Identification of Shocks in Emerging Economies – A Structural VAR Approach for Brazil

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June 20, 2008

Abstract

This paper presents an estimate of the importance of international shocks for the Brazilian economy, based in SVAR methodology. According to results, external shocks represents, on average, 40% of the fluctuations in the main variables of the Brazilian economy. This result is not sensitive to the forecast horizon, and it is lower than those values found in the literature. The correct specification of external shocks is marked as a necessary condition to produce proper inference from the effects of shocks in monetary policy and in the exchange rates.

1 Introduction

The identification of monetary, demand and supply shocks using Structural Vector Autoregressions (SVAR) by itself is a difficult task: problems with selection of variables to form the system, identification hypothesis, evaluating the content of the estimated time series of the shocks are among the problems constantly faced by researchers in the field. The use of the same procedure to identify shocks in the framework of a small open economy brings additional problems: identifying the response of exchange

*Acknowledgments: I would like to thank CAPES/Brazilian Ministry of Education and the Central Bank of Brazil for financial support during the PhD. I am also indebted to the friends in class at ECON395E3 for comments on previous the early draft of this paper. However, none of these institutions or people are responsible for eventual errors and omissions in the paper, which are entirely my fault. Also, all the views expressed in this work represent only my opinions, not necessarily reflecting those of the Central Bank of Brazil and CAPES or its staff.

rate and disentangling external shocks from domestic changes in monetary policy are two common features that SVARs try to explain. Very few researchers, however, have tried to take a step ahead and use SVAR models to estimate the dynamics of the so-called emerging economies. The main difficulties in the application of this procedure are:

- Sample size and data reliability: emerging economies, in general, do not have long time series available with good quality in order to obtain reliable estimations of the structural parameters of a model.

- Structural breaks and shocks: historically, emerging economies had multiple changes in monetary policy and exchange rate regimes. In fact, not only the transition path to a new monetary arrangement constitutes a problem, but also the differences in the conduction of monetary policies across regimes may invalidate some of the hypothesis of the SVAR identification procedure. As an example, in fixed exchange rate regimes, by definition, changes in the country's monetary policy must be equivalent to the changes in the world interest rates – otherwise, capital flows will impose pressures on the nominal exchange rate. In an alternative exchange rate arrangement, countries with the so called *crawling peg* regimes also use international reserves to reduce (not eliminate) exchange rate volatility. However, under this regime, the direct mapping between world interest rates and country-specific monetary policy is not straightforward anymore, as some degree of discretion is given to the monetary authority to balance the use of interest rates and international reserves to control exchange rate volatility. Thus, in the SVAR structure, imposing the restriction of equivalence between internal and external interest rates for countries following a *crawling peg* regime is not a reasonable assumption.

- Crisis: irrespective of being a problem of bad economic policy or bad fortune with shocks, emerging economies are usually facing episodes of hyperinflation, extreme recessions and currency crisis. Disentangling the "bad policy" from the "bad fortune" component in such small time series is very difficult, as these episodes are followed by changes in the monetary or exchange rate arrangements. Thus, establishing a cause-consequence type of relationship between policy and shocks in order to control for the event is very difficult.

The main references in the literature are Cushman and Zha (1997, [7]) and Kim (2001, [11]), with SVARs for small open economies. In this papers, the authors estimate the effects of shocks from the US to small but developed economies, assuming without further references that shocks in these economies have negligible effects on the US economy. For emerging economies, the SVAR methodology is used for a panel of countries, like in Canova (2005, [1]) and Mackowiak (2007, [12]), generally assuming that changes in economic policy can be controlled in the sample by the use of appropriate exogenous variables. In terms of country selection, Canova (2005, [1]) focus his evaluation on Latin American countries, while the majority of countries considered in Mackowiak (2007, [12]) are Asian. Specifically for Brazil, Minella (2003, [13]) estimated SVARs for three different subsamples using monthly data and controlling the external shocks only adding a measure for the country risk premium.

In this paper, we expand the literature on the field using data from Brazil to estimate the effect of internal and external shocks, based in the same two-step procedure commonly adopted. The case of Brazil is interesting as monetary and exchange rate regimes have not changed since the beginning of 1999, constituting almost ten years of the same economic policy. Of course, it is not the most appropriate sample size, but it allows some basic inference from small models in the business cycle frequency. Also, the use of an extended time series dataset in order to precisely estimate the set of external shocks, as in Canova (2005 [1]), avoids additional noise in the identification of internal shocks.

The main results of the paper highlight the importance of a proper consideration of the external shocks when estimating models for the Brazilian economy, as the impulse responses can describe quite different paths for the main variables of the system, especially when describing the effects of monetary policy and exchange rate shocks. The influence of the external shocks in the Brazilian economy is characterized by a variance decomposition exercise. As a result, external shocks explain an average of 40% of total variation in the main Brazilian variables. In terms of internal shocks, movements in the nominal interest rates and in the exchange rate are the main sources of economic fluctuations in Brazil.

