The Determinants of the Brazilian Farm Prices

Humberto F. S. Spolador

E-mail:hfsspola@esalq.usp.br

Geraldo Sant´Ana de Camargo Barros

E-mail: gscbarro@esalq.usp.br

Mirian Rumenos Piedade Bacchi

E-mail: mrpbacch@esalq.usp.br

Professors of Economics at "Luiz de Queiroz" College of Agriculture - Department of Economics, Administration and Sociology – ESALQ/USP

Av. Pádua Dias, nº 11, P.O. BOX 132, ZIP: 13400-970. Piracicaba-SP-Brazil

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Abstract: The findings presented in this paper come from our study of the effects of Brazilian macroeconomic policy on the Brazilian Farm [product] Price Index using an adapted version of Frankel's (1986 & 2006) theoretical model. The study examined the connection between Brazilian farm prices and external variables (worldwide importation of agribusiness products, international commodity prices, and foreign real interest rates) and between Brazilian farm prices and domestic variables (GDP, the real exchange rate, and local interest rates).

Key Words: Brazilian farm prices, interest rate differentials, international commodity prices and exchange rate.

JEL: Q, E4, E5

1. Introduction

The agribusiness sector – including farm inputs, farm output, agro-industries and distribution - represents approximately 25% of the Brazilian GDP and 40% of all Brazilian exports. The sector's producers have succeeded in keeping domestic food prices relatively low while generating a significant amount of foreign currency. Three main factors have made this possible in the presence of an overvalued currency: gains in productivity, increased international trade, and increasing international commodity prices. Barros (2007) notes that in the period from 1989 through 2006, "*exported volume increased fourfold; at the same time international U.S. dollar prices remained practically the same….*" (p. 20).

Figure 1 shows the evolution of Brazilian agribusiness export volumes, the effective exchange rate, mean international US$ prices, and domestic currency FOB export prices. Most of the time, the exchange rate and dollar prices moved in opposite directions so that FOB Brazilian Real *(BR$)* prices oscillated within a 25% range below and above the average prices.

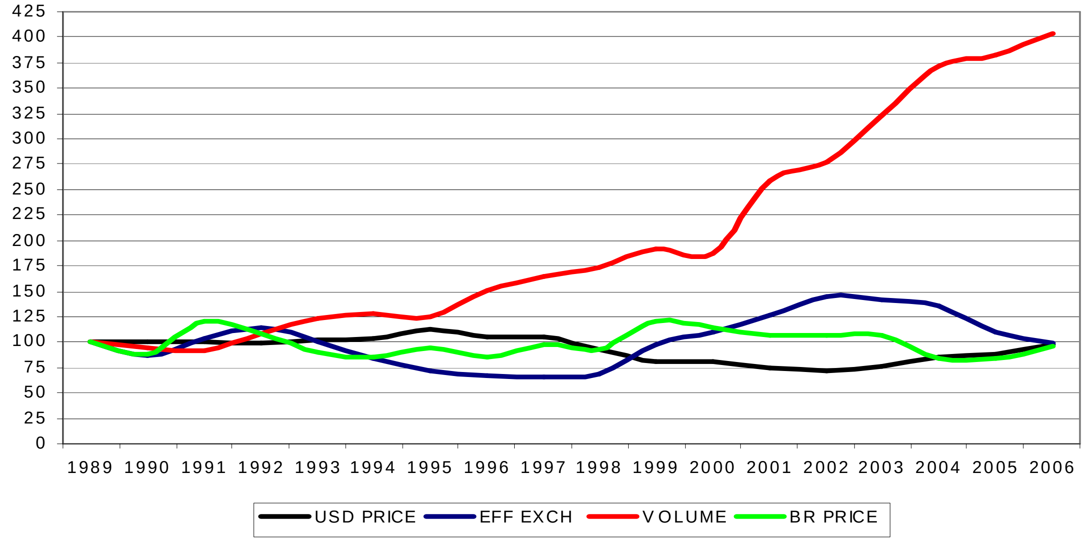

Figure 1. Agriculture and livestock exports volumes, effective exchange rates, and US$ and BR$ FOB prices – Index (1989 = 100); 1989 to mid 2006.
Source: Barros (2007)

The recent commodity price boom is connected with monetary policy, as Frankel (1986 & 2006) demonstrated for a group of countries. In Brazil, for instance, the real interest rate is inversely related with real domestic agribusiness export prices, as shown in the Figure 2.

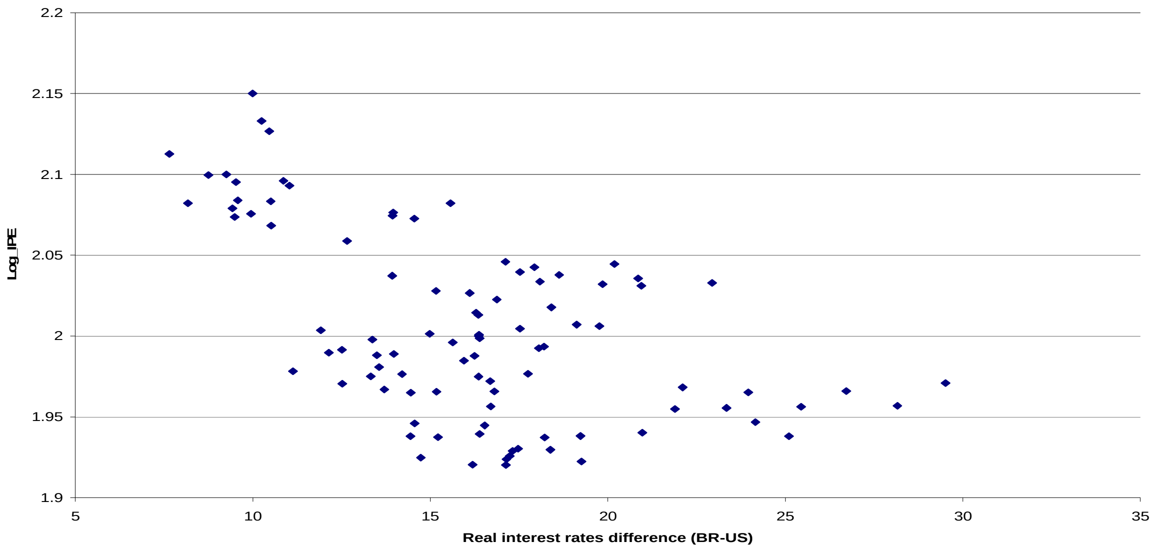

Figure 2. Brazilian Agribusiness Export Price Index (IPE) - logarithm - and the difference between the U.S. and Brazilian interest rates – Jan.2000 to Dec.2007.
Source: CEPEA/USP-ESALQ and IMF

There is not a clear negative relationship between mean farm prices and interest rate differentials, as indicated in Figure 3. The relationship is muddied by the inclusion of an export margin (related to logistic costs and trader profits) and the costs and profits of agents along the supply chain leading to the farm. In addition, agricultural output includes commodities not traded externally, the prices of which are only indirectly affected by the prices of tradable commodities, mainly, through supply side effects.

