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Neutral Real Interest Rate, Monetary Policy and Business Cycle: Using the Kalman Filter and a Counterfactual Structural Approach for a Large Emerging Market

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Abstract

Central banks monitor the evolution of economic aggregates in order to enhance the effectiveness of monetary policy, within the context of inflation targeting regimes. This paper assesses whether controlling or not the path of the neutral real interest rate alters business cycle responses to structural shocks in monetary policy. For this purpose, the study uses the Kalman filter to extract the latent variable of neutral interest rates, as well as a counterfactual exercise based on parsimonious SVAR models, both applied to Brazil. The evidence suggests that omitting the trajectory of the neutral real rate introduces biases in the estimated stochastic responses of economic activity to unanticipated changes in monetary policy. Quantitatively, this omission results in a loss of approximately 5% of the estimated marginal effects in the first 12 months, in addition to bringing forward the initial impacts by 6 months, and a loss of up to 70% in the estimated effects over a 24-month horizon. Such results were robust for the inclusion of the US long term real interest rate and the country risk perception.

Keywords: neutral real interest rate, monetary policy, business cycle, Kalman filter, SVAR

JEL Classification: E32; E52; E58.

1. Introduction

The IS function is a central component of macroeconomic models, especially those used by central banks (Clarida et al., 1999; Laubach & Williams, 2003) under an inflation targeting regime. It describes the relationship between aggregate output (or income) and the interest rate in an economy. The IS curve is derived from the equilibrium in the goods market, where aggregate demand equals aggregate supply. In central banks' benchmark models, the IS function is important for several reasons: 1). It helps to understand how interest rates, controlled by central banks, affect the level of economic activity. A reduction in the interest rate, for example, can stimulate demand for investments and, therefore, increase output; 2). The IS function allows for the analysis of how demand shocks, such as changes in government spending or private consumption, impact the economy.

The Central Bank of Brazil, following the practice of other central banks around the world, also uses a structural benchmark model in its macroeconomic analyses (Central Bank of Brazil, 2024). This model incorporates the IS function, along with other key functions such as the Phillips curve and a monetary policy rule (usually a Taylor rule), to understand the dynamics between variables like the interest rate, inflation, and output.

The distinction is that the Central Bank of Brazil not only uses this model internally but also publishes its results and the estimated parameter values of the model. This increases transparency and the credibility of monetary policy, allowing analysts and the general public to understand the economic foundations behind the decisions of the Monetary Policy Committee.

These periodic estimates are essential to adjust the model to the current conditions of the Brazilian economy, such as: i) the elasticity of aggregate demand to the interest rate (a parameter of the IS function); ii) inflation expectations; iii) other external and internal shocks. Together, these elements help the Central Bank to form the so-called risk balance for monetary policy decision-making.

Thus, the Central Bank of Brazil aligns itself with the trend of greater communication and clarity in its economic projections, contributing to the effectiveness of its monetary policy. Nevertheless, the estimation of the IS function in the context of structural macroeconomic models, such as the one used by the Central Bank of Brazil, needs to take into account the deviation of the real interest rate from the neutral interest rate, or the natural rate of interest (Laubach & Williams, 2003; Gomes & Araújo, 2016) (Note 1).

The neutral interest rate is the one that keeps the economy in equilibrium, that is, when output is at its potential level and inflation is at its target. If the real interest rate (the nominal rate adjusted for inflation) is below the neutral rate, it tends to stimulate the economy, generating inflationary pressure. On the other hand, if the real rate is above the neutral rate, the effect is contractionary, reducing economic growth.

In the IS function, this difference between the real rate and the neutral rate is crucial because: 1. deviations of the real rate from the neutral rate signal how monetary policy is acting to either stimulate or contract the economy; 2. the concept of the neutral rate is closely linked to the economy's potential output. The difference between observed output and potential output (the output gap) is a key variable in the IS function, being influenced by monetary conditions; 3. The IS function needs to capture cyclical fluctuations in the economy, and the neutral rate is a crucial reference for identifying whether monetary policy is in a stimulative (dovish) or restrictive (hawkish) stance, especially in response to demand shocks.

Therefore, when estimating the IS function, it is necessary to incorporate the notion of deviation from the neutral rate to correctly capture the impact of monetary policy on economic activity. This also involves a significant technical challenge, as the neutral rate is not directly observable and needs to be inferred through econometric models.

In this sense, this study employs the Kalman Filter (Harvey, 1989) to extract the neutral interest rate as a latent variable, being consistent with a robust technique that has been widely adopted in empirical studies, including those conducted by central banks, such as the Brazilian one (Central Bank of Brazil, 2024).

