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Performing a Bayesian VAR to analyze how monetary policy's credibility is affected and affects over time: the Brazilian experience

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Abstract

This article measures and analyzes how the monetary policy's credibility is dynamically related to macroeconomic performance in Brazil. Performing a *Bayesian VAR with Litterman/Minnesota priors*, we obtain results highlighting that monetary policy's credibility gains (and losses) are affected by inflation rate shocks, while the higher such credibility the easier the control of inflationary expectations and thereby taming effective inflation rates becomes a natural result over time. Furthermore, we verified other important new-keynesian predictions for Brazil, such as the *pass-through effect*, the output-inflation relation (*Phillips curve*), the interest rate-output one (*IS curve*), as well as the reaction of such a rate to inflation shocks (*Taylor rule*). At last, the monetary policy's credibility is negatively affected by an undervaluated domestic currency.

Keywords: monetary policy's credibility; expected inflation; Kalman filter; Brazil.

1. Introduction

Monetary policy's credibility has become a key feature into the monetary policy literature. Particularly for inflation targeting regimes, such credibility is associated with an efficient monetary policy, which is compatible with inflation control without expressive social costs (Woodford, 2003). In general, the higher the monetary policy's credibility

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degree the lower the inflation inertia, so that the Central Bank does not need to adjust aggressively basic interest rates to tame expected and effective inflation rates over time (Lalonde, 2005; Argov et al, 2007). However, empirical works dealing with this issue face an operational problem, because monetary policy's credibility is not a directly observable variable. Thus, the related literature has proposed some methods for measuring such a phenomenon, such as in Cecchetti & Krause (2002) and De Mendonça (2004).

This article aims at analyzing the dynamic relationships between monetary policy's credibility and relevant macroeconomic variables, such as output, observed and expected inflation, exchange rate and basic interest rate, taking into account the Brazilian experience from January 2005 to July 2012*. As Brazil follows an inflation targeting regime, knowing the dynamic relationships of the Brazilian monetary policy's credibility is fundamental to understand how the Central Bank can build more reputation and what are the main consequences of such a process for the macroeconomic dynamics as a whole.

So as to extract the monetary policy's credibility we will apply the *Kalman filter* (Harvey, 1989) on an expected inflation rule that expresses its main determinants over time. In such a case, we follow Moreira (2013a; 2013b; 2014) approach, which defines monetary policy's credibility as the inverse of the correlation between expected and observed inflation rates. In turn, after extracting the credibility proxy, we will include it into a *Bayesian Vector Autoregressive (BVAR)* (Chauvet & Potter, 2012; Moreira et al 2014) model with those other relevant macroeconomic variables. To estimate the parameters' prior distributions we have initially performed a BVAR model using the *Litterman/Minnesota prior* (Koop and Korobilis, 2010).

The article is structured as follows: Section 2 defines the methodology and empirical results regarding the monetary policy's credibility index for Brazil, according to Moreira (2013a; 2013b)'s Kalman filter approach; Section 3 presents the methodological and empirical elements from the BVAR model; Section 4, in turn, highlights the way by which robustness tests have been performed and the related results. At last, concluding remarks, references and statistical attachments are shown.

2. Data Set and the measurement of monetary policy's credibility

The data set is composed by monthly series for Brazil, from January 2005 to July 2012. They are listed as: EXP_P = expected inflation for 12 months forward; P = observed consumer inflation accumulated in the last 12 months; I = the effective basic interest rate (Selic rate); Y = proxy for the GDP behavior measured by the Brazilian Central Bank; E = the nominal exchange rate (R$ against US$).

In order to measure monetary policy's credibility we need an empirical proxy, as such credibility is not directly observable. Conventional approaches have been proposed into the related literature, such as Cecchetti and Krause (2002) and De Mendonça (2004), among others, but these methods lack structural foundations, as the measurement method relies on ad hoc limits. Moreira (2013a; 2013b; 2014), however, has proposed an empirical method based on monetary policy's structural credibility, that is, in a theory for such credibility, that expresses it as the inverse of the correlation expected and observed inflation rates.

From the theoretical perspective, we adopt the following monetary policy's structural credibility equation (Moreira, 2014):

$$(1)\ E_t[\pi_{t+1}] = \rho E_{t-1}[\pi_t] + (1-\rho)\,[\mu + (1 - C_{t-1})(\pi_{t-1}) + \sum_{i=1}^{n} a_i\, \chi_{i_{t-1}}\ ] + \omega_t$$

Where $E_t[\pi_{t+1}]$ stands for expected inflation, C_{t-1} for credibility in t-1 period, π_{t-1} for effective inflation, and χ for a sample of control variables. The parameters are positive and ω represents a white noise shock. In such a way the

* We have adopted such a sample because since 2005 Brazil has stabilized its inflation target at 4.5% per year by the Broad Consumer Prices Index.

