Biofuels versus food: How much Brazilian ethanol production can affect domestic food prices?

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Selected paper prepared for presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 27-29, 2014

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INTRODUCTION

The agricultural commodities prices have seen significant increases since the beginning of 2000s. For many commodities, international prices reached marks near or at records over the period. Simultaneously, biofuels production was expanded around world. The two most important producers, USA and Brazil had a remarkable increasing on their ethanol production over 2000-2010. USA corn ethanol production grew from 15 billion liters to 50 billion liters while Brazilian sugarcane production increased from 10 to 25.6 billion liters. Also, Brazilian biodiesel production expanded from 2 billion liters to 12 billion liters.

These two parallel events have stimulated food vs. fuel debate and induced questions about the extent to which biofuels have contribute to the increase in food prices, once biofuels reduce demand for oil and increase demand for agricultural products (Hochman et al. 2011; Chen and Khanna, 2013). The issue of biofuel-food correlation came to be examined carefully and a research on a possible increasing production and prices of biofuels cause prices increasing of related agricultural commodities as well has become more frequent (Vacha et al., 2013). For high-income countries, however, with crops comprising a small share of the final cost of food on consumer basket, the impacts of biofuels on food prices tend to be smaller than on low-income countries prices where expenditure on less processed food is higher (Hochman et al., 2011).

[1] The author wishes to thank the Brazilian Bioethanol Science and Technology Laboratory for supporting the beginning of this research.

Regarding this concern to the development countries, the objective of this paper is to assess the impacts of sugarcane ethanol prices in the major crops and food commodities prices in the Brazilian market. The empirical discussion will rely on the study of sugarcane expansion since the establishment of bi-flex fuel vehicle fleet in 2003 which led to an impulse in the sugarcane cropping, mostly destined to hydrated ethanol production. Brazil is the largest sugarcane producer in the world and the greatest sugar and ethanol exporter. In the past decades, domestic production was concentrated in the Southeast. Recent movements have expanded production to other areas in the Mid-West, traditional on extensive crops and cattle production which motivate the current analysis of prices relationship.

Results from this study can provide a more comprehensive analysis of commodities prices relationship with biofuels at one of the most important bioethanol market in the world. The study findings can contribute with the recent current literature over biofuels and food debate and give a better understanding of biofuels impacts in the Brazilian domestic food commodities prices.

BACKGROUND

The food crisis of 2008 has produced a large number of papers examining the causes for the food commodities price peaks. The growing importance of *biofuels vs. fuel* debate has motivated research interested in the most relevant markets. Several studies proposed the impacts assessment of US corn ethanol production over crops production and food commodities prices (Rajagopal et al., 2007; Sexton et al., 2008; Ajanovic, 2008; Hochman et al., 2012; Serra et al.; 2011; Zilberman et al.; 2012). However, the literature results are in general quite unclear and arguable, which is probably a consequence of the using of diverse methodological approach with different assumptions by authors, bringing to different results (Hochman et al., 2011; Zilberman et al., 2013; Vacha et al., 2013). Thereby, interest in the food crisis can be motivated by hypothetical impacts of food commodity prices on food security. The importance of emerging markets on ethanol production such as Brazil has motivated a research in order to understanding how much biofuels production can affect domestic crops-food production and prices.

The economic impacts of sugarcane expansion in Brazil has been more discussed in the literature concerned of land use change aspects in the crops production, pastures and forest (Nassar et al. 2011; Nuñez et al. 2013). However, few studies proposed a detailed examination of domestic food prices and ethanol production long-term relationship in Brazil. In the general literature, previous studies have dealt with price transmission and causality effects on food-biofuels system. Attempts to theoretically model food-biofuels price relations are relative new and generally focus on evaluating price level patterns. Price links have been using partial equilibrium models that differ in term of complexity and underlying assumptions Time series models may be useful to predict the sign, price behavior and relative magnitude of the impact. Also, some general statistical properties of time-series dynamics should be considered to provide accurate price forecast (Serra and Zilberman, 2013). A central property of time-series is that the dynamics of a system of variables may be characterized by the existence of a long-run relationship and a built-in tendency to adjust to this equilibrium (Chen et al. 2010; Serra and Zilberman, 2013).

The price level interaction among biofuels and commodities markets is predominantly focused on US biofuels market, using different data and periodicity. Most of these studies have tested the connection between biofuels and feedstock prices also using fossil fuel prices. The most common methodological approaches used in the literature focused on US market consist of cointegration analysis, Granger causality test as well as the estimation of a Vector Auto-Regressive Model with errors correction (VECM) (Serra and Zilberman, 2013).

A study focused in Brazilian biofuel market was applied by Balcombe and Rapsomanikis (2008). The authors investigated the long run connection among ethanol, sugar and oil prices. Their findings pointed out to the importance of oil prices on ethanol and sugar prices as well as the causality from sugar prices on domestic ethanol prices. The paper conclusions suggest that biofuels do not seem to have any significant impact on commodities prices in this market.

Using times-series framework on fuels and agricultural prices, this study proposes a methodological approach that comprises cointegration analysis and the estimation of a Structural VECM, consisting in a system of simultaneous equations that enable obtaining the dependency relationships between the variables. Furthermore, this method can provide the variance decomposition of forecast errors as well as estimate shocks through an impulse-response function from a structured contemporaneous relations matrix, as proposed by Sims (1986) and Bernanke (1986).

