Supply and Demand Shocks and the Growth of the Brazilian Agriculture

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Contents: 1. Introduction; 2. The Economic Model; 3. Methods; 4. Results and Discussion; 5. Conclusion.
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In the last decades the Brazilian agriculture had a strong growth. Our hypothesis is that most of that growth may be attributed to two general factors, which may conveniently be related to two types of shocks acting upon agriculture: demand-related and technological supply-related shocks. Demand shocks are originated both from domestic economy and from external markets. We use Blanchard and Quah (1989) type of economic model to test the relative importance of supply and demand shocks on Brazilian agricultural growth. Our results indicate that supply and demand shocks have permanent effects upon agricultural output and prices. We estimate that the agricultural output growth in Brazil is attributed in large proportion to yield increases and that integration to international markets was important to assure the profitability of continuous use of new technology that led to yield improvements. This is why exchange rate plays is relevant in explaining the performance of the Brazilian agriculture. We anticipate that, if investments in science and technology are maintained and international integration expanded, Brazil will be able to substantially increase its supply of agricultural products both for domestic and foreign markets.

Nas últimas décadas a agricultura brasileira teve um forte crescimento. Nossa hipótese é que grande parte deste crescimento pode ser atribuído a dois fatores, que podem ser relacionados a dois tipos de choques: de demanda e de oferta. Nossos resultados indicam que tais choques têm efeitos permanentes sobre produção e preço. O crescimento do produto agrícola pode ser atribuído em grande

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proporção ao aumento da produtividade. A integração aos mercados internacionais é essencial para garantir a lucratividade do uso contínuo de novas tecnologias que levam a ganhos de produtividade. Esse é o motivo pelo qual a taxa de câmbio desempenha um papel relevante na explicação da performance da agricultura brasileira.

1. INTRODUCTION

The excellent international market performance of the Brazilian agriculture in the last decade has drawn worldwide attention. In this paper we intend to measure the driving forces behind this performance. We believe that Brazil is reaping the results of long term investments in agricultural technology and thus in productivity. These transformations began after the World-War II largely influenced by a public decision to stimulate production through a package of policy instruments including cheap and abundant rural credit, subsidized price support and storage programs. As a matter of fact, this package was an important part of the more general strategy of pursuing national economic growth through import substitution. These agricultural programs warranted a rapid growth based mostly on extensive use of land at constant productivity. Special public programs along with foreign investments created the necessary conditions for a rapid occupation of new lands in the center-west of Brazil. By the mid-1980, however, public resources were largely exhausted and – because of foreign debt default – so were the possibilities of attracting foreign capital. The agricultural sector growth strategy had to change from one based on central government incentives to other based on market-oriented mechanisms.

Fortunately the public research and extension system created on the early seventies were reasonably kept working in the eighties and nineties and permitted that new technologies could be produced particularly for poor acid soils in frontier lands. Since then agriculture growth tended to respond to national and international demand, being based mostly on yield increases than on land expansion. Efficiency became essential to stay in business in a highly integrated and competitive world market.

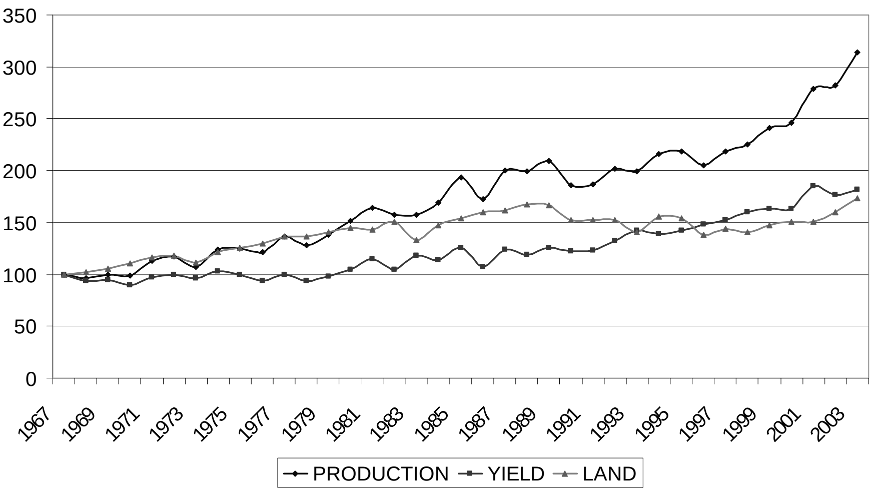
We hypothesize that integration to external markets was important to assure a continuous modernization of the agricultural sector since domestic GDP behaved rather poorly over the last decades. Productivity increases, however, would be self-deterrent if agriculture depended only on inelastic domestic demand because the inevitable severe price decreases would soon eliminate the profitability of modern techniques. Because external demand tends to be more elastic than domestic demand, productivity-induced price reductions could be mitigated if part of increased production was deviated to international markets.

This evolution is in accordance with information in Figure 1 which shows that from the sixties to the early eighties agricultural crops output growth is closely associated with land use growth. Afterwards cropland use stagnated and output growth strongly relates to yield increases. In the two last years there are indications that yield somewhat stabilized and land expansion began to be observed again.

