953} = -0,1757 \quad (7)$$

This result can be explained by the fact that price rises of soybean oil may result in an increased demand for palm oil and, consequently, in a reduced demand for soybeans. It is worth noting that the coefficients of cross-price elasticity of soybean meal and oil in relation to the Brazilian soybeans exports showed different signs and magnitudes, which corroborates the fact that even though deriving from the same raw material and produced by the same companies they are traded in markets with different characteristics.

The effect of fluctuations in the real exchange rate was also estimated by the econometric model and the results show that exchange rate depreciations contribute to increased exports, *ceteris paribus* (Equation 8).

$$E_{Q_g TRC_{R\$xUS\$}} = \beta_5 \frac{\overline{REXCHANGE}}{\overline{QTXG}} = 2.902,130 \frac{3,29}{10.280,953} = 0,9287 \quad (8)$$

In this case, a 10% appreciation of the exchange rate tends to reduce soybean exports in 9.29% *ceteris paribus*. Likewise, a 10% depreciation of the exchange rate tends to result in an increase of 9.29% of the exported volume. This shows the importance of the exchange rate and corroborates the theories postulated by Zini Júnior (1995) and Krugman and Obstfeld (2010) that exchange rate variations produce changes in the purchasing power of products and, therefore, interferes with the exported volume.

Income, as proposed by the authors studied, is also a representative variable in the analysis of trade flows. Thus, the coefficient of elasticity of soybean exports in relation to the domestic income ($E_{Q_g I_d}$) and that of international markets ($E_{Q_g I_a}$) was calculated, as shown in Equations 9 and 10.

$$E_{Q_g I_d} = \beta_6 \frac{\overline{GDPBR}}{\overline{QTXG}} = 2.527,052 \frac{6.590,54}{10.280,953} = 1,6200 \quad (9)$$

It was expected negative sign for coefficient $E_{Q_g I_a}$, because as observed by Krugman and Obstfeld (2010), a GDP growth in the exporting country tends to result in an increased domestic consumption, including imports. But the opposite sign and the magnitude of the same can be accepted, once the companies that are part of Brazil' soybean processing industry are mostly held by groups that also have subsidiaries in other markets and, regardless the domestic conditions of the Brazilian economy, they need to supply the industries located in other countries.

On the other hand, the coefficient ($E_{Q_g I_a}$) confirmed the theoretical postulates and empirical studies conducted by Goldstein and Khan (1978), Zini Júnior (1988; 1995), Dornbusch and Fischer (1994), Castro and Cavalcanti (1997), Cavalcanti and Ribeiro (1998), Onunkwo and Epperson (1999), Santana (2002) and Barros et al. (2002).

$$E_{Q_g I_a} = \beta_7 \frac{\overline{GDPAS}}{\overline{QTXG}} = 5.206,334 \frac{2.666,97}{10.280,953} = 1,3506 \quad (10)$$

This shows that Brazil's exports of soybeans are elastic to the Asian income. In this respect for every 10% increase in the Asian income, the trend is an increase of 13.51% in Brazilian exports of soybeans, *ceteris paribus*. The opposite is also true. However, this situation requires a careful analysis, especially the planning of policies to reduce the dependence on this market, since in times of crisis trade tensions or something with Asia, or even the development of technologies that would enable to add part of the African land to soybean production, the Brazilian supply chain would be significantly impacted.

Econometric analysis of Brazil's exports of soybean meal

As occurred in the estimation of the exports model for soybeans, the econometric estimation for the analysis of the soybean meal market aggregated historical series in the 1980-2000 period. The indirect influence of the European Gross Domestic Product (a key consumer market for soybean meal) and the corn price (product that complements soybean meal in the production of animal feeds) was calculated, as well as the direct influences of variables PXF , PXF^2 , PXG , PXO , $REXCHANGE^2$, $GDPBR$, $GDPAS$.

The J Statistics at the level of 1.14 and the P-value (J Statistics) of 0.56 confirm the orthogonality of the parameters. The adjusted R-squared indicates that 75.96% of the variations in soybean exports are directly explained by changes in the prices of soybean meal, soybeans and soybean oil, the exchange rate and the GDP *per capita* in Brazil and Asia, and indirectly by

variations in the GDP *per capita* in Europe and the international price of corn.