The impulse-response function provides the forecast of impulse elasticities for k further coming periods. The elasticities represent the price variables behavior under individuals' shocks in one variable based on their past and current errors allowing forecasting the path of simultaneous shocks under the system variables. The variance decomposition of predictable errors helps the understanding of the portion of each variable in the explanation of the others showing the evolution of their dynamic behavior and enabling to sort out the predictable errors that can be explained by the own variable as well by the others (Enders, 2005). Also, the

Structural VECM improves the autoregressive vector with errors correction estimation for the contemporaneous relationship of the variables system allowing the indication of properly number of matrix restrictions, regarding the economic theory and the restriction of maximum number of contemporaneous restrictions (Hamilton, 1994). The structural VECM consist on a structural VAR with errors correction. The SVAR is represented by the following equation:

$$B_{0xt} = B_{1\,xt-1} + B_{2\,xt-2} + \cdots + B_{p\,xt-p} + e_t \qquad (1)$$

Where $\boldsymbol{x_t}$ is the vector of each system variable; $\boldsymbol{B_j}$ are the matrices (*n x n*) for each *j* and $\boldsymbol{B_0}$ is the matrix of contemporaneous relationship; $\boldsymbol{e_t}$ is a vector *n x 1* of orthogonal shocks where the components are not serially correlated.

The errors corrections are considered in the SVAR if the cointegration analysis point out to the existence of long run relationship in the simultaneous variables system. The cointegration analysis adopted is based on the methodological approach proposed by Johansen (1998). The Johansen test is indicated on models with two or more variables. This test provides the ranking with the number of cointegration vector and can be expressed as the following equation:

$$\Delta y_t = \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \Pi y_{t-1} + \mu + \varphi d_t + \varepsilon_t \qquad (2)$$

Where $\boldsymbol{y_t}$ is a vector (*k x 1*) of variables I(1); and $\varepsilon_t \sim (0,\Sigma)$ and $E(\varepsilon_t\, \varepsilon_{s'}) = 0$ for each *t* different than s; ***d*** is a vector o binaries variables to capture the stationary variation.

The employments of Johansen test as well as the VECM are applied to combinations of ethanol prices and agricultural commodities prices as the feedstock that represents some of the most important agricultural market in Brazil. Also, others important variables that can affect domestic commodities prices are included as the international oil prices and the exchange rate.

The cointegration test must be preceded by a test of nonstationarity for each individual variable under consideration. For this study, the augmented Dickey-Fuller unit root test is considered. The test is generated from the following regression:

$$\Delta y_t = \alpha + \beta_t + \eta y_{t-1} + \sum_{i=1}^{p-1} \phi i \Delta y_{t-1} + e_t \qquad (3)$$

Where y_t is the variable assessed; α is a constant; β is the coefficient on a time trend; p is the lag order of the autoregressive process; and e_t is the stochastic term named white noise.

DATA

Data for the empirical analysis consist on monthly cash prices for sugarcane, ethanol, agricultural commodities, and oil as well as for exchange rate. All agricultural commodities prices, but sugarcane, were obtained from the Center for Advanced Studies on Applied Economics of the University of Sao Paulo (CEPEA) for the period from February 2004 through February 2014 (121 observations). Those cash prices refer to main producing areas in the nearby of sugarcane production. Sugarcane prices were collected from the Brazilian Sugarcane Industry Association and represent the payment method adopted by most sugarcane producers and millers in the State of Sao Paulo. Beyond sugarcane and ethanol prices (hydrated), the model includes sugar, soybeans, corn, wheat, rice and cassava (starch). Also, the model comprises the international oil prices (Europe Brent spot price) and exchange rate among Brazilian Real and US dollar. A dummy variable is used regarding the period over 2008-2009, to control the impacts of international crisis and the commodities prices increasing.

RESULTS

Before exploring the main findings from the time series models estimation, a chart analysis is presented to ilustrate the commodities and fuels prices behavior around the period from 2004-2014 (Appendix). Overall, agricultural commodities prices in Brazil have similar trade patterns during the study considered periods (Figure 6 - Appendix). Prices exhibit an abnormal increasing through 2008, which are result from the general increasing on international commodities prices. Sugar and cassava prices exhibit a higher volatility and a significant increase over 2009-10 and 2010-11. The ethanol prices show a peak in first quarter of 2011, but generally has less volatility than other prices (Figure 7 - Appendix). The Figure 8 (Appendix) shows the calculated volatility for each prices during the whole considered period.

For the price series stationarity analysis the augmented Dickey-Fuller unit root test was employed. This test was utilized to test the null hypothesis of the unit root in each price series for the considered period. The price series were transformed to a logarithm basis and tested for the existence of a unit root. The test statistics supported the presence of a unit root in the level data indicating nonstationarity in each of the price series[2]. After testing the same procedure with the inclusion of one difference on the price series, the results suggest the lack of a unit root with 99% confidence level of each series.

The Johansen trace test applied to combination of fuels, agricultural prices and exchange rate detected the presence of long-run relation among them[3]. The results pointed out the presence of two cointegration vectors at the 1% significance level (Table 1). To investigate the long-run

[2] The ADF unit root test results are available from the author request.
[3] Lag length determination test suggest the use of one lag in the estimation of Johansen test as well of VECM.

relationship among the variables as well as their particular short-run interactions, the VECM is estimated.

Table 1 – Results from Johansen cointegration test to the general model

H_0: (p-r)	H_A: (r)	Eig.Value	Trace	Trace*	Frac95	P-Value	P-Value*
10	0	0.558	316.772	302.258	239.121	0.000*	0.000*
9	1	0.407	219.672	210.729	197.220	0.002*	0.008*
8	2	0.337	157.409	151.793	159.319	0.064***	0.121
7	3	0.245	108.421	105.091	125.417	0.344	0.443
6	4	0.212	75.055	73.118	95.514	0.543	0.615
5	5	0.127	46.674	45.694	69.611	0.772	0.806
4	6	0.112	30.468	29.973	47.707	0.697	0.722
3	7	0.075	16.334	16.145	29.804	0.695	0.708
2	8	0.049	7.070	7.021	15.408	0.576	0.581
1	9	0.009	1.097	1.094	3.841	0.295	0.296

* Significant at 1% level; ** Significant at 5% level; *** Significant at 10% level.