Over the last ten years, Brazil's agriculture was able to amplify its degree of integration to international markets even though international dollar prices and the effective exchange rate were not both favoring such integration (Figure 2). From 1994 to 1999, exchange rates were excessively overvalued and international prices were relatively high; from 1999 (when Brazil devalued its currency – the real – and adopted a flexible regime) on, the exchange rates became more favorable (devalued) but international prices tended to be relatively low. The conversion of external to international real prices, however show that in the last 5 years exporting has been relatively attractive – compared to previous 5 years – to Brazilian farmers.

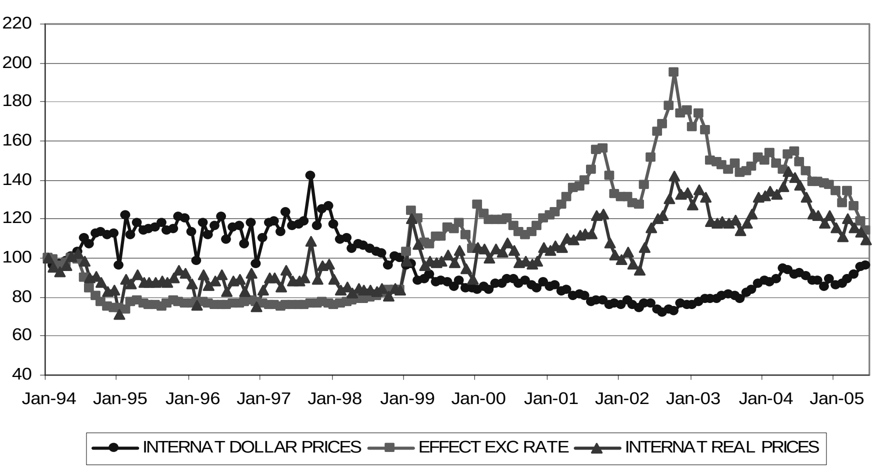
Figure 3 shows that *quantum* indexes of agricultural exports by Brazil have been growing expressively over the last 30 years, particularly for processed products. During the last 7 years, the growth rate of these exports became even higher. The overall performance may be attributed to productivity

Figure 1 – Agricultural land, yield and output – Brazil, 1967-2003



Source: IBGE

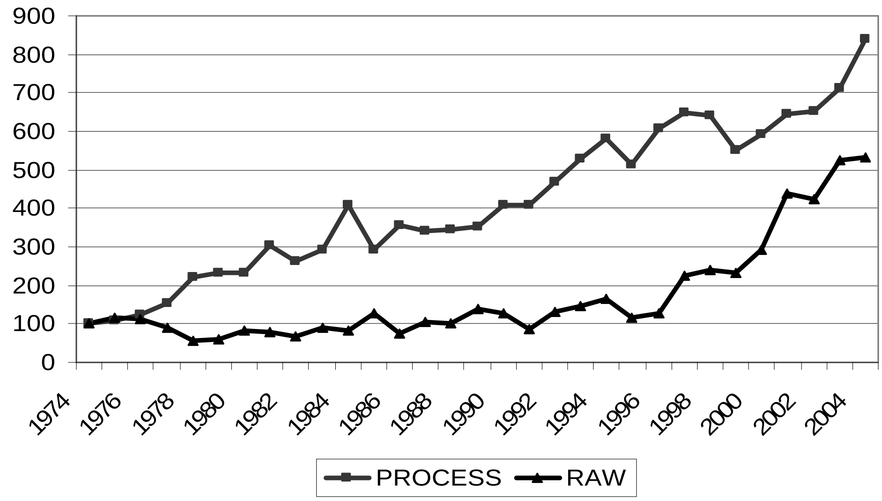
Figure 2 – Effective exchange rates, international dollar and real prices – 1994/2005



Source: FGV and CEPEA

growth and exchange rate adjustments. Anyhow, it is quite evident that an important integration of the Brazilian agriculture to international market occurred in the considered period.

Figure 3 – Exports of raw and processed agricultural products (quantum indexes) – 1974/2004



Source: IPEA

In what follows we present a model and empirical procedures to measure the effects and relevance of demand and supply shocks to explain the evolution of the output of agricultural crops in Brazil. We intend to check the pattern of these effects and whether these shocks have permanent or temporary impacts on output.

2. THE ECONOMIC MODEL

In a macroeconomic context, Blanchard and Quah (1989) presented an economic model to explain how demand and supply shocks affected US GDP growth and unemployment rate. Changes in these variables were derived as moving averages of random shocks associated to monetary (demand) and productivity (supply). Blanchard and Quah (1989) obtain the relations between shocks and changes in GDP growth and the level of unemployment by appropriately restricting the moving average coefficients. We do not adopt this identification approach. Rather we stick with the so-called Bernanke procedure for Structural Vector Auto Regression. (SVAR)

We intend to specifically explain the Brazilian agricultural output growth as a result of productivity or yield (supply) and demand shocks (related both to GDP and exchange rate shocks). Following Blanchard and Quah (1989) we simplify the analyses by assuming unitary elasticity everywhere.

The demand for agricultural products (in log) is given by:

$$y_t^d = m_t - p_t + \mu_t \tag{1}$$

where: y is the agricultural production; m is the real national income, and; p is the domestic relative price of agriculture and μ is the real exchange rate (domestic currency price of foreign currency).

This is a simplified version of the usual demand for agricultural product including income and domestic price. The exchange rate is included to capture the foreign market effect.

