Monetary Policy and Regional Output in Brazil*

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Contents: 1. Introduction; 2. Literature review; 3. Methodology; 4. Effects of monetary policy on Brazilian regional output; 5. Conclusion; A. Data; B. Variance decomposition of VARbr (related to Figure 1); C. ARDL specification for region's sensitivity to the common component - alternative to equation [4.1].

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This work presents an analysis of whether the effects of the Brazilian monetary policy on regional outputs are symmetric. The strategy developed combines the techniques of principal component analysis (PCA) to decompose the variables that measure regional economic activity into common and region-specific components and vector autoregressions (VAR) to observe the behavior of these variables in response to monetary policy shocks. The common component responds to monetary policy as expected. Additionally, the idiosyncratic components of the regions showed no impact of monetary policy. The main finding of this paper is that the monetary policy responses on regional output are symmetrical when the regional output decomposition is performed, and the responses are asymmetrical when this decomposition is not performed. Therefore, performing the regional output decomposition corroborates the economic intuition that monetary policy has no impact on region-specific issues. Once monetary policy affects the common component of the regional economic activity and does not impact its idiosyncratic components, it can be considered symmetrical.

O presente estudo consiste em verificar se são simétricos os efeitos da política monetária brasileira sobre a atividade econômica das cinco grandes regiões que integram o país. A estratégia desenvolvida combina as técnicas de análise de componentes principais (ACP), para decompor as variáveis que

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medem a atividade econômica regional em componente comum e componentes região-específicos, e de vetores autorregressivos (VAR), com objetivo de observar o comportamento dessas variáveis em resposta a choques de política monetária. O componente comum respondeu à política monetária conforme o esperado. Adicionalmente, os componentes idiossincráticos das regiões indicaram ausência de impacto da política monetária. A principal contribuição deste artigo está na constatação de que os efeitos da política monetária no produto regional indicam simetria quando há decomposição do produto e assimetria quando esta decomposição não é realizada. Efetuar a decomposição é um procedimento mais adequado e os resultados apresentam-se conforme a intuição econômica de que a política monetária não impacta questões região-específicas. Portanto, ao afetar o componente comum à atividade econômica regional e não impactar seus componentes idiossincráticos, a política monetária pode ser considerada simétrica.

1. INTRODUCTION

The theory of optimum currency area (OCA) emerged in the 1960s from the articles of Mundell (1961), Mckinnon (1963) and Kenen (1969). Since that time, it is almost undisputed that the monetary policy in a particular country may have effects beyond its territory. It is common to consider an OCA as comprising a group of countries; however, "[i]n principle, an optimal currency area could also be smaller that a country, that is, more than one currency could circulate within a country." (Alesina et al., 2002, p.2). Particularly in countries with a large geographical area, such as Brazil, a single monetary policy could have regional asymmetric effects on economic variables.

Monetary policy affects economic activity and inflation through several transmission mechanisms. Taylor (1995) argues that views on monetary policy transmission mechanisms differ in terms of the emphasis they place on money, credit, interest rates, exchange rates, asset prices, and the role of financial institutions. For Meltzer (1995), the monetary transmission mechanism is conditioned upon a type of hypothesis or theoretical orientation. According to the real business cycle hypothesis, for example, there are no monetary effects on real variables. However, from the perspective of other schools of economic thought, monetary impulses produce at least temporary real effects. Empirical studies highlight the relevance of different transmission mechanisms.

The literature on the effects of monetary policy shows that regional asymmetries of these effects can be explained by differences in the economic structures of regions. To investigate whether the United States is an OCA, Kouparitsas (2001) adopted the strategy of separating the real regional output into two components: a common component and an idiosyncratic (or region-specific) component. He did not reject the hypothesis that the effects are symmetrical.

The objective of the present study is to examine the effects of the Brazilian monetary policy on its five major regions. The regional effects of monetary policy on Brazilian economic activity are examined using two approaches: without and with the decomposition of the regional output, similarly to Kouparitsas (2001). According to the literature, asymmetry is expected in the first case and symmetry in the second.

To verify the behavior of macroeconomic variables in response to monetary policy shocks and to measure the impact of this policy, we estimate a vector autoregression (VAR). To decompose the regional output into common and idiosyncratic components, we use principal component analysis (PCA). Although the high correlation among the series of regional outputs indicates co-movement, we verify whether the common component has similar responses to the national output if it is included in a vector autoregressive model. The strategy continues with the analysis of the idiosyncratic, or region-specific, component to verify whether there are significant effects in response to monetary policy and whether these effects are symmetrical.

The main finding of this paper is that the monetary policy responses on regional output are symmetrical when the regional output decomposition is performed, and the responses are asymmetrical when this decomposition is not performed. Therefore, performing the regional output decomposition corroborates the economic intuition that monetary policy has no impact on region-specific issues.

This paper is divided into five sections, including the introduction and conclusion. The second section presents the literature review on theories of optimum currency area and on transmission channels of monetary policy and the third section presents the methodology and the data. In the fourth section, we analyze the Brazilian case, verifying the behavior of the variables of interest by combining the techniques of PCA and VAR.

2. LITERATURE REVIEW

2.1. Optimum Currency Area

The theory of optimum currency area (OCA) emerged in the 1960s from the articles of Mundell (1961), Mckinnon (1963) and Kenen (1969), which were written in the context of the debate on fixed or flexible exchange rates. The question then was whether a country was an OCA by definition-or, from a different perspective, if the optimum number of currencies was lower than the number of countries, how many countries should constitute monetary areas (Alesina et al., 2002).

Mundell (1961), in discussing the recurrent balance-of-payments crisis, questioned what the proper domain of a currency area would be. He argued that as long as fixed exchange rates and price rigidity prevent the occurrence of a natural adjustment process, the international price crisis would remain inherent within the international economic system. He contested the main solution proposed at the time, which was a system of national currencies connected by flexible exchange rates. The issue became more explicit in the definition of a currency area as an area in which exchange rates are fixed: "[W]hat is the appropriate domain of a currency area?" (p. 509). The theory of optimum currency area was his response. Noting that the movement in favor of flexible exchange rates was already strengthened, he argued that a system of flexible exchange rates should be adopted and be based on regional currencies, not on national currencies, for an optimum currency area would correspond to a region that does not necessarily coincide with the borders of a country. He acknowledged, however, the political components of currencies: "[I]n the real world, of course, currencies are mainly an expression of national sovereignty, so that actual currency reorganization would be feasible only if it were accompanied by profound political changes" (p.512). His paper generated a vast literature on the subject and triggered the debate over monetary unions.

Mckinnon (1963) proposed broader concepts of the subject, starting with the definition of optimum. While Mundell would consider the area in which it was possible to stabilize employment and the level of domestic prices to be optimum, McKinnon would consider an area in which the monetary, fiscal, and exchange rate flexibility could be used to achieve full employment, balance of payments stability, and stability of domestic prices to be optimum. According to McKinnon, to determine an optimal currency area, it is necessary to consider the size and the degree of openness of an economy, not only geographical considerations on the mobility of factors.

Kenen (1969) contributed to the debate with the perspective of the effects of monetary shocks by type of industry. He argued that the more similar the production structures, the more likely the economies constitute an optimal currency area. The reasons lie in the greater mobility of skilled labor (ignoring regulatory obstacles) and the common response to monetary shocks because countries with similar production structures have similar effects in terms of trade with the outside world. Further-more, highly diversified economies are more likely to constitute an optimal currency area. Finally, the author includes in his analysis the importance of fiscal integration between these economies.

The core of the theory of optimum currency area was structured in these seminal articles mentioned above. Further studies placed more emphasis on empirical verification. Frankel and Rose (1998) listed four criteria mostly considered in the literature on the analysis of the interrelationship between potential members of an OCA: extensions of trade, similarity of shocks and cycles, degrees of labor mobility, and tax and transfer systems. They concluded that some countries apparently are unsuitable candidates to join a monetary union, but their admittance *per se*, regardless of the reasons, allows commercial expansion, which can result in a higher correlation with business cycles. Therefore, it is more reasonable to expect that a country meets the criteria for entry into a monetary union in an *ex post* analysis than in an ex ante analysis (p. 22). Rose and Engel (2000) conducted a study to verify whether countries belonging to monetary unions are as integrated as regions forming a political union.[1] They used the criteria of Mundell (1961) to conclude that countries belonging to a monetary union are more integrated than countries with their own currency; however, they are less integrated than the regions that form a political union.

Although the hypothesis to be tested in the current study is narrower than the concept of an optimum currency area, it is essential to understand that a country having its own currency is not necessarily the country's best option. According to Rose (2000), monetary unions are generally perceived as having microeconomic benefits and macroeconomic costs. The benefits are usually associated with a reduction in transaction costs by eliminating the exchange rate risk, while the most obvious cost is the possible loss or reduction of the effectiveness of counter-cyclical policies. The main concern of a monetary union is which countries will possess greater clout in determining the monetary policy to be adopted. Although it is more common to think of a group of countries belonging to an optimum currency area, this area may be smaller than the borders of a country, especially in countries with a large geographical area, such as Brazil.

2.2. Transmission channels of monetary policy

The "Monetary Transmission Mechanism" symposium held in 1995 and the resulting papers published in the Journal of Economic Perspectives in the same year are considered focal to the study of the transmission channels of monetary policy.