A VECM specifies the short-run dynamics of each price series from a framework that is related to a long-run equilibrium relationship. The first results from the estimation of a structural VECM consist on a matrix of contemporaneous relationship that provides the outputs according the previous coherent economic structuration of each variables relations inside the VECM.

Basically, the structure of VECM was built simulating an influence of ethanol and sugarcane prices on all crops prices as well as sugar. Also, it is assumed that sugarcane, ethanol and sugar prices may affect each other. Another assumption is that oil prices is an important variable that can affect all agricultural prices once its impact on the agricultural inputs costs. The exchange rate is an important variable to be tested against some agricultural prices, especially those with large interaction in Brazilian international trade, as soybeans, corn, sugar and wheat. Finally, some specifical interactions may be considered as the connection among soybeans and corn prices. A dummy variable was considered as exogenous variable[4]. The results are expressed in table 2 (Appendix).

Overall, only a third of coefficients are statistically significant as those found by impacts simulation from ethanol shocks on sugar and soybeans prices, from oil on soybeans and wheat prices, from exchange rate on sugar, soybeans and wheat prices, and impacts from soybeans on corn price. Despite that, all estimated coefficients and their standard deviation have not exhibited large amplitudes which suggest a reasonable adjustment in the model. The coefficient signs are mostly satisfactory as expected. The most significant exception are the inverted sign given from the impact on ethanol over soybeans prices and from the impacts on exchange rate over sugar and corn and from sugar over ethanol and sugarcane. All the described exceptions exhibit negative signs suggesting that an increasing on ethanol and sugar prices, as a devaluation on exchange rate, will result in a decrasing of commodities prices.

Applying the variance decomposition of forecast errors for each variable, some interesting results were found. Overall, crops prices variance decomposition results exhibit similar degrees of influence from ethanol prices, oil prices and exchange rate (Table 3 through table 10 in Appendix). The participation of these variables on crops prices explanation are generally small and does not seems to be quite significant. Oil prices and exchange rate had shown none relevance over any agricultural market. Ethanol had exhibited a large connection only with its complementary or substitute goods as sugarcane and sugar.

Sugarcane prices are only important to explain sugar prices (Table 5), as expected, but they are not relevant for ethanol (Table 3) nor other crops (Table 6-10). The same inference was

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[4] The dummy was considered to correct the high agricultural commodities prices increasing over 2007-2008.

found with ethanol prices, basically significant to explain sugar prices (Table 5). However, sugar prices are similar significant to explain both ethanol and sugarcane prices (Table 3 and 4), suggesting that is also an important product for price discovering under this production chain. Soybeans prices had also shown a relative importance to explain corn prices, but has no influence over other markets (Table 6). Other interesting finding is the (small) influence of rice prices on cassava prices. Although with small share, rice prices are the most important variable to explain cassava prices (Table 10). The both cases (soybeans and rice) might suggest that some particular agricultural markets may be also relevant to explain a portion of crops prices, as biofuels, oil prices or some macroeconomic variables, as the exchange rate.

The impulse-response estimatives support the most of previous findings. There is no significant evidence of large commodities price increasing after positives shocks over the explanatory variables (ethanol, sugarcane, oil and exchange rate) although function simulations provided some close connections in the sugarcane production chain as well as small impacts over some crops. The main results are expressed in the Figures 1 through 5, and represent the cumulative shocks from increasing on ethanol, sugarcane and oil prices as in the exchange rate.

An ethanol shock exhibited significative impacts basically on sugar price (Figure 1). One percent increasing on ethanol price led to sucessive increasing on the own ethanol prices, cumulating 1.5%, beyond impacting sugarcane prices with 1.4%. This shock also indicated a small increasing on cassava prices (0.2%). On other crops, ethanol shocks produced null or slighty negative cumulative impacts. A similar scenario was observed from a shock on sugarcane price, that increased significantly mainly sugar price (1.3%), providing higher groing level than on the own sugarcane prices (cumulative effect of 0.9%) (Figure 2). Also, it suggested moderately effect over ethanol price (0.4%) and small increasing on corn prices (0.2%). Similar (or larger) trends on agricultural prices increasing are observed, for example, from a given shock on soybean prices (Figure 5), that increased corn (0.85%), ethanol (0.7%), sugar (0.5%) and cassava prices (0.3%).