Methodologically, this work estimates a small-scale structural VAR (SVAR) model that includes the percentage change in monthly real GDP as a proxy measure of economic activity and the real interest rate cycle (the difference between the real rate and the neutral rate estimated with the Kalman Filter). SVAR models allow for a "Shock View" approach, which analyzes how the unanticipated responses of a particular variable occur in response to a structural shock (an unforeseen change) in other model variables (Sims, 1980; Moreira & Monte, 2021).

The objective is to identify the dynamic relationships between the variables and observe how shocks in the real interest rate cycle affect the business cycle. Subsequently, a second small-scale structural VAR model includes the same variables as the first (GDP variation and real interest rate cycle) but with the neutral interest rate as an endogenous and stochastic variable in the system. This adjustment allows the dynamics of the neutral rate to be considered directly in the model, controlling for it. The idea was to observe how unforeseen variations in the real interest rate cycle (shocks) impact economic activity, considering the neutral rate as an endogenous factor that also reacts to economic shocks.

The main goal of this counterfactual exercise was to verify whether including the neutral interest rate in the model alters the interpretation of the effects of shocks in the real interest rate cycles on economic activity. This represents, in our view, a novelty in the literature applied to the Brazilian case. That is, the study tests whether controlling for the dynamics of the neutral rate modifies the conclusions regarding the impact of real interest rate cycles on business cycles. Although there is available evidence that structural shocks in real interest rates effectively impact the temporal dynamics of prices and inflation in the Brazilian economy (Moreira & Monte, 2021), as well as the dynamics of real cycles via household consumption (Moreira, 2024), such studies have not implemented the necessary control for the neutral interest rate, nor have they performed an adequate comparison using a counterfactual method.

Therefore, the method proposed in this paper can reveal whether the neutral rate is indeed an important mediator of these dynamics, or if the impact of real interest rate shocks is consistent regardless of the behavior of the neutral rate. Such an approach has the potential to provide valuable insights for monetary policy, as it clarifies the importance of monitoring the neutral interest rate and how deviations from it affect economic cycles.

To illustrate the importance of this monitoring, suppose there is an unanticipated increase in deviations of real interest rates. This could occur due to a monetary policy decision that raises the Selic (the short-term nominal rate) above market expectations, given inflation expectations and the neutral interest rate; but it is also consistent with a scenario where the Central Bank of Brazil keeps the Selic unchanged, given inflation expectations, while there is a reduction in the neutral interest rate (e.g., due to improvements in country risk or productivity levels) (Note 2). Nonetheless, in both cases where deviations in real interest rates increase, in the latter scenario, the contractionary effect on activity may be smaller, given the context of an overall improvement in the business environment. Thus, by not controlling for or monitoring the evolution of the neutral interest rate, monetary policy may lose efficiency in the calibration process of the anticipated and desired effects, underestimating the effectiveness of a real interest rate shock.

This paper is organized as follows: Section 2 provides an overview of the data and time series used in the estimation process, along with the methodological approach and the results of preliminary tests. Section 3 presents the core analysis of the impulse response functions (IRFs), based on baseline models. In turn, section 4 presents a robustness checking by extending the macroeconomic modelling. Finally, the paper concludes with final remarks, a list of references, and the Appendix.

2. Data, Methodological Strategy and Preliminary Tests

The neutral interest rate has a latent nature, meaning it is a variable that, by definition, is not directly observable. However, the assumption that, in the medium term, real interest rates tend to converge to their natural levels aids in the task of estimating this intrinsic component. From an empirical perspective, based on time series analysis, it is possible to define the model underlying the dynamics of the real interest rate:

$$r_t = \beta r_{t-1} + (1-\beta){r^*}_t + \varepsilon_t \quad (1)$$

In this context, r_t represents the short-term real interest rate, ${r^*}_t$ refers to the neutral interest rate, and ε_t is a white noise term with zero mean and constant variance. Modeling a first-order autoregressive component (AR(1)) in the real interest rate is consistent with Favero (2001). Thus, the parameter β captures the degree of persistence in the real interest rate. While the real rate is an observable variable and accessible through the Fisher equation, the neutral interest rate, in turn, needs to be estimated. A viable approach for this estimation is the use of the Kalman filter (Harvey, 1989).