2 Identification Strategy, Methodology and Data

In order to identify the model structure, Brazil is considered a small open economy, while the United States is viewed as a good representation of the rest of the world. Thus, for a small open economy, a structural model can be written using the block exogeneity assumption (variables with the superscript w

represent US variables):

$$\begin{bmatrix} A_{01}^0 & A_{02}^0 \\ 0 & A_{02}^0 \end{bmatrix} \begin{bmatrix} y_t \\ y_t^w \end{bmatrix} = \begin{bmatrix} A_{11}^1 & A_{12}^1 \\ 0 & A_{22}^1 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ y_{t-1}^w \end{bmatrix} + A_0^2 X_t + \begin{bmatrix} \varepsilon_t \\ \varepsilon_t^w \end{bmatrix} \quad (1)$$

$$A^0 Y_t = A^1 Y_{t-1} + A_0^2 X_t + e_t$$

with $A^0 = \begin{bmatrix} A_{01}^0 & A_{02}^0 \\ 0 & A_{02}^0 \end{bmatrix}$, $A^1 = \begin{bmatrix} A_{11}^1 & A_{12}^1 \\ 0 & A_{22}^1 \end{bmatrix}$, $Y_t = \begin{bmatrix} y_t \\ y_t^w \end{bmatrix}$ and $e_t = \begin{bmatrix} \varepsilon_t \\ \varepsilon_t^w \end{bmatrix} \sim iid\left(0, \begin{bmatrix} \Sigma_{\varepsilon_t} & 0 \\ 0 & \Sigma_{\varepsilon_t^w} \end{bmatrix}\right)$. X_t is a vector of exogenous variables.

The block exogeneity assumption is characterized by the entries $A_{21}^0 = A_{21}^1 = 0$ in the parameter matrix.

Three methodologies are commonly adopted in order to identify these shocks: the recursive approach, based in the Cholesky decomposition of the covariance matrix of residuals; the long-run identification scheme, where restrictions in the long-run multipliers are imposed; and the signal restriction on impulse responses methodology, normally used in Bayesian estimations. The last methodology is not applied in this paper, as we adopt the classical procedure to estimate and make inference over the parameters[1]. The long-run identification scheme was first used in this paper, in order to identify productivity shocks in the US economy. However, problems with results, mainly related with the elimination of the price puzzle and stability of the impulse response functions, and also the similarity of the estimated time series of shocks led the choice of the recursive scheme[2].

In order to implement the recursive identification, note that the system of equations above can be written in reduced form as:

$$\begin{bmatrix} y_t \\ y_t^w \end{bmatrix} = \begin{bmatrix} B_{11}^1 & B_{12}^1 \\ 0 & B_{22}^1 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ y_{t-1}^w \end{bmatrix} + B_0^2 X_t + \begin{bmatrix} u_t \\ u_t^w \end{bmatrix} \quad (2)$$

$$Y_t = BY_{t-1} + B_A^2 X_t + U_t$$

with $B = \begin{bmatrix} B_{11}^1 & B_{12}^1 \\ 0 & B_{22}^1 \end{bmatrix} = \begin{bmatrix} A_{01}^0 & A_{02}^0 \\ 0 & A_{02}^0 \end{bmatrix}^{-1} \begin{bmatrix} A_{11}^1 & A_{12}^1 \\ 0 & A_{22}^1 \end{bmatrix}$, $B_A^2 = \begin{bmatrix} A_{01}^0 & A_{02}^0 \\ 0 & A_{02}^0 \end{bmatrix}^{-1} B_0^2$ and

[1] Canova (2005, [1]) is one reference of this methodology in the same type of problem worked in this paper.

[2] Another potential problem with the use of the long-run identification scheme would be the use of instrumental variables estimation in a small sample, as the one available for the Brazilian economy. However, as the problems with the price puzzle already appeared in the model for the US, the scheme was not even experimented with Brazilian data.

$$U_t = \begin{bmatrix} u_t \\ u_t^w \end{bmatrix} = \begin{bmatrix} A_{01}^0 & A_{02}^0 \\ 0 & A_{02}^0 \end{bmatrix}^{-1} \begin{bmatrix} \varepsilon_t \\ \varepsilon_t^w \end{bmatrix}.$$

Note that there is a direct mapping between the structural and the reduced form coefficients of the VAR in this formulation. However, the residuals of the reduced form can not be seen as structural shocks – in fact, the residuals of the reduced form are linear combinations of the structural shocks ε_t and ε_t^w. The recursive identification is implemented based in the uniqueness of the Cholesky decomposition of the covariance matrix of residuals (Ω):

$$\Omega = E\left(U_t U_t'\right) = C \Lambda C' \qquad (3)$$

with C as the lower triangular matrix of eigenvectors of Ω. Thus, assuming a recursive contemporaneous relationship among variables in the system, the matrix A^0 can be recovered by the decomposition of Ω, with $C = \left(A^0\right)^{-1}$.