The agricultural output supply (in log) is expressed by:

$$y_t^s = n_t + \theta_t \tag{2}$$

where n is the harvested area; θ is the land productivity. Here we follow B&Q approach – that define output as the product of labor quantity times labor productivity – and use the identity that output is the product of land area times productivity or yield.

The relationship between harvested area and agricultural price is:

$$n_t = E_{t-1}(p_t) \tag{3}$$

The hypothesis is that farmers define planted land area based on expected prices for the harvest period. Below we admit that expected price equals the mathematical expectation of equilibrium price.

Finally, the model is affected by three independent shocks:

(a) Domestic demand shocks (e_1^d):

$$m_t = m_{t-1} + e_{1t}^d \tag{4}$$

(b) External demand shocks (e_2^d):

$$\mu_t = \mu_{t-1} + e_{2t}^d \tag{5}$$

(c) Productivity (supply) shocks (e^s):

$$\theta_t = \theta_{t-1} + e_t^s \tag{6}$$

The disturbances e_1^d, e_2^t and e_t^s have zero mean, are uncorrelated among each other and present no autocorrelation. These shocks are supposed to be of the random walk type. Nelson and Plosser (1982) indicated that most macroeconomic variable, such as output and productivity, tend to behave like a random walk, presenting stochastic trend. As for the real exchange rate, Whitt Jr. (1992) reviews the discussion about whether or not it behaves as a random walk, concluding for the presence of high autocorrelation, but not unit root. Thus we use the random walk hypothesis as reasonable approximation to the behavior of output, exchange rate and productivity. According to Dixon and Lim (2008), random walk shocks will lead to permanent effects.

2.1. The Growth Rates of Agricultural Output and Price

Using (1):

$$\Delta y_t = y_t - y_{t-1} = (m_t - m_{t-1}) - (p_t - p_{t-1}) + (\mu_t - \mu_{t-1})$$

And using (4) we obtain:

$$\Delta y_t = e_{1t}^d - (p_t - p_{t-1}) + e_{2t}^d$$

To find $(p_t - p_{t-1})$ we substitute (3) into (2):

$$y_t = E_{t-1}(p_t) + \theta_t$$

so that

$$E_{t-1}(y_t) = E_{t-1}(p_t) + \theta_{t-1} \tag{7}$$

Furthermore, from (1):

$$E_{t-1}(y_t) = E_{t-1}(m_t) - E_{t-1}(p_t) + E_{t-1}(\mu_t) \tag{1'}$$

Therefore, from (7) and (1’):

$$E_{t-1}(p_t) = \frac{1}{2}\left[E_{t-1}(m_t) + E_{t-1}(\mu_t) - \theta_{t-1}\right]$$

$$E_{t-1}(p_t) = \frac{1}{2}(m_{t-1} + \mu_{t-1} - \theta_{t-1})$$

Then (3) becomes:

$$n_t = \frac{1}{2}\left[m_{t-1} + \mu_{t-1} - \theta_{t-1}\right] \tag{3'}$$

Using (3’) in (2):

$$y_t = \frac{1}{2}\left[m_{t-1} + \mu_{t-1} - \theta_{t-1}\right] + \theta_t \tag{8}$$

and

$$y_{t-1} = \frac{1}{2}\left[m_{t-2} + \mu_{t-2} - \theta_{t-2}\right] + \theta_{t-1}$$

thus

$$\Delta y_t = \frac{1}{2}(e^d_{1t-1} + e^d_{2t-1} - e^s_{t-1}) + e^s_t \tag{8'}$$

Then, applying (8) into (1):

$$\Delta p_t = e^d_{1,t} + e^d_{2,t} - \frac{1}{2}\left[e^d_{1,t-1} + e^d_{2,t-1} - e^s_{t-1}\right] - e^s_t \tag{9}$$

and from (3’):

$$\Delta \eta_t = \frac{1}{2}(e^d_{1,t-1} + e^d_{2,t-1} - e^s_{t-1}) \tag{3''}$$

The theoretical results in (8’), (9) and (3”) indicate that positive demand shocks – either domestic or external – tend to (a) positively affect domestic prices; with a lag, this effect is partially reduced (because of output expansion) (b) with a lag, increase the land area (because of the effect on expected price); (c) with a lag, increase output (idem). Positive supply shocks tend to (a) reduce price (because of expanded output) and, with a lag, the effect is partially reduced (because land area is reduced after expected price falls); (b) with a lag tend to reduce land area (idem); (c) increase output and, with a lag, the effect is partially reduced (idem). Three important aspects of these effects are worth emphasizing: (a) positive demand effects on prices are partially reduced with a lag, due to supply response increasing land use and output, (b) positive (productivity increasing) supply effects are also partially offset with a lag. (c) supply and demand shocks have permanent effects, but long run effects are lower than contemporaneous ones.

For the specification of the SVAR below it is important to notice – considering jointly the equations (8’) and (9) – that an increase in y is associated with a decrease in p.

We work with the hypothesis that shocks to domestic demand and exchange rate play similar roles in explaining output growth. In addition, a negative domestic demand shock, for instance, can be offset by a rise in exchange rate. An increase in productivity will have a larger effect in output if domestic and/or foreign positive demand shocks totally or partially offset the decreasing price effect upon land use.