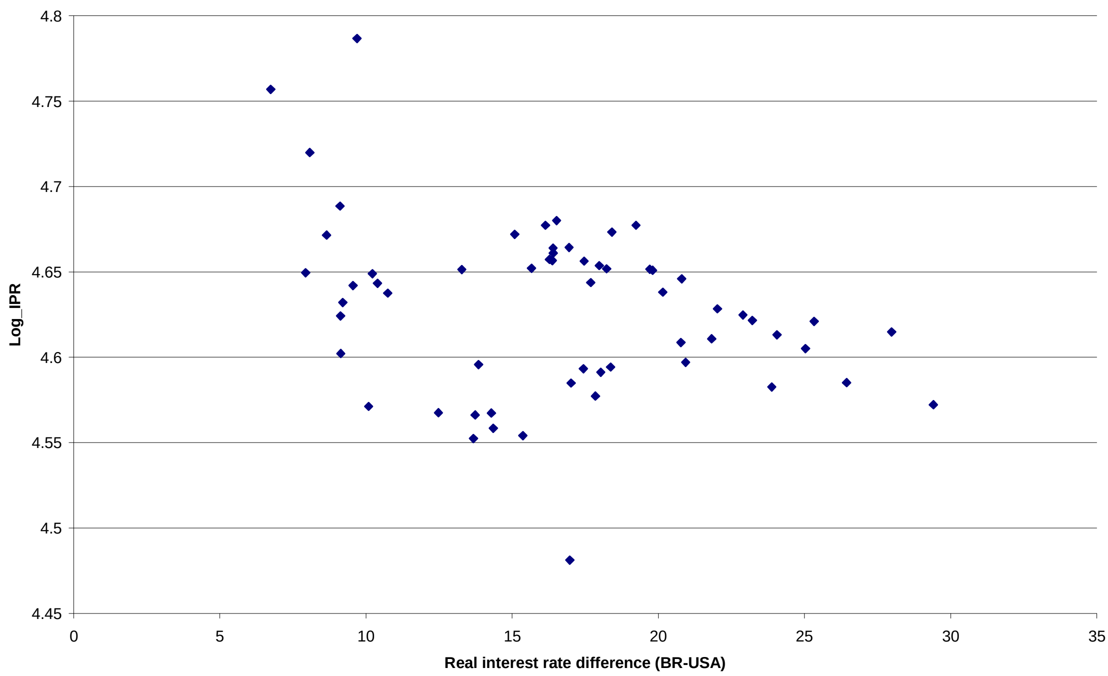

Figure 3. Brazilian real Farm Price Index (IPR) - logarithm - and the Brazilian-US Interest Rate Differential – Jan.2000 to Dec.2007.
Source: FGV and IMF

This paper presents the results from our study analyzing the effects of monetary policy and macroeconomics variables on the Brazilian Farm Price Index (IPR) using the theoretical model developed by Frankel (1986 & 2006). The initial premise is that the Brazilian farm product price is explained by domestic GDP and interest rates on the one hand and external variables on the other.

2. The Economic Model

We intend to adapt Frankel's economic model (1986 & 2006) to the Brazilian agribusiness sector and then to econometrically test the adapted model. Frankel's (1986) model considered commodity price levels to be a function of the expected price level, interest rates, and money supply growth. His basic hypothesis is that the economy produces two groups of goods: commodities (agricultural or mineral) and manufactures. The most important difference between these two types of goods is that commodity prices are perfectly flexible while manufactures prices are stuck over the short run.

The results from Frankel (1986) and Frankel (2006) suggest an inverse relationship between interest rates and the demand for storable commodities. High interest rates reduce commodity prices by reducing the demand for storable commodities or by increasing their supply. According to Frankel (2006), this movement occurs "by encouraging speculators to shift out of commodity contracts" and "by increasing the incentive for extraction today rather than tomorrow" (Frankel, 2006, p.5). Evidently, low interest rates have the opposite effect.

2.1 The Commodity Market

Following Frankel (2006), we assume that economic agents in the commodity market observe the evolution of real commodity prices relative to their prices over the long run, expecting that the actual price will converge with the long run equilibrium price over time, as follows[1]:

$$E[\Delta(s-p)] \equiv E[\Delta q] = -\theta \cdot (q-\bar{q}) \qquad (1)$$

Or,

$$E(\Delta s) = -\theta \cdot (q-\bar{q}) + E(\Delta p) \qquad (2)$$

Where,
s ≡ the commodity spot price;
$\bar{s}$ ≡ the commodity long run equilibrium nominal price;
p ≡ the economy price index;
q ≡ s-p, or the commodity real price;
$\bar{q}$ ≡ the commodity long run real equilibrium price;

Commodity prices negotiated in the global market are expressed in U.S. dollar units. A small country is just a *price taker* in the market. There is an opportunity cost associated with holding a commodity, with an arbitrage condition that can be expressed as follows:

$$E(\Delta s) + c = i \qquad (3)$$

Where,
i ≡ short-term nominal interest rate;
c ≡ the benefit-cost to maintain the stocks.

Combining (3) and (2):

$$(q-\bar{q}) = -\left(\frac{1}{\theta}\right) \cdot [i - E(\Delta p) - c] \qquad (4)$$

Equation (4) shows the inverse relationship between the real interest rate and the real commodity price. To better evaluate the effect of interest rates on commodity prices, the model includes an exchange rate factor, which is discussed in Section 2.4.

2.2 The Manufacture Market

Frankel (1986) assumes that the price level of manufactures can be adjusted in response to excess demand by a basic Phillips curve:

$$\dot{p}_m = \pi(d - \bar{y}_m) + \mu \qquad (5)$$

Where,
p_m = the log of manufactures price;
d = the log of demand for manufactures;
$\bar{y}_m$ = the log of potential output;
μ = the expected rate of money growth.

In the long run, by definition, the excess demand is zero. Frankel (1986) defined excess demand in terms of the ratio of the commodity price relative to the manufactures price and the interest rate:

$$d - \bar{y}_m = \delta \cdot (q - p_m) - \sigma \cdot (i - \mu - \bar{r}) \qquad (6)$$

$\bar{r}$ is a constant term, standing for long run interest rate.

Substituting (6) on (5):

$$\dot{p}_m = \pi \cdot [\delta \cdot (q - p_m) - \sigma \cdot (i - \mu - \bar{r})] + \mu \qquad (7)$$

2.3 The Money Market

Demand for money is defined by Frankel (1986) as

[1] All variables are on the log form.

$$m - p = \phi \cdot y - \lambda \cdot i \qquad (8)$$

m = the log of money supply;
p = the log of the overall price level;
y = log of the total output;
λ = the elasticity of money demand in respect to output
φ = the semi elasticity of money demand in respect to the interest rate.

The nominal interest rate over the long run ($\bar{i}$) converges to $\bar{r} + \mu$, with exogenous real factors determining the relative prices as

$$\bar{q} = \bar{p}_m = \bar{p} = \overline{m} - \phi \cdot \bar{y} + \lambda \cdot (\bar{r} + \mu) \qquad (9)$$

From equations (4) and (9), one is able to determine the complete commodity price equation:

$$q = \overline{m} - \phi \cdot \bar{y} + \lambda \cdot (\bar{r} + \mu) - \left(\frac{1}{\theta}\right) \cdot [i - E(\Delta p) - c] \qquad (10)$$

2.4 Inclusion of the Exchange Rate

As noted in Section 2.1, commodity prices are formed in the international market and are expressed in U.S. dollars; for this reason, our discussion of commodity pricing must consider the exchange rate between a local currency and the U.S. dollar. Frankel (2006) shows that the log spot price of the commodity in terms of currency *j* is

$$s_j = s_{j/\$} + s_{\$/c} \qquad (11)$$

Where,
$s_{j/\$}$ = the exchange rate (currency *j* per US$);
$s_{\$/c}$ = the spot price of commodity c in US$.