The block exogeneity assumption allows some interesting features in terms of estimation procedures. The estimation of the system can be done in two steps, first estimating the equations for y_t^w, then using the estimated shocks $\widehat{\varepsilon_t^w}$ as variables in the reduced form system of equations for y_t. Second, as the system of equations representing y_t is completely exogenous from shocks in y_t^w, the sample size used to estimate y_t can be different from the sample size used for the system representing y_t^w. This is particularly interesting for the proposed application, as the uncertainty resulting from the small sample for Brazil does not avoid a proper estimation of $\widehat{\varepsilon_t^w}$ – the set of shocks from the US. Furthermore, the assumption also allows for changes in other properties of the system, such as the lag length and the number of variables in each block.

The matrix y_t^w is composed of four variables for the United States: the log of the real GDP, the log of the Consumer Price Index (CPI) and the beginning of quarter Fed Funds Rate and growth rate of M1 . Data is not seasonally adjusted, and dummy variables are added in the VAR to correct for seasonal effects. In terms of order of integration, these are the same variables used in Christiano, Eichenbaum and Evans (2005, [4]). The sample expands the one adopted in Canova (2005, [1]), covering the period between the first quarter of 1980 until the end of 2007. The time span was selected based on the sensitivity of results concerning the price puzzle and the stability of the coefficients: Hanson (2004, [10]) notes that the price puzzle is mostly associated with estimations using data prior to 1979, and even the use of other variables, like commodity prices, is not enough to correct the problem.

The vector of exogenous variables is common to the systems for y_t and y_t^w. Two variables are used:

the difference between the log of the crude materials price in the PPI and the CPI and the spread of the BAA and the AAA bonds. The first variable is normally added in VAR estimations to correct the price puzzle[3]. The second variable is a measure of risk aversion, trying to capture effects not exactly related with shocks in the American or in the Brazilian economy. Canova (2005, [1]) used the EMBI and the EMEI indexes to capture these effects. However, as pointed out by Uribe and Yue (2006, [15]), there is a strong causal relation from the emerging economies shocks to the country spreads, measured by the EMBI+ stripped spread. Thus, the assumption that the EMBI and the EMEI are exogenous to Brazilian shocks may not be a proper approximation. On the other hand, the spread between the BAA and the AAA bonds seems to have good properties representing market's risk aversion. Figure 1 compares the BAA-AAA spread with the Fed Funds rate and the NBER recession dates. Despite the similar trends in both series, it is worth noting that, especially during recessions, the two variables move in opposite directions[4]. This effect is evident right after the 2001 recession, when monetary policy in the US reacted in order to avoid a deeper recession due to the collapse of the technological bubble in the stock market.

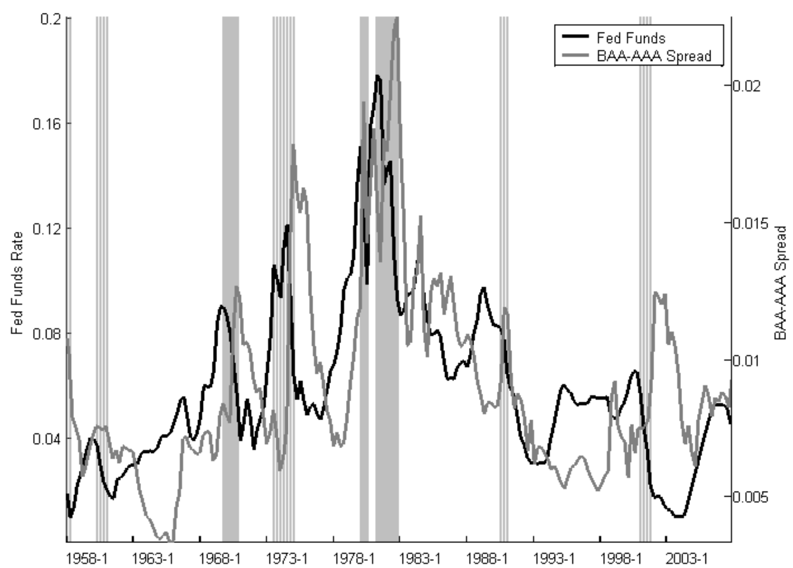

Figure 1: Fed Funds rate, BAA-AAA spread and NBER recession dates - 1958(1) to 2007(4)

The system of equations for Brazil – the block of equations for y_t in (1) – is also formed by four variables: the log of the real GDP, the log of the Extended National Consumer Price Index (IPCA), the

[3] As an example, this variable was used by Shapiro and Watson (1988, [14]).