3. METHODS

3.1. Data and the Econometric Model

A VAR system (Vector Auto Regression)[1] in the Brazilian GDP, real exchange rate, the agricultural yield and output is estimated using annual observations from 1967 through 2003. The Instituto de Pesquisas Econômicas Aplicadas (IPEA) publishes the macroeconomic variables (exchange rates and the deflators (Brazil's IGP-DI and USA's PPI) and Fundação Getulio Vargas (FGV) is the source of farm output prices; individual crop outputs are estimated by Instituto Brasileiro de Geografia e Estatística (IBGE). The annual value of the output variable is a weighed average of individual crop outputs, the weigh for each crop being the average of yearly prices for the whole sample period.[2] This procedure intends to capture the growth in output avoiding the price-change effects related to supply and demand changes.

Impulse responses and the variance decompositions are obtained under the assumption that those five variables are endogenous in principle. Unlike Blanchard and Quah (1989), we identify our model through restrictions on matrix of contemporaneous relations (A_0 below) and do not impose restrictions on the coefficients of moving average representation of the impulse response. We apply the Bernanke's procedure using the RATS software and as suggested by (Enders, 2004, p. 270–272).

We consider the following Vector Auto Regression System

$$A_0 x_t = \alpha + \sum_{i=1}^{p} A_i x_{t-i} + \epsilon_t \tag{10}$$

where A_0 , 5 x 5, is a matrix of contemporaneous relations among the 5 endogenous variables (x_t). ϵ_t is a (5x1) vector of white-noise uncorrelated disturbances. The variance-covariance matrix Σ_ϵ of these disturbances is diagonal. According to the economic model, we define

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

and

$$A_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix}$$

Therefore we take m and μ (macroeconomic variables) and è (yield, technologically determined) to be contemporaneously exogenous. Following Equation 8' we include the two demand shocks plus the supply shock – but no price shocks – in the output equation. In addition, we follow Equation 9 and include demand and supply contemporaneous shocks plus output shocks (and indicated in Equation 8') as affecting price.

Following (Enders, 2004, p.281–283), and considering the relatively small sample size, the criteria of Akaike (AIC) and Schwartz (SC) were used to choose between a model with one or two lags. had indicated that one lag would have to be used in the model (13). Dickey-Fuller's unit root tests and Johansen's cointegration tests indicate that the series were integrated of order one and presented two cointegrated vectors. So an error-correction procedure was applied to the VAR model (Enders, 2004, p.381–386).

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

[2]The crops are: cotton, peanut, rice, potato, cocoa, coffee, edible beans, tobacco, castor beans, manioc, corn, soybean, tomato, wheat, grapes. Each element of the price vector was the simple average of the deflated prices of each crop over the sample period.

From (10) we obtain the reduced form:

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

or

$$\mathbf{x_t} = \mathbf{B_0} + \sum_{\mathbf{i=1}}^{\mathbf{p}} \mathbf{B_t x_{t-1}} + \mathbf{e_t} \tag{11}$$

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

Under stability conditions (Enders, 2004, p.272–279),

$$x_t = \mu + \sum_{i=0}^{\infty} \phi_i \epsilon_{t-i} \tag{12}$$

can be obtained and taken as the impulse response function. From (12) it is possible to calculate the forecast error variance decomposition. For instance, the n-step-ahead forecast error is:

$$\mathbf{x_{t+n}} - \mathbf{E_t x_{t+n}} = \sum_{\mathbf{i=0}}^{\mathbf{n-1}} \phi_\mathbf{i} \epsilon_\mathbf{t+n-i}$$

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

Since we have an over identified system in (10) considering $\mathbf{A_0}$, we use a four-step estimation procedure known as Generalized Method of Moments (Enders, 2004, p.299–300): (a) estimate the unrestricted VAR in (11), (b) obtain the unrestricted variance-covariance matrix $\mathbf{\Sigma_e}$ and construct $\sum_\epsilon = \mathbf{A_0 \Sigma_\epsilon A_0^{'}}$, (c) maximize the log likelihood function:

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

If the tests of unit root and cointegration indicate that the series are integrated and cointegrated, an error-correction model, as the presented in equation (13), must be used.

$$\mathbf{A_0 \Delta x_t} = \alpha^* + \sum_{\mathbf{i=1}}^{\mathbf{p-1}} \mathbf{A_i \Delta x_{t-i}} + \beta \mathbf{z_{t-1}} + \epsilon_\mathbf{t}^* \tag{13}$$

where $\mathbf{z_{t-1}}$ is an error correction vector.

In order to estimate the historical decomposition of the variables in the model, we follow, for instance, Flacker and McMillin (1998) and express (12) as:

$$\mathbf{x_{t+j}} = (\mu + \sum_{\mathbf{i=0}}^{\mathbf{j-1}} \phi_\mathbf{i} \epsilon_\mathbf{t+j-i}) + \sum_{\mathbf{i=j}}^{\infty} \phi_\mathbf{i} \epsilon_\mathbf{t+j-i}$$

where we express the value of the variable vector as the summation of (a) expectation of $\mathbf{x_{t+j}}$ given information available at time t – "base projection" – represented by the second term on right hand side and (b) the difference between the actual series and the projection based on period t information is given by the first hand side term. This gap between actual series and their base projections is the sum of the contributions of each structural innovation.

