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Evaluating Crop Substitution: An Empirical Approach Involving Sugarcane, Soybean, Beef and Corn

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Introduction

With the objective of evaluating the relationship between the relative use of Brazilian agricultural areas in the production of soybean, beef, corn and sugarcane as a function of relative prices and other economic constructs, we fit an econometric model using the Cobb-Douglas family. The empirical exercise is of importance in the actual Brazilian context, where drastic changes are envisioned for the agricultural profile of the country, in response to the potential world increase in demand for bio-fuels and the likely increase of the area cultivated with sugarcane. The subject of the substitution of Brazilian agricultural areas, usually used in the cultivation of foods, for bio-fuels production is important because there is doubt on the effectiveness of the international market and on the markets in general. Otherwise, the production would be guided by the law of the comparative advantage: each country would specialize in the products that they are more competent and therefore increase its GDP. Still, the growth of the sugarcane area would lead to the growth of the price for food and a new equilibrium point would be found. High prices and competition among crops would stimulate technological development, and this, in turn, would result in falling prices after the initial elevation. In other words, the market would lead to a new equilibrium, certainly more advantageous than that produced interventionists measures. However, there are objective reasons to doubt of market effectiveness. For example there are wars that can disturb the supply of foods severely. The rich countries frequently disrespect the competitive paradigm, with subsidies, tariff and no-tariff barriers, quotas and other measures that distort the markets of agricultural products. Other reasons relate to the potential occurrences of plagues, diseases, inundations and droughts and the fragile international mechanisms to deal with conflicts and controversies. The correct road to follow is to carry out studies leading to scenarios from which one can identify which measures, the Brazilian government, in the present instance, needs to take to counterbalance, and the possible over concentration in sugarcane, within the paradigms accepted by the rules of the international trade. The context should be always of transitory measures, except those that seek to increase the productivity of the cultures.

Material and Methods

The objective of this study is to assess the substitution effect related to the use of agricultural land for soybean, corn, sugarcane and pasture as a function of the relative prices of those products, the exchange rate, the interest rate and of other factors represented by a trend component. The model used in the analysis is in the Cobb-Douglas family:

$$\frac{q_i}{q_j} = \gamma \; e^{\delta t} \left(\frac{p_i}{p_j} \right)^{\alpha} c^{\beta} r^{\lambda} \varepsilon$$

In this expression *i* and *j* denote crops, q_τ cultivated area, p_τ prices, *c* is the nominal exchange rate, r the nominal interest rate, *t* time and ε is a positive random shock. The quantities $\gamma, \alpha, \beta, \lambda, \delta$ are unknown parameters. For the case of soybean and sugarcane, to represent the evolution of prices, we considered the Fisher's method (COELLI ET AL., 1998) to arrive at a price index combining prices of raw and crushed grain and oil in the case of soybean and sugar and ethanol in the case of sugarcane. The observations used in the analysis cover the period 1994-2005 and, except for the nominal exchange rate and the nominal interest rate they were transformed to indexes with base in 1994. The pasture area was obtained from the animal population using the ratio heads by area, observed in the last agricultural census (IBGE, 1998). Regarding prices, all the data used in the study refer to international prices (U$/t) with the exception of price of beef, that refers to price received by Brazilian producers, adjusted by the nominal exchange rate. The data sources are IBGE (1998), FAO (2007) and IPEA (2007).

Results and Discussion

Table1 shows the evolution of prices and quantities of concern in this work. Relevant variation in prices is seen only for soybean and corn in the period. Prices for these commodities are typically higher in the period.

Table 1: Evolution in indexes of cultivated area and price for soybean, corn, pasture (beef) and sugarcane. Price indexes for soybean and sugarcane were calculated according to the approach of the ideal index of Fisher.

Year	$q_{soybean}$	q_{corn}	$q_{sugarcane}$	$q_{pasture}$	$p_{soybean}$	$p_{sugarcane}$	p_{beef}	p_{corn}
1994	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1995	1.01298	1.01437	1.04920	1.01886	0.98127	1.08642	0.98366	1.11489
1996	0.89363	0.87104	1.09321	1.00029	1.18420	1.02853	0.85014	1.51107
1997	0.99662	0.91369	1.10789	1.02005	1.20582	1.02319	0.86616	1.10052
1998	1.15429	0.76992	1.14742	1.03104	0.94066	0.79708	0.87256	0.93774
1999	1.13327	0.84454	1.12740	1.04030	0.74140	0.55341	0.66211	0.83500
2000	1.18493	0.86483	1.10569	1.07351	0.79353	0.67891	0.78087	0.83277
2001	1.21341	0.89718	1.14099	1.11467	0.74929	0.75358	0.67336	0.82810
2002	1.41942	0.85542	1.17379	1.17129	0.82156	0.58022	0.60845	0.90548
2003	1.60730	0.94304	1.23606	1.23577	0.99800	0.62748	0.66714	0.93439
2004	1.86883	0.90267	1.29607	1.29239	1.18572	0.66229	0.72441	1.00914
2005	1.99115	0.84003	1.33606	1.30910	0.96015	0.78971	0.83393	0.83430

Source: Indexes calculations made by authors with original data from IBGE (1998), FAO (2007), IPEA (2007).