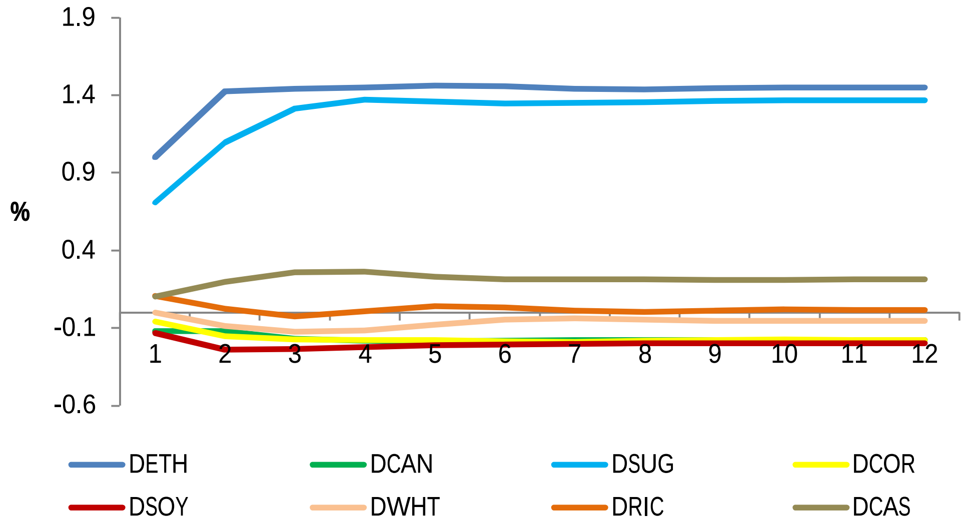

Figure 1 – Impulse-response function from a given shock on ethanol prices

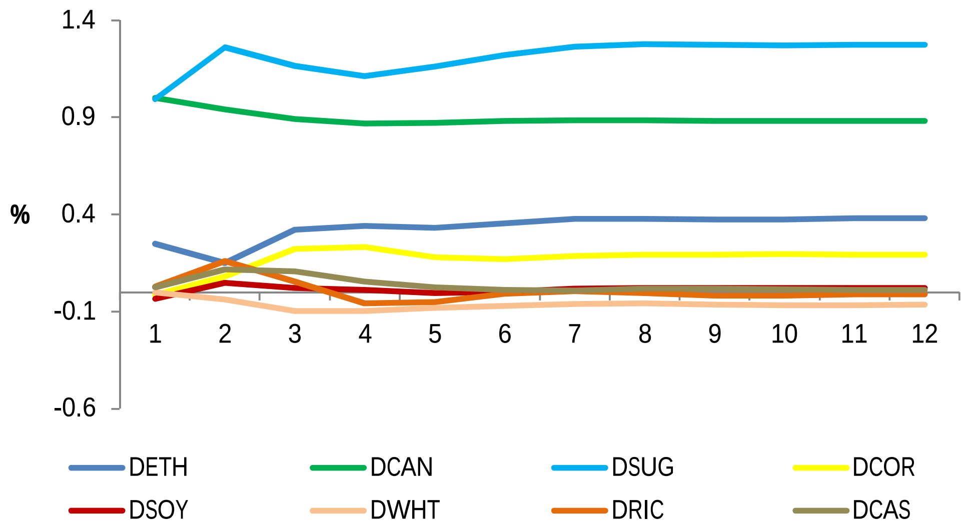

Figure 2 - Impulse-response function from a given shock on sugarcane prices

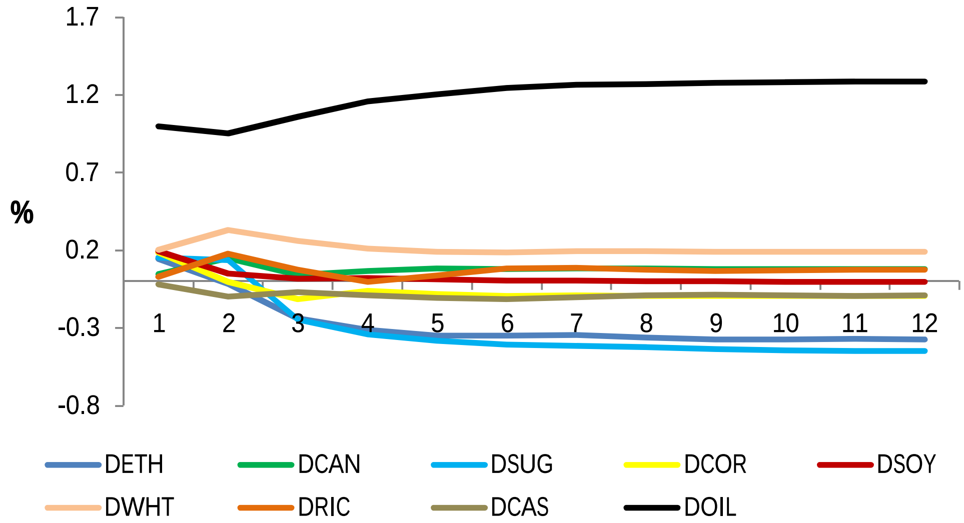

Figure 3 - Impulse-response function from a given shock on oil prices

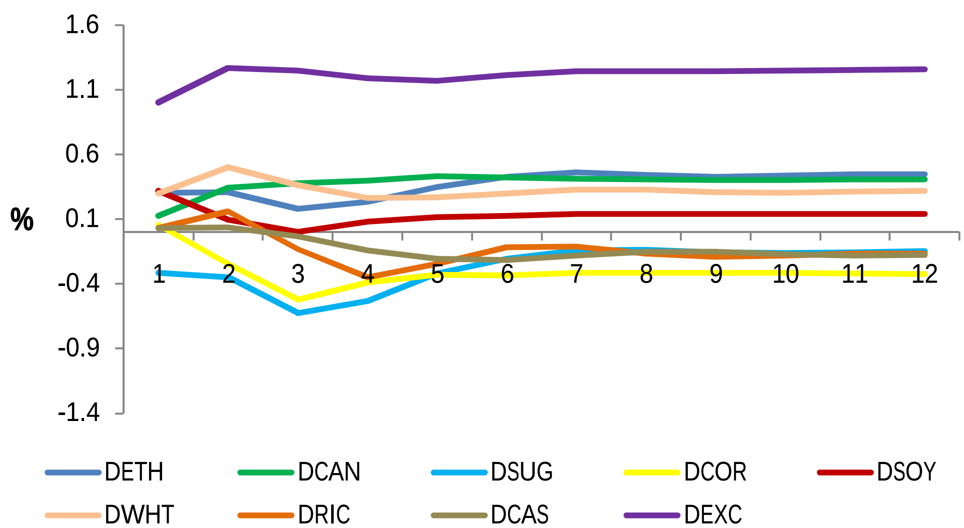

Figure 4 - Impulse-response function from a given shock on exchange rate

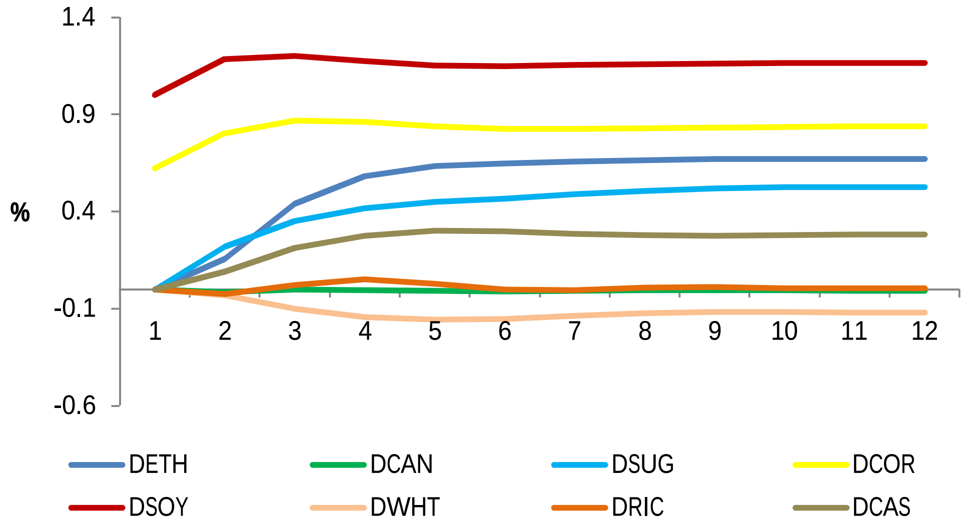

Figure 5 - Impulse-response function from a given shock on soybeans prices

The simulation of positive shock over oil prices had also showed weak effetcs on agricultural commodities prices, as observed previously from the shocks on ethanol and sugarcane prices. Wheat prices seems to be the only commodity that exhibited a small increasing, close to 0.2% (Figure 3). Soybeans (0.2%), rice (0.2%), sugar (0.15%) and ethanol (0.15%) exhibited small increasing in the first or second period after oil shock, but the effects are neutralized or become negative in the following periods. This may indicate that agricultural markets tend to react quickly by oil shocks (costs increasing) but are able to recover the market equilibrium still in the short run.

The exchange rate had resulted in some agricultural commodities prices increasing, although the impacts look quite narrow as those found from the previous shocks described above. A positive shock over this variable resulted on small and moderate price increasing of wheat (0.3%), soybeans (0.15%), sugarcane (0.4%) and ethanol (0.45%), which are mostly Brazilian agricultural markets largely connected in the international trade (Figure 4). In the short run, some impacts may be higher, as observed over soybeans prices (0.3%), rice (0.15%) and wheat (0.5%). Regarding the exchange rate an important consideration must be done. Along the study considered period, Brazilian exchange rate had presented relative stabilization, not exhibiting large deviations as in the past. So, the impulse-response findings suggest that moderate variations in the exchange rate may incurs on similar or larger impacts on Brazilian agricultural prices than fuels prices.

CONCLUSIONS