A state-space model can be expressed as follows:

$$J_t = {z'}_t \theta_t + \mu_t \quad (2)$$

$$\theta_t = T_t \theta_{t-1} + \eta_t \quad (3)$$

Where J_t represents the observable variables, which are related to an M × 1, θ_t, called the state vector (t = 1, ... , T); ${\mathrm{z}'}_t$ is an N x M matrix, while μ_t is an N x 1 vector of disturbances with zero mean and covariance G_t.

In turn, although the elements in θ_t are latent, they can be determined by a first-order Markov process, while T_t is an M x M matrix, and η_t is a B x 1 vector of uncorrelated residuals with zero mean and covariance matrix Q_t. The estimation of the neutral interest rate can then be represented in the state-space model and extracted using the Kalman filter.

The temporal behavior of ${r^*}_t$ is the latent variable of interest for this study. In the case of the Brazilian economy, the real interest rate (r_t) was measured by defining a standard Fisher equation, taking the difference between the effective annual Selic rate (Banco Central do Brasil) and the inflation expectations based on the IPCA (Broad Consumer Price Index - IBGE) for the following 12 months (*ex-ante* real rate). Figure 1 shows the temporal behavior of the real interest rate, the neutral rate extracted by the Kalman Filter, from Feb/2003 to Dec/2022, as well as the real interest rate cycle component (rc_t), i.e., the difference between the observed real rate and the neutral rate extracted by the filter ($rc_t = r_t - {r^*}_t$). Particularly, the declining trend of the neutral interest rate over the last two decades is in line with a Brazilian stylized fact (Central Bank of Brazil, 2023/2024).

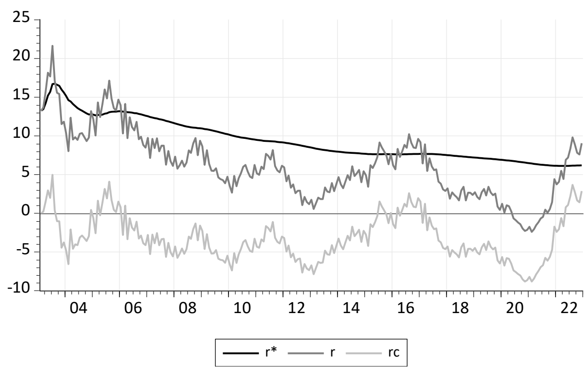

Figure 1. Real interest rate, neutral rate, and real interest rate cycle (Brazil: Feb/03–Dec/22)

Source: Own elaboration.

Conversely, the variable y_t, used as a proxy for the business cycle in the Brazilian economy, was the percentage change in monthly GDP (deflated using the IPCA) compared to the value from twelve months earlier (the monthly GDP data in current values and the IPCA were collected from the Brazilian Central Bank). Figure 2 shows the temporal behavior of the y_t series. The shaded areas reflect the periods of the greatest contractions in the growth rate of the Brazilian economy in recent decades: firstly, in 2003, the impacts of the electoral crisis of 2002, followed by the effects of the Subprime crisis (2008/2009); the domestic recessionary crisis (2014/2015); and at last the recessionary effects of the COVID-19 pandemic (2020). The estimations were conducted using monthly-frequency time series to increase the number of observations, given the sample limitations and the recognized volatility of Brazilian data. Hence, I opted not to use quarterly series.

A fundamental initial step in the time series estimation process is the identification of the order of integration. In order to test the null hypothesis of a unit root, the Augmented Dickey-Fuller (ADF) test was applied, with automatic lag selection for the test equation based on the Schwarz Information Criterion (SIC).

Table 1 presents the ADF test result for the three time series, r_t^*, rc_t, y_t. The result demonstrates that all three time series are integrated of order zero (I(0)), meaning they are stationary at level, given the rejection of the null hypothesis. Therefore, multivariate models, such as the Structural Vector Autoregressive (SVAR) model, can be estimated with variables at level, without incurring in spurious estimates.

In the second stage of the research, the objective was to infer unforeseen effects on the business cycle resulting from structural innovations in the real interest rate cycle of the Brazilian economy. For this, the Structural Vector Autoregressive (SVAR) method was applied. An SVAR model is a method that can address the identification problem in macroeconomics (Sims, 1980).

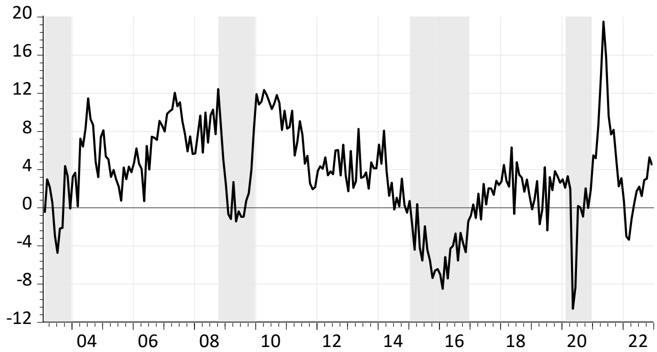

Figure 2. Business cycle (Brazil: Feb/03–Dec/22)

Source: Own elaboration.