[4] The contemporaneous correlation between the variables is 0.5114; on the other hand, the correlation between the Fed Funds and the first lag of the spread drops to -0.1370.

beginning of quarter SELIC rate – the Brazilian short-run interest rate – and the log of the nominal exchange rate. The sample covers the period between the second quarter of 1999 until the fourth quarter of 2007. Just like the block of equations for y_t^w, data is not seasonally adjusted and seasonal dummies are added to the regression. The selection of variables and the sample size avoid the three frequent problems verified in emerging economies, as shown in the introduction:

- In terms of sample size and data reliability, this sample period does not include the hyperinflation crisis of the early 1990's. As a consequence, distortions in the measurement of the real GDP and discussions about the order of integration of the inflation (the first difference of the log of the price level) are avoided[5].

- The sample also avoids the period of highest volatility in the nominal exchange rate, due to the crisis of the end of 1998, covering a period with a single monetary policy and exchange rate regime. Thus, the estimated impulse response functions are not affected by crises and the identification scheme is consistent with the policy for all the sample[6].

- Despite not including the crisis of 1998/99, the sample period includes two important episodes: the burst of the investment bubble in the US in 2001 and the crisis in Argentina in 2002. Interestingly, despite these two major events, economic policy framework was not changed in Brazil, which is a rare event in emerging economies.

In terms of variable selection, the VAR for y_t included the minimum set of variables in order to provide a reasonable description of the economy, given the obvious restrictions in the sample size. When comparing with the VAR for the US economy, the set of equations for Brazil, on the one hand, does not include monetary aggregates, as the monetary policy framework in the period is characterized by the use of the short run nominal interest rate as an instrument. On the other hand, the set of equations include the nominal interest rate, just like most of the literature for small open economies, in order to capture the effect of external shocks.

[5] For the debate about the order of integration of inflation in Brazil, the seminal reference is Cati, Garcia and Perron (1999, [2]).

[6] Impulse response functions, available upon request, including the first quarter of 1999 provided unexpected results, like the positive growth of the economy after a contractionary monetary policy shock.

3 Estimating External Shocks: VAR for US

The VAR with US data contains one lag. The selection was made based on both Schwartz and Akaike Information Criteria (SIC and AIC). The table below reports the estimated values for the SIC and the AIC for lags 1 to 3. Given the sample size, expanding the VAR for extra lags imply severe problems with overfitting of parameters and incorrect signs from the impulse response functions. The AIC and the SIC values reported refer to the system where Brazilian variables are completely exogenous[7].

Table 1 – Lag Selection: $VAR(p)$

p	AIC	SIC
1	-38.8913	-38.4059
2	-39.2186	-38.3398
3	-39.5060	-38.2294

Figure 2 plots the estimated responses and the 95% confidence interval of a unity shock[8] in each variable. In the figure, each row of graphs represents the response for one shock. The path of the variables is consistent with results in Canova (2005, [1]) and in Christiano, Eichenbaum and Evans (2005, [4]): an increase in the nominal interest rates reduces the price level in the long run[9], reduces the output and the growth rate of nominal balances; a productivity shock initially reduced the price level; a positive shock in the price level is smoothed by a contractionary reaction from the monetary policy, resulting in a high variability of output.

[7] As the system of equations contain variables that are possibly integrated of order one, the problem of spurious regressions may contaminate the statistic used to verify this hypothesis. According to Hamilton (1994, [9]), pp.554, the LR test for block-exogeneity does not possess the typical chi-square statistic. As a consequence, the main hypothesis present in the literature is taken for granted here, assuming that shocks from Brazil do not influence the US economy.

[8] Confidence intervals computed by bootstrap procedure.

[9] Christiano, Eichenbaum and Evans (2005, [4]), using the GDP deflator, eliminate completely the price puzzle in their estimation. Here, the price level is measured by the CPI. Note also, that, despite the central value points to an immediate increase in inflation after the shock, the confidence bands sign that the increase is not statistically significant.