Mishkin (1995) presented an overview of the concepts and theoretical positions discussed at the symposium. He emphasized the importance of the topic because politicians and economists advocated output and inflation stabilization through monetary policy instead of fiscal policy. This preference was due in part to persistently high budget deficits and in part to the doubts about the ability of the political system to make timely decisions to stabilize output and prices. Thus, monetary policy became the focus of macroeconomic policymakers. Although powerful, monetary policy sometimes generates unexpected or unwanted effects. To implement successful policies, monetary authorities must be conscientious about the timing and the effects of their actions, which is only possible if the mechanisms through which monetary policy affects the economy are known.

For Taylor (1995), views on the transmission mechanisms of monetary policy differ in the emphasis they place on currencies, credits, interest rates, exchange rates, asset prices, and financial institutions. He focused on the international component, considering that exchange rates assume a key role in the transmission mechanisms. Obstfeld and Rogoff (1995) also directed their analysis to exchange rates. They noted that no one would expect that, after the collapse of fixed exchange rate regimes in the

[1] The authors draw upon the concepts of intra-national political unions as "sovereign states with a single currency but also common laws, political environments, cultures, and so forth" and of international currency unions as "sovereign countries that have delegated monetary policy to some international or foreign authority but retain sovereignty in other domains." The United States, France and the UK are examples of political unions.

1970s, exchange rates would behave as volatile as they did in the following decades. The authors analyzed empirical data from recent crises and reinforced the understanding that monetary policy loses autonomy under fixed exchange rates; thus, the policy reflects events outside the country. Bernanke and Gertler (1995) argued mainly about the credit transmission channel,[2] highlighting two linkages: the balance sheet channel, whose analysis rests on the borrowers' balance sheets and income statements, including cash flow and liquid assets, and the bank lending channel, in which they assessed the effects of monetary policy on bank lending. Meltzer (1995) stated that the monetary transmission process is conditional on some type of hypothesis or theoretical orientation. The author argued that the understanding of the transmission process helps to interpret the events during the tense interlude between the time that political action is taken and the moment that the effects on output and inflation become visible. During this interlude, pressures on the monetary authority to abandon its rule or change its policy tend to be intense (p. 70).

Several empirical studies aimed to measure the effects of monetary policy on macroeconomic aggregates. Sims (1980), with his criticism of large-scale models used in macroeconomics, offered the seminal work. His argument refers to the low resemblance of the models to reality, criticizing the use of a high number of parameters and constraints, as well as the choice of variables that are considered exogenous. In his proposed solution, estimation by vector autoregression (VAR), these models are used in a reduced form and the variables are endogenous. Table 1 summarizes these studies, including those with Brazil as the object of study. The empirical evidence with respect to different models and periods indicates the existence of effects of monetary policy on the level of activities.

Table 1: Summary of the models on the effects of monetary policy

Reference	Country	Period	Technique	Variables used in the model	Effect of monetary policy on output
Sims (1980)	USA Germany	1949-1975 1958-1976	VAR	Output; money; unemployment; income; inflation; import prices.	Significant.
Bernanke and Gertler (1995)	USA	1965-1993	VAR	Output; output deflator; commodities index; federal funds.	Significant.
Christiano et al. (1999)	USA	1965-1995	VAR	Output; output deflator; commodities index; federal funds; international reserves; money.	Significant.
Minella (2003)	Brazil	1975-2000	VAR	Output; inflation; interest rate; money.	Significant.
Arquete and Jayme Jr. (2003)	Brazil	1994-2002	VAR	Output gap; inflation; interest rate; exchange rate; international reserves.	Significant.
Céspedes et al. (2005)	Brazil	1994-2004	VAR	Output; inflation; exchange rate; interest rate.	Significant.
Sales and Tannuri-Pianto (2007)	Brazil	1994-2004	VAR	Industrial production; inflation; international reserves; interest rate; exchange rate; discount rate.	Significant.
Minella and Souza-Sobrinho (2009)	Brazil	1999-2007	Semi-structured model	Aggregate demand and supply; financial sector; monetary policy; external sector.	Significant.
Aragón and Portugal (2009)	Brazil	1995-2006	MS-VAR	Industrial production; inflation; interest rate.	Significant.
Tomazzia and Meurer (2009)	Brazil	1999-2008	VAR	Output; inflation; interest rate; exchange rate; industrial sectors.	Significant.

2.3. Regional effects of monetary policy

The original proposition of Mundell (1961) generated other research fields. One such field aims to evaluate the effects of the monetary policy of a country in the regions that constitute it. Based on

[2] The authors argue that the so-called "credit channel" refers to a set of factors that amplify and propagate the effects of interest rates, and not a distinct mechanism of transmission of monetary policy such that the term would be inappropriate. They recognize, however, that the term is consolidated.

quarterly data from 1958 to 1992 relating to forty-eight U.S. states grouped into eight regions defined by the Bureau of Economic Analysis (BEA), Carlino and Defina (1998) found asymmetry of the regional effects of the US monetary policy. The sources of these asymmetric effects are derived from the different structures of the states. Carlino and DeFina especially highlighted the banking structure, which affects the transmission of monetary policies through the credit channel, and the industrial structure, which affects the transmission by the size of enterprises and the types of production. A structural VAR model was used to measure the dynamic relationships between the real *per capita* income of the states, the interest rates of federal funds, core inflation, the index of leading indicators of the BEA, and the producer price index for fuels and related products relative to the overall producer price index.

Kouparitsas (2001) examined quarterly data between 1969 and 2001 for the same eight BEA regions, combining unobserved components and VAR techniques with the argument that it is necessary to evaluate separately the common and the idiosyncratic movements of each region. According to the author, in 1913, there were doubts about the viability of the U.S. Federal Reserve System because of the previous two failures to establish a central bank in the country.[3] Similar doubts were also raised about the viability of the European Monetary Union, and one of the arguments was that this region would not be an optimum currency area. For Kouparitsas, despite the fact that the United States is not an optimum currency area, a monetary union was feasible; thus, the same argument may apply to the European Monetary Union. The author's main objective was to demonstrate that the United States, a successful monetary union, does not necessarily behave as an optimum currency area as a whole; thus, by analogy, the same finding could hold true for Europe. In this context, the hypothesis of symmetry in the regional effects of U.S. monetary policy is not rejected if the common and idiosyncratic components of regional outputs are evaluated separately: "idiosyncratic responses to monetary policy shocks are not statistically different from zero in all eight BEA regions. This finding stands in contrast to the general conclusion of Carlino and Defina (1998) that monetary policy has a greater effect on the income of more manufacturing oriented regions, such as the Great Lakes" (Kouparitsas, 2001, p. 18).

Regarding the impact of Brazilian monetary policy in their regions, Vasconcelos and Fonseca (2002) adopted a similar strategy as Carlino and Defina (1998) to analyze the effects on regions in Brazil in relation to the credit channels and the size of industries. They concluded that the North and Northeast regions tend to suffer from greater impacts resulting from changes in interest rates. In the same vein, Bertanha and Haddad (2008) found that the North and Northeast regions are those whose employment levels are most affected by increases in interest rates in the economy. Araújo Jr. (2004), in turn, concluded that the South has a stronger reaction to monetary policies than the Northeast.

Following Kouparitsas (2001), Teles and Miranda (2006) analyzed data from Brazilian regions. They found that the responses to the short-term dynamics vary dramatically between regions and that the idiosyncratic components are the main causes of regional cycles (p. 279). They claimed that despite the advantages of a single currency, such as the reduction of financial and transaction costs, the same monetary policy would not have the ability to be stabilizing for all regions, impacting the regional distribution of income.

Ishii (2008) assessed the Brazilian regions by measuring the regional economic activity based on data from a state tax, the Tax on Circulation of Goods and Services. He concluded that Brazil is not an optimum currency area; however, he found that shocks on the interest rate and on the indicator of national activity have a similar behavior between regions (p.112), despite the differences of the idiosyncratic component as the source of regional disturbance. Silva et al. (2010) presented what they called the theoretical limitations of the conventional theory on regional impacts of monetary policy and concluded, under the post-Keynesian conception, that the effects are asymmetric.

[3] From 1791 to 1811 and from 1816 to 1836, institutions similar to the Bank of England were created in the United States, which functioned both as a monetary authority and as a commercial bank under private equity control. On both occasions, Congress did not renew the authorization of their operation.

Rocha et al. (2011) used monthly data from January 1995 to December 2010 on industrial production in Brazil and Brazilian states, inflation, and interest rates. From the impulse response functions obtained from their VAR model, they concluded that Brazilian states have asymmetric responses to monetary policies. They emphasized that they found no response patterns if the states were grouped within five geographic regions (p. 420). The Central Bank of Brazil (BCB), in its Regional Bulletin of January 2011, announced the study "Regional Business Cycle Synchronization" (Banco Central do Brasil, 2011a), which analyzed the regional correlations through the cycles extracted from the series of regional economic activity by passing the Hodrick-Prescott filter. According to the BCB, the fact that the correlations between regions are high suggests the relevance of common factors influencing the regional cycles (p.93). The BCB concludes that monetary policy decisions that seek to respond to aggregate shocks to ensure compliance with the inflation target do not tend to induce asymmetric effects on regional economic activity in Brazil (p.90). The analysis of correlations, however, does not allow comparisons of sources and responses of disturbances in the regions, which justifies the relevance of a broader use of techniques such as vector autoregression.

In short, the reviewed literature suggests that countries do not necessarily behave as an optimum currency area, experiencing asymmetric effects of monetary policies on the regions. However, the result of symmetry of monetary policies obtained by Kouparitsas (2001), by separating the common component from the idiosyncratic component of regional outputs in the United States, offers an alternative analysis for the Brazilian case.