All estimated parameters, except for that associated with the Brazilian income (GDPBR), are statistically different from zero at the levels of 1%, 5% or 10. The results are shown in Table 2. The coefficient of price

$$\epsilon_p = \frac{dQ}{dP} * \frac{\overline{P_x}}{\overline{Q_x}} = (b + 2c\overline{P_x}) * \frac{\overline{P_x}}{\overline{Q_x}} = -39.409,11 + 2 * 28,71 * 324,65 * \frac{324,65}{10.280,953} = -0,6567 \quad (11)$$

This result is attributed to the unavailability of close substitutes for soybean meal in animal feeds. Thus, as soybean meal is essential to feed the total swine, poultry and dairy cattle herds in Europe and Asia, it ensures the consumption of the product in the short and medium term even at high prices.

For the processing industry, the low elasticity means a possibility of price increases and a consequent increase in profits, because trade is made in an oligopolized market protected by barriers to entry. However, exports of soybean meal are traded by firms of the soybean processing industry and animal feed industries directly linked to the production of meat, dairy products and eggs, which results in an oligopolistic competition because it puts face to face two strong segments of the national and international agribusiness.

The coefficient of cross-price elasticity of soybean meal in relation to the price of soybeans ($E_{Q_f P_g}$) was positive and at the level of 0.8817. This shows that for every 10% rise in the soybeans price, exports of meal tend to increase 8.81%, *ceteris paribus* (Equation 12).

$$E_{Q_f P_g} = \beta_3 \frac{\overline{P_X G}}{\overline{Q_{TXF}}} = 23.798,57 \frac{384,43}{10.376.291,07} = 0,8817 \quad (12)$$

The result $E_{Q_f P_g} > 0$ indicates a substitutability relationship between Brazilian exports of soybeans and soybean meal. The effect obtained by the econometric model is consistent with what is observed in the international market because increases in the exports price of soybeans tend to result in an increase of the production costs of soybean meal produced in industrial plants located outside Brazil. This result complements the analysis of the cross elasticity relationship of exports of soybeans with the price of soybean meal (Equation 6). The cross relationships between soybean meal and oil were investigated by the cross-price elasticity of the demand of soybean meal in relation to the price of oil ($E_{Q_f P_o}$). The coefficient sign was consistent with the economic theory once the negative sign associated with the coefficient indicates complementarity relation. Such relationship exists especially on the side of supply, once the production of meal and oil is inseparable (Equation 13).

elasticity of supply of soybean meal (E_{P_f}) presented a sign consistent with the economic theory and indicates that exports of soybean meals are price inelastic. Thus, for every 10% rise in the meal price, a reduction of 6.56% is expected in soybean meals exports, *ceteris paribus*.

$$E_{Q_f P_o} = \beta_4 \frac{\overline{P_X O}}{\overline{Q_{TXF}}} = -4.823,505 \frac{791,75}{10.253.892,27} = -0,3724 \quad (13)$$

It is estimated that a 10% reduction in the price of soybean oil, *ceteris paribus*, tends to result in a rise of 3.72% in soybean meal exports. However, it is important to note that even though derived from the same raw material, meal and oil are sold in markets with distinct characteristics: the first is mostly sold to the animal feed industry and does not have close substitutes in the quantity demanded by the market; the latter is mostly consumed by human populations and can be easily substituted with palm, sunflower, rice, corn, canola oils, among others.

The effects caused by variations in the exchange rate of Brazilian exports of soybean meal were analyzed by the coefficient of cross elasticity of the supply of soybean meal in relation to the exchange rate ($E_{Q_g TRC_{RSxUS\$}}$). The conclusion reached is that the coefficient sign is consistent with theory, but the exchange rate changes tend not to interfere significantly in exports, *ceteris paribus*, as can be seen in Equation 14.

$$E_{Q_g TRC_{RSxUS\$}} = \beta_5 \frac{\overline{REXCHANGE}}{\overline{Q_{TXF}}} = 54.555,23 \frac{3,30}{10.253.892,27} = 0,0176 \quad (14)$$

The coefficient of elasticity of supply of soybean meal exports in relation to the domestic income ($E_{Q_f I_d}$) did not present statistical significance, so it was not analyzed.