The purpose of this study was to investigate the impacts of sugarcane and ethanol production expansion in Brazil on domestic agricultural commodities markets. In particular, this research focused on price analysis and the long run relationship of fuels and agricultural prices. The study assessment proposed the use of cointegration analysis as well as the estimation of an autoregressive vector model with errors correction (VECM). A structural VECM was applied for the most reasonable connections among the considered variables, proposing the identification of the main causality effects from positive shocks on key independent variables as ethanol, sugarcane, oil prices and exchange rate.

General results show that, regarding the expansion of sugarcane and ethanol production in Brazil over the past years, the agricultural commodities prices do not seems to be largely affected by biofuels production in the domestic market. The model outputs suggest that there are no significant effects of sugarcane and ethanol prices on the major consumed crops prices. These findings emphasize one related issue that has been discussed in the price analysis literature regarding the following research topic. The paper conclusions converge to some recent findings of several papers that used time series models to capture prices long run relationship and causality to assess the impacts of biofuels production on food prices. In the Brazilian context the general results are linked to the main findings described by Balcombe and Rapsomanikis (2008) in a study focused on fuels and food interactions in the Brazilian market.

Although the long run relationship of the variables considered in the model, it cannot be assumed that ethanol or sugarcane are the most important variables that explain commodities prices. First, it is necessary to highlight that at least on cointegration vector over multiple commodities prices interacting at one restrict market is expected. Second, according the findings from VECM estimation it is possible to verify that oil prices and exchange rate have similar impacts on agricultural prices than sugarcane or ethanol prices which in turn can also explain the two cointegration vectors found from the Johansen test estimation.

The VECM results pointed out for similar effects on agricultural prices from both ethanol and sugarcane as from oil and exchange rate. Except some specific cases as the higher percentage of ethanol and sugarcane explaining each other and sugar, and vice versa, or from soybeans on corn, all the others findings had pointed out to similar status of variables independency. Therefore, the importance of Brazilian biofuels on the explanation of agricultural prices are equivalent than those resulted from oil prices or exchange rate.