3. METHODOLOGY

3.1. Estimation

The influential paper by Sims (1980) disseminated the use of vector autoregressions for the analysis of the dynamics of economic systems.

A time series yt can be modeled as autoregressive,

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + ... + \phi_p y_{t-p} + \varepsilon_t, \tag{1}$$

with

$$E(\varepsilon_t) = 0 \tag{2}$$

$$\begin{aligned} E(\varepsilon_t \varepsilon_\tau) &= \sigma^2, for\ t = \tau \\ &0, for\ t \neq \tau \end{aligned} \tag{3}$$

A vector autoregression of the order p, denoted VAR (p), is a generalization of [3.1] to [3.3]:

$$y_t = c + \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + ... + \Phi_p y_{t-p} + \varepsilon t, \tag{4}$$

where y_i is a $n \times 1$ vector containing endogenous variables for $i = t, t-1, ..., t-p$, c is a $n \times 1$ vector of constants, and Φ_j is a $n \times n$ matrix of autoregressive coefficients for $j = 1, 2, ..., p$. The vector ε_t has the dimension $n \times 1$ and is a generalization of white noise:

$$\begin{aligned} E(\varepsilon_t) &= 0 \\ E(\varepsilon_t \varepsilon_\tau`) &= \Omega, para\ t = \tau \\ &0, para\ t \neq \tau \end{aligned}$$

A vector autoregression is a system in which each variable is regressed against a constant, p lags of itself and p lags of the other variables (Hamilton, 1994, p.258). (Hamilton, 1994, p. 291-4) shows that estimating Φ by OLS is equivalent to maximizing its likelihood function. However, some issues that are not undisputed in the literature remain, such as the most appropriate way to recover the parameters of the structural model or the question of whether the variables included in the VAR must be stationary.[4]

Regarding the recovery of structural parameters, the present work follows Sims (1980) in that we impose minimum restrictions to the theoretical model; thus, we use a Cholesky decomposition. Regarding the stationarity of the series, there are different treatments in the literature: for example, all series in its stationary form, all series in level, and use of error correction mechanisms.[5] Hamilton (1994) mentioned three alternatives:

1) ignore the non-stationarity and estimate the VAR in level;

2) differentiate the non-stationary variables before estimating the VAR;

3) scrutinize the nature of the non-stationarity and test the possibility of a co-integration between the variables.

In the present study, we chose to use variables in a stationary form because the different orders of integration of the variables discard the use of models that incorporate co-integration relationships.[6] Additionally, the use of variables in a stationary form fits better with the technique of a principal component analysis (PCA), as described in subsection 4.1.

Because an unrestricted VAR is by nature sub-identified,[7] it becomes necessary to impose additional constraints to generate the impulse response functions (IRF). The triangular decomposition of residuals is called a Cholesky decomposition. In a bivariate case, it involves imposing that y_t does not contemporaneously affect z_t. Despite the restriction that a shock εy_t produces no direct effect on z_t, there is an indirect effect because lags of y_t contemporaneously affect values of z_t. A key aspect to observe is that this decomposition forces a potential asymmetry in the system because a shock εz_t contemporaneously affects yt and z_t (Enders, 2004, p. 275).

In the estimation process, the following steps are taken:

(a) decomposition of proxy variables of regional economic activity into common and region-specific components by principal component analysis;

(b) unit root test on variables;

(c) estimation of the VAR parameters;

(d) determination of the number of lags;

(e) calculation of the IRF and its confidence intervals.

[4]In this context, stationarity is equal to covariance stationarity.

[5]The references to the theoretical debate are, among others, citetHamilton1989, Hamilton1994, Christiano and Eichenbaum (1989), and Sims et al. (1990).

[6]We assessed a model with non-stationary variables that resulted in a worse specified model, although with similar results.

[7]In a VAR with n variables, an accurate identification requires the imposition of $(n^2 - n)/2$ restrictions on the relationship between the estimated residuals and the structural innovations (Enders, 2004, p. 291-5).

3.2. Data

The data relating to exchange and interest rates and to the economic activity of the country and its five regions were obtained from the website of the Central Bank of Brazil (BCB). The data relating to inflation were available on the website of the Brazilian Institute of Geography and Statistics (IBGE). The complete references can be found in the Appendix. The database covers the period between January 2002 and December 2011 (one hundred and twenty observations) and is limited by the availability of monthly data on regional economic activity. The following are comments on the variables used to estimate the models.

The Central Bank of Brazil in January 2009 presented the Regional Economic Activity Index of Rio Grande do Sul (IBCR-RS), stating that the timely monitoring of monthly activity of regional economies is often a relevant tool for understanding the evolution of national indicators (Banco Central do Brasil, 2009). Using stylized data from the state of Rio Grande do Sul, IBCR-RS showed a strong adherence to the annual regional output measured by the IBGE. Subsequently, this indicator was expanded to measure the activity of some states and of all regions of the country. In March 2010, a national indicator, the Economic Activity Index of Central Bank - Brazil (IBC-Br), was established. By embodying the characteristics of the regional IBCRs, the IBC-Br reflects the contemporary evolution of the country's economic activity and contributes to the development of the monetary policy strategy (Banco Central do Brasil, 2010, b).

In the studies reviewed in section 2, industrial production and employment data were typically used as proxies for regional economic activity-for example, by Araújo Jr. (2004) and Bertanha and Haddad (2008). Although data from industrial production and employment correlate to economic activity, they do not capture all movements that may occur in a region. In some cases, annual data were used; for example, Teles and Miranda (2006) used regional outputs divulgated by the IBGE. However, the frequency of annual data limits the effectiveness of measuring the effects of monetary policy, as noted by (Teles and Miranda, 2006, p. 269) and Kouparitsas (2001, p. 4).

Therefore, when constructing indicators of economic activity for the country and its regions on a monthly basis, the BCB has provided new and important variables that can be incorporated into models that use some measures of economic activity. These data are relevant to works that attempt to measure regional effects of monetary policies because its methodology produces uniform rates for different regions of the country while capturing their idiosyncrasies.

In the present analysis, we follow the principal studies on the Brazilian economy, reviewed in the preceding section, regarding the inclusion of variables to obtain a properly specified model. In general, in addition to a variable referring to economic activity, variables that represent monetary policies and price behavior are used. Thus, we use:

i) the National Index of Consumer Price Index (IPCA) as a measure of inflation;

ii) the Real/U.S. dollar exchange rate as a representative of the external sector (USD);

iii) the rate of the Special System for Settlement and Custody (SELIC) as a proxy of the economy's basic interest rate;

iv) the IBC-Br and the IBCRs that represent national and regional economic activity. Table 2 presents the descriptive statistics and Table 3 a correlation matrix for the variables.

Table 2: Descriptive statistics

	IPCA	USD	SELIC	IBC_BR	IBCR_CO	IBCR_N	IBCR_NE	IBCR_S	IBCR_SE
Mean	145,37	2,27	14,90	120,81	118,44	125,23	118,80	115,33	120,09
Median	144,59	2,16	13,66	121,62	115,45	127,25	116,99	112,78	117,53
Maximum	187,78	3,81	26,32	142,02	149,00	154,66	147,75	143,60	148,29
Minimum	100,52	1,56	8,65	99,91	98,37	98,48	97,70	99,06	98,49
Std. Dev.	23,20	0,56	4,55	12,69	14,01	16,52	15,20	12,15	15,93
Skewness	-0,09	0,73	0,72	0,01	0,44	-0,10	0,35	0,50	0,25
Kurtosis	2,18	2,62	2,90	1,77	2,06	1,92	1,96	2,07	1,76
Jarque-Bera	3,5121	11,4027	10,5030	6,7753	8,3347	6,0927	7,8683	9,4016	8,9749
Probability	0,1727	0,0033	0,0052	0,0338	0,0155	0,0475	0,0196	0,0091	0,0112
Sum	17444	273	1788	13048	14212	15027	14256	13840	14411
Sum Sq. Dev.	64035	37	2463	17241	23348	32494	27494	17561	30195
Observations	120	120	120	108	120	120	120	120	120

Table 3: Correlation matrix

	IPCA	USD	SELIC	IBC_BR	IBCR_CO	IBCR_N	IBCR_NE	IBCR_S
USD	-0,867							
SELIC	-0,803	0,820						
IBC_BR	0,976	-0,905	-0,838					
IBCR_CO	0,989	-0,836	-0,773	0,975				
IBCR_N	0,968	-0,927	-0,823	0,981	0,957			
IBCR_NE	0,993	-0,867	-0,795	0,985	0,995	0,973		
IBCR_S	0,970	-0,820	-0,779	0,976	0,985	0,947	0,982	
IBCR_SE	0,986	-0,889	-0,822	0,996	0,987	0,977	0,993	0,984

4. EFFECTS OF MONETARY POLICY ON BRAZILIAN REGIONAL OUTPUT

4.1. Decomposition of variables that measure economic activity

Kouparitsas (2001) adopted a strategy of variables decomposition that measures regional outputs to separately evaluate its common and region-specific or idiosyncratic components.[8] His model, written in state space format for the likelihood function to be calculated with the Kalman filter, allows unobserved variables to be dynamic and associated with observed variables. The resulting model is not entirely parsimonious because there are many parameters to be estimated. However, because Kouparitsas analyzed a period of more than thirty years, from 1969 to 2001, it was necessary to adopt a model with time-varying parameters that is more sensitive to structural changes.