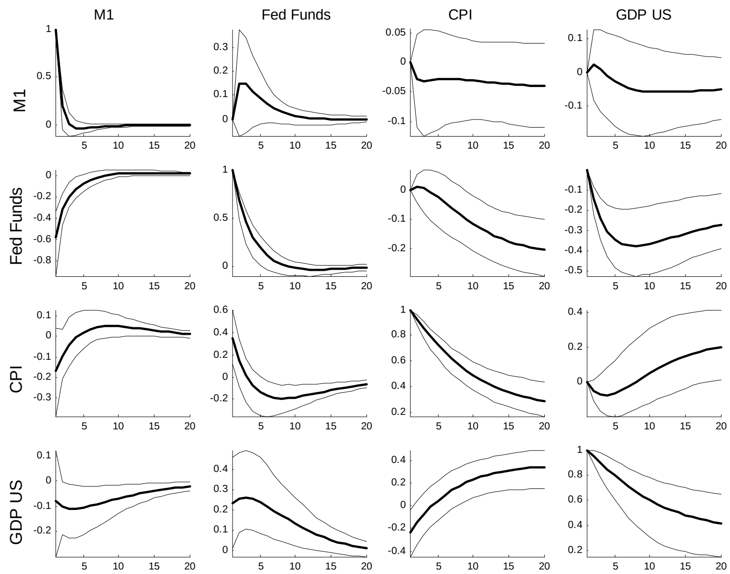

Figure 2: Impulse response functions – US

The time series of the shocks are plotted in the figure below. It is interesting to note that even this sample identification scheme provides similar properties for the times series of the shocks proposed by Canova (2005, [1]): 1) high variance of the monetary and supply shocks in the beginning of the sample, reflecting the adjustment to the oil price shock in the end of the previous decade; 2) a decline in the productivity in the middle of the 80, reflected by negative disturbances in the shock from GDP. A third fact highlighted by Canova (2005, [1]) – the adjustment in aggregate demand after the bubble in the stock market in 2001 – does not appear as a shock, but, instead, as figure 1 shows, as an increase in aggregate risk. Thus, the use of the BAA-AAA spread as an exogenous variable eliminates that effect. Overall, except for this last feature, the same qualitative properties highlighted by an identification scheme based on signal restrictions were obtained by the recursive scheme.

Thus, given the time series of the US shocks, the next step is to incorporate this matrix of innovations in a VAR with Brazilian and identify the responses from shocks in the main variables of the system.

Figure 3: Time series of US shocks

4 Responses From Small Open Economy: The Case of Brazil

Following the same procedure to identify the matrix of contemporaneous shocks for the United States, a sequence for the lower triangular decomposition of the variance matrix must be imposed. The VAR for Brazil assumes that the nominal exchange rate is affected contemporaneously by all the variables in the economy. In the sequence, it is assumed, just like the VAR for the United States, that the nominal interest rate is affected by prices and output, but not contemporaneously by the exchange rate. Implicitly, the hypothesis claim that the nominal exchange rate is a very noisy information of the economy, and the Central Bank waits until taking a stance to respond to the shock. Finally, in the sequence for the recursion, the prices and output are not affected contemporaneously by the interest rates, and output is not affected by prices. In this last case, switching the order of the variables does not qualitatively change the results.

In the VAR, the time series of the US shocks enter contemporaneously in the equations. Another formulation including one lag of the shocks was testes, with results qualitatively very similar to those presented here, but with one disadvantage: the increase in the number of parameters to be estimated decreased the precision of the estimates, resulting in larger confidence bands.

The number of lags for the VAR was restricted to one, despite the claim of both Information Criteria for more lags. The reason for this choice was the evidence of overfitting problems, as a consequence of a large number of parameters estimated with a small sample size: the impulse response functions displayed an oscillating, non-stationary path for all variables after an exogenous shock; furthermore, the LM statistics for first-order autocorrelation do not reject the hypothesis of residual autocorrelation, even with a VAR(2). The estimated VAR(1) does not present this explosive behavior, and the residuals up to second order can be considered well behaved. The table below display the information criteria and the LM statistic for autocorrelation of first order for the tested VAR.

Table 2 – Lag Selection: $VAR(p)$ – Brazil

p	AIC	SIC	$LM(1):E$	$LM(1):IPCA$	$LM(1):GDP$	$LM(1):SELIC$
1	-34.118	-33.211	0.72143	1.8295	0.061447	5.435
2	-34.475	-32.826	1.8051	5.5929	2.3398	2.8102
3	-36.485	-34.080	1.6033	6.9892	2.6596	10.051

Also considering stationarity issues, the formulation in levels seems to include all the necessary cointegration vectors to guarantee a good estimation, as the impulse response functions converge regularly to the new steady state and the confidence intervals do not seem to explode in longer horizons. The non-explosive behavior for a formulation in levels in the period is consistent with results with monthly data in Minella (2003, [13]) for a sample starting in the third quarter of 1994 (the last stabilization plan to control inflation – the Real Plan – was fully implemented in June of 1994).

The variance decomposition of the estimated VAR is presented in table 3. The table highlights the average variance decomposition for four different horizons: the variance from 1 to four periods ahead, capturing mainly short run movements of the economy; the average decomposition for the first part of the business cycle horizon, for the period between 6 and 10 periods ahead; the long part of the business cycle, from 11 to 15 periods ahead; and a long run perspective, with the average between 16 and 20 quarters. For all the horizons, the external shocks contributes with at least 21% of the changes in the main indicators of the Brazilian economy. The largest individual influence comes from the US productivity shock over the Brazilian real GDP at the business cycle horizon, with 22.3% of participation. The US monetary policy shocks has a moderate influence over the Brazilian interest rates, responding for 12 percent of the changes in the nominal interest rate in Brazil on average. It is almost the same weight verified for the exogenous shocks in prices, from the PPI – Crude materials.