Despite these findings suggest low influence of biofuels (ethanol) production on crops markets prices with similar significance than two important variables as oil and exchange rate, the research results are still not sufficient to assert that biofuels does not cause increasing on Brazilian commodities prices. One reason that can explain that is the government intervention in the gasoline production, prices and distribution in the Brazilian market in the past ten years. The

Brazilian federal government has been adopting a policy to control gasoline prices in order to maintain the economy policy goals regarding the inflation desirable targets. The gasoline prices have been kept stabilized and discouraging higher increasing on ethanol (biofuels) prices.

Considering this issue a model adjustment should be taken into account. The use of another binary variable should adjust the econometric model. Also, an alternative approach is expanding data periodicity or includes additional analysis to understanding the long run relationship of gasoline, biofuels and crops prices. So far, this study has produced preliminary results and some methodological assumption and data adjustment must be done. The next round of estimation will consider weekly data, which will increase the number of variables and enable a new understanding of prices lags behavior. Also, new dummies might be considered as the period with federal control over gasoline prices. Another consideration is the use of others agricultural prices of markets that can also be affect by sugarcane expansion in Brazil. New models must be tested including milk, cattle, poultry and orange juice prices.

Overall, paper findings can offer new insights on the food-biofuel debate in a development economy. Also, this study might provide new perceptions once it assess a market where sugarcane ethanol is important and do not compete directly to feed production as corn ethanol. The adoption of time series models can provide alternative methodological approach to the previous researches, with a comprehensive study including several commodities important to domestic food security. In particular, results can shed light on the discussion of biofuels social and economic sustainability and also on futures policies regarding biofuels production incentives.

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APPENDIX

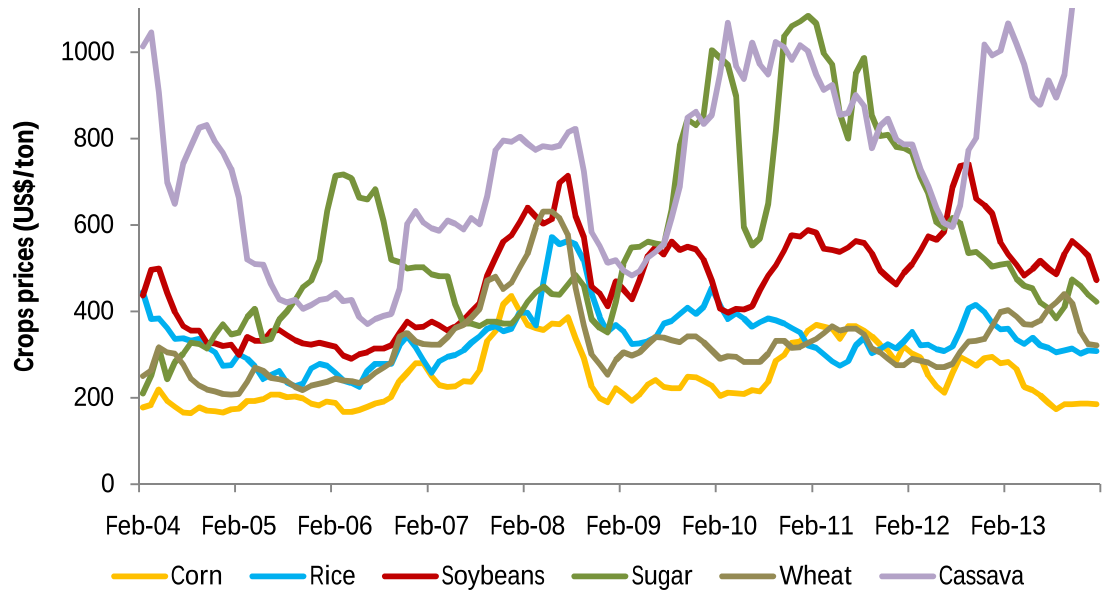

Figure 6 – Monthly cash prices of agricultural crops in Brazil, 2004-2014.

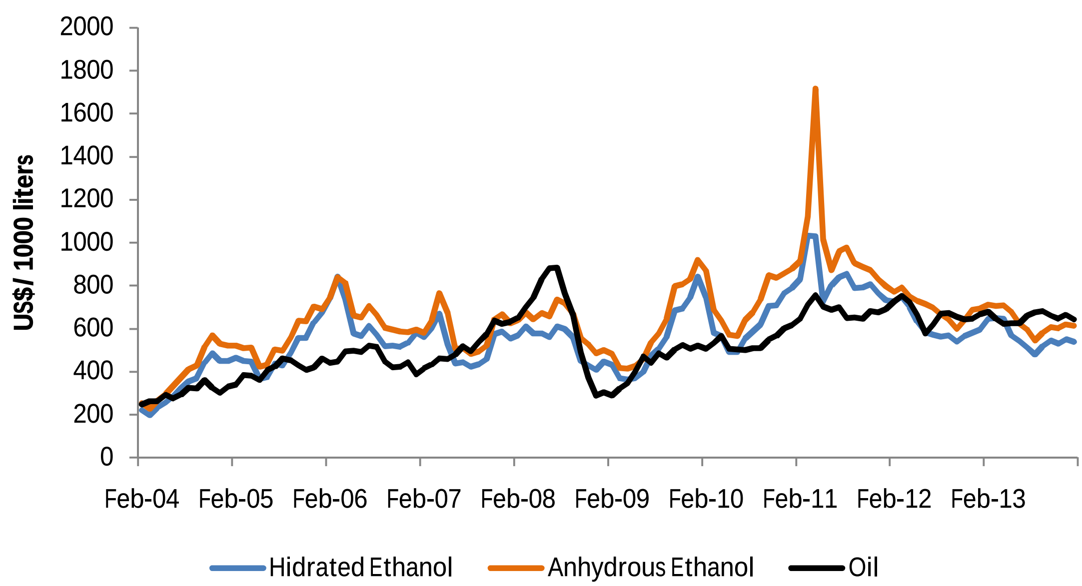

Figure 7 – Monthly cash prices of fuels in the Brazilian market, 2004-2014.