4. RESULTS AND DISCUSSION

Dickey-Fuller's unit root tests indicated that the series were integrated of order one, except GDP that is stationary around a trend (Table 1). Although the tests of unit root have indicated that variable GDP is stationary, it was used as being integrated of first order taking account that: (i) frequently the tests of unit root do not allow a clear distinction between a stationary process in the differences and a stationary process around a trend; (ii) the results of this test are not reliable for the small samples, (iii) the results of a adjusted VAR model with the original series GDP had shown no long run convergence for the impacts of shocks. The Johansen's procedure for the cointegration test showed that the null hypothesis that the variables are not cointegrated must be rejected (Table 2) and that the variables presented one cointegrated vector. Therefore an error-correction procedure was applied to the VAR model (Enders, 2004).

Table 1 – Results of unit root tests

Variáveis	Model 1*					Model 2**
	τ_τ	$\tau_{\beta\tau}$	τ_μ	$\tau_{\alpha\mu}$	τ	τ
GDP	-2,788	1,4	-3,559$^{\#\#}$	3,750$^{\#}$	1,636	-1,8
Yield	-1,123	1,578	1,523	-1,405	3,537	-2,990$^{\#}$
Output	-1,906	1,927	-0,034	0,092	3,924	-3,693$^{\#}$
Exc. Rate	-2,408	-0,265	-2,5	2,392	-0,668	-2,102$^{\#\#}$
Price	-2,242	-2,307	-0,6	0,353	-0,839	-3,999$^{\#}$

Table 2 – Results of cointegration tests between GDP, yield, output, exchange rate and price

Null Hypothesis	Alternative Hypothesis	λ_{trace}	$\lambda_{\max}$
$r = 0$	$r > 0$	92.80	44.44
$r \leq 1$	$r > 1$	48.36	25.54
$r \leq 2$	$r > 2$	22.82	14.98
$r \leq 3$	$r > 3$	7.84	4.97
$r \leq 4$	$r > 4$	2.88	2.88

Table 3 – Coefficient and standard error estimates for matrix A_0 (output as the 4$^{\text{th}}$ variable)

Coefficient	Estimates	Standard Error
A41	-0.643	0.143
A42	-0.267	0.051
A43	-0.794	0.087
A51	-0.717	0.658
A52	-0.416	0.244
A53	-0.169	0.586
A54	0.791	0.622

We now report the estimates of the elements of A_0 in Table 3. We notice that all coefficients – except one – have the right sign[3] The impact of θ (yield) on p, given by a_{53}, is the smallest of all elasticity coefficients (either in absolute terms or compared to its standard deviation) in A_0 and presents the wrong sign. We conclude that the contemporaneous impact of yield upon price is not important. Other coefficients are either relatively large and /or significant. Anyway, the Chi-Square test (10.923, 3 df.) indicates absence of over-identification at 1% of probability.

Table 4 – Decomposition of variance of the GDP forecast errors

Step	GDP	Exc. rate	Yield	Output	Price
1	100.0	0.0	0.0	0.0	0.0
2	93.8	0.2	0.0	0.2	5.8
3	93.7	0.3	0.2	0.2	5.6
4	93.6	0.3	0.2	0.2	5.7
5	93.5	0.3	0.3	0.2	5.7
6	93.5	0.3	0.3	0.2	5.7
7	93.5	0.3	0.3	0.2	5.7
8	93.5	0.3	0.3	0.2	5.7
9	93.5	0.3	0.3	0.2	5.7
10	93.5	0.3	0.3	0.2	5.7

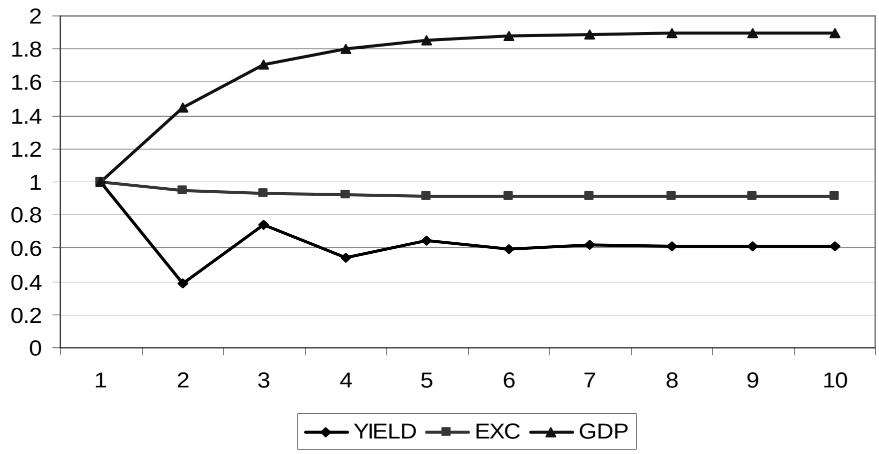
Table 5 – Decomposition of variance of the exchange rate forecast errors

Step	GDP	Exc. rate	Yield	Output	Price
1	0.0	100.0	0.0	0.0	0.0
2	18.0	80.3	1.7	0.0	0.0
3	19.8	77.0	2.2	0.0	1.0
4	20.4	76.0	2.6	0.1	1.0
5	20.4	75.8	2.7	0.1	1.0
6	20.5	75.7	2.8	0.1	1.0
7	20.5	75.7	2.8	0.1	1.0
8	20.5	75.7	2.8	0.1	1.0
9	20.5	75.6	2.8	0.1	1.0
10	20.5	75.6	2.8	0.1	1.0

Before we examine the impacts of supply and demand shocks, it is interesting to check the nature of these shocks themselves. In Figure 4 we see that all three shocks are permanent. GDP shocks tend to be cumulative in such way that a given initial increase would be almost doubled within 5 to 6 periods. Exchange rate shocks are rather persistent, experiencing a very mild change following an initial shock. Productivity shocks, on the other hand, is also permanent but ends up loosing almost 40% of initial impact, after some oscillatory pattern.