The comparison of the variance decomposition with the results in Canova (2005, [1]) highlights the importance of the sample selection and the changes in monetary policy and exchange rate regimes. In Canova (2005, [1]), with the same number of lags in the VAR, the external shocks responds to, at least 35% of the variation of Brazilian indicators, with values reaching 84% for the interest rate and 65% for the nominal exchange rate. Given that, in part of his sample, Brazil conducted the exchange rate regime under strict bands (the *crawling peg* regime of 1995-1998 is the classic example), it is expected that external shocks have more influence in the Brazilian economy.

Table 3 – Variance Decomposition – $VAR(1)$ – Brazil

	1-5 periods ahead				6-10 periods ahead			
	Exchange Rate	Interest Rates	IPCA	GDP BR	Exchange Rate	Interest Rates	IPCA	GDP BR
Exchange Rate	0.558	0.192	0.210	0.145	0.555	0.270	0.249	0.144
Interest Rates	0.072	0.293	0.113	0.123	0.088	0.234	0.252	0.132
IPCA	0.002	0.001	0.180	0.030	0.002	0.001	0.142	0.057
GDP BR	0.014	0.009	0.171	0.282	0.024	0.016	0.110	0.272
Total: Internal Shocks	0.646	0.495	0.674	0.580	0.669	0.521	0.753	0.605
BAA-AAA Spread	0.031	0.016	0.060	0.058	0.026	0.016	0.053	0.043
PPI Crude Materials	0.136	0.138	0.045	0.093	0.124	0.140	0.031	0.089
M1 – US	0.089	0.046	0.132	0.019	0.082	0.052	0.115	0.016
Fed Funds – US	0.014	0.150	0.081	0.029	0.013	0.121	0.035	0.022
CPI – US	0.006	0.013	0.003	0.002	0.008	0.011	0.007	0.002
GDP US	0.077	0.142	0.004	0.220	0.078	0.139	0.005	0.223
Total: External Shocks	0.353	0.505	0.325	0.421	0.331	0.479	0.246	0.395

	11-15 periods ahead				16-20 periods ahead			
	Exchange Rate	Interest Rates	IPCA	GDP BR	Exchange Rate	Interest Rates	IPCA	GDP BR
Exchange Rate	0.552	0.280	0.253	0.126	0.549	0.279	0.253	0.124
Interest Rates	0.088	0.227	0.301	0.164	0.088	0.225	0.321	0.197
IPCA	0.002	0.001	0.133	0.076	0.003	0.002	0.129	0.088
GDP BR	0.029	0.022	0.092	0.267	0.031	0.025	0.085	0.249
Total: Internal Shocks	0.671	0.530	0.779	0.633	0.671	0.531	0.788	0.658
BAA-AAA Spread	0.026	0.015	0.050	0.043	0.026	0.015	0.048	0.043
PPI Crude Materials	0.122	0.138	0.025	0.076	0.122	0.137	0.023	0.066
M1 – US	0.080	0.051	0.107	0.022	0.080	0.051	0.104	0.029
Fed Funds – US	0.013	0.116	0.025	0.018	0.013	0.115	0.021	0.016
CPI – US	0.008	0.011	0.009	0.002	0.008	0.011	0.010	0.003
GDP US	0.080	0.140	0.006	0.206	0.080	0.140	0.006	0.185
Total: External Shocks	0.329	0.471	0.222	0.367	0.329	0.469	0.212	0.342

Observing the main contributions from the internal shocks, most of the variables are very influenced by changes in the monetary policy and by shocks in the exchange rate. Shocks in these two variables are responsible for more than 50% of the total changes in themselves and in prices in the business cycle horizon. The recursive restriction reduces the participation of these shocks in the short run to values close to 30%. The influence of monetary policy shocks and exchange rate shocks on output varies between 25% to a little more than 30%, depending on the forecasting horizon. On the other hand, productivity shocks have an immediate impact on prices, representing 17% of the fluctuations in the short run, but this effect vanishes very quickly, as the participation of this shocks in the changes in prices falls to values under 10% after 5 quarters.

4.1 Impulse Response Functions: The Effect of Internal Shocks in Brazil

The impulse response functions have the signs as expected by traditional DSGE models in the literature. Again, in figure 4, just like in figure 2, each row of graphs display the results of one of the internal shocks. It is interesting to highlight that a monetary policy shock seems to induce stronger effects on prices, in the short run, from the appreciation of the nominal exchange rate, while, in the long run, is the lower growth of the economy that induces lower price changes. On the other hand, a shock in the nominal exchange rate results in an increase of the nominal exchange rate and in prices and a moderate contraction in output.