The income of consumer markets, taken directly from the Asian GDP and indirectly from the European GDP, indicated a sign consistent with the theory, corroborating the assumptions and results found by Goldstein and Khan (1978), Zini Júnior (1988, 1995), Dornbusch and Fischer (1994), Castro and Cavalcanti (1997), Cavalcanti and Ribeiro (1998), Onunkwo and Epperson (1999), Santana (2002) and Barros et al. (2002). Equation 15 indicates that for a 10% growth in the Asian GDP, a 9.11% increase in the Brazilian exports of soybean meal is estimated, *ceteris paribus*. The opposite is also true.

$$E_{Q_f I_a} = \beta_7 \frac{\overline{GDPAS}}{\overline{Q_{TXF}}} = 3.579,755 \frac{2.609,10}{10.253.892,27} = 0,9109 \quad (15)$$

Table 2. Regression to explain export of soybean meal from Brazil.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11.165.955.00	2.172.628.00	5.1394	0
PXF	-39.409.12	16.803.71	-2.3453	0.028
PXF ²	28.72	14.51	1.9786	0.06
PXG	23.798.57	12.244.68	1.9436	0.0643
PXO	-4.823.51	2.613.15	-1.8459	0.0778
REXCHANGE ²	54.555.23	29.700.98	1.8368	0.0792
GDPBR	-1.033.63	806.3	-1.2819	0.2126
GDPAS	3.579.76	1.306.30	2.7403	0.0117
R-squared	0.8157	Mean dependent variable		10.253.892.00
Adjusted R-squared	0.7597	S.D. dependent variable		2.274.299.00
S.E. of regression	1.115.081.00	Sum squared resid		2.86E+13
Durbin-Watson stat	1.4908	J-statistic		1.1401
Instrument rank	10	Prob(J-statistic)		0.5654

In this context, it can be seen that the increase of the international income contributed to the expansion of Brazil's exports of soybean meal. Likewise, the coefficient also captured the effects of the increase of income and demand of meats (chicken and pork), milk and eggs, because soybean meal is an input for these segments.

Econometric analysis of Brazil's exports of soybean oil

Many factors have contributed to the growing world supply of edible oils in the recent decades, such as the significant population growth (Brum, 1993, 2002), the increased income in the developed and developing economies (Giordano, 1999) and the adoption of new technologies, which resulted in a larger supply of raw materials and higher yields in the process of extraction of soybean oil (Thomas, 2003).

In this process, the growing production of palm, soybean, canola and sunflower oils began to account for most of the additional supply of vegetable oils (FAO, 2012), but unlike the soybeans and meal markets, soybean oil trade occurs in an environment with close substitutes.

To examine the order of integration and the existence of co-integration between these markets, the variables relating to the average world price of palm oil exports (PWPALMOIL), average world price of soybean oil exports (PWSOYOIL), average world price of canola oil (PWCANOLAOIL) and the average world price of sunflower oil exports (PWSUNFLOWEROIL) were submitted to the Augmented Dickey-Fuller (ADF) unit root test and to Johansen's (1988) co-integration test.

The results of the ADF unit root test showed that all variables are first-order integrated, with intercept. Johansen's co-integration test (Table 3) indicates the existence of long-term relationships between the palm,

soybean, canola and sunflower oil markets, because the trace test indicated four co-integrating vectors at 5% probability.

Thus, the null hypothesis of non-integration between the series is rejected and the alternative hypothesis is accepted, and the hypothesis that the prices and quantities of soybean, palm, canola and sunflower oils are defined in a same market is confirmed. So, part of Brazil's exports of soybean oil is determined by the market conditions for vegetable oils. Therefore, the analysis of Brazil's exports of soybean oil should include, in addition to the soybean oil price, exchange rate, domestic income and international income, the price of the main substitute products.