coefficient that relates lagged inflation to the dependent variable becomes β = (1 –C)(1 – ρ). Hence, we can calculate the structural credibility by the simple expression C = 1 – [β/(1 – ρ)]. To estimate it for Brazil, from January 2005 to July 2012 and based on the *Generalized Method of Moments* (GMM), we estimated the following empirical regression[†]:

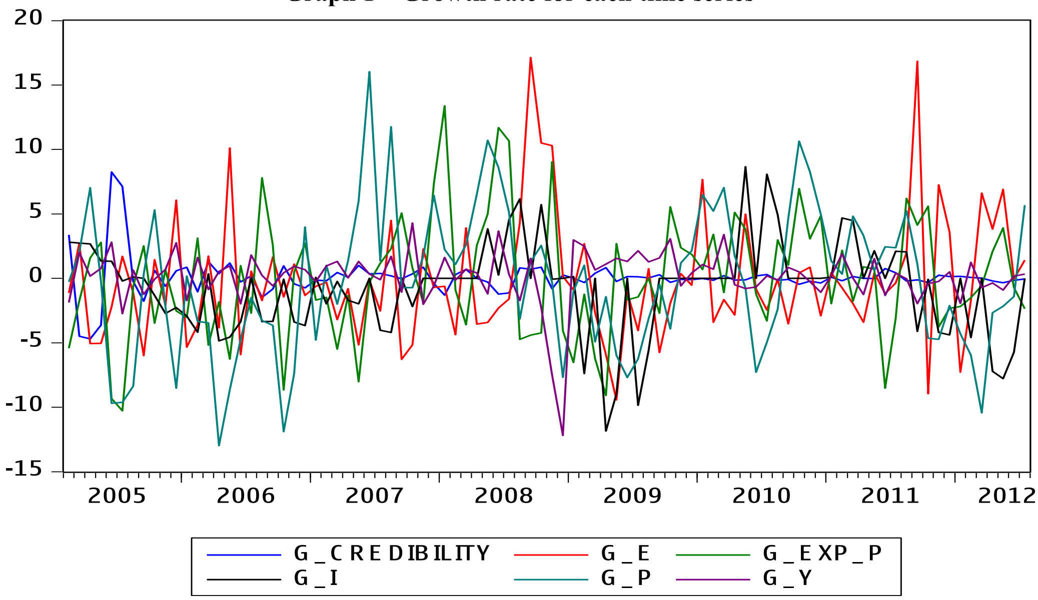
(2) LOG(EXP_P) = Constant + LOG(EXP_P(-1)) + LOG(P(-1) + LOG(Y(-1))

The estimates are presented in Table 1 (Appendix). Thus, the Kalman filter (Harvey, 1989) was applied on such estimates, imposing *prior*s on the mean and variance values of β, which are collected from the statistical properties of its estimates. These priors are, respectively, (0.096; 0.0006) for regression (2). Therefore, performing C = 1 – [β/(1 – ρ)] for each month, we have a new time series, called by CREDIBILITY that will be included into the analysis forward.

3. Bayesian Vector Autoregression: Litterman/Minnesota prior

Before applying the BVAR model we have examined the integration order of each series using the Phillips-Perron (PP) unit root test. As we can view in Table 2 (Appendix), all the series are I(1), i.e. integrated of first order. In such a case, using the time series in their level values can lead to spurious results, so that we have adopted them in their *growth rate form*. Thus, G_CREDIBILITY stands for the growth rate of the CREDIBILITY, G_EXP_P FOR EXP_P, and so on. Graph 1 presents the behavior of the times series in their growth rate form.

Graph 1 – Growth rate for each time series



Source: Own elaboration.

[†] Other specifications were performed by OLS and GMM following Moreira (2014), but the current regression presented better fitness to data. As we identified, all the time series are I(1) (Appendix). So, the regression takes the variables into their level form and tests for cointegration based on the Engle & Granger approach.

Litterman/Minnesota priors

Although VAR models have been very popular in empirical works for Economics, Bayesian VAR ones have been largely used as a robust alternative to the formers. In BVAR models the parameters are regarded as random variables with prior probabilities. Following Chauvet & Potter (2012) and Moreira et al (2014), a Vector Autoregressive Vector is expressed as:

$$(3)\ \Delta Y_t = A' x_t + u_t$$

Let u_t be the disturbances vector which is uncorrelated with x_t. Equation (3) can be also specified as:

$$(4)\ \Delta y = (I_M \otimes x)\alpha + u$$

Such that α = vec(A) and $u \sim N(0, \Theta \otimes I_T)$. If we make the OLS of A:

$$(5)\quad \hat{A}' = [\sum_{t=1}^{T} \Delta Y_t x_t'][\sum_{t=1}^{T} x_t x_t']^{-1}$$