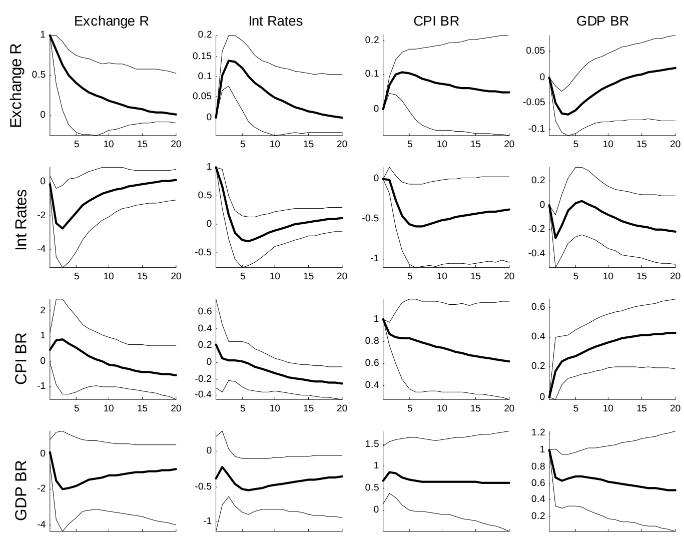

Figure 4: Impulse response function – Brazil

In order to highlight the importance of the external shocks to the Brazilian economy, the figures below display the impulse response functions for two shocks with internal sources: an increase in the nominal interest rate, representing a contractionary monetary policy shock, and an increase in the level of the nominal exchange rate, simulating an exogenous change in the terms of trade. The two thick lines in the graph compares the impulse responses of the benchmark VAR (blue line without markers) against a VAR with the same number of lags, but without the external shocks (red line with markers). As can be seen in figure 5, the impulse response function that takes into account the effects of international shocks over Brazil predicts a stronger effect of the shock over output and a smaller effect over the exchange rates. The impulse responses after a shock in the nominal exchange rate are standard in both cases, with an increase in the price level, a positive response of the nominal interest rates and an increase of the GDP after a small contraction of the economy. However, the persistence of the shock is quite different, showing that there might be a mispecification in the equations that do not take into account these effects.