Based on the Generalized Method of Moments (GMM), with information of the 1980-2010 period, an equation was estimated to examine Brazil's exports of soybean oil (QTXO). The data were weighed by the HAC matrix (Bartlett kernel, Newey-West with fixed bandwidth = 4,000). The instrumental matrix aggregated the variables PWSOYOIL, REXCHANGE, GDPBR, GDPEU, GDPAS, PWPALMOIL, PWCANOLAOIL and PWSUNFLOWEROIL. The results are displayed in Table 4.

The J Statistics, at the level of 1.77 and P-value (J Statistics) of 0.41, confirms the parameters orthogonality and model consistency. The coefficient of determination of adjusted R-squared indicates that 80% of the variations in Brazil's exported quantities of soybean oil are directly explained by variations in the international price of soybean oil, real exchange rate, Brazil income, Europe income, the price of substitute products (palm, canola and sunflower oils), and indirectly by the Asian market income.

All parameters were statistically significant at 1% probability, except those associated with the variables REXCHANGE and PWSUNFLOWEROIL, which were statistically different from zero at 5% probability.

Table 3. Johansen Cointegration Test to assess long-term relationship in the vegetable oil markets.

Sample (adjusted): 1964 2010				
Included observations: 47 after adjustments				
Trend assumption: Linear deterministic trend				
Series: D(SOJA) D(PALMA) D(CANOLA) D(GIRASSOL)				
Lags interval (in first differences): 1 to 1				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue λ_i	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.820807	157.515	47.85613	0.0000
At most 1 *	0.47316	76.7083	29.79707	0.0000
At most 2 *	0.44517	46.58795	15.49471	0.0000
At most 3 *	0.331113	18.90056	3.841466	0.0000
Trace test indicates 4 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue λ_i	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.820807	80.80666	27.58434	0.0000
At most 1 *	0.47316	30.12035	21.13162	0.0021
At most 2 *	0.44517	27.68738	14.2646	0.0002
At most 3 *	0.331113	18.90056	3.841466	0.0000
Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

The cross-price elasticity coefficient of Brazil's exports of soybean oil in relation to the international price of soybean oil ($E_{Q_0 P_{PMOSOJA}}$) was of -4.28 and shows that the Brazilian exports are extremely elastic in relation to the international prices (Equation 16).

$$E_{Q_0 P_{PMOSOJA}} = \beta_1 \frac{PWSOYOIL}{QTXO} = -6.955,622 \frac{849,74}{1.381.182,22} = -4,28 \quad (16)$$

In this context, for every 1% rise in the international price of soybean oil it is expected a reduction of 4.28% in the amount exported, *ceteris paribus*. This result is explained by the high competition in the sector, once palm, canola, sunflower, rice, corn, olive oils and others have the same physical, chemical and nutritional quality standards of, or even higher than, those found in soybean oil, which makes these products perfect substitutes. Thus, as the soybean oil price rises, the expectation is that the reduced consumption of this good is replaced by an increased consumption of substitutes.

The elasticity calculated by Equations 17, 18 and 19 allow to refine this analysis since all coefficients showed

positive signs, indicating a substitutability relationship, as demonstrated by Miller (1981), Varian (2006) and Santana and Ribeiro (2008).

$$E_{Q_0 P_{palma}} = \beta_5 \frac{PWPALMOIL}{QTXO} = 1.353,102 \frac{733,43}{1.381.182,22} = 0,72 \quad (17)$$

$$E_{Q_0 P_{canola}} = \beta_6 \frac{PWCANOLAOIL}{QTXO} = 5.051,924 \frac{913,41}{1.381.182,22} = 3,34 \quad (18)$$

$$E_{Q_0 P_{girassol}} = \beta_7 \frac{PWSUNFLOWEROIL}{QTXO} = 1.155,094 \frac{951,02}{1.381.182,22} = 0,80 \quad (19)$$

In particular, the substitutability of canola oil in relation to the soybean oil stands out, since the elasticity coefficient was at 3.34, indicating that for every 1% increase in the canola oil price, the trend is an increase of 3.34% in Brazil's exports of soybean oil, *ceteris paribus*. The opposite is also reciprocal. But with respect to the changes in the international price of palm and sunflower oils, Brazil's exports of soybean oil were less elastic. Yet, the model corroborates that for every 10% increase in the