[3] It is important to remind that the coefficients in A_0 will present the opposite signs when the system is expressed in the reduced form (11). Alternative A_0 coefficients estimates – with land area substituted for output – are presented in Table 4.

Figure 4 – Evolutions of yield, exchange rate and GDP shocks



Source: The authors

Table 6 – Decomposition of variance of the yield forecast errors

Step	GDP	Exc. rate	Yield	Output	Price
1	0.0	0.0	100.0	0.0	0.0
2	0.0	0.1	99.5	0.0	0.3
3	0.2	0.3	99.0	0.1	0.5
4	0.2	0.3	98.8	0.1	0.6
5	0.2	0.4	98.7	0.1	0.6
6	0.3	0.4	98.6	0.1	0.6
7	0.3	0.4	98.6	0.1	0.6
8	0.3	0.4	98.6	0.1	0.6
9	0.3	0.4	98.6	0.1	0.6
10	0.3	0.4	98.6	0.1	0.6

Next we report the estimated variance of the one to ten step-ahead forecast errors and its decomposition in portions explained by each variable's shock (Lima, 1997). In Tables 4 and 6 we see that the GDP (m) and yield (è) behave as exogenous variables, in the sense that most (more than 90%) of their forecast error variances are explained by shocks in themselves. These facts are in accordance with our economic model's assumptions. Also, in Table 6 we see that a high proportion of the error variance of the exchange rate (i) is attributable to shocks in itself, although around 20% of the variance is due to shocks in the GDP.

Table 7 shows a small proportion (less than 20%) of the agricultural output (y) forecast variance being attributable to own shocks. Between 50% and 60% of the variance are due to shocks in the yield. In addition around 10% of the variance is related to GDP variations and around 16% to exchange rate variations. These results suggest that agricultural output is highly dependent on supply shocks; but demand shocks impacts are not negligible.

In Table 8 we see that the largest portion of the variance of the forecast errors of agricultural prices is due to own shocks while around 20% is attributable to shocks in the yield. Contrary to our assumption,

Table 7 – Decomposition of variance of the output forecast errors

Step	GDP	Exc. rate	Yield	Output	Price
1	13.2	17.4	51.9	17.4	0.0
2	11.3	16.8	54.4	15.6	1.9
3	10.9	16.3	56.1	14.9	1.8
4	10.7	16.1	56.7	14.7	1.8
5	10.7	16.1	56.8	14.6	1.8
6	10.7	16.1	56.9	14.6	1.8
7	10.7	16.1	56.9	14.6	1.8
8	10.7	16.0	56.9	14.6	1.8
9	10.7	16.0	56.9	14.6	1.8
10	10.7	16.0	56.9	14.6	1.8

price variance is predominantly affected by shocks in itself. One hypothesis to be considered in the future will be related to a possible role of international price – not included in this analysis - as the dominant factor affecting domestic price. So it would be possible that domestic price is really exogenous with respect to the set of variables – except for yields – considered in our analysis.

Table 8 – Decomposition of variance of the agricultural price forecast errors

Step	GDP	Exc. rate	Yield	Output	Price
1	0.5	4.0	6.8	4.3	84.3
2	2.6	3.3	14.0	3.6	76.6
3	2.5	3.2	18.0	3.4	72.9
4	2.6	3.1	19.9	3.3	71.1
5	2.5	3.1	20.7	3.3	70.4
6	2.5	3.1	21.0	3.3	70.2
7	2.5	3.1	21.1	3.3	70.1
8	2.5	3.1	21.1	3.3	70.0
9	2.5	3.1	21.1	3.3	70.0
10	2.5	3.1	21.1	3.3	70.0

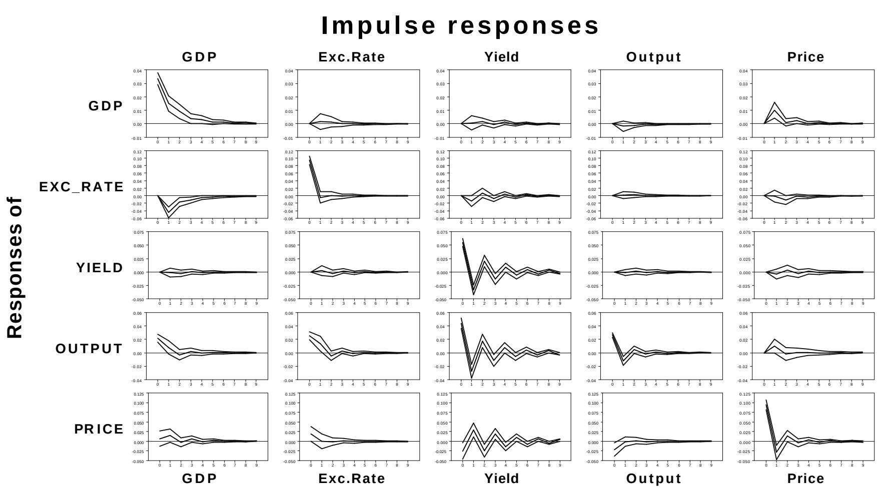
In Table 9 the historical decomposition of the output forecast errors is presented using a sub-sample from 1967 to 1990. It is to be noticed that from 1991 to 2003 most of the times the GDP contributed to lower the forecasts errors, while the Yield variable favored higher errors, that is, to observed outputs higher than expected. The Yield variable had especially high positive effect after the Real Plan. On the other hand, the Exchange Rate and Output Prices had only minor effects upon the forecast error.