This strategy, according to (Commandeur and Koopman, 2007, p.113), "[i]s closely related to the factor analysis and principal component analysis". Therefore, considering that, in the present study,

[8] According to Commandeur and Koopman (2007, p.113), "The existence of a common component can lead to more insights in certain aspects of the time series of interest".

we analyze a period of just ten years, equivalent to one hundred and twenty observations, the main interest is in impulse response functions. Additionally, because models in state space format increase the number of parameters to be estimated, we opted for an alternative strategy, principal component analysis (PCA), to estimate the common component separately; this technique consists of applying orthogonal transformations of a possibly correlated group of variables to convert them into a set of uncorrelated data, called principal components. This transformation is defined such that the first principal component contains the maximum variance possible, and so on for the other components, subject to constraints of orthogonality.

Accordingly, the variables representing regional economic activity were decomposed into unobserved components to extract a common component. Following Kouparitsas (2001), it is assumed that the output of region i at time t, y_{it}, is the sum of two unobserved components: a component common to all regional outputs χ_t and an idiosyncratic, or region-specific, component χ_{it}. Regions may have different sensitivities to the common component, measured by parameter γ_i. Thus,

$$y_{it} = \gamma_i \chi_t + \chi_{it}, \tag{5}$$

for all i = 1, ..., 5.

Note that the common component χ_t is the country output smoothed by eliminating idiosyncratic components of the regions, which is confirmed by high correlations[9] between this common component and the IBC-Br, an indicator that measures Brazilian economic activity. Parameters γ_i and series χ_{it} were obtained by ordinary least squares (OLS). Table 4 demonstrates the significance of parameters γ_i for all regions.[10]

Table 4: OLS regression by principal component against the IBCR by region

Dependent variable	**Variable**	**Coefficient**	**p-value**
dln_ibcr_co100	pc	0.2578	0.0000
dln_ibcr_n100	pc	0.6769	0.0000
dln_ibcr_ne100	pc	0.2601	0.0000
dln_ibcr_s100	pc	0.5349	0.0000
dln_ibcr_se100	pc	0.5026	0.0000

4.2. Unit root tests

Considering the recognized low power of unit root tests, we evaluate two of the most adopted tests in the literature: the Augmented Dickey-Fuller (ADF) and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) tests.

[9] 0.99 and 0.67 for series taken in level and in first difference, respectively.

[10] As the equation 4.1 results in a static specification of the region-specific components, we included lagged elements in the equation in order to introduce dynamics in the relationship between regional outputs and the common component:
$y_{it} = \gamma_{i0}\chi_t + \gamma_{i1}\chi_{t-1} + \ldots + \gamma_{ip}\chi_{t-p} + \beta_{i1}y_{t-1} + \beta_{i2}y_{t-2} + \ldots + \beta_{iq}y_{t-q} + X_{it},$

for all i = 1, ..., 5.

We tested models with up to six lags (p and q) and found no statistical significance in these lags (results are in the Appendix 3), indicating that the specification [4.1] is appropriate.

The results of the ADF test for the common component to regional outputs and data levels of prices and exchange rates does not reject the null hypothesis of a unit root. Moreover, the interest rate and idiosyncratic components of regional outputs reject the hypothesis of the presence of a unit root. These results are in line with those reported in the literature. The KPSS test confirmed these results, except for the IBC-Br and IBCR-SE series. As described in the following sections, the results regarding the impulse response functions with data from the Brazilian economy were similar in terms of significance and lag effects. However, the residuals for variables in a stationary form showed a better behavior, and the results were similar to those found in the literature. Considering that the strategy of a principal component analysis to obtain region-specific components fits better if variables are stationary, we chose to evolve the models in this respect; i.e., we take the first difference of the natural logarithm, multiplied by 100, of a series corresponding to regional outputs and its principal components, inflation and exchange rates. The interest rate received no transformation because the hypothesis of the presence of a unit root was rejected for the level series. We further included a constant and a linear time trend as pre-determined variable.

4.3. Estimation

The parameters of the VAR models were estimated by a maximum likelihood method using EViews 7.0. We adopted the most common procedure, which is to define variables that comprise each VAR from the economic theory and similar studies; then, we chose the lag length based on certain information criteria, such as Akaike or Schwarz. If the residuals were normally distributed, homoscedastic and not serially correlated, the model was fitted; generally, if this did not occur, we attempted to eliminate the serial correlation by increasing the lag length and heteroscedasticity with dummy variables.

Our results are in line with those reported in the literature: poor models in terms of normality, but with an absence of serial correlation and, generally, homoscedastic. Because this present study is directed toward the behavior and significance of impulse response functions (IRF), the confidence intervals of these IRF are relevant. We estimated these intervals by an analytical method and Monte Carlo simulation (10,000 replicates), finding similar results in terms of significance, as described in the following sections.

4.3.1. VAR Brazil (VARbr)

First, we estimated a country model in its reduced form with four endogenous variables: common component, inflation, exchange and interest rates, in addition to a constant and linear trend. The first principal component of variables representing regional economic activity, the common component, was obtained by the method described in section 4.1 and explained 40% of the IBCR variance, indicating the existence of a common component. The results are reported in Table 5.

The high correlation[11] between this common component and the proxy of national output offers strong evidence that it is representative of national economic activity. However, a more robust assessment of this representation is to verify if the behavior of this common component, measured by impulse response functions generated in a vector autoregressive model, is similar to that observed in studies on the Brazilian economy referred to in section 2, which generally use the quarterly GDP or industrial production as a proxy for national economic activity.

For this study, a VAR model with a 2 lag length was chosen considering Akaike and also Schwarz as information criteria. According to this specification, the hypothesis of no serial correlation in residuals was not rejected based on the Breusch-Godfrey test. Despite the fact that normality in residuals by the Jarque-Bera test and homoscedasticity according to ARCH-LM was rejected, even when imposing

[11] 0.99 and 0.67 for series taken in level and in the first difference, respectively.

Table 5: Principal Component Analysis

Eigenvalue Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	1.982598	0.689634	0.3965	1.982598	0.3965
2	1.292964	0.564780	0.2586	3.275.562	0.6551
3	0.728184	0.169165	0.1456	4.003746	0.8007
4	0.559019	0.121784	0.1118	4.562765	0.9126
5	0.437235	—	0.0874	5.000000	1.0000

dummies[12], this specification was considered appropriate for our purposes. The appropriateness of its use was confirmed by the impulse response functions behavior showed in the following graphics.

The unrestricted vector autoregressive models estimated in reduced form must have additional restrictions to obtain IRF, as mentioned earlier. The following order was adopted to identify structural parameters recursively from a residual triangular decomposition (Cholesky decomposition): common component, inflation, exchange and interest rates. Therefore, it is assumed that innovations in output, measured by the common component, affect but are not contemporaneously affected by inflation and exchange and interest rates; the inflation innovations have contemporaneous effects on the exchange and interest rates and lagged effects on output; the exchange rate innovations have contemporaneous effects on the interest rate and lagged effects on output and inflation; and interest rate innovations have lagged effects on output, inflation and exchange rates. Implicit in this structure is the understanding that the monetary authority both reacts to and affects the economy when setting its policy.

Although this ordering has an economic logic, it is usually possible to make another ordering that also seems consistent, which is a common criticism of this method. However, an important aspect described by Enders (2004) to exemplify a bivariate model should be considered: *It is crucial to note that the importance of the ordering depends on the magnitude of the correlation coefficient between e1t and e2t (p. 276). If the correlation coefficient between* e_{1t} *and* e_{2t} *is low, the ordering is not likely to be important (p.292).* In our model, the residual correlation matrix indicated a low correlation between residuals, which facilitated the acceptance of the proposed order. Additionally, we evaluated generalized impulse response functions, as proposed by Pesaran and Shin (1998), as an alternative to the problem of variables ordering. The results of both approaches converge.

Figure 1 shows graphics of the IRF VARbr model, and complete variance decomposition tables are in Appendix. The resulting IRF exhibits a similar behavior to that reported in the literature reviewed in section 2, showing the significance of the monetary policy (SELIC) for the real output (PC); the relevance of the exchange rate shocks (USD) for prices (IPCA); the significance and puzzle effect of prices in response to monetary policy; and the response of monetary policy to inflationary shocks. Although the expected significance of the response of the exchange rate to monetary policy is not observed - in the literature this relationship is not often found in empirical analysis - the response of the exchange rate shocks to monetary policy was as expected, as observed in the last graph of Figure 1. Given this behavior, the VARbr model was considered satisfactorily specified for the purpose of reproducing findings from the literature on stylized facts of the Brazilian economy.

[12]Dummies regarding the internal crisis in late 2002 and early 2003 and the global financial crisis in late 2008.