Based on Dornbusch's (1976) overshooting model, Frankel (2006) derived the following equation:

$$\left(s_{j/\$} - \bar{s}_{j/\$}\right) - \left(p_j - \bar{p}_j\right) + \left(p_\$ - \bar{p}_\$\right) = -\left(\frac{1}{v}\right) \cdot \left(i_j - i_\$ - \left[E\left(\Delta p_j\right) - E\left(\Delta p_\$\right)\right]\right) \qquad (12)$$

From equation (11) we have:

$$s_{j/\$} - \bar{s}_{j/\$} = \left(s_{j/c} - \bar{s}_{j/c}\right) - \left(s_{\$/c} - \bar{s}_{\$/c}\right) \qquad (13)$$

Substituting (13) on (12):

$$\left(s_{j/c} - \bar{s}_{j/c}\right) - \left(s_{\$/c} - \bar{s}_{\$/c}\right) - \left(p_j - \bar{p}_j\right) + \left(p_\$ - \bar{p}_\$\right) = -\left(\frac{1}{v}\right) \cdot \left(i_j - i_\$ - \left[E\left(\Delta p_j\right) - E\left(\Delta p_\$\right)\right]\right)$$

By the definition in Section 2.1

$$\left(s_{j/c} - \bar{s}_{j/c}\right) - \left(p_j - \bar{p}_j\right) = q_{j/c} - \bar{q}_{j/c}$$

and,

$$\left(s_{\$/c} - \bar{s}_{\$/c}\right) - \left(p_\$ - \bar{p}_\$\right) = q_{\$/c} - \bar{q}_{\$/c}$$

then,

$$\left(q_{j/c} - \bar{q}_{j/c}\right) - \left(q_{\$/c} - \bar{q}_{\$/c}\right) = -\left(\frac{1}{v}\right) \cdot \left(i_j - i_\$ - \left[E\left(\Delta p_j\right) - E\left(\Delta p_\$\right)\right]\right) \qquad (14)$$

From equation (4)

$$\left(q_{\$/c} - \bar{q}_{\$/c}\right) = -\left(\frac{1}{\theta}\right)\cdot\left[i_{\$} - E(\Delta p_{\$}) - c\right]$$

and substituting (4) in (14), one gets

$$\left(q_{j/c} - \bar{q}_{j/c}\right) = -\left(\frac{1}{v}\right)\cdot\left(i_j - i_{\$} - \left[E(\Delta p_j) - E(\Delta p_{\$})\right]\right) - \left(\frac{1}{\theta}\right)\cdot\left[i_{\$} - E(\Delta p_{\$}) - c\right]$$

$$\left(q_{j/c} - \bar{q}_{j/c}\right) = -\left(\frac{1}{v}\right)\cdot\left(r_j - r_{\$}\right) - \left(\frac{1}{\theta}\right)\cdot\left(r_{\$} - c\right) \qquad (15)$$

Where,
r_j = the US real interest rate;
$r_{\$}$ = the real interest in country *j*.

Equation (15) is the result of the Frankel (2006) model that adds the exchange rate through application of the Dornbusch overshooting model. By combining equations (9) and (15), we obtain the equation for Brazilian farm prices used in our study:

$$q_{j/c} = \bar{m} - \phi\cdot\bar{y} + \lambda\cdot\left(\bar{r} + \mu\right) - \left(\frac{1}{v}\right)\cdot\left(r_j - r_{\$}\right) - \left(\frac{1}{\theta}\right)\cdot\left(r_{\$} - c\right) \qquad (16)$$

Through equation (16), we observe that an increase in the money supply will cause the same relative increase in the commodity price. But, if the price of manufactures is stuck over the short run, the real interest rate will fall below its long term level. The real interest rate has an inverse proportional effect on the commodity price.

The next section presents an econometric model to estimate the effects of the variables expressed in equation (16) on the Brazilian Farm Price Index.

3. Methods

3.1 The Data

Chart 1 summarize all variables used in our econometric model, their sources, and the period considered.

Variable	***Generic Source***	**Period**
CRB Index - foodstuffs	Index (1970 = 100)	1970 to 2006
World Agribusiness Imports (US$ value)	Index (1970 = 100)	1970 to 2006
Real Interest Rate Difference (BR-US)	% aa	1970 to 2006
Brazilian Real Exchange Rate	Index (1970 = 100)	1970 to 2006
Brazilian GDP	Index (1970 = 100)	1970 to 2006
Brazilian Farm Price Index	Index (1970 = 100)	1970 to 2006

Chart 1. Summary of the variables used in the econometric model.

The Institute for Applied Economic Research (IPEA) and the Fundação Getúlio Vargas (FGV) published the interest rate, GDP, exchange rate, and farm price data used in our study. Information about agribusiness world imports comes from the Untied Nations Food & Agriculture Organization (FAO). The values for the CRB index, world agribusiness imports, real interest rate differentials (Brazil_USA), Brazilian real exchange rate, Brazilian real GDP, and Brazilian Farm Price Index are annual figures from 1970 through 2006. The annual value of the farm prices variable is the sum of crop prices received by Brazilian farmers weighed by the crop share of Brazilian agricultural output.[2] The interest rate differential is the difference between the Brazilian real interest rate (SELIC - % aa) and the comparable US Treasury Bill's real interest rate (% aa).

3.2 The Econometric Model

A Vector Auto Regression [3] (VAR) is estimated for a set of the following six variables using annual data from 1970 through 2006: the Brazilian Farm Price Index (IPR), the Brazilian_U.S. real interest rate differential, the BR$_U.S.$ real exchange rate, the Brazilian real GDP, the CRB index, and the U.S. dollar value of world agribusiness imports. Impulse responses and variance decompositions are obtained under the assumption that those six variables are endogenous in principle. Following Bernanke's procedure, our restrictions apply to the matrix of contemporaneous relations among endogenous variables (A_0 below). We employ RATS software and procedures suggested by Enders (2004).

We consider the following Vector Auto Regression System:

$$A_0 x_t = \alpha + \sum_{i=1}^{p} A_i x_{t-i} + \varepsilon_t \qquad (17)$$

Where A_0 , 6×6, is a matrix of contemporaneous relations among the *6* endogenous variables (x_t). ε_t is a (*6x1*) vector of white-noise uncorrelated disturbances. The variance-covariance matrix Σ_ε of these disturbances is diagonal. According to the economic model, we define

$$x_t = [m_t, \mu_t, r_t, \theta_t, y_t, p_t]'$$

and,

$$A_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ a_{41} & 0 & a_{43} & 1 & a_{45} & 0 \\ a_{51} & 0 & 0 & 0 & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix}$$

which indicates that world agribusiness imports (*m*), the CRB index (μ) and the real interest rate differential (r) are not contemporaneously related; but both world agribusiness imports and the real interest rate differential contemporaneously affect the real exchange rate (θ), and all variables affect the Brazilian Farm Price Index (*p*).

Brazil is a historically relevant, international commodities exporter that has seen its commodity export business increase significantly since 2003. In our econometric

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[2] The crops are: cotton, peanut, rice, potato, cocoa, coffee, edible beans, tobacco, castor beans, manioc, corn, soybean, tomato, wheat, grapes etc.

[3] See Sims (1980) and Sims (1986) for presentations of the recursive and structural (Bernanke's procedure) VAR methods.

model, we assume that world agribusiness imports (*m*) contemporaneously affect Brazilian real GDP (y).