Table 1. ADF Test for the baseline model's time series: Feb/03–Dec/22

	t-Stat	Prob.
rc	-3.188**	0.022
r^*	-5.627***	0.000
y	-3.483***	0.009

Note. test equations with a significant intercept and no trend for rc and y; and without intercept and trend for r^*.

Source: Own elaboration.

The method imposes recursive restrictions on the unanticipated variations of endogenous variables. Thus, emphasis is placed on the unanticipated responses of a specific variable to structural shocks in both the variable itself and the other variables in the model. The reduced form of an SVAR is given by:

$$X_t = \Gamma^{-1}B(L)X_t + \Gamma^{-1}e_t \quad (4)$$

where X_t is a vector of endogenous variables, Γ^{-1} is the inverse matrix of contemporaneous coefficients (Γ), $B(L)$ denotes the matrix of lagged coefficients, and e_t represents the variance-covariance innovation matrix. Consider $B^* = \Gamma^{-1}B$ and $u_t = \Gamma^{-1}e_t$. Thus,

$$X_t = B^*(L)X_t + u_t \quad (5)$$

It should be noted that the identification of restrictions assumes that innovations are orthogonal, so the covariance between two shocks in the variances is restricted to zero. Additionally, the SVAR imposes a normalization on the variances, making each of them unitary. This procedure allows the impulse response functions to be interpreted as the modeled system's response to unitary innovations, with $\Sigma_e = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} = I$, in the case of a bivariate model.

The identification, or order of causality, is determined by exclusion restrictions on Γ. For example, consider a bivariate model with x_{1t} and x_{2t}. Assume that a structural innovation (shock) in x_{1t} does not cause unexpected changes in x_{2t} ($\delta_{1,2} = 0$). The Γ matrix would be:

$$\Gamma = \begin{pmatrix} 1 & \delta_{2,1} \\ 0 & 1 \end{pmatrix} \quad (6)$$

This means that a condition of exogeneity was adopted (i.e., x_2 is contemporaneously exogenous, and x_1 is endogenous). In other words, an innovation $e_{2t} > 0$ causes unforeseen variations in x_{2t} ($u_{2t} > 0$) and also in x_{1t}. Empirically, exclusion restrictions must be justified, either based on theory or prior evidence.

The methodological strategy of this article is to estimate a first small-scale SVAR model that includes the percentage change in real monthly GDP as a proxy measure of economic activity and the real interest rate cycle (the difference between the real rate and the neutral rate estimated using the Kalman Filter). The objective is to identify the dynamic relationships between the variables and observe how shocks in the real interest rate cycle affect the business cycle. Subsequently, a second small-scale SVAR model includes the same variables as the first (GDP variation and real interest rate cycle), but with the neutral interest rate as an endogenous and stochastic variable in the system. Henceforth, we will refer to the first model as SVAR1 (rc_t and y_t) and the second as SVAR2 (rc_t, y_t and r_t^*).

For the SVAR1 model, the assumption was made that the real interest rate cycle is the contemporaneously exogenous variable, as it depends on a monetary policy decision by the Central Bank. An innovation in the real interest rate cycle ($e_{rc} > 0$) causes unforeseen variations in y_t ($u_y > 0$) and also in rc_t. Thus, the Γ matrix is as follows:

$$\Gamma_{SVAR1} = \begin{pmatrix} 1 & 0 \\ \delta_{rc,y} & 1 \end{pmatrix} \quad (7)$$

In turn, the SVAR2 model establishes exclusion restrictions based on the assumption that the neutral interest rate is the most contemporaneously exogenous variable, since it is linked to real factors and supply-side factors, making it less sensitive to the short-term business cycle. A change in the neutral interest rate then impacts the economy through changes in the real interest rate cycle and, consequently, in economic activity. Hence, $\delta_{x_i,r^*} = 0$, with x_i representing the other variables (rc and y). This indicates that unit shocks in both rc and y do not create unanticipated changes in r^*.