Koop and Korobilis (2010) suggest Litterman/Minnesota method to estimate priors. According to Chauvet and Potter (2012), it implies that $\otimes$ is substituted by an estimation process, such that:

$$(6)\ \alpha \sim N(\underline{\alpha}_{nM}, \underline{V}_{nM})$$

From using Normal distribution:

$$(7)\ \alpha | y \sim N(\overline{\alpha}_{nM}, \overline{V}_{nM})$$

Regarding:

$$(8)\ \overline{V}_{nM} = [\underline{V_{nM}}^{-1} + \hat{\Theta}^{-1} \otimes (x'x))]^{-1}$$

And:

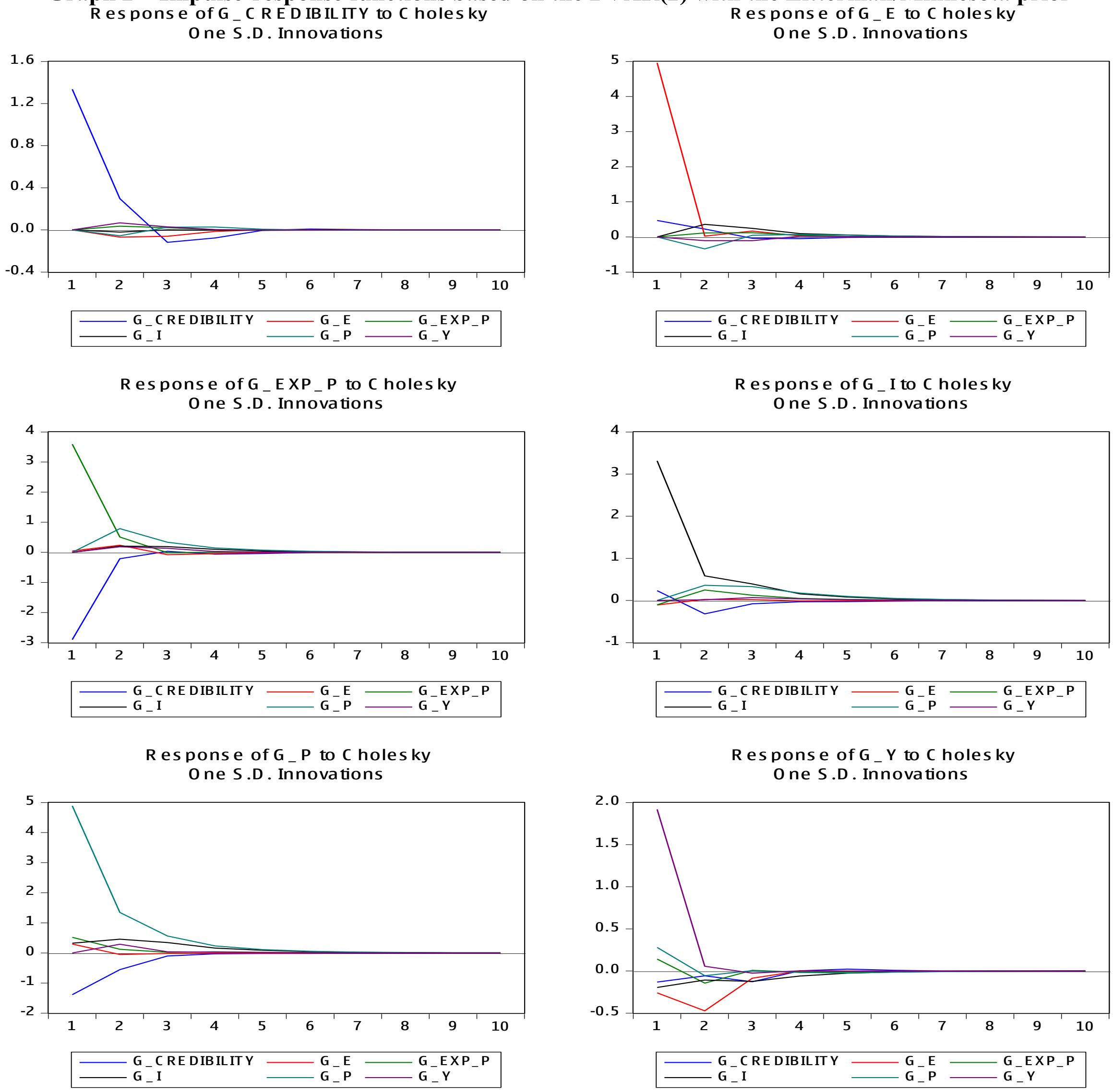
$$(9)\ \overline{\alpha}_{nM} = \overline{V}_{nM}[\underline{V_{nM}^{-1} \alpha_{nM}} + (\hat{\Theta}^{-1} \otimes x)' y]$$