From (17) we obtain the reduced form:

$$\mathbf{x_t} = \mathbf{A_0^{-1}\alpha} + \sum_{i=1}^{p} \mathbf{A_0^{-1} A_i x_{t-i}} + \mathbf{A_0^{-1} \varepsilon_t}$$

or

$$\mathbf{x_t} = \mathbf{B_0} + \sum_{i=1}^{p} \mathbf{B_t x_{t-1}} + \mathbf{e_t} \qquad (18)$$

and $\mathbf{\Sigma_e}$ is the variance –covariance matrix of the reduced form disturbances.

Under stability conditions (Enders, 2004, 381-386),

$$\mathbf{x_t} = \boldsymbol{\mu} + \sum_{i=0}^{\infty} \boldsymbol{\varphi}_i \boldsymbol{\varepsilon}_{t-i} \qquad (19)$$

can be obtained and taken as the impulse response function. The forecast error variance decomposition can be calculated from equation (19). For instance, the n-step-ahead forecast error is

$$\mathbf{x_{t+n}} - \mathbf{E_t x_{t+n}} = \sum_{i=0}^{n-1} \boldsymbol{\varphi}_i \boldsymbol{\varepsilon}_{t+n-i}$$

from which is possible to calculate the n-step-ahead forecast variances and the contribution of shocks in each variable on those variances.

Since we have an over identified system in (17) considering $\mathbf{A_0}$, we use a four-step estimation procedure known as the Generalized Method of Moments (Enders, 2004) to (a) estimate the unrestricted VAR in (18), (b) obtain the unrestricted variance-covariance matrix $\mathbf{\Sigma_e}$, construct $\sum_\varepsilon = \mathbf{A_0 \Sigma_\varepsilon A_0}'$, and (c) maximize the log likelihood function:

$$-\frac{T}{2}\ln\left|\mathbf{A_0}^{-1}\textstyle\sum_\varepsilon(\mathbf{A_0}')^{-1}\right| - \frac{1}{2}\sum_{t=1}^{T}\hat{\mathbf{e}}_t\,\mathbf{A_0}'\textstyle\sum_\varepsilon^{-1}\mathbf{A_0}\,\hat{\mathbf{e}}_t)$$

If the unit root and cointegration tests indicate that the series are integrated and cointegrated, an error-correction model, as that presented in equation (17), must be used:

$$\mathbf{A_0 \Delta x_t} = \boldsymbol{\alpha}^* + \sum_{i=1}^{p-1} \mathbf{A_i \Delta x_{t-i}} + \boldsymbol{\beta}\mathbf{z_{t-1}} + \boldsymbol{\varepsilon}_t^* \qquad (20)$$

Where: Δ is a difference operator, such that $\mathbf{\Delta x_t} = \mathbf{x_t} - \mathbf{x_{t-1}}$, and $\mathbf{z_{t-1}}$ is an error correction vector. We predefine the lag order of the auto-regression following the MAIC criteria for unit root tests (GLS- DF test)[4]. A Johansen's cointegration test was used.

4. Results and Discussion

[4] Conventional unit root test are known to lose power against stationary alternatives with a low order moving average process: a characterization that fits well to a number of macroeconomic time series. Along the lines of the ADF test, a more powerful variant is the DF-GLS test proposed by Elliott; Rothenberg; Stock (1996). This test is similar to an augmented Dickey-Fuller *"t"* test, but has the best overall performance in terms of small-sample size and power, dominating the ordinary Dickey-Fuller test. The DF-GLS test has substantially improved power when an unknown mean or trend is present. MAIC criterion (Ng and Perron 2001), which is much more appropriate than SC or AIC in the presence of negative moving average components was used.

The results of unit root tests and cointegration, the estimates for matrix A_0 and the forecast errors variance decomposition are shown in tables 1 thru 9 in the Appendix.

An error correction procedure was applied to the VARS model (Enders, 2004) because DF – GLS unit root tests indicated that all series are integrated of order one (Table 1) while Johansen's procedure for cointegration testing (Table 2) suggested five cointegrated vectors. The Akaike (AIC) and the Schwarz (SC) criteria had indicated that one lag should be used in the model (18).

Estimates of the elements of $A_{0,}$ Table 3, show that all coefficients except a_{45} and a_{63} present the correct sign, which agrees with the economic theory. The negative signal of a_{41} shows that world agribusiness imports induced the exchange rate overvaluation ("Dutch Disease") observed from September/October 2004 to 2010, despite the financial crisis in 2008/2009.[5]

All coefficients of matrix A_0 are derived from Frankel's model (1986 & 2006) adapted to the Brazilian case. The matrix A_0 demonstrated the effects of the international and domestic markets (a_{61} and $a_{62;}$ a_{65}) and the effects of macroeconomic variables, such as interest rates and real exchange rates (a_{63}; a_{64}) on farm prices. Although the signal of a63 is not the expected (negative), the cumulative shock of the interest rate differential on the farm price is negative, following Frankel's theoretical model (1986 & 2006).

Figure 4 presents the nature of the cumulative impact of a shock to each variable on the variable itself. All shocks have a permanent effect on the shocked variable. Shocks to world agribusiness product imports tend to be cumulative in such a way that a given initial increase would be almost 50% greater within 5 to 6 periods. Shocks to the CRB index, the exchange rate, and the interest rate differential have the same dynamic. The effect of farm price shock is also permanent but ends up loosing almost 40% of its initial impact after some oscillation. A GDP shock, on the other hand, while also permanent ends up at the same magnitude as the initial impact after some oscillation.

[5] In the last months 2008 and initial months of 2009, Brazilian exchange rate had undervaluated but on the second semester of 2009 the exchange was overvalued again.

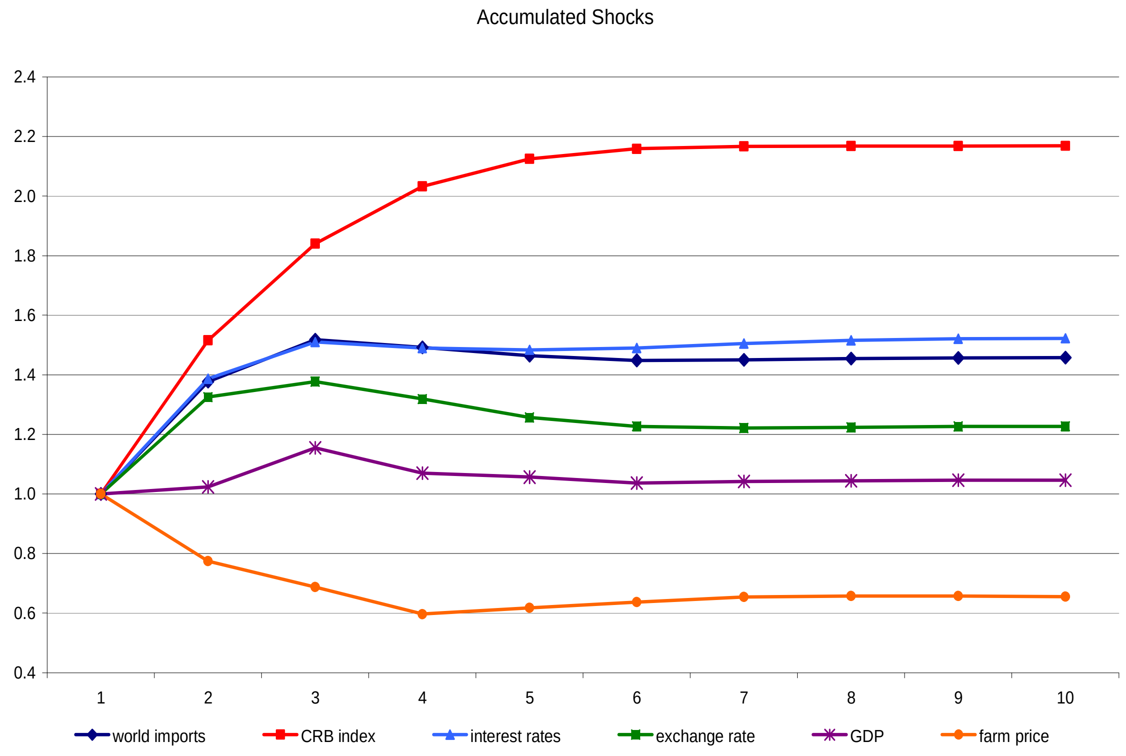

Figure 4. Evolution of World Agribusiness Imports, CRB Index, Interest Rate Difference, Real Exchange Rate, GDP, Farm Price Index - Cumulative Shock