Impulse effects of unexpected shocks in any individual variable upon all variables in the model are presented in Figure 5; 5% confidence intervals are also represented. For ease of presentation we refer to cumulative impacts in the next figures. Figure 6 shows the cumulative impulse effects of demand (GDP) shocks on agricultural output and price. Results are expressed as elasticities, indicating that a 10% unexpected positive shock in GDP will immediately raise agricultural output and price by 6.5% and 2%, respectively. Long run effect will be an 8% and a 7% rise, respectively.

Table 9 – Historical variance decomposition of the output forecast errors (percentage values) – 1981 to 2003

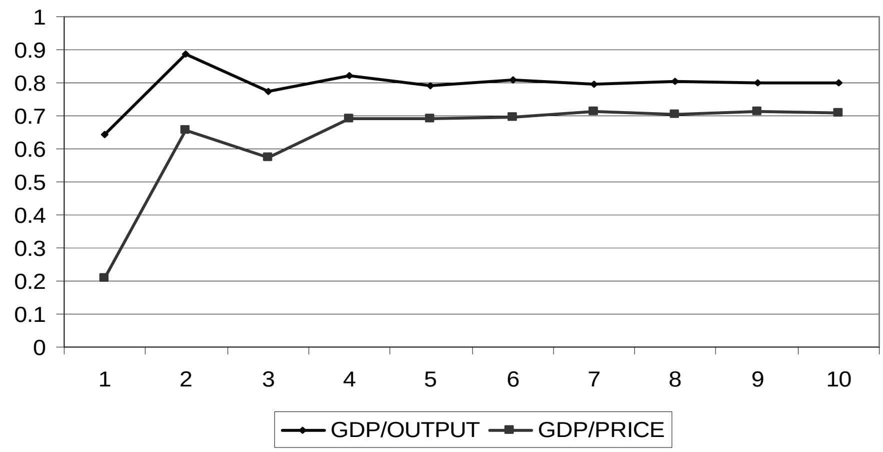
Step	GDP	Exc. rate	Yield	Output	Price
1991	-1.577	-0.563	-2.888	1.256	0.000
1992	-0.374	-1.730	0.355	3.169	0.270
1993	-3.032	-1.287	7.278	-5.292	0.344
1994	-2.143	0.572	3.733	-3.450	0.423
1995	-3.861	2.367	6.398	-2.097	1.166
1996	-4.860	2.074	7.181	-3.967	1.094
1997	-5.599	0.952	7.881	-3.226	0.881
1998	-3.330	1.059	8.575	-6.355	1.057
1999	-1.369	-0.361	7.127	-3.000	1.533
2000	-1.693	-2.193	7.334	-4.561	0.691
2001	1.108	-0.840	13.160	-5.024	0.082
2002	1.999	-1.802	7.451	-3.622	0.628
2003	5.734	-2.302	8.057	0.270	1.144

Figure 5 – Impulse response of the model's variables to unexpected shocks in each variable



Source: The authors

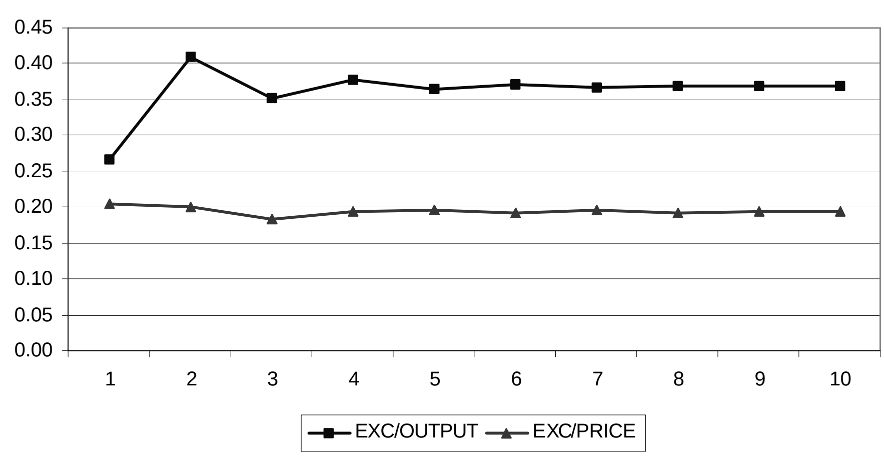
Figure 6 – Impacts of shocks in GDP on agricultural output and price



Source: The authors

Figure 7 reports results for demand shocks related to exchange rate changes. A 10% unexpected devaluation on exchange rate will immediately increase agricultural output and price by 2.7% and 2% respectively. The long run effects will be same as the immediate one for price and 3.5% for output.