Additionally, the prior $\overline{\alpha}_{nM}$ is regarded as zero and the variance-covariance matrix $\otimes$ is assumed to be diagonal (Chauvet & Potter, 2012). Litterman/Minnesota method is composed by the following priors: μ_1, λ_1, λ_2 and λ_3 (Liang et al, 2008). μ_1 is the prior mean and it is set as zero to lessen the risk of over-fitting; λ_1 is the overall tightness on the variance (first lag) and controls the relative importance of sample and prior information. We defined it as 0.1 so as to allow prior information dominates the sample information; λ_2 represents the relative tightness of the variance of other Variables. We defined it as 0.99; λ_3 represents the lag decay and we choose it as 1.0 to force a linear decay, following Kadiyala & Karlsson (1997).

Empirical results

Regarding monetary policy's credibility, its growth rate initially reduces as a result of G_P and G_E positive shocks, converging to the normal value after 05 months (Graph 2). It means that the Central Bank in Brazil is penalized by an acceleration of inflation rates and domestic currency undervaluation cases are also followed by credibility losses, probably due to the pass-through effect. In turn, G_CREDIBILITY positive shocks are accompanied by a decrease of G_P and G_EXP_ P; such results corroborate our theoretical predictions, as credibility gains are translated into decreasing inflationary expectations, such that taming effective inflation rates become easier over time.
Our estimates confirm other relevant new-keynesian predictions. First, the lagged positive effect of G_Y on G_P highlights an important relationship previewed by the Phillips curve (Clarida et al, 1999), while G_E positive shocks are followed by an increase of G_EXP_P and G_P. Such findings are consistent with the so-called pass-through effect (Taylor, 2000).

Graph 2 – Impulse-response functions based on the BVAR(2) with the Litterman/Minnesota prior



Source: Own elaboration.

Concerning the monetary policy rule or feedback, we verify that Brazil's Central Bank practices a basic interest rate above its normal value, as a response to G_P and G_EXP_P positive shocks, which converges to the monetary policy's Taylor rule, especially from 02 to 03 months after such shocks . On the other hand, the downturn movement of G_Y after G_I positive shocks is also observed and it persists over 06 months (new-keynesian IS curve).

Concluding remarks

Measuring monetary policy's credibility is not a conventional task, as it is not a directly observable variable and there exist several different methods to calculate it. However, Moreira (2013a; 2013b; 2014) proposed an empirical approach based on a theory for monetary policy's structural credibility, which we applied for Brazil over January 2005 to July 2012.

In turn, we performed a Bayesian VAR with Litterman/Minnesota priors so as to empirically study the dynamic relationships between such credibility and other relevant macroeconomic variables. Regarding the main subject of this article we found evidences corroborating the mutual relations between credibility and observed and expected inflation, as highlighted in Argov et al (2007), Lalonde (2005) and Moreira (op. cit.). Moreover, the impulse-response functions have demonstrated that stylized facts concerning the so-called new-kenesian model are well adjusted to Brazil. Among them, we attained findings confirming the pass-through effect, the Phillips and IS curves and the Taylor rule.

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Appendix

Table 1 – GMM estimates for regression (2). Dependent variable: LOG(EXP_P)

	Constant	LOG(EXP_P(-1))	LOG(P(-1))	LOG(Y(-1))
Coefficient	-1.413***	0.792***	0.096***	0.328***
Stand. error	(0.197)	(0.039)	(0.025)	(0.040)
t-statistic	[-7.164]	[20.087]	[3.841]	[8.160]
EG (t-stat)*	**EG (Prob.)**	**J-statistic**	**J-stat (prob)**	**Adj. R^2**
-7.918	0.000	10.032	0.282	0.913

Notes: The instrumental variables were C, log(exp_p(-1)), log(exp_p(-2)), log(exp_p(-3)), log(p(-1)), log(p(-2)), log(p(-3)), log(y(-1)), log(y(-2)), log(y(-3)), log(e(-1)), log(e(-2)), log(e(-3)); "( )" for standard error and "[ ]" for t-statistic; *** for statistical significance at 1%, ** at 5% and * at 10%. EG refers to the Engle & Granger (1987) approach of cointegration, by means of the ADF unit root test, applied on the residual series from the regression. Source: Own elaboration.

Table 2 – Phillips-Perron unit root test (Adj. t-statistics)

	Level	First Difference	I(n)
CREDIBILITY	-3.034	-16.584	I(1)
EXP_P	-2.929	-7.564	I(1)
P	-2.171	-4.746	I(1)
Y	-2.426	-8.431	I(1)
E	-2.257	-9.109	I(1)
I	-1.809	-6.559	I(1)

Notes: Critical value at 10% (Level and 1º difference): -3.156. Estimates by the Bartlett Kernel method. Trend and intercept in test equation.
Source: Own elaboration.