Figure 1: Selected graphics of impulse response functions from the VARbr model

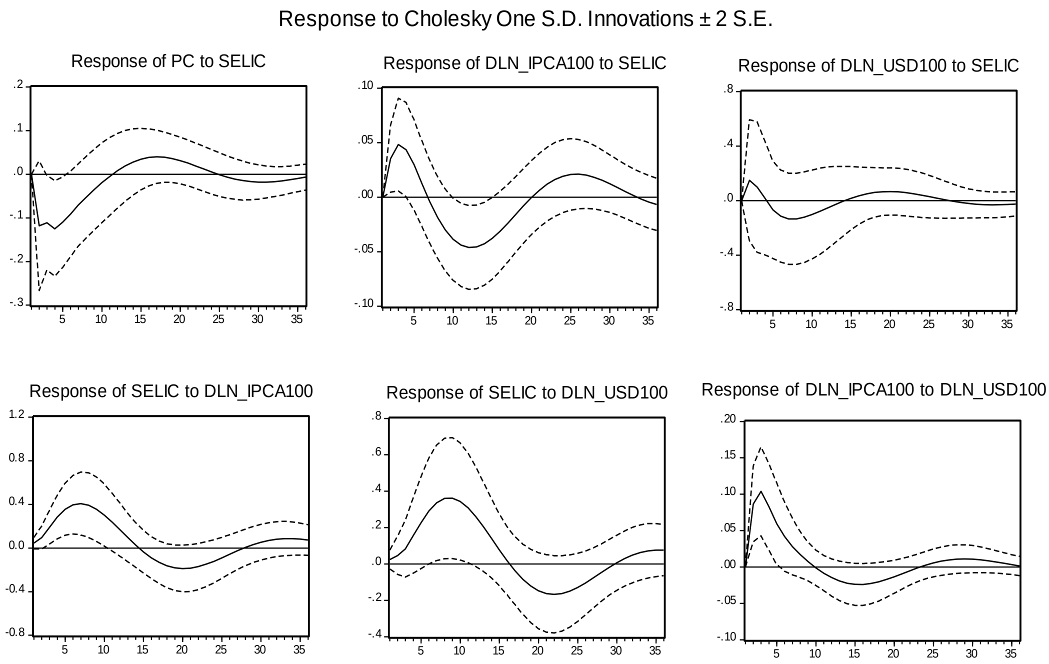


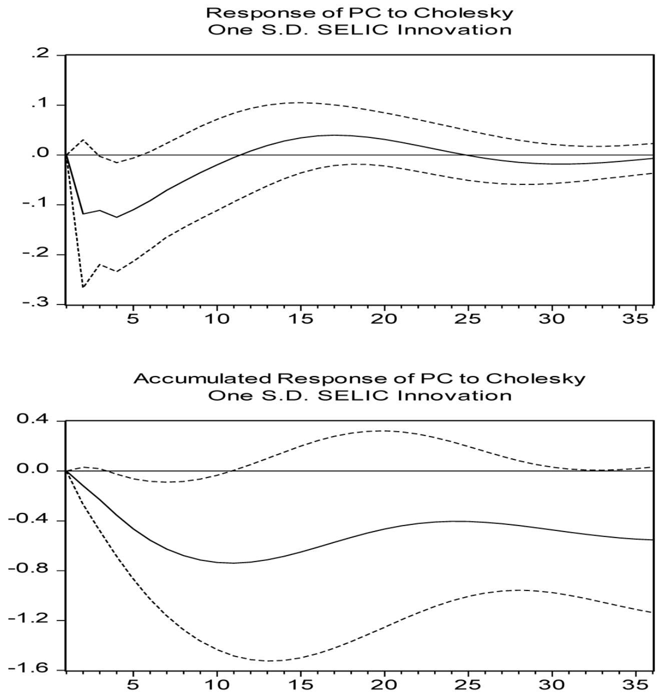
Figure 2 shows the IRF of the common component response and the accumulated common component response to a monetary policy shock. We observe the same findings as those reported in the literature: a lagged effect, significantly different from zero and with a hump-shaped form, whose effects dissipate over time, and a peak reduction between the first and second quarters after the shock. Therefore, two observations can be made:

1) the Brazilian monetary policy affects real output, in line with the reviewed literature, and this impact can be measured by a common component to regional outputs because it is representative of national output;

2) by affecting the common component to all regions, monetary policy shows signs of symmetry.

However, it is necessary to analyze what occurs with respect to the idiosyncratic components of regions. This analysis is the subject of the next subsection.

Figure 2: Impulse response and cumulative impulse response of the common component to monetary policy shocks, VARbr model



4.3.2. Region-specific VAR

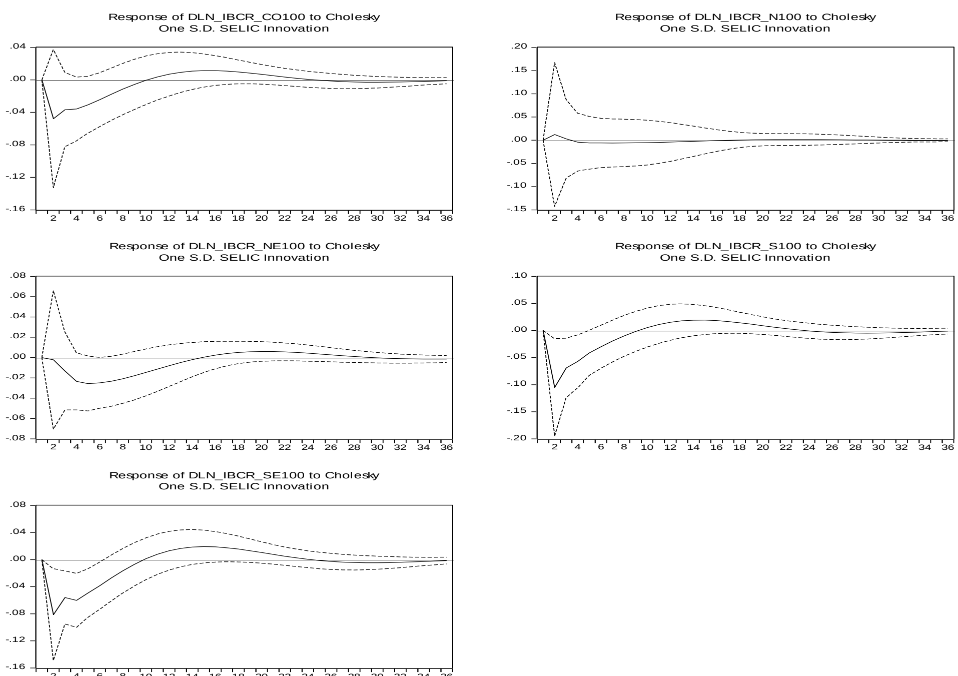
The previous subsection confirmed one of the findings on the regional effects of monetary policy in Brazil, namely, that there is an impact. This impact was measured with the output component common to all regions, following Kouparitsas (2001) and Teles and Miranda (2006). The next step is to understand what occurs with the component of each region that is not common.

Two approaches were adopted to assess regional outputs behavior. One approach was in line with most studies reviewed; namely, the VAR of each region consists of regional outputs, inflation, and exchange and interest rates, ignoring the possibility of output decomposition. In this format, we expected to observe asymmetric monetary policy effects on regional outputs, in line with similar studies. In the second approach, we decomposed regional outputs into common and idiosyncratic components, the latter corresponding to x_{it} in [4.1]. Thus, each region-specific VAR contains five endogenous variables: common component, inflation, exchange rates, interest rates and idiosyncratic component. If the findings are similar to those of Kouparitsas (2001) for the United States, the response to monetary policy shocks will be significant for the common component and non-significant for the idiosyncratic components, indicating symmetry of this policy. It should be added that the idiosyncratic component was ordered as a last variable in the Cholesky decomposition, which means it does not affect other variables contemporaneously but is affected by them. Another ordering could be chosen without affecting results because the correlation between residuals is low. Generalized impulse response functions results, as proposed by Pesaran and Shin (1998), show a similar behavior to the ordering chosen by the Cholesky decomposition, reinforcing this argument.

Estimates began observing a lag length indicated by the Akaike and Schwarz information criteria; if divergent, they began with the most parsimonious one. If the specification indicated the presence of a serial correlation by the Breusch-Godfrey test, the lag length was increased until it was eliminated, which was necessary only for the South region. Similar to the VARbr model, the residuals tests indicated the rejection of the hypothesis of normality. Likewise, the residuals initially showed heteroscedasticity, which in most models was resolved with dummies.[13]

The results of interest were presented as expected. If the estimates did not consider a decomposition of regional outputs into common and idiosyncratic components (Figure 3), the effects of monetary policy were asymmetric: the output responses of the North, Northeast and Midwest to monetary policies were not significantly different from zero, whereas in the South and Southeast regions they were significant. These results are in line with most studies reviewed in section 2. This approach, however, does not emphasize that the regional output contains components that are specific, such as agricultural crops dependent on the weather, which are not subject to national monetary policy.

Figure 3: Impulse response of regional outputs to monetary policy shocks



However, if the outputs were decomposed, an approach suggested by Kouparitsas (2001), we observed that the regional common component (PC) was responsive to monetary policy shocks (SELIC), whereas the idiosyncratic component responses (id_co; id_n; id_ne; id_s and id_se) were not significantly different from zero, regardless of whether the confidence interval was generated analytically or by the Monte Carlo simulation, as well as when using generalized impulse response functions (Figures 4-6). Another expected result was that the regional idiosyncratic components were significantly different from zero and dissipated quickly due to shocks in this component itself, as shown in Figure 7.

[13]Dummies regarding the internal crisis in late 2002 and early 2003 and the global financial crisis in late 2008.