Table 4. Regression to explain Brazilian exports of soybean oil.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-522.886.70	536.222.20	-0.9751	0.3396
PWSOYOIL	-6.955.62	1.111.53	-6.2577	0
REXCHANGE	175.521.90	68.758.63	2.5527	0.0178
GDPBR	-315.8	90.57	-3.4869	0.002
GDPEU	136.19	35.23	3.8661	0.0008
PWPALMOIL	1353.1	444.54	3.0438	0.0058
PWCANOLAOIL	5051.92	1.193.15	4.2341	0.0003
PWSUNFLOWEROIL	1.155.09	549.92	2.1004	0.0469
R-squared	0.8467	Mean dependent var		1.381.182.00
Adjusted R-squared	0.8	S.D. dependent var		656.195.70
S.E. of regression	293.441.30	Sum squared resid		1.98E+12
Durbin-Watson statistic	1.274	J-statistic		1.7713
Instrument rank	10	Prob(J-statistic)		0.4125

international price of palm oil, a 7.2% increase in Brazil's exports of soybean oil is expected, *ceteris paribus*. Also, a 10% increase in the international price of sunflower oil tends to result in 8% increase of Brazil's exports of soybean oil. So, the integration of these markets and its impact on Brazil's exports of this product are reaffirmed.

The degree of interrelation of these markets is also explained by the composition of the international supply of edible oils, where soybean, palm, canola and sunflower oils account for 82% of the supply and are the most consumed oils, mainly in markets such as Brazil, India, China, South Africa, Mexico, among others, whose *per capita* income is not as high as that in the developed countries (FAO, 2012).

The effects of the fluctuations in the exchange rate are demonstrated in Equation 20. It can be seen that the coefficient of cross elasticity of the exported amount of soybean oil in relation to the real exchange rate was positive. The sign is consistent with the theory, once devaluations of the exchange rate, *ceteris paribus*, represent a reduction in the relative prices and purchasing power of dollar, as described by Krugman and Obstfeld (2010).

$$E_{Q_oTRC_{R\$xUS\$}} = \beta_2 \frac{\overline{REXCHANGE}}{\overline{QTXO}} = 175.521,90 \frac{3,30}{1.381.182,22} = 0,42 \quad (20)$$

Thus, the results indicate that exchange rate fluctuations tend to result in less than proportional fluctuations in Brazil's exports of soybean oil. Under this perspective, for a 10% devaluation on the exchange rate, a 4.2% growth is expected in the exports of soybean oil.

In contrast, the impact of the domestic income is greater once the coefficient of cross elasticity of the exports of soybean oil in relation to the domestic income ($E_{Q_oI_d}$) was of -1.49 (Equation 21). Both the sign and the magnitude are in agreement with the theory, once the

increase in domestic income represents greater purchasing power and domestic consumption of soybean oil derivatives, e.g., margarines, mayonnaise, dressings, breads, sweets, candies, chocolates, among other pharmaceutical, industrial and medical products. Under this perspective, for every 1% rise in Brazil's GDP, it is expected a 1.49% reduction in the exports of soybean oil, *ceteris paribus* and vice-versa.

$$E_{Q_oI_d} = \beta_3 \frac{\overline{GDPBR}}{\overline{QTXO}} = -315,7994 \frac{6.495,55}{1.381.182,22} = -1,49 \quad (21)$$

This coefficient confirms the importance of the domestic market for the industry of vegetable oils and derivatives and, indirectly, for the production of soybeans and soybean meal, demystifying the common sense that soybean is only an export product. On the other hand, the coefficient of cross elasticity of soybean oil exports in relation to the European income ($E_{Q_oI_e}$) was of 1.85, which indicates the importance of the European market for Brazilian exports of soybean oil and confirms the postulates of Goldstein and Khan (1978), Zini Júnior (1988), Dornbusch and Fischer (1994), Zini Júnior (1995), Santana (2002), Castro and Cavalcanti (1997), Cavalcanti and Ribeiro (1998), Onunkwo and Epperson (1999), Barros et al. (2002) and Santana (2002) that the domestic and international income impact trade in a different manner.