On the other hand, shocks in r^* impact rc and y. Therefore, $\delta_{r^*,rc}$ and $\delta_{r^*,y}$ are contemporaneous relationships that are different from zero. Furthermore, assume that shocks in the real interest rate cycles create simultaneous and unexpected changes in the business cycle, so $\delta_{rc,y}$ is not restricted to zero. The resulting matrix is:

$$\Gamma_{SVAR2} = \begin{pmatrix} 1 & 0 & 0 \\ \delta_{r^*,rc} & 1 & 0 \\ \delta_{r^*,y} & \delta_{rc,y} & 1 \end{pmatrix} \quad (8)$$

Since the SVAR model is composed of dynamic interactions and time lags in the relationships between endogenous variables, a preliminary step in estimating the SVAR1 and SVAR2 models was identifying their respective optimal lags. This identification is based on three information criteria: Akaike (AIC), Schwarz (SIC), and Hannan-Quinn (HQ). Table 2 shows the statistics obtained. It is concluded that the SVAR1 model should be estimated with 4 lags, while SVAR2 with 5 lags.

Table 2. Test for identification of the optimal lag

	Lag	AIC	SC	HQ
SVAR1	0	10.78237	10.8119	10.79428
	1	8.191315	8.279913	8.227038
	2	7.867776	8.015439*	7.927314
	3	7.870859	8.077588	7.954212
	4	7.756419*	8.022213	7.863587*
	5	7.787100	8.11196	7.918083
SVAR2	0	15.33826	15.38256	15.35613
	1	6.119826	6.297021	6.191271
	2	5.062029	5.372122	5.187059
	3	4.885668	5.328658	5.064281
	4	4.799607	5.375493	5.031804
	5	4.082163*	4.790947*	4.367944*

Source: Own elaboration.

In addition, to validate the stability of the estimated model parameters – a necessary condition to ensure no loss of reliability in the estimated central responses – this article also adopted the unit circle (inverse roots) test. The results show (Appendix) that all inverse roots satisfy the condition of values smaller than one, thus suggesting that our models' parameters present stability.

Once the SVAR1 and SVAR2 models are validated, impulse response functions (IRFs) are used for the purpose of the proposed counterfactual exercise. Canonical works that employed IRFs in the context of SVAR models were fundamental in the development of empirical evidence and methods in macroeconomics, such as Blanchard and Quah (1989), Galí(1999), and Christiano et al. (1999). Furthermore, criteria for dealing with autocorrelation, heteroscedasticity and normality in residuals were also considered (Note 3).

3. Core Analysis: The Impulse Response Functions

Starting from the estimation of the impulse response function with the SVAR1, a structural innovation of one standard deviation in the real interest rate cycle is accompanied by a downward trend in the growth rate of Brazilian real GDP over the next 24 months, compared to the normal growth rate. However, it is crucial to consider the confidence interval criterion (+/- 2 standard deviations). A very common error in economic analyses using IRFs is the omission of the statistical significance criterion, focusing solely on the economic direction of the estimated central response. On the other hand, when considering the statistical criterion, it is observed that the unanticipated responses of y to the structural shock in rc have statistical significance only in the 3rd, 6th, and 8th to 9th months after the occurrence of the structural innovation. These months are highlighted with shaded areas in Figure 4.

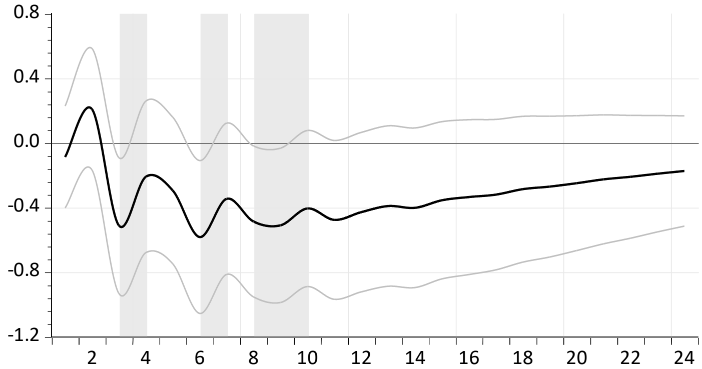

Figure 4. SVAR1: response of y to a structural shock (1 standard deviation) in rc

Source: Own elaboration.

The evidence is consistent with the theory and the prediction that a positive surprise in the real interest rate deviation triggers a contraction in consumption and investment decisions (also with potential losses in net exports due to exchange rate appreciation), thereby slowing down GDP growth. The most significant marginal effect occurs in the 6th month, with a decrease of 0.58 percentage point compared to the median or expected growth rate (3.1%). To illustrate, this means that, ceteris paribus, the monthly growth of real GDP would be around 2.52% in the 6th month following the mentioned shock.