The regression estimates derived from the Cobb-Douglas representation are shown in Tables 2-6. Table 2 shows statistical results for the pair soybean/sugarcane. One notices that the interest rate and trend dominate the relationship. The relative price elasticity is about 0.04 and is not significant. The exchange rate has a negative non significant coefficient.

Table 2: Model for soybean/sugarcane. Response and relative price for soybean/corn. R^2=96.2%.

Parameter	df	Estimate	Std. Error	t	Pr > |t|
intercept	1	-0.501	0.072	-6.98	0.0004
relative price	1	0.035	0.106	0.34	0.7490
exchange rate	1	-0.064	0.094	-0.69	0.5183
interest rate	1	0.231	0.072	3.24	0.0177
trend	1	0.079	0.013	6.08	0.0009

The relationship beef/sugarcane is investigated in Table 3. For this model we do not observe any association of the response with the variables of interest. A mean seems to fit the data indicating stationarity of the response.

Table 3: Model for beef/sugarcane. Response and relative price for beef/sugarcane. R^2=73.0%.

Parameter	df	Estimate	Std. Error	t	Pr > |t|
intercept	1	-0.128	0.041	-3.11	0.0208
relative price	1	-0.097	0.078	-1.25	0.2595
exchange rate	1	0.057	0.039	1.44	0.1990
interest rate	1	0.098	0.050	1.94	0.1008
trend	1	0.002	0.007	0.26	0.8041

Table 4 relates to corn/sugarcane. One notices a marginal negative association with relative price and a strong negative trend component. The exchange rate has a positive significant effect.

Table 4: Model for corn/sugarcane. Response and relative price for corn/sugarcane R^2=77.0%.

Parameter	df	Estimate	Std Error	t	Pr > |t|
intercept	1	-0.004	0.123	-0.03	0.9781
relative price	1	-0.259	0.169	-1.53	0.1772
exchange rate	1	0.404	0.162	2.50	0.0468
interest rate	1	0.087	0.105	0.83	0.4383
trend	1	-0.067	0.022	-3.08	0.0217

Table 5 shows statistics for soybean/beef. One notices significant effects only for the exchange rate and trend. The last two years indicate growth of the response following increase in relative prices no strong enough to influence estimation.

Table 5: Model for soybean/beef. Response and relative price for soybean/beef. R^2=96.1%

Parameter	df	Estimate	Std Error	t	Pr > |t|
intercept	1	-0.497	0.075	-6.66	0.0006
relative price	1	-0.017	0.100	-0.17	0.8698
exchange rate	1	-0.055	0.092	-0.59	0.5753
interest rate	1	0.229	0.072	3.17	0.0193
trend	1	0.080	0.013	6.07	0.0009

Finally, the model for soybean/corn shows significance only for the trend component which is positive. Here we detect collinearity effects. The trend component has a variance inflation factor of 16.4 and for this reason our option was the more parsimonious model shown in Table 6. Now we see some of a positive joint effect of the relative price and the exchange rate.

Table 6: Model for soybean/corn. Response and relative price for soybean/corn. R^2=79.7%.

Parameter	df	Estimate	Std Error	t	Pr > |t|
intercept	1	0.183	0.150	1.22	0.2617
relative price	1	0.949	0.413	2.30	0.0549
exchange rate	1	0.363	0.158	2.30	0.0550
interest rate	1	-0.002	0.214	-0.01	0.9916

Conclusions and Outlook

In our study we did not find statistical evidence that sugarcane agricultural area is invading significantly the agricultural areas of beef, soybean and corn as a function of the respective relative prices. Marginally significant substitution effects are noticed between soybean and corn and sugarcane and corn. The occupation of degraded areas of pastures by the sugarcane observed in the recent past in the south of Brazil, typically in São Paulo, is not strong enough to change the regression results involving beef and sugarcane. From the analysis we see indication that if the price of soybean relative to sugarcane favors soybean than this culture will tend to invade sugarcane areas. This statement is supported by the trend coefficient which is highly significant and positive and the sign of the relative price elasticity. From this perspective we also see sugarcane invading corn areas and soybean invading beef areas.

References

COELLI, T.; RAO, D.S.P. AND BATTESE, G.E. (1998). An Introduction to Efficiency and Productivity Analysis. Boston: Kluwer Academic Publishers. 275p.

FAO. (2007). Food and Agriculture Organization of the United Nations. FAOSTAT. 2007. Available in: <http://faostat.fao.org/>. Access on: 18 May 2007.

IBGE. (1998). Instituto Brasileiro de Geografia e Estatística. Censo Agropecuário 1995-1996. 1998. Available in: <http://www.ibge.gov.br/home/>. Access on: 22 May 2007.

IPEA. (2007). Instituto de Pesquisa Econômica Aplicada. IPEADATA: Dados macroeconômicos e regionais. 2007. Available in: <http://www.ipeadata.gov.br/>. Access on: 22 May 2007.