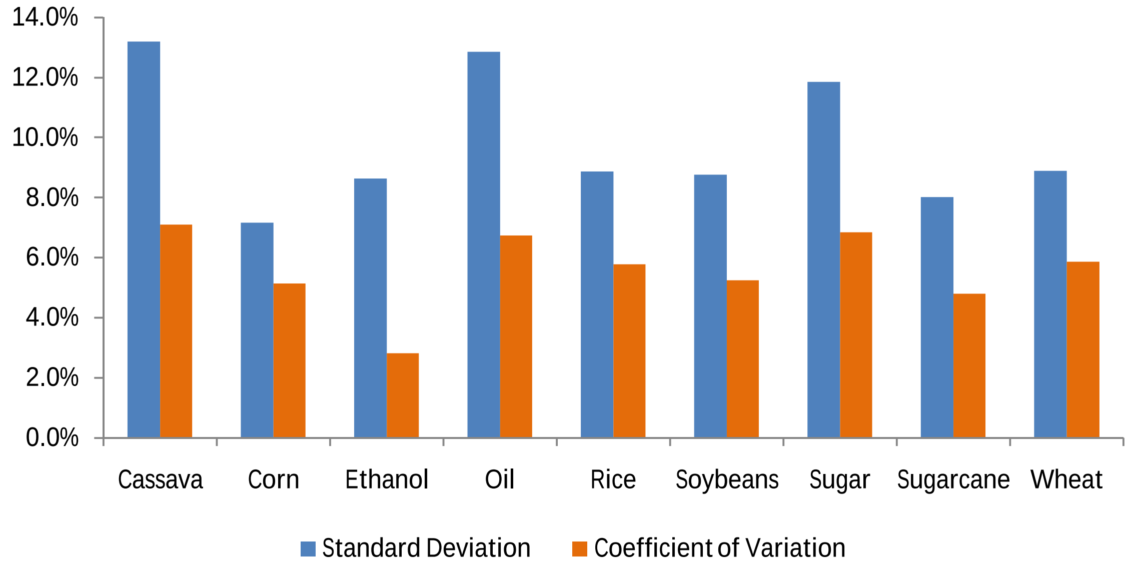

Figure 8 – Dispersion measures of commodities prices in Brazil, 2004-2014.

Table 2 – Estimated coefficients in the contemporaneous relationship matrix

Shocks From	On	Estimated Coefficients	Std Error	Signif. Level
Sugarcane	Ethanol	0.865	1.241	0.486
Sugarcane	Ethanol	-0.622	0.584	0.287
Oil	Ethanol	0.201	0.171	0.238
Ethanol	Sugarcane	0.095	0.285	0.738
Sugar	Sugarcane	-0.305	0.310	0.325
Oil	Sugarcane	0.081	0.087	0.352
Ethanol	Sugar	0.804	0.381	0.035**
Sugarcane	Sugar	0.793	0.693	0.252
Exc. Rate	Sugar	-0.656	0.238	0.006*
Ethanol	Corn	0.027	0.065	0.674
Soybeans	Corn	0.622	0.106	0.000*
Oil	Corn	0.063	0.087	0.467
Exc. Rate	Corn	-0.152	0.183	0.406
Ethanol	Soybeans	-0.134	0.055	0.016*
Oil	Soybeans	0.214	0.073	0.003*
Exc. Rate	Soybeans	0.360	0.159	0.023**
Ethanol	Wheat	0.000	0.050	0.999
Oil	Wheat	0.205	0.065	0.002*
Exc. Rate	Wheat	0.297	0.144	0.039**
Ethanol	Rice	0.108	0.064	0.093***
Oil	Rice	0.016	0.080	0.843
Ethanol	Cassava	0.104	0.070	0.139
Oil	Cassava	-0.034	0.088	0.698

* Significant at 1% level; ** Significant at 5% level; *** Significant at 10% level.

Table 3 – Variance decomposition of forecast errors for ethanol prices, 2004-2014

Month	Variance Decomposition for DETH (%)									
	DETH	DCAN	DSUG	DCOR	DSOY	DWHT	DRIC	DCAS	DOIL	DEXC
1	76,32	1,66	19,41	0,00	0,00	0,00	0,00	0,00	1,37	1,25
2	72,25	1,54	15,58	0,21	0,67	4,02	2,25	0,03	2,44	1,01
3	65,71	1,98	14,27	0,20	2,65	5,20	2,08	2,30	4,53	1,08
4	64,46	1,95	14,01	0,45	3,10	5,41	2,40	2,44	4,69	1,09
5	64,15	1,94	14,03	0,49	3,16	5,42	2,41	2,47	4,74	1,21
6	63,99	1,94	14,00	0,49	3,15	5,41	2,55	2,47	4,72	1,27

Table 4 – Variance decomposition of forecast errors for sugarcane prices, 2004-2014

Month	Variance Decomposition for DCAN (%)									
	DETH	DCAN	DSUG	DCOR	DSOY	DWHT	DRIC	DCAS	DOIL	DEXC
1	3,51	84,98	10,38	0,00	0,00	0,00	0,00	0,00	0,46	0,67
2	3,32	80,75	9,83	0,24	0,03	0,22	0,02	0,53	2,46	2,61
3	3,70	78,07	9,78	0,55	0,05	0,21	0,02	0,59	4,48	2,55
4	3,73	77,70	9,78	0,55	0,05	0,22	0,21	0,65	4,57	2,56
5	3,72	77,54	9,77	0,58	0,05	0,25	0,24	0,64	4,60	2,60
6	3,72	77,48	9,78	0,58	0,05	0,28	0,26	0,65	4,60	2,60