Source: The Authors

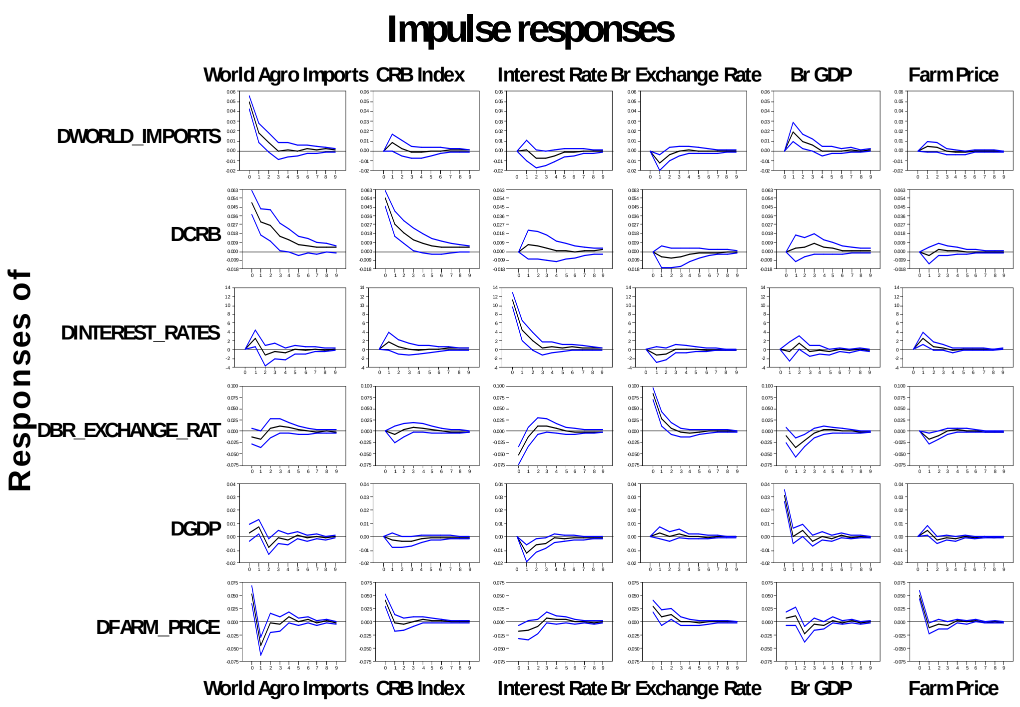

Figure 5. Impulse Response of the Model's Variables to Unexpected Shock

Source: The authors

We next report the variance of the one to ten step-ahead estimated forecast error variance decomposition. As shown in Table 4, the value of world agribusiness imports demonstrates exogenous behavior (approximately 77%), but the influence of Brazilian GDP is not insignificant (12%). About 50% of the CRB forecast error variance is due to shocks to world agribusiness imports (Table 5). In accordance with our model's assumptions, the interest rate differential between Brazilian and U.S. rates shows autoregressive behavior (Table 6). Brazilian GDP also shows autoregressive behavior (Table 8).

Evolution of the real exchange rate is found to be in accordance with Brazil's macroeconomic situation (Table 7). As Brazil is an important agribusiness product exporter, world agribusiness imports are an important determinant of the exchange rate forecast error variance decomposition (9.5%); but the most important determinant of this forecast error variance decomposition is the interest rate differential (26%), which is consistent with Brazil's economic opening and adoption of an inflation targeting system in the 1990s. GDP is found to be responsible for 13% of the real exchange rate forecast error variance decomposition.

Results for the farm price variance decomposition, Table 9, suggest the importance of the exchange rate (9%) and GDP (6.3 %) on the farm price forecast error variance. World agribusiness imports had the greatest influence on this variance (44.4%) following by the CRB index (14.7 %).

Figure 6 shows the cumulative impulse effect of the real interest rate differential on the Brazilian Farm Price Index (IPR). Results, expressed as elasticities, indicate that a 10% unexpected positive shock in the real interest rate will immediately depress farm prices by 0.04% and that after five months farm prices will remain 0.02% lower that at the time of the shock. This is a permanent very weak shock that stabilized after 6 months.

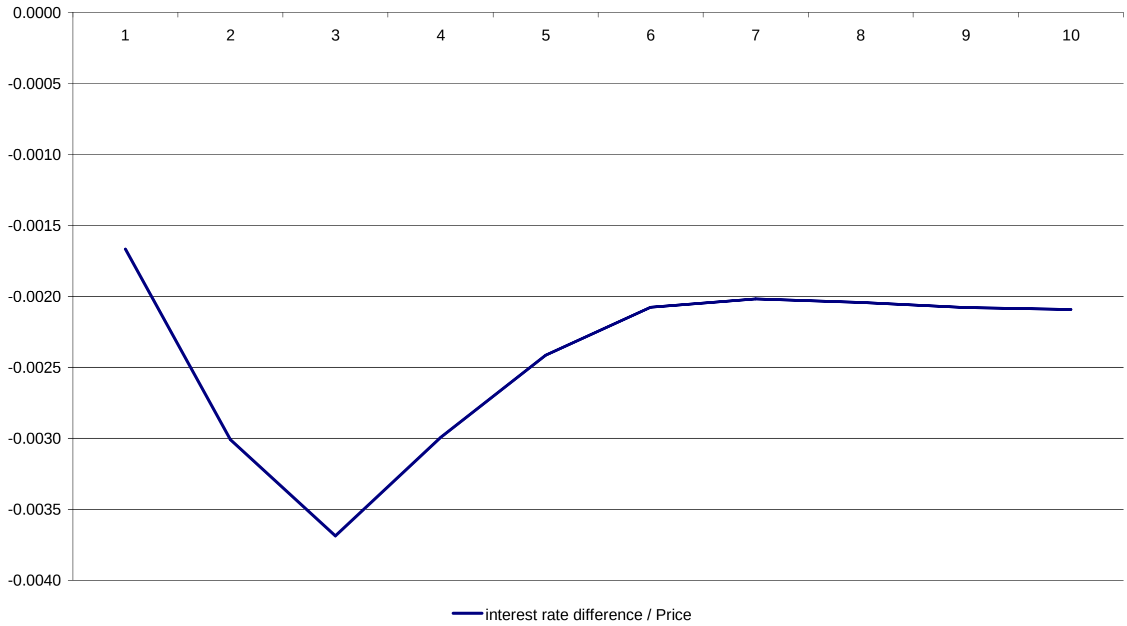

Figure 6. Cumulative impacts of real interest rate shocks on the farm price index
Source: The Authors

Figure 7 shows the cumulative impact of a shock to the real effective exchange rate on Brazilian farm prices. It was found that a permanent 1% unexpected positive real effective exchange rate shock will immediately raise the Brazilian Farm Price Index by 0.35% and by 0.6% after six months.