However, the SVAR1 is estimated without explicitly including the neutral interest rate r^* as an endogenous variable. In contrast, the SVAR2 model includes this variable. The proposed counterfactual experiment compares the estimated effects of structural innovations in the real interest rate cycle on the business cycle, based on both models. Therefore, the estimation of the IRF through SVAR2 is the next step in the analysis.

Figure 5 presents the obtained evidence. It is observed that, in the case of SVAR2, controlling for the dynamics of r^*, a structural shock in rc is accompanied by more persistent and significant effects on y, with statistical significance from the 9th to the 21st month (shaded area). The most significant marginal effect occurs in the 12th month, with a decrease of 0.63 percentage point compared to normal growth (median of 3.1%). To illustrate, this means that, ceteris paribus, the growth of real GDP would be around 2.47% in the 12th month after the mentioned shock.

In comparative terms, the omission of the neutral rate in SVAR1 results in a loss of approximately 5% of the estimated marginal effects in the first 12 months (when measuring the sum of the statistically significant effects in both models), in addition to anticipating the initial impacts by 6 months. Moreover, there is a loss of up to 70% in the estimated effects over the 24-month horizon, compared to the projected responses in SVAR2. The corollary is that the calibration of monetary policy effects loses efficiency when central banks do not assess (or misassess) the dynamics of the neutral interest rate in the relevant horizon, and as a consequence of a real interest rate cycle surprise. Such a surprise proves to be much more effective on the business cycle when possible changes in the neutral interest rate are controlled.

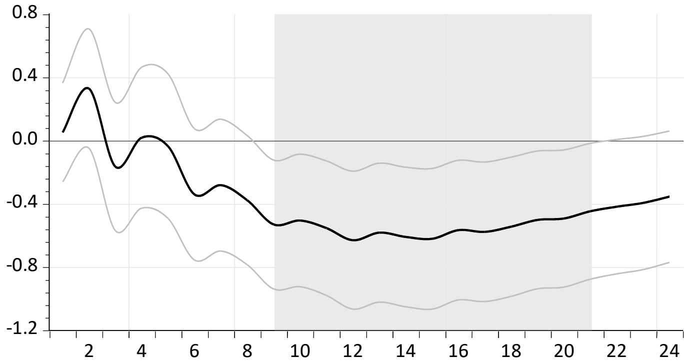

Figure 5. SVAR2: response of y to a structural shock (1 standard deviation) in rc

Source: Own elaboration.

4. Robustness Checking and Extended Model: US Long-Term Real Interest Rate and Country Risk

One way to assess the robustness of the obtained evidence is through an extension of the estimated parsimonious models. This can be done by including variables with macroeconomic relevance for determining the neutral interest rate and the monetary policy decisions of the Central Bank of Brazil. Therefore, the long-term real interest rate in the US (10-year Treasuries, source: FRED economic data) and the country risk measure (EMBI+ Brazil, source: JP Morgan) for the Brazilian economy were included. Both variables are fundamental in the international investors' arbitrage process, according to the theory of covered interest rate parity, and help to explain the neutral interest rate in Brazil (Barbosa et al., 2016; Central Bank of Brazil, 2023). Moreover, the country risk measure can be considered an explanatory variable for the fiscal dimension of the country, through its inverse and antecedent effects on Brazil's fiscal credibility (Demura & Moreira, 2020).

Following the same procedure as the baseline models, the ADF unit root test was applied to the two new time series: us for the long-term real interest rate in the US, and $risk$ for the country risk. The results showed that while the country risk measure is stationary in level, us is integrated of the first order, I(1). Thus, it was included in first difference in the new models ($d(us)$).

In the recalibrated model without the neutral interest rate, r^*, the variation in the US real interest rate was considered more exogenous, given its independence from Brazil. In turn, this reference rate theoretically impacts the perception of available liquidity for riskier, or emerging, economies, thereby influencing country risk. Both variables condition monetary policy decisions and, through the latter, the business cycle of the Brazilian economy. Therefore, the resulting matrix for the contemporaneous relationships Γ is,

$$\Gamma_{SVAR3} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ \delta_{d(us),risk} & 1 & 0 & 0 \\ \delta_{d(us),rc} & \delta_{risk,rc} & 1 & 0 \\ \delta_{d(us),y} & \delta_{risk,y} & \delta_{rc,y} & 1 \end{pmatrix} \quad (9)$$