Figure 4: Impulse response of regional outputs decomposed into common and idiosyncratic components to monetary policy shocks (analytical confidence interval)

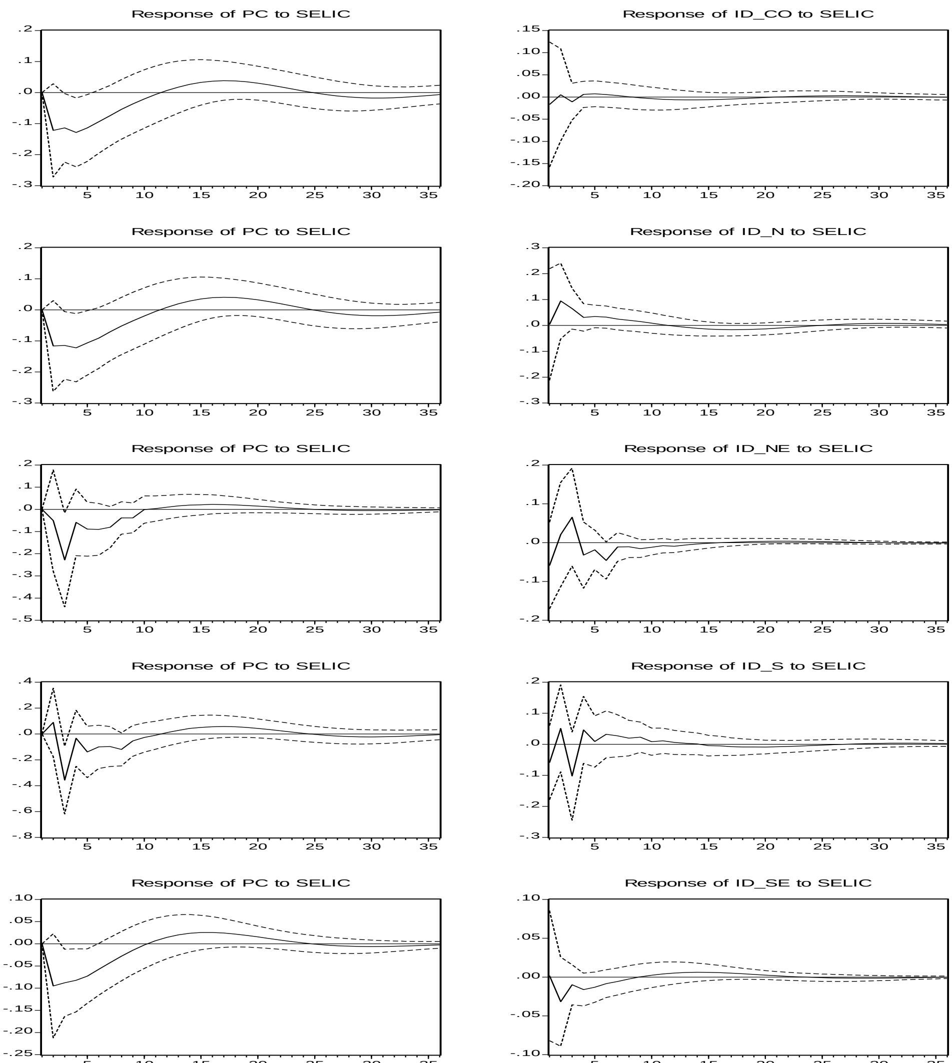


Figure 5: Impulse response of regional outputs decomposed into common and idiosyncratic components to monetary policy shocks (Monte Carlo simulation confidence interval with 10,000 repetitions)

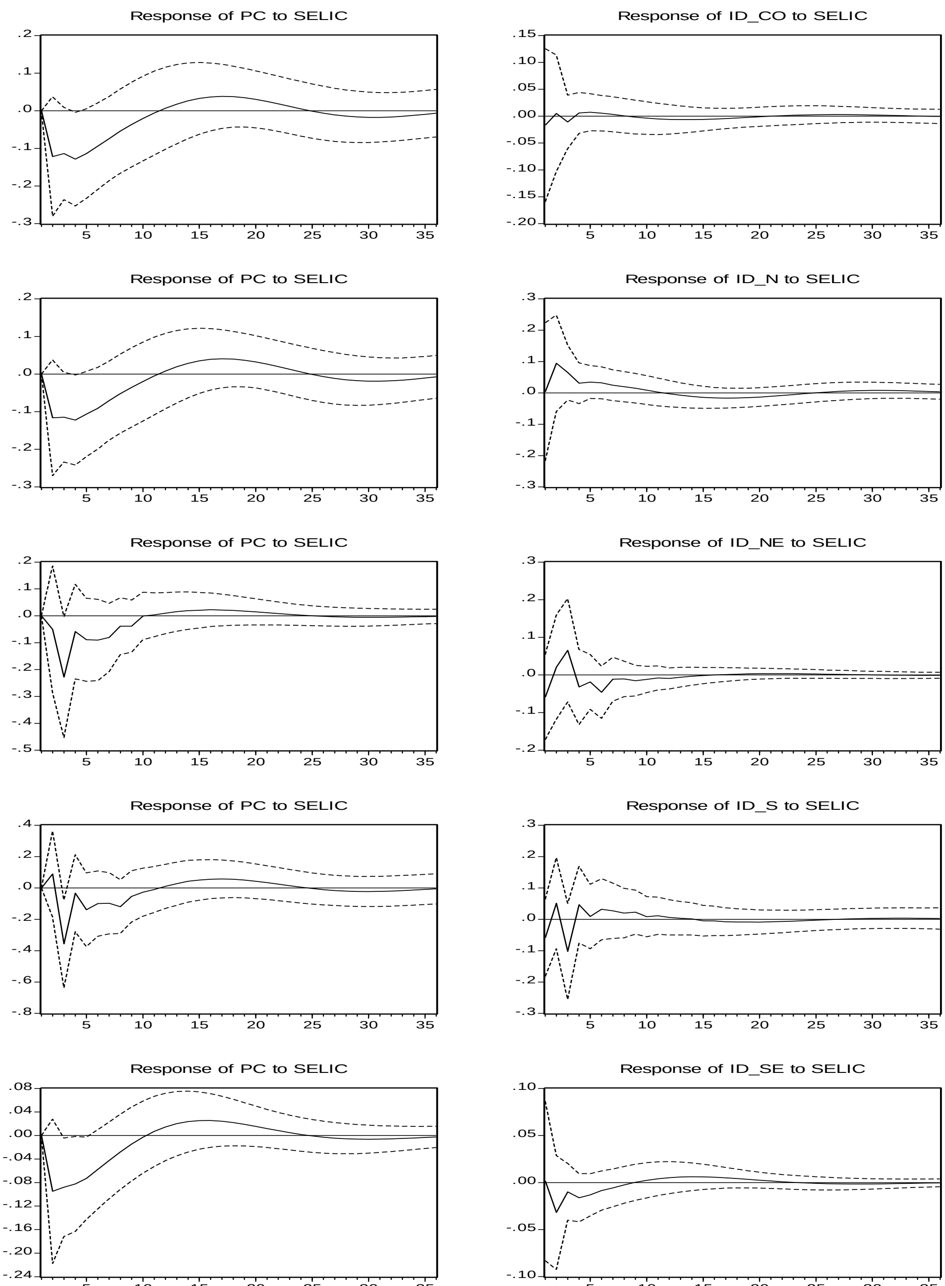


Figure 6: Generalized impulse response of regional outputs decomposed into common and idiosyncratic components to monetary policy shocks