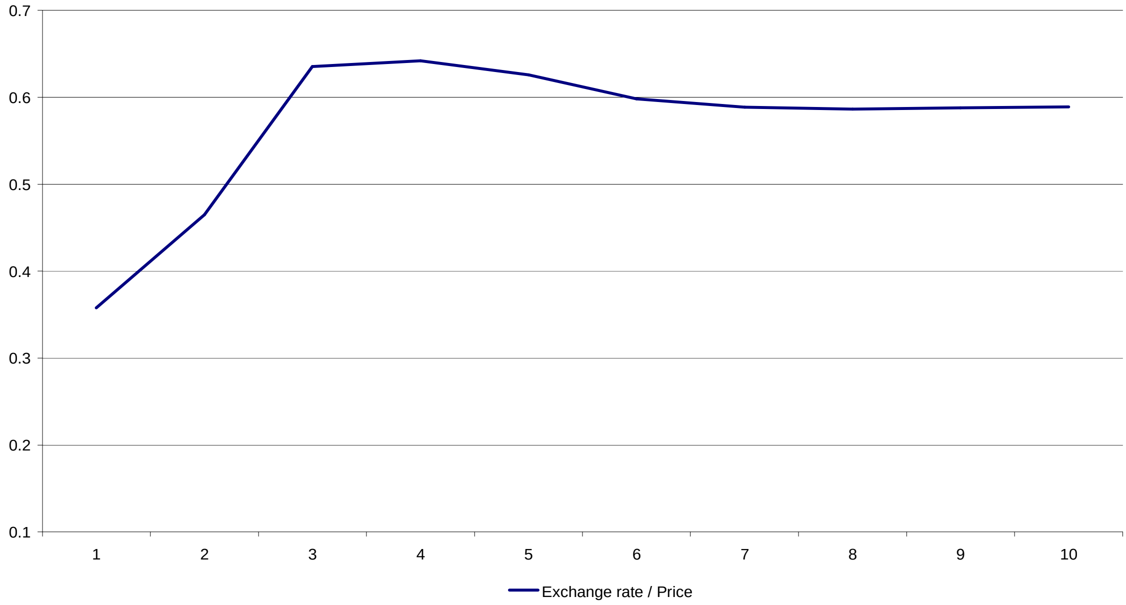

Figure 7. Cumulative impacts of real exchange rate shocks on farm price index
Source: The Authors

Figure 8 shows the cumulative impact of a shock to Brazilian GDP on farm prices. It was found that a 1% positive GDP shock will produce an immediate 0.5% farm price increase that will invert to a 0.4% price decline after 3 months.

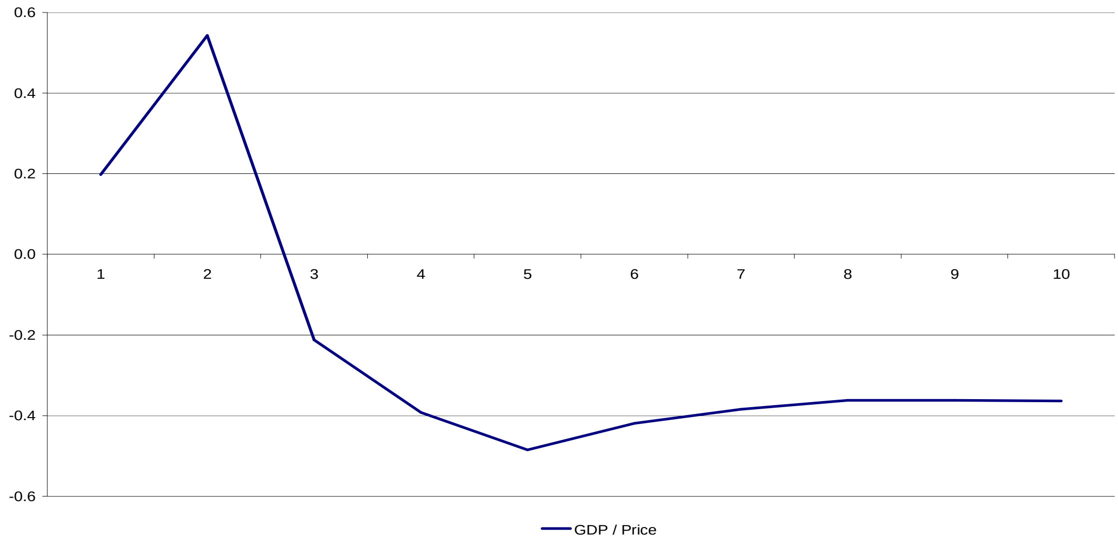

Figure 8. Cumulative impacts of GDP shocks on the Brazilian Farm Price Index
Source: The Authors

Figure 9 and Figure 10 present the cumulative impacts on Brazilian farm prices from shocks to world agribusiness imports and to the CRB index, respectively. The cumulative effect of 1% positive shock to world agribusiness importation is a 1.1% rise in Brazilian farm prices in the first month that falls to a 0.2% increase after 6 months. A 1% positive shock to the CRB index will increase Brazilian farm prices approximately 0.75% after six months.

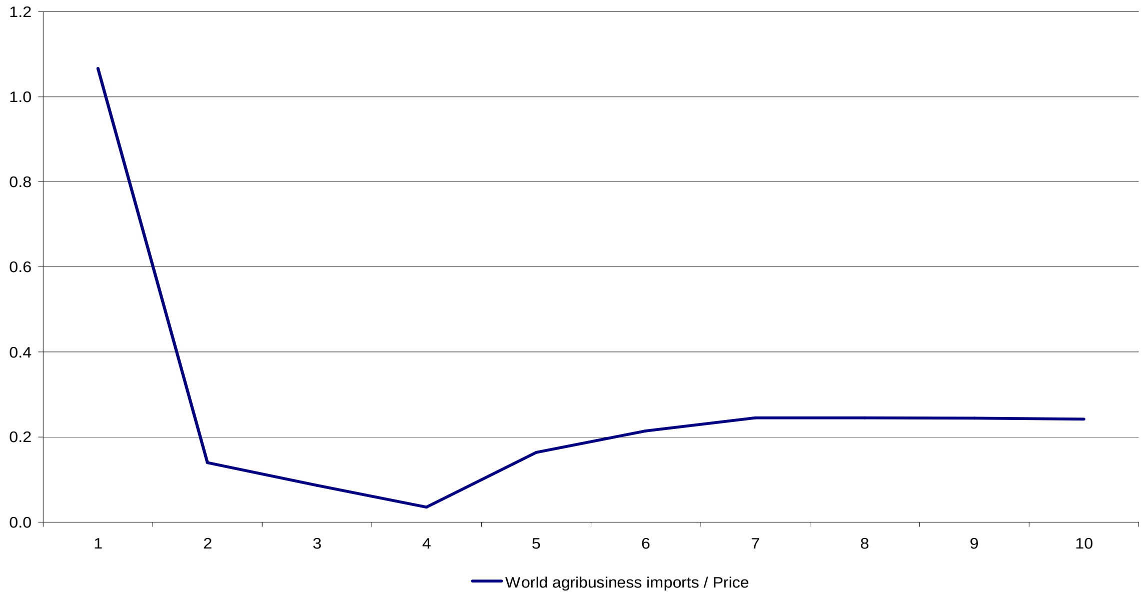

Figure 9. Cumulative impacts of world agribusiness imports shocks on the Brazilian Farm Price Index
Source: The Authors