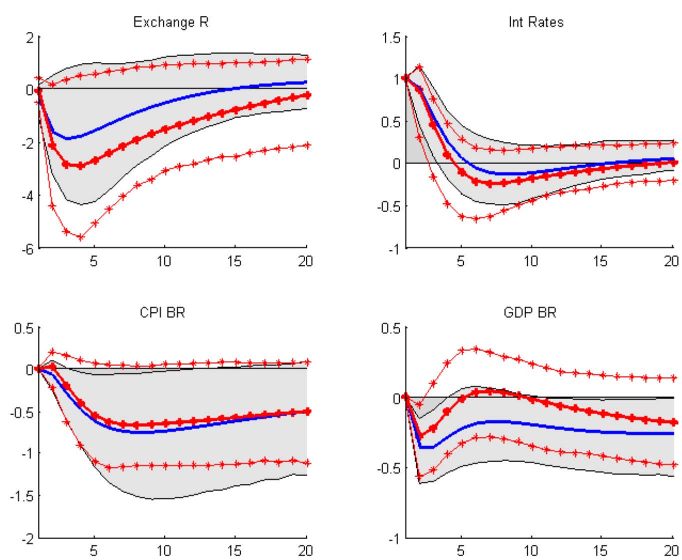

Figure 5: Effect of external shocks – Monetary policy shock

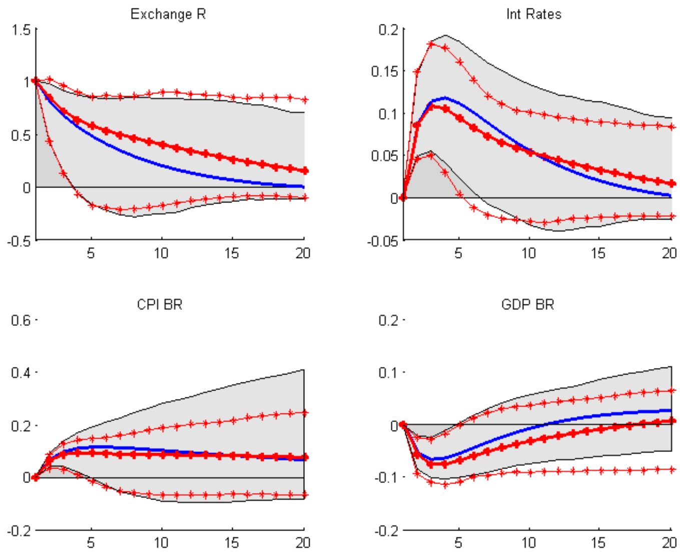

Figure 6: Effect of external shocks – Exchange rate shock

4.2 Impulse Response Functions: The Effect of External Shocks in Brazil

The impact of external shocks in Brazil is measured with a compatible scale, where each initial shock is given by one standard deviation of the residuals from the US VAR. Here, six external shocks are simulated, with increases in risk aversion (measured by a shock in the BAA-AAA spread), oil prices, US money demand, Fed Funds rate, US CPI and the log of US GDP. Figure 7 shows the plots of the impulse response functions for all the six shocks in the main variables. The signs of the responses matches conventional intuition about the responses of a small open economy after a external shock. One interesting feature is the response of the Brazilian economy after an increase in the Crude materials prices: the appreciation of the exchange rate and increase in the GDP growth just confirm the importance of tradeables goods, especially commodities, for the Brazilian economy.

Another interesting feature is the comparison between the impacts of a shock in the BAA-AAA spread and a monetary policy shock in the US: the impulse responses for nominal exchange rate and GDP are very similar, both in terms of shape and magnitude. The main differences are on the monetary policy and price responses: while a shock on the spread does not trigger a significant response from monetary policy and prices, the contractionary monetary policy shock is promptly compensated by an increase in nominal interest rates in Brazil and a strong contemporaneous positive response in inflation.

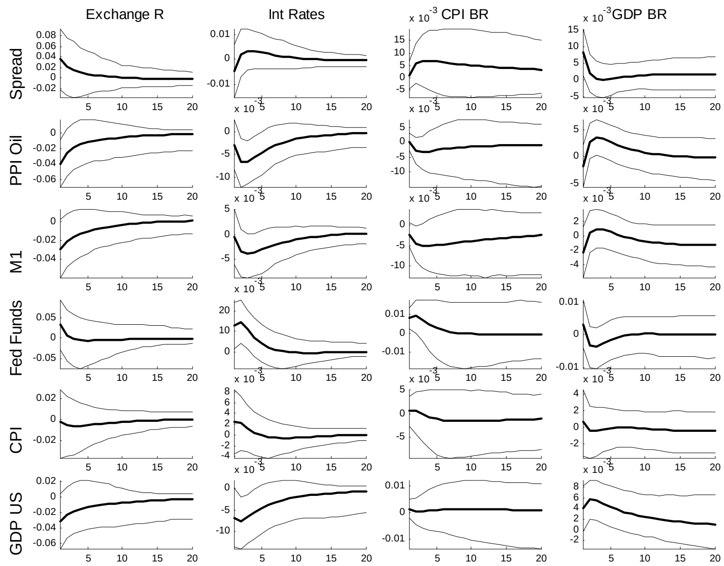

Figure 7: Impulse response function – Impact of external shocks in Brazil

The transmission of productivity shocks from the US to Brazil is almost immediate and significant. The last row of graphs in figure 7 shows that a productivity shock in the US increases the GDP growth in Brazil, appreciates nominal exchange rate and reduces the nominal interest rate. This is a behavior consistent with the idea of continental business cycles movements, as if the increase in US productivity spills over for other countries, also increasing their own productivity. If this effect was not present, the expected effect of an increase in US productivity would be a depreciation of the nominal exchange rate and an increase in nominal interest rate, which is monetary policy reaction consistent with the idea of keeping inflation on the target.

5 Conclusion

In this paper, an estimation of empirical impulse responses for Brazil was conducted taking into account the main problems faced by estimations using data from emerging economics. The estimated impact of external shocks in the Brazilian economy, with an influence over an average of 40% of the total fluctuations in the economy, is a new feature that must be considered in future projects. The focus is on the importance of a proper setting to estimate external shocks affecting emerging economies, as the inclusion of these shocks may substantially change the implicit dynamics of the model. The comparison of the results with the literature, especially with Canova (2005, [1]), stressed the importance of considering the changes in the monetary policy and exchange rate arrangements, despite eventual losses caused by the short sample.

In terms of future extensions, it is obvious that, as the sample increases, richer dynamics should be considered both for the Brazilian and for the US economy. Another consequence of the increase in the sample size is the possibility of including extra variables in the VAR, allowing the incorporation of other shocks in the system – the use of government expenditure, as in Christiano, Eichenbaum and Evans (2005, [4]), in order to control for fiscal policy shocks is a natural candidate. In terms of econometric procedure, verifying more carefully the block exogeneity assumption with an actual test would be valid, especially in such a way that is possible to avoid the spurious regression problem. Finally, in terms of research on emerging economies, using the impulse response functions to estimate the deep structural parameters of a DSGE model for emerging economies seems to be a nice challenge for a project.

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