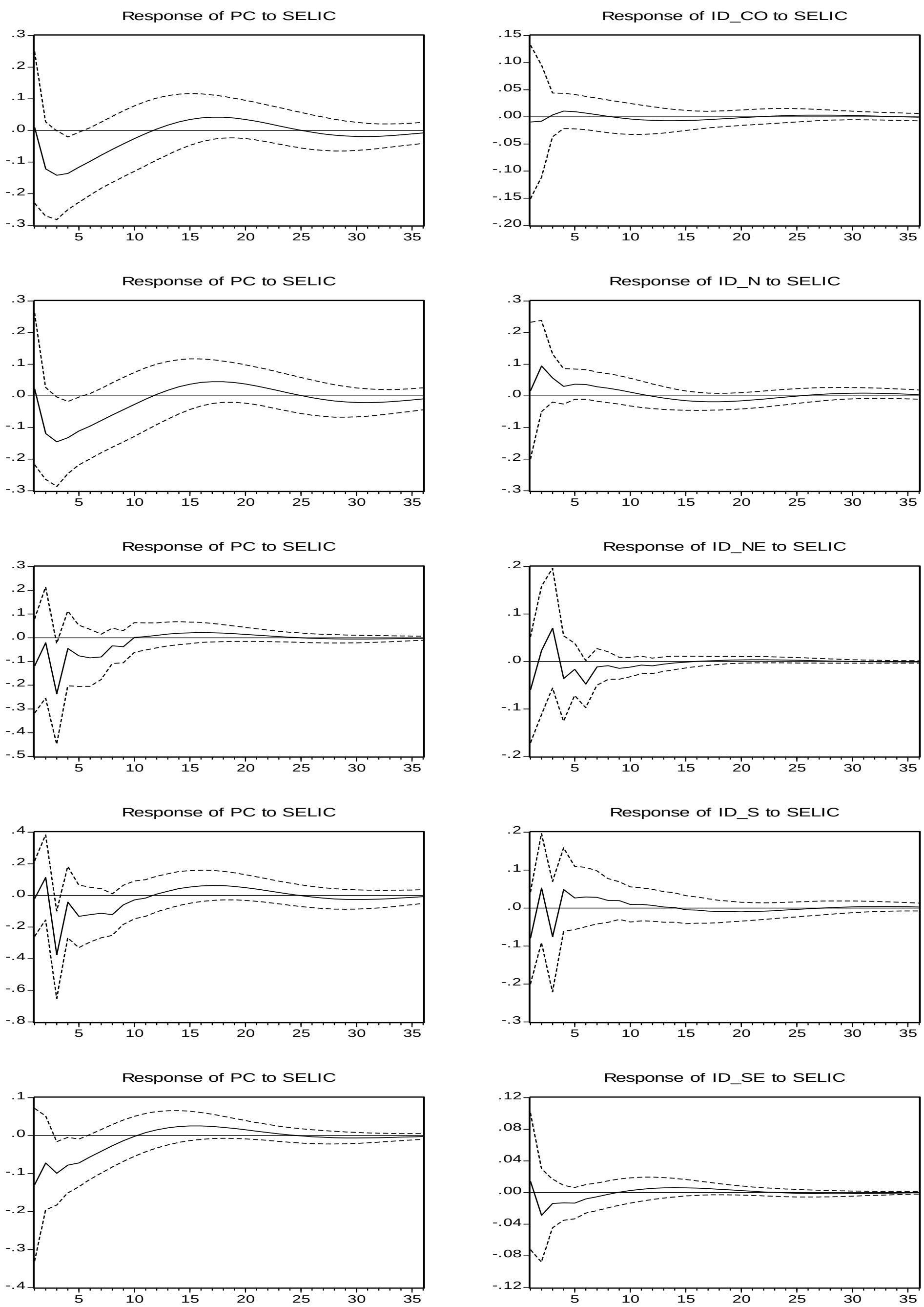
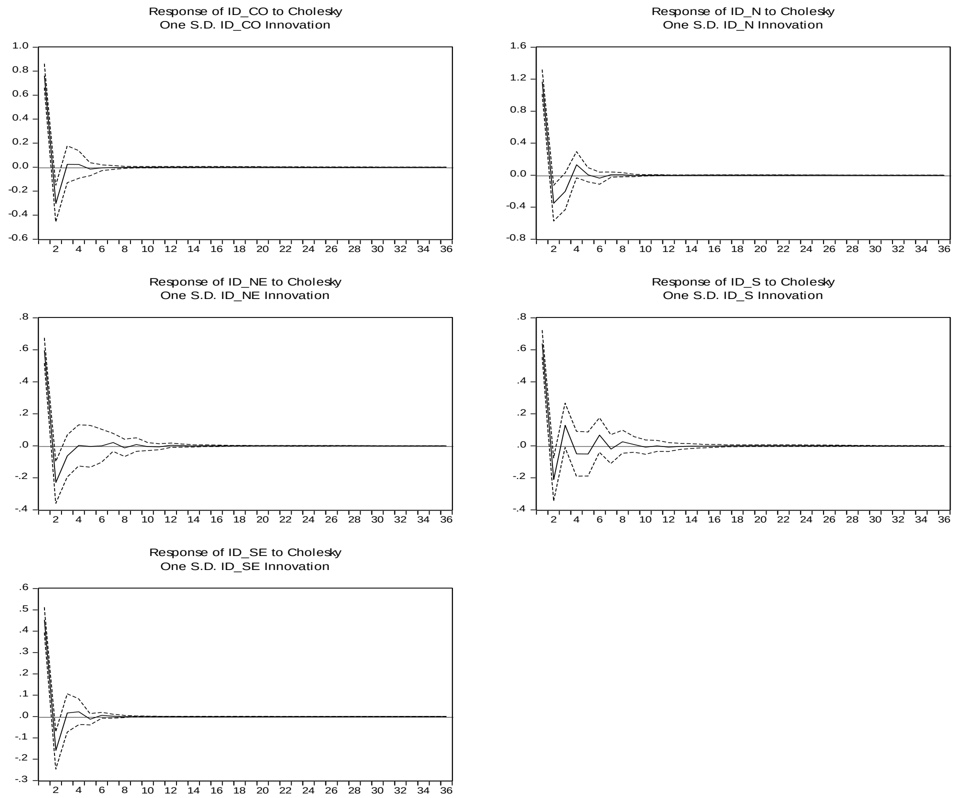


Figure 7: Impulse response of regional idiosyncratic components



Additionally we analyzed the forecast error variance decomposition (FEVD) two steps ahead and ten steps ahead. Table 6 contains the percentage of the total variation in the responses of regional outputs to different sources of innovation. Among the results of interest, we highlight the relevance of common component shocks on itself, and, similarly, the relevance of innovations in the idiosyncratic component on itself. It can be observed that the percentage of the shocks of the components on themselves remains high in the results of the ten steps ahead variance decomposition (bottom of the table), but at a lower intensity, because other sources of innovation gain importance. We observed some regional differences, as the relevance of the external sector in the Midwest, North and South, as well as the relevance of the common component in the Southeast. It should be registered that, as expected, monetary policy shocks increase its importance in explaining the behavior of the common component, but remain non-significant in explaining the region-specific component (standard errors: 10,000 Monte Carlo repetitions), reinforcing the evidence from the analysis of IRF with regard to the symmetry of the effects of the monetary policy on regional outputs.

Table 6: Variance decomposition of regional outputs - common and idiosyncratic components

A. Two steps ahead — Percentage of total variation due to innovation

Output	Source of innovation	common componet (PC)	prices (IPCA)	external sector (USD)	monetary policy (SELIC)	Total common shocks	idiosyncratic component (ID)	Total all shocks
Midwest								
	common	97,7	0,2	0,8	0,8	99,5	0,5	100,0
	idiosyncratic	0,4	1,0	1,1	0,0	2,5	97,5	100,0
North								
	common	98,2	0,1	0,8	0,8	99,9	0,1	100,0
	idiosyncratic	0,3	0,3	0,0	0,6	1,2	98,8	100,0
Northeast								
	common	97,6	0,0	0,8	0,2	98,6	1,4	100,0
	idiosyncratic	0,3	0,1	0,4	0,9	1,7	98,3	100,0
South								
	common	96,7	2,0	0,6	0,5	99,8	0,2	100,0
	idiosyncratic	4,4	1,8	1,1	1,2	8,5	91,5	100,0
Southeast								
	common	97,6	0,5	0,2	0,7	99,0	1,0	100,0
	idiosyncratic	4,7	0,3	1,6	0,4	7,0	93,0	100,0

B. Ten steps ahead — Percentage of total variation due to innovation

Output	Source of innovation	common componet (PC)	prices (IPCA)	external sector (USD)	monetary policy (SELIC)	Total common shocks	idiosyncratic component (ID)	Total all shocks
Midwest								
	common	79,0	0,9	15,4	3,6	98,9	1,1	100,0
	idiosyncratic	0,4	2,5	1,4	0,1	4,4	95,6	100,0
North								
	common	79,0	1,0	16,0	3,0	99,0	1,0	100,0
	idiosyncratic	0,3	1,2	0,8	1,1	3,4	96,6	100,0
Northeast								
	common	81,8	1,6	4,1	5,7	93,2	6,8	100,0
	idiosyncratic	2,1	1,4	2,7	2,7	8,9	91,1	100,0
South								
	common	70,2	2,8	15,0	8,1	96,1	3,9	100,0
	idiosyncratic	4,6	5,8	6,0	3,6	20,0	80,0	100,0
Southeast								
	common	93,8	1,3	0,9	2,7	98,7	1,3	100,0
	idiosyncratic	5,7	1,5	1,8	0,6	9,6	90,4	100,0

5. CONCLUSION

This study intended to contribute to the contemporary debate on the effects of monetary policy on economic activities in regions that comprise a given country. Most of the studies reviewed indicate that these effects are asymmetric, i.e., that regions generally behave differently in response to a monetary policy shock.

However, Koupartitsas (2001), evaluating data from the U.S. economy, and Ishii (2008) and the Banco Central do Brasil (2011b), conducting research on the Brazilian economy, found evidence of regional symmetry. The change of perspective proposed by Kouparitsas (2001) to evaluate regional effects of monetary policies is encouraging because perceiving the regional output as consisting of two unobserved components-one being common to all regions-facilitates the understanding that, even with different characteristics, regions can produce symmetrical responses to monetary policies. Similar strategy was adopted in the present study.

First, we analyzed the behavior of the common component by obtaining impulse response functions (IRF) of this component to various shocks. The resulting IRF showed a similar behavior to the one reported in the reviewed literature: a relevant impact of the external sector on domestic prices, measured by exchange rate shocks; monetary policy responses to inflationary shocks; and the significance of the monetary policy for real output. Likewise, the common component response to monetary policy shocks reproduces findings from the literature: effects that are lagged and significantly different from zero with a hump-shaped format that dissipates over time. Therefore, two important findings include the following: 1) the Brazilian monetary policy affects real output, and this impact can be measured by a common component in each region's output because it is representative of the national output and 2) by affecting the common component to all regions, monetary policy shows signs of symmetry.

We proceeded to evaluate region-specific components subjected to monetary policy shocks. Two approaches were adopted. One approach was in line with most studies reviewed; i.e., the VAR of each region consists of regional outputs, inflation, and exchange and interest rates, ignoring the possibility of output decomposition. In the second approach, we decomposed regional outputs into common and idiosyncratic components; thus, each region-specific VAR contains five endogenous variables: common component, inflation, exchange rates, interest rates and idiosyncratic components. The results of interest were consistent with our expectations. If the estimates did not consider the decomposition of regional outputs into common and idiosyncratic components, the effects of monetary policies were asymmetric: the output responses of the North, Northeast and Midwest to monetary policies were not significantly different from zero, whereas in the South and Southeast regions, they indicated significance. This approach does not consider that the regional output contains components that are specific, which are not subject to national monetary policy. However, if the outputs were decomposed, an approach suggested by Kouparitsas (2001), we observed that the regional common component was responsive to monetary policy shocks, whereas the responses of the idiosyncratic components were not significantly different from zero.