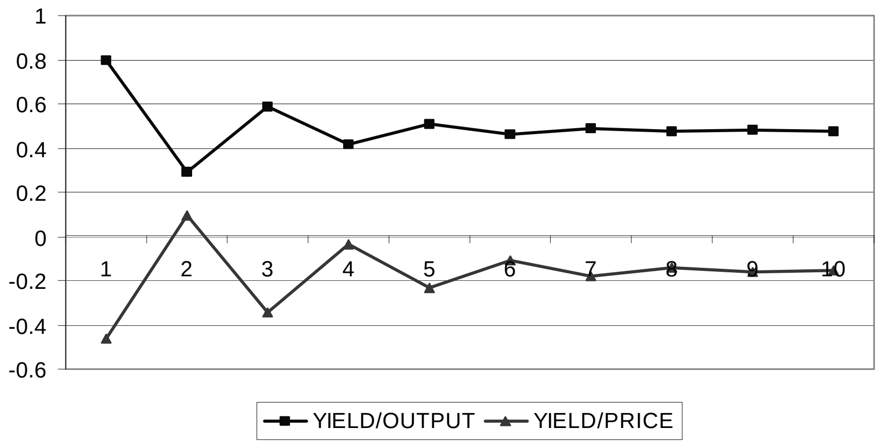
Figure 7 – Impacts of shocks in exchange rate on agricultural output and price



Source: The authors

In Figure 8 we see that a 10% increase in crop yield will immediately increase output by 8% and reduce price by 4%. Long run effects will be a 4.2% rise in output and a 0.18% reduction in price. It is interesting to notice that the moderate impact on price is possibly due to the alternative of exporting the additional output. That this might really be the case is indicated by a 2% to 2.5% appreciation of the domestic currency that follows the typical shock in productivity. This appreciation would hypothetically be the result of an expansion in the trade balance after a positive productivity shock. Anyhow, a small fall in price – possibly due an increase in exports – is the factor warranting the profitability of the new technologies associated with yield increases.[4]

Figure 8 – Impacts of shocks in yield on agricultural output and price



Source: The authors

5. CONCLUSION

The evolution of the Brazilian agricultural output – over the last 40 years – is in a large proportion (more than 50%) explained by productivity or yield increases, which result in moderate reduction in prices. We could measure that a 10% increase in yield would – in the long run – raise output by 4.8% and reduce price by 1.6%, so that farm income would end up increasing by around 3.1%. This of course stimulates the continuous use of new yield improving technologies. Indeed in the past two decades agricultural output grew rapidly and practically only because of yields increases. Brazil's GDP, exchange rate and agricultural output prices explain just a little of the output behavior.

Since domestic demand is certainly inelastic, we attribute the continuous growth of agricultural output to integration to international markets. This, of course, makes the exchange rate a relevant factor for agricultural growth. We measured that a 10% devaluation in exchange rate would – in the long run – raise agricultural output by 3.7%. It is interesting to see that the impacts of a 10% devaluation or, alternatively, a 10% increase in yield have similar impacts in terms of output.

We also verified that GDP growth can potentially have very expressive effects on output and prices;, however, in the last decade or so, GDP explains very little of the behavior of agricultural output. That would be mainly because of the inexpressive growth of the Brazilian economy over that period. If, on the other hand, Brazil is able to attain high domestic GDP growth rates, a strong growth of demand for agricultural products is expected. There is no indication, however, that this will be a problem, but rather a new opportunity of expansion to be explored by farmers and the agribusiness sector. We anticipate that, if investments in science and technology are maintained and international integration expanded, Brazil will be able to substantially increase its supply of agricultural products both domestically and to foreign markets.

[4]In the alternative model – with area instead of output – the effect of yield change on price is almost identical as the one presented in the text. But it is possible to detect a small negative effect (around - 0.1) of yield on the land use, meaning that there exists a small land-saving impact of yield-improving technology.

BIBLIOGRAPHY

Blanchard, O. J. & Quah, D. (1989). The dynamic effects of aggregate demand and supply disturbances. *The American Economic Review*, 79(4):655–673.

Dixon, R. & Lim, G. C. (2008). A univariate model of aggregate labor productivity. Technical Report 9/08, Institute.

Enders, W. (2004). *Applied Econometric Time Series*. Wiley, New York.

Flacker, J. S. & McMillin, W. D. (1998). Historical decomposition of aggregate demand and supply shocks in a small macro model. *Southern Economic Journal*, 64(3):648–664.

Lima, E. C. R. (1997). A interdependência entre os mercados de frango e bovinos: Uma aplicação da metodologia VAR-estrutural. Brasília: Instituto de Pesquisa Econômica Aplicada, 21 p. (IPEA. Texto para discussão, 501).

Nelson, C. R. & Plosser, C. I. (1982). Trends and random walks in macroeconomic time series: Some evidence and implications. *Journal of Monetary Economics*, 10:139–162.

Sims, C. A. (1980). Macroeconomics and reality. *Econometrica*, 48(1):1–49.

Sims, C. A. (1986). Are forecasting models usable for policy analysis? *Federal Reserve Bank of Minneapolis Quarterly Review*, Winter:3–16.

Whitt Jr., J. A. (1992). Long run behavior of the real exchange rate. *Journal of Money, Credit, and Banking*, 24(1):72–82.