Table 5 – Variance decomposition of forecast errors for sugar prices, 2004-2014

Month	Variance Decomposition for DSUG (%)									
	DETH	DCAN	DSUG	DCOR	DSOY	DWHT	DRIC	DCAS	DOIL	DEXC
1	43,23	29,96	23,55	0,00	0,00	0,00	0,00	0,00	1,75	1,52
2	45,29	25,92	19,64	0,03	1,53	4,47	0,40	0,05	1,43	1,24
3	40,92	22,02	17,50	0,03	1,74	5,38	1,24	0,91	8,40	1,87
4	40,14	21,55	17,31	0,21	1,82	5,59	1,37	1,46	8,63	1,92
5	39,63	21,32	17,14	0,33	1,82	5,68	1,68	1,44	8,61	2,34
6	39,45	21,29	17,08	0,35	1,82	5,73	1,68	1,54	8,60	2,47

Table 6 – Variance decomposition of forecast errors for corn prices, 2004-2014

Month	Variance Decomposition for DCOR (%)									
	DETH	DCAN	DSUG	DCOR	DSOY	DWHT	DRIC	DCAS	DOIL	DEXC
1	0,39	0,01	0,10	73,94	21,83	0,00	0,00	0,00	3,67	0,07
2	1,35	0,34	0,29	65,72	20,45	1,63	2,00	0,00	6,45	1,78
3	1,30	1,03	0,27	61,85	19,34	1,80	3,27	1,03	7,06	3,06
4	1,29	1,02	0,41	61,06	19,08	2,32	3,24	1,04	7,21	3,34
5	1,28	1,10	0,63	60,63	18,96	2,39	3,21	1,22	7,20	3,38
6	1,28	1,11	0,63	60,62	18,95	2,39	3,21	1,23	7,21	3,38

Table 7 – Variance decomposition of forecast errors for soybeans prices, 2004-2014

Month	Variance Decomposition for DSOY (%)									
	DETH	DCAN	DSUG	DCOR	DSOY	DWHT	DRIC	DCAS	DOIL	DEXC
1	3,39	0,07	0,86	0,00	86,21	0,00	0,00	0,00	6,00	3,46
2	4,76	0,44	1,30	0,02	77,66	0,67	1,91	0,68	8,05	4,51
3	4,70	0,48	1,49	0,22	76,77	0,66	2,11	0,78	8,10	4,70
4	4,69	0,48	1,50	0,23	76,21	0,66	2,25	1,12	8,03	4,83
5	4,70	0,49	1,50	0,23	75,98	0,67	2,31	1,24	8,02	4,85
6	4,70	0,50	1,51	0,23	75,93	0,71	2,32	1,24	8,02	4,85

Table 8 – Variance decomposition of forecast errors for wheat prices, 2004-2014

Month	Variance Decomposition for DWHT (%)									
	DETH	DCAN	DSUG	DCOR	DSOY	DWHT	DRIC	DCAS	DOIL	DEXC
1	0,00	0,00	0,00	0,00	0,00	88,14	0,00	0,00	8,17	3,68
2	1,14	0,08	0,49	0,06	0,08	83,29	0,68	3,18	7,43	3,57
3	1,29	0,26	0,61	0,37	0,37	81,22	1,29	3,11	7,60	3,90
4	1,27	0,26	0,63	0,45	0,49	79,91	1,53	3,64	7,77	4,07
5	1,44	0,27	0,61	0,45	0,50	79,26	1,88	3,91	7,70	4,00
6	1,60	0,27	0,62	0,44	0,50	79,13	1,88	3,91	7,66	4,00

Table 9 – Variance decomposition of forecast errors for rice prices, 2004-2014

Month	Variance Decomposition for DRIC (%)									
	DETH	DCAN	DSUG	DCOR	DSOY	DWHT	DRIC	DCAS	DOIL	DEXC
1	1,83	0,04	0,46	0,00	0,00	0,00	97,51	0,00	0,13	0,03
2	2,58	0,89	0,41	0,46	0,04	0,00	92,46	0,09	2,66	0,42
3	2,63	1,31	0,45	0,94	0,15	0,06	88,55	0,14	3,52	2,26
4	2,59	1,73	0,44	1,18	0,19	0,06	86,49	0,22	3,95	3,14
5	2,70	1,72	0,51	1,19	0,21	0,07	85,79	0,38	4,10	3,34
6	2,66	1,77	0,54	1,20	0,26	0,09	85,24	0,37	4,24	3,64

Table 10 – Variance decomposition of forecast errors for cassava prices, 2004-2014

Month	Variance Decomposition for DCAS (%)									
	DETH	DCAN	DSUG	DCOR	DSOY	DWHT	DRIC	DCAS	DOIL	DEXC
1	1,43	0,03	0,36	0,00	0,00	0,00	0,00	98,12	0,04	0,02
2	2,16	0,35	0,31	0,65	0,42	0,00	1,01	94,49	0,59	0,02
3	2,48	0,33	0,88	0,61	1,12	0,00	4,13	89,71	0,62	0,12
4	2,44	0,43	1,09	0,60	1,30	0,04	4,93	88,19	0,65	0,34
5	2,54	0,46	1,10	0,65	1,32	0,09	5,05	87,73	0,66	0,41
6	2,55	0,46	1,10	0,68	1,31	0,14	5,28	87,41	0,67	0,41