Conversely, the counterfactual exercise in this robustness analysis was conducted based on the SVAR4 model, which includes the neutral interest rate r^*. From the perspective of the matrix of contemporary restrictions, the difference lies in the inclusion of the neutral interest rate as an intermediary between country risk and the real interest rate cycle. Thus, the resulting matrix is as follows,

$$\Gamma_{SVAR4} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ \delta_{d(us),risk} & 1 & 0 & 0 & 0 \\ \delta_{d(us),r^*} & \delta_{risk,r^*} & 1 & 0 & 0 \\ \delta_{d(us),rc} & \delta_{risk,rc} & \delta_{r^*,rc} & 1 & 0 \\ \delta_{d(us),y} & \delta_{risk,y} & \delta_{r^*,y} & \delta_{rc,y} & 1 \end{pmatrix} \quad (10)$$

The estimation of the models was then performed using the same information criteria (AIC, SIC, and HQ) adopted for defining the optimal number of lags and for the parameter stability tests, as in the baseline model. The tests indicated that both models, SVAR3 and SVAR4, should adopt 02 lags, and that their respective parameters are stable. Criteria for improving the properties of the residuals were similarly considered (Note 3).

For the SVAR3 model (without including r^*), the contractionary responses of the business cycle lose statistical significance (Figure 6), although the expected economic sign is maintained. Additionally, there is a positive response in the real GDP growth rate, occurring solely in the 2nd month following the monetary policy innovation.

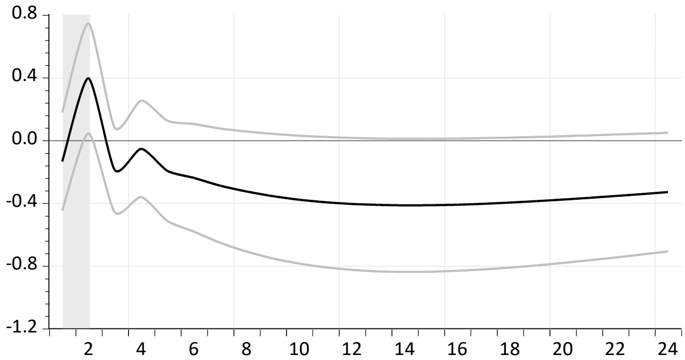

Figure 6. SVAR3: response of y to a structural shock (1 standard deviation) in rc

Source: Own elaboration.

However, in the SVAR4 model, when accounting for the endogenous dynamics of r^*, the real GDP growth rate remains below the normal level from the 7th to the 18th month after the monetary policy shock, with statistical significance (Figure 7). There is also an isolated, non-recurring response where the GDP growth rate exceeds the normal level in the 2nd month, similar to what was observed with the SVAR3 model. One way to explain this unexpected result, despite its non-recurrence within the relevant time horizon, is through the inertia of economic activity. It is widely accepted in the literature that the effects of monetary policy are only observed with time lags. Therefore, in the event of a real interest rate surprise (i.e. a rate above the expected level), the business cycle may delay and even show expansion in the very short term.

The joint analysis of the results from the response of the business cycle to shocks in rc across the two estimated models (SVAR3 and SVAR4) demonstrates the robustness of the preliminary estimates (baseline model), as there was a more pronounced deceleration response in the real GDP growth rate—considering statistical criteria—in the model that controls for the endogenous dynamics of the neutral interest rate.

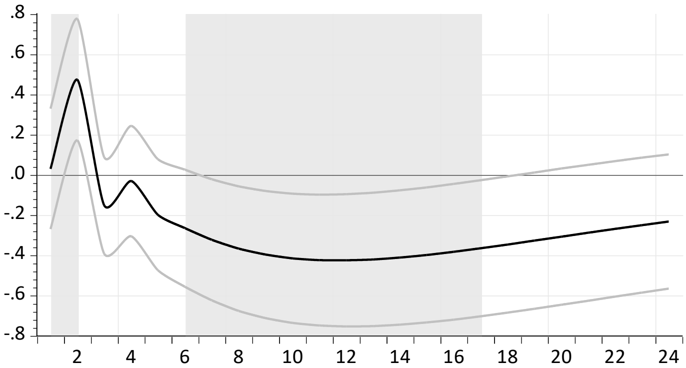

Figure 7. SVAR4: response of y to a structural shock (1 standard deviation) in rc

Source: Own elaboration.

5. Concluding Remarks

This brief article conducted a counterfactual experiment by comparing IRFs of two small-scale or parsimonious SVAR models. The objective was to verify whether the identification of the endogenous dynamics of the neutral interest rate has significant impacts on the estimated responses of the business cycle to structural monetary policy shocks.