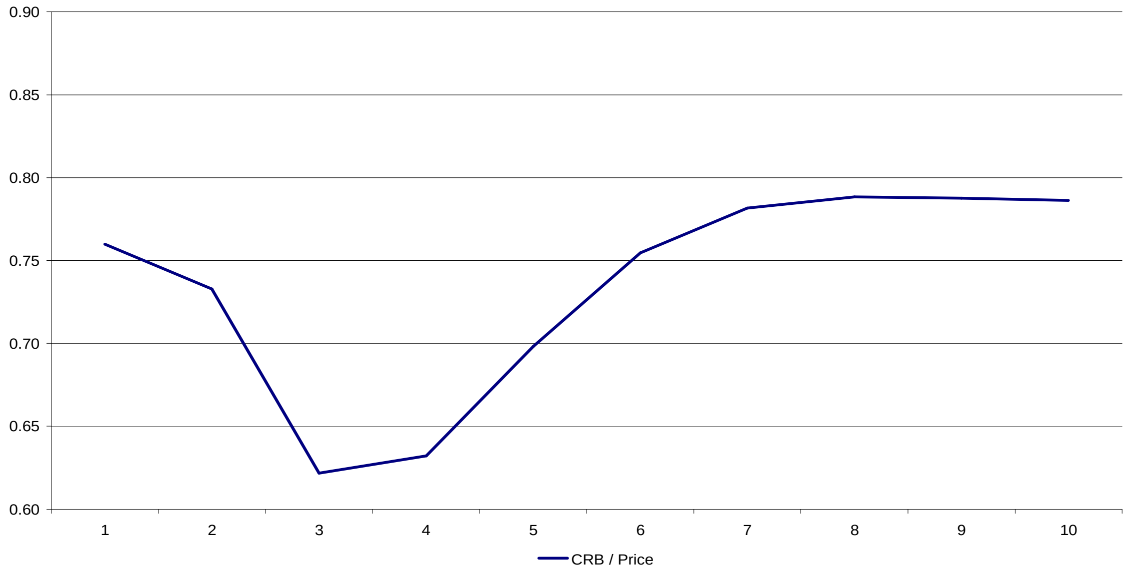

Figure 10. Cumulative impacts of CRB index on farm price index
Source: The Authors

Figure 11 shows the historical variance decomposition of the Brazilian Farm Price Index forecast error variance decomposition for the period from 1980 through 2006. Using historical variance decomposition, one is able to determine the importance of each exogenous shock to the deviation of a variable's value from that forecast at the beginning of a period. Our analysis of the data shown in Figure 12 led us to conclude that the deviation of the observed values from those forecast can be attributed to exogenous shocks to world agribusiness product importation.

The forecast overestimates farm prices between 1998 and 2001 and underestimates farm prices in two distinct periods: 1983 to 1989 and 2002 to 2005. When the forecast is determined using four of the model's variables (CRB index, exchange rate differential, interest rate, and GDP) it approximated the actual farm price values, reducing the magnitude of overestimation and underestimation; but if the forecast is determined using those four variables and the variable representing world agribusiness importation, the result is nearer to and more consistent with the actual value.

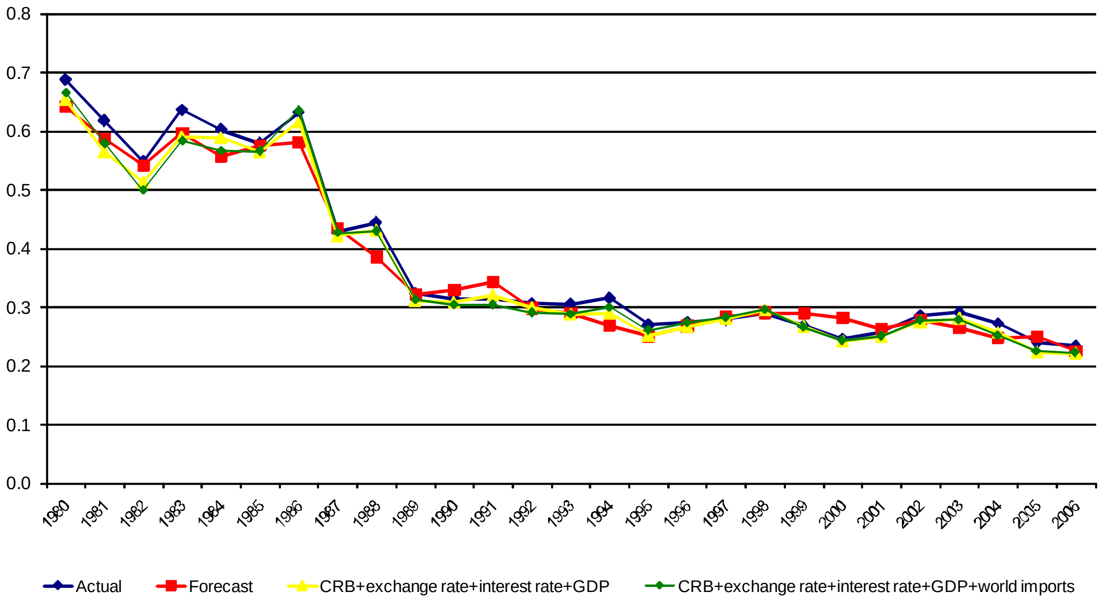

Figure 11. The historical variance decomposition for Brazilian Farm Price Index (IPR) forecast errors

Source: The Authors

5. Conclusion

This paper has resumed the study of commodity price behavior, presenting the results from the application of Frankel's theoretical model (1986 and 2006) adjusted to Brazilian agriculture. The empirical results show that the behavior of the Brazilian Farm Price Index is associated with two external variables (world imports and international commodities prices) and one domestic variable (the real exchange rate).

The study showed that the Brazilian currency's real exchange rate overvaluation has been more than compensated for by high international commodities prices, especially after 2003, and the increased exportation of Brazilian agribusiness products. It was found that an unexpected shock increasing world agribusiness imports 1% or increasing the value of the Brazilian currency relative to the US$ 1% would increase the Brazilian Farm Price Index 0.2% and 0.6, respectively.

Since the 1970s, substantial investment in R&D has resulted in greatly improved Brazilian crop yields and agricultural sector total factor productivity (TPF). These changes and an expansion in the amount of land under cultivation have substantially increased Brazilian agricultural production as international commodity prices rose. This confluence of events kept domestic food prices relatively stable, supported official programs designed to reduce poverty and income concentration, and improved the country's competitive position in the international market.

Our study demonstrated the importance of world agribusiness importation and the real exchange rate on the behavior of Brazilian farm product prices. To assure the country's competitiveness in foreign commodities markets and enhance its domestic producers' financial sustainability, it is imperative that Brazil maintain investments in agricultural science and technology while continuing to support international economic integration.