$$E_{Q_oI_e} = \beta_4 \frac{\overline{GDPEU}}{\overline{QTXO}} = 136,1875 \frac{18.734,07}{1.381.182,22} = 1,85 \quad (22)$$

In this sense, the 10% increase in Europe's *per capita* income tends to result in a 18.5% growth in Brazil's exports of soybean oil, *ceteris paribus*. These results are consistent with the current conditions, in which the major

European importers (Holland, Germany and Spain) do not impose tariffs or quotas for soybean oil imported from Brazil (BRASIL, 2012).

Finally, the analyses allow stating that as a function of the competition by other edible oils, especially palm, sunflower and canola oils, the soybean processing industry cannot project its market dominance to the segment of vegetable oils. This situation explains the *filière* strategy of investments in “key activities” at the links directly upstream and downstream in the soybean supply chain. This was the alternative found to determine governance and, from it, create conditions for designing a scenario to enable the sale of soybeans and oil.

Thus, the high competition in the supply of vegetable oils tends to result in the submission of soybean producers to the interests of the industry, especially those who are unassisted by government credit lines and depend on trading companies to survive.

Therefore, this study neither minimizes the importance of the industry to agriculture nor the importance of the grains processing industry for the expansion of the area planted and increased soybean yields in Brazil, but underlines that the markets are ruled by a small number of corporations (Bunge Alimentos S.A., Cargill Agrícola S.A., ADM do Brasil Ltda., Louis Dreyfus Commodities Brasil Ltda., and Multigrain S.A., among others), and emphasizes the importance of the government in offering credit lines for investment, expenditures and marketing, as well as effective efforts to support fair competition. Hence, the market relationships throughout the soybean supply chain will be fairer and more balanced.

DISCUSSION

The econometric analysis allowed quantifying the importance of price, fluctuations in the exchange rate and in the domestic and international income for the Brazilian exports of soybeans, soybean meal and oil.

The results showed that Brazil's exports of soybeans are price inelastic, the growth of exports is directly and positively associated with the international income growth, especially in Asia, and that exports fluctuations are also influenced, to a lesser degree, by fluctuations in the exchange rate.

Similar results were found in the analysis of exports of soybean meal, in which it was observed price inelasticity for soybean meal, a substitutability relationship between soybean meal and soybeans in exports, the reduced effect of exchange rate fluctuations and the importance of the Asian income.

But in the analysis of exports of soybean oil, a long-term relationship in the markets of soybean oil, palm oil, canola oil and sunflower oil was found by four co-integrating vectors pointed by the Johansen's co-integration test. This implies the existence of a dynamic and integrated movement in the global key oil producing markets. This finding is confirmed by the econometric

estimation of the soybean oil export function, in which a high price elasticity of this product and cross elasticity of this product with other oils, particularly canola oil, were found. As observed for the markets of soybeans and meal, the international income is an important determinant of Brazil's exports, and the exchange rate does not play a major part in this process.

Therefore, by trading inelastic products and protected by barriers at entry, the soybean processing industry can shift the market breakeven point to a position that maximizes the economic outcomes, that is, the dominant firms can project their position to attract the surplus produced by soybean farmers.

So, it is clear that a significant portion of the transnational corporations' competitiveness in the soybean business results from strategies of positioning themselves at the links directly upstream and downstream in the supply chain, Brazil's large domestic and international market share and the low price elasticity of soybeans and soybean meal.

Thus, the authors can conclude that soybean growers are in a weak situation, because they demand inputs from an oligopolistic market, offer their production to an oligopsonized market, and the prices for their commodity are inelastic.

Finally, it is suggested that the creation of mechanisms to reduce the exposure of soybean growers to the market power exerted by big companies, and the creation of sectorial policies to foster competition, without which the soybean supply chain would be at risk of being consolidated as a mere instrument for capital accumulation by big transnational corporations.

Conflict of Interest

The authors have not declared any conflict of interest.

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