Using time series data for the Brazilian economy, from Feb/2003 to Dec/2022, the article provided evidence that disregarding the neutral rate leads to a misspecification problem in the estimated structural model. There is a loss or underestimation of the effects on the business cycle when considering innovations in the real interest rate cycle.

These results have implications for monetary policy decision-making, both for the Central Bank of Brazil and for central banks around the world. The estimated structural models (Dynamic Stochastic General Equilibrium and/or SVARs models) should not only use a sample average estimate for the neutral rate, but also ensure that the projections of such models are generated based on the endogeneity and temporal dynamics of this rate. Failing to do so exposes monetary policy to risks of miscalibration in the adjustments of short-term nominal and real interest rates, which may result in unnecessary costs to society in terms of unemployment rate instability and slower economic growth. The current evidence was found to be robust for the inclusion of relevant times series in the determination of the neutral rate and of monetary policy decisions, such as the US long term real interest rate and the country risk perception.

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Competing Interests

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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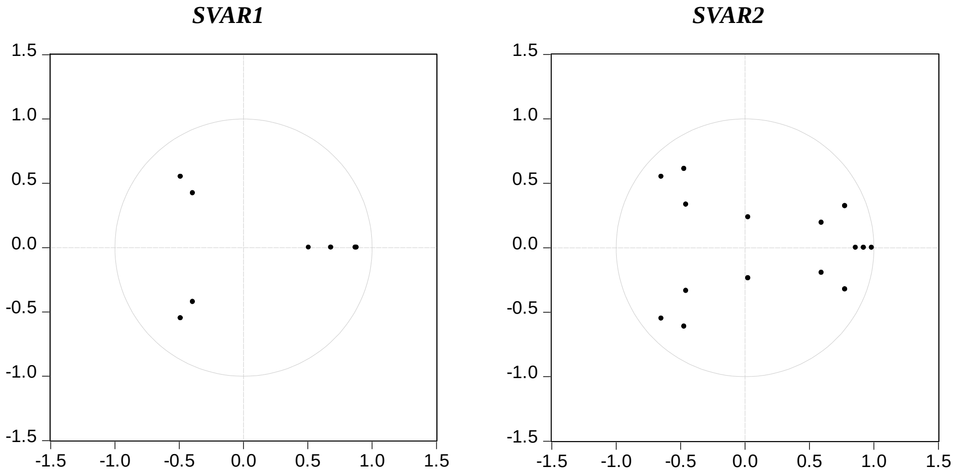
Notes

Note 1. For the purpose of this work, we focus on neutral rates. There exist some issues about neutral and natural rates as equivalent or different levels. For a discussion about possible divergences, see Obstfeld (2023). In summary, neutral rates are more relevant for monetary policy studies over the short and medium terms, as well as in the face of nominal rigidities (new Keynesian models); on the other hand, natural rates are more adherent to long term growth and flexible prices (walrasian) assumptions.

Note 2. Indeed, dos Santos and Moreira (2020) presented findings for Brazil indicating that an increase in total factor productivity (TFP) was associated with a reduction in consumer inflation rates. This suggests that, with accelerated productivity growth, there is likely a corresponding downward adjustment in the neutral interest rate, driven by a persistently lower inflation trajectory.

Note 3. All estimated models—including those in the robustness section—were specified with an emphasis on enhancing residual properties to determine the appropriate lag structure. Generally, increasing the order of VAR models effectively addresses issues of serial autocorrelation and heteroskedasticity (Lütkepohl, 2005). Residual non-normality, however, is a recurring issue in studies focusing on Brazil, given limited sample sizes and the country's economic volatility. In turn, the seminal work by Sims et al. (1990) underscores the specification of VAR models based on information criteria, as applied here, as well as parameter stability, without direct concern for residual properties. This approach is particularly suitable when the objective is not to generate out-of-sample economic forecasts. Accordingly, the SVAR models were estimated with the minimum number of lags necessary. Besides, there is a well-established distinction between statistical significance and practical significance in the sciences at large. While the former pertains to the likelihood or probability of an observed effect under test, the latter concerns the real-world magnitude or relevance of the effect (Ongaro et al., 2024; Kirk, 1996). Thus, the estimated effects in this paper are economically substantial and robust enough to offset potential issues from specific statistical hypothesis testing limitations. Nevertheless, further statistical refinements to the estimated models are encouraged, particularly through an expansion of the sample size.

Appendix



Test of the inverse roots of the characteristic polynomial (unit circle)

Source: Own elaboration.

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