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APPENDIX

Table 1. Results of Unit Root Tests

Table 1. Results of Unit Root Test (DF – GLS)

Variables	Constant	Constant and trend
World agribusiness import	-1,054	-1,911
CRB index	-0,443	-2,089
Interest rate difference real	-1,660	-2,102
GDP	2,354	-2,050
Farm price	-0,230	-2,112
Exchange rate	-1,004	-1,694

Source: The Authors

Note: 1. Approximate critical value for the GLS detrended test are taken from Elliott-Rothenberg-Stock (1996) (-2.62 for .1 percentile, -2.91 for .05 percentile and -3.42 for .01 percentil). Approximate critical value for the GLS demeaned test is identical to those applicable to the no-constant, no-trend Dickey-Fuller test.

2. If the DF-GLS value is positive, the process is no stationary.

Table 2. Results of Cointegration Tests among World Agribusiness Imports, CRB Index, Interest Rate Difference, Real Exchange Rate, GDP and Farm Price

Hipótese nula	Hipótese alternativa	λ_{trace}	λ_{critic}
$r \leq 5$	r > 5	9.049	9.142
$r \leq 4$	r > 4	22.782	20.164
$r \leq 3$	r > 3	42.357	35.07
$r \leq 2$	r > 2	65.792	53.945
$r \leq 1$	r > 1	114.969	76.813
r = 0	r > 0	201.955	103.679

Source: The Authors

Table 3. Coefficient and Standard Error Estimates for Matrix A_0

Coefficient	Estimates	Standard Error
A_{21}	1.0150	0.1918
A_{41}	-0.2133	0.2794
A_{43}	-0.0047	0.0012
A_{45}	-0.2748	0.4597
A_{51}	0.0633	0.1063
A_{61}	0.3592	0.2263
A_{62}	0.7598	0.1494
A_{63}	0.000025	0.00087
A_{64}	0.3579	0.1061
A_{65}	0.2959	0.2628

Source: The Authors

Table 4. Decomposition of Variance of the World Agribusiness Imports Forecast Errors

Step	Std Error	World agribusiness. imports	CRB index	Diff. Interest Rate	Real exchange rate	GDP	Farm price
1	0.041	100.000	0.000	0.000	0.000	0.000	0.000
2	0.048	84.046	1.945	0.013	3.519	10.083	0.394
3	0.050	79.912	1.973	1.733	3.565	12.217	0.600
4	0.050	78.142	1.999	3.350	3.488	12.433	0.587
5	0.050	77.490	2.112	3.964	3.511	12.321	0.601
6	0.051	77.358	2.154	4.047	3.520	12.306	0.615
7	0.051	77.346	2.159	4.051	3.521	12.307	0.617
8	0.051	77.346	2.159	4.051	3.521	12.307	0.617
9	0.051	77.345	2.159	4.051	3.521	12.307	0.617
10	0.051	77.345	2.159	4.051	3.521	12.307	0.617

Source: The Authors

Table 5. Decomposition of Variance of the CRB Index Forecast Errors

Step	Std Error	World agribusiness. imports	CRB index	Diff. Interest Rate	Real exchange rate	GDP	Farm price
1	0.060	47.890	52.110	0.000	0.000	0.000	0.000
2	0.070	49.168	49.486	0.631	0.397	0.143	0.175
3	0.075	50.961	46.859	0.913	0.760	0.345	0.162
4	0.076	51.028	45.977	0.921	1.018	0.881	0.174
5	0.077	51.023	45.679	0.931	1.070	1.113	0.184
6	0.077	50.978	45.591	0.984	1.075	1.188	0.184
7	0.077	50.961	45.563	1.020	1.075	1.199	0.184
8	0.077	50.955	45.555	1.031	1.074	1.200	0.184
9	0.077	50.954	45.553	1.034	1.074	1.200	0.184
10	0.077	50.954	45.553	1.034	1.074	1.200	0.184

Source: The Authors

Table 6. Decomposition of Variance of the Real Interest Rate Difference Forecast Errors

Step	Std Error	World agribusiness. imports	CRB index	Diff. Interest Rate	Real exchange rate	GDP	Farm price
1	9.208	0.000	0.000	100.000	0.000	0.000	0.000
2	10.424	4.306	1.910	89.705	0.727	0.112	3.240
3	10.657	5.277	2.035	86.958	1.064	1.381	3.284
4	10.681	5.516	2.055	86.590	1.114	1.414	3.311
5	10.710	5.897	2.105	86.123	1.137	1.434	3.304
6	10.718	5.919	2.119	86.008	1.151	1.502	3.301
7	10.719	5.922	2.119	85.998	1.151	1.510	3.301
8	10.720	5.922	2.119	85.998	1.151	1.511	3.300
9	10.720	5.921	2.119	85.997	1.151	1.511	3.300
10	10.720	5.921	2.119	85.997	1.151	1.511	3.300

Source: The Authors

Table 7. Decomposition of Variance of the Brazilian Real Exchange Rate Forecast Errors

Step	Std Error	World agribusiness. imports	CRB index	Diff. Interest Rate	Real exchange rate	GDP	Farm price
1	0.078	1.474	0.000	30.898	66.854	0.774	0.000
2	0.089	3.868	0.348	25.260	57.386	11.260	1.878
3	0.091	3.911	0.463	25.572	54.319	13.572	2.164
4	0.094	5.179	1.184	26.464	52.054	13.048	2.072
5	0.095	5.708	1.641	26.474	51.201	12.897	2.080
6	0.095	5.796	1.750	26.390	51.034	12.938	2.093
7	0.095	5.797	1.758	26.384	51.014	12.952	2.093
8	0.095	5.797	1.758	26.390	51.010	12.952	2.093
9	0.095	5.797	1.758	26.391	51.009	12.952	2.093
10	0.095	5.797	1.758	26.391	51.009	12.952	2.093

Source: The Authors

Table 8. Decomposition of Variance of the Brazilian GDP Forecast Errors

Step	Std Error	World agribusiness. imports	CRB index	Diff. Interest Rate	Real exchange rate	GDP	Farm price
1	0.025	1.073	0.000	0.000	0.000	98.927	0.000
2	0.028	5.843	0.302	13.177	0.754	78.189	1.735
3	0.030	9.639	1.244	14.883	0.723	71.586	1.924
4	0.030	9.427	1.752	15.641	1.074	70.207	1.898
5	0.030	9.542	1.841	15.606	1.082	69.985	1.945
6	0.030	9.549	1.844	15.600	1.083	69.980	1.944
7	0.030	9.548	1.844	15.604	1.085	69.975	1.944
8	0.030	9.549	1.845	15.604	1.085	69.974	1.944
9	0.030	9.549	1.845	15.604	1.085	69.974	1.944
10	0.030	9.549	1.845	15.604	1.085	69.974	1.944

Source: The Authors

Table 9. Decomposition of Variance of the Brazilian Farm Prices Forecast Errors

Step	Std Error	World agribusiness. imports	CRB index	Diff. Interest Rate	Real exchange rate	GDP	Farm price
1	0.072	37.277	21.208	4.546	10.137	0.474	26.357
2	0.084	48.525	15.753	5.565	8.192	1.421	20.544
3	0.087	45.020	14.905	5.671	9.170	6.066	19.169
4	0.087	44.621	14.756	6.150	9.079	6.271	19.124
5	0.088	44.570	14.726	6.460	9.008	6.282	18.954
6	0.088	44.474	14.754	6.564	9.018	6.295	18.895
7	0.088	44.467	14.763	6.564	9.017	6.301	18.889
8	0.088	44.464	14.763	6.564	9.017	6.305	18.888
9	0.088	44.464	14.763	6.565	9.017	6.305	18.887
10	0.088	44.463	14.763	6.565	9.017	6.305	18.887

Source: The Authors