Therefore, considering that the economic activity in each region of Brazil has a common component that responds to monetary policy and a region-specific component that does not respond to it, the results obtained in the present study do not permit us to reject *the hypothesis that the effects of the Brazilian monetary policy on regional economic activity are symmetric.*

Thus, one can argue that the current monetary policy equally affects the economic activities of Brazil's regions, except for compensatory measures. Moreover, this conclusion follows from an econometric exercise that is open to improvements. Therefore, this subject can be approached with a diverse treatment of variables integrating models, other measures of regional economic activities or alternative techniques to extract common components. Additionally, other theoretical approaches can be considered to identify monetary policy shocks.

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A. DATA

Mnemonics	Description	Source
IPCA	Price index that measures the inflation for Brazilian consumers. Used for inflation targets.	Instituto Brasileiro de Geografia e Estatística.
dln_ipca100	=[ln IPCA - ln IPCA(-1)]*100	-
SELIC	Interest rate in percentage points on an annual basis. Reflection of the most traded securities of public debt in the Special System for Settlement and Custody. Considered the benchmark interest rate in Brazil.	Banco Central do Brasil (BCB), series 4189.
USD	Average monthly rate of exchange purchases between the Real and the U.S. Dollar.	BCB, series 3697.
dln_usd100	=[ln USD - ln USD(-1)]*100	-
IBC-br	Proxy indicator of economic activity in Brazil, with strong adherence to the GDP. Monthly index 2003 = 100 base. Seasonally adjusted.	BCB, series 17632.
IBCR-CO	Proxy indicator of economic activity in the Midwest region, with strong adherence to the GDP. Monthly index 2002 = 100 base. Seasonally adjusted.	BCB, series 17720.
IBCR-N	Proxy indicator of economic activity in the North region, with strong adherence to the GDP. Monthly index 2002 = 100 base. Seasonally adjusted.	BCB, series 17756.
IBCR-NE	Proxy indicator of economic activity in the Northeast region, with strong adherence to the GDP. Monthly index 2002 = 100 base. Seasonally adjusted.	BCB, series 17751.
IBCR-S	Proxy indicator of economic activity in the South, with strong adherence to the GDP. Monthly index 2002 = 100 base. Seasonally adjusted.	BCB, series 17740.
IBCR-SE	Proxy indicator of economic activity in the Southeast, with strong adherence to the GDP. Monthly index 2002 = 100 base. Seasonally adjusted.	BCB, series 17754.
dln_ibcr_co100	=[ln IBCR-CO - ln IBCR-CO(-1)]*100	-
dln_ibcr_n100	=[ln IBCR-N - ln IBCR-N(-1)]*100	-
dln_ibcr_ne100	=[ln IBCR-NE - ln IBCR-NE(-1)]*100	-
dln_ibcr_s100	=[ln IBCR-S - ln IBCR-S(-1)]*100	-
dln_ibcr_se100	=[ln IBCR-SE - ln IBCR-SE(-1)]*100	-
pc	Principal component (first component) extracted from the regional IBCR	Obtained by the Principal Component Analysis.
id_co	= x_{it} equation [4.1] for i = Midwest	-
id_n	= x_{it} equation [4.1] for i = North	-
id_ne	= x_{it} equation [4.1] for i = Northeast	-
id_s	= x_{it} equation [4.1] for i = South	-
id_se	= x_{it} equation [4.1] for i = Southeast	-

B. VARIANCE DECOMPOSITION OF VARBR (RELATED TO FIGURE 1)

Period	S.E.	PC	DLN_IPCA100	DLN_USD100	SELIC
Variance Decomposition of PC:					
1	1.289359	100.0000	0.000000	0.000000	0.000000
2	1.302693	98.19361	0.181973	0.801623	0.822795
3	1.416230	83.27245	0.810224	14.60383	1.313495
4	1.430761	81.58962	0.817895	15.54350	2.048982
5	1.440036	80.66601	0.833545	15.89534	2.605102
6	1.443891	80.24700	0.832282	15.92772	2.992995
7	1.446652	79.94579	0.854451	15.97949	3.220270
8	1.448477	79.74439	0.900499	16.01139	3.343724
9	1.449697	79.61038	0.941452	16.05008	3.398092
10	1.450391	79.53457	0.967937	16.08411	3.413385
Variance Decomposition of DLN_IPCA100:					
Period	S.E.	PC	DLN_IPCA100	DLN_USD100	SELIC
1	0.265487	4.475983	95.52402	0.000000	0.000000
2	0.325545	4.596129	87.15889	7.065028	1.179950
3	0.355626	4.239586	78.48624	14.44742	2.826758
4	0.370456	3.936118	73.72847	18.34629	3.989118
5	0.377150	3.797785	71.53842	20.19102	4.472776
6	0.379900	3.743005	70.62122	21.11482	4.520951
7	0.381001	3.721740	70.23043	21.54245	4.505375
8	0.381836	3.706656	69.92767	21.64735	4.718319
9	0.383209	3.681637	69.49003	21.52934	5.298993
10	0.385474	3.639576	68.84761	21.27793	6.234887
Variance Decomposition of DLN_USD100:					
Period	S.E.	PC	DLN_IPCA100	DLN_USD100	SELIC
1	3.865837	0.419439	3.804328	95.77623	0.000000
2	4.100478	0.442576	4.177558	95.24753	0.132335
3	4.203855	1.059271	5.521466	93.23870	0.180560
4	4.224665	1.153665	6.253070	92.41265	0.180610
5	4.234825	1.205907	6.612270	91.97694	0.204878
6	4.240025	1.208939	6.740324	91.77454	0.276197
7	4.244499	1.208204	6.801277	91.61536	0.375158
8	4.248522	1.206025	6.835479	91.48510	0.473395
9	4.251871	1.204175	6.861190	91.38037	0.554266
10	4.254463	1.202742	6.881370	91.30508	0.610812
Variance Decomposition of SELIC:					
Period	S.E.	PC	DLN_IPCA100	DLN_USD100	SELIC
1	0.287203	0.001528	2.419887	0.699164	96.87942
2	0.572105	0.748064	3.410292	0.843812	94.99783
3	0.861502	0.600161	6.359939	1.306836	91.73306
4	1.144138	0.417283	9.727590	2.578250	87.27688
5	1.408845	0.285892	12.78127	4.297049	82.63579
6	1.644704	0.209864	15.18364	6.279150	78.32734
7	1.843344	0.169225	16.96011	8.321362	74.54930
8	2.000490	0.149697	18.22231	10.30208	71.32591
9	2.116069	0.142872	19.08641	12.13000	68.64072
10	2.193837	0.143740	19.64083	13.73769	66.47773
Cholesky Ordering: PC DLN_IPCA100 DLN_USD100 SELIC					

C. ARDL SPECIFICATION FOR REGION'S SENSITIVITY TO THE COMMON COMPONENT - ALTERNATIVE TO EQUATION [4.1]

Region / (lag)	(p , q)	(1,1)	(1,2)	(2,1)	(2,2)	(3,1)	(3,2)	(3,3)	(4,4)	(5,5)	(6,6)
Midwest											
xt-p : p-value for γ_p	(0)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(1)	0.9876	0.8464	0.9766	0.8789	0.9847	0.8781	0.9855	0.9931	0.7722	0.6666
	(2)			0.9005	0.4814	0.8145	0.4187	0.3492	0.3474	0.2896	0.5261
	(3)					0.6516	0.5916	0.8418	0.7491	0.8766	0.7991
	(4)								0.6279	0.6891	0.7113
	(5)									0.1671	0.0726
	(6)										0.4706
yt-q : p-value for β_q	(1)	0.1521	0.2399	0.1536	0.2389	0.1511	0.2358	0.1397	0.1225	0.1198	0.0662
	(2)		0.1416		0.1054		0.1036	0.0607	0.0785	0.1600	0.2258
	(3)							0.0522	0.0488	0.1004	0.2541
	(4)								0.7654	0.5880	0.7903
	(5)									0.0274	0.0091
	(6)										0.0404
North											
xt-p : p-value for γ_p	(0)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(1)	0.7446	0.7076	0.7186	0.7199		0.6628	0.6675	0.6318	0.7899	0.8483
	(2)			0.7837	0.8203		0.8041	0.7769	0.8532	0.7412	0.8335
	(3)						0.6212	0.6487	0.7654	0.6242	0.7124
	(4)								0.5698	0.5347	0.6850
	(5)									0.1532	0.1991
	(6)										0.1521
yt-q : p-value for β_q	(1)	0.2446	0.2351	0.2624	0.2340		0.2416	0.2724	0.2544	0.1162	0.1708
	(2)		0.4530		0.4646		0.4318		0.4750	0.4582	0.4760
	(3)								0.9958	0.7794	0.8433
	(4)								0.2399	0.1353	0.1556
	(5)									0.0003	0.0003
	(6)										0.7771
Northeast											
xt-p : p-value for γ_p	(0)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(1)	0.5164	0.4909	0.5184	0.5078	0.3309	0.3191	0.3284	0.3095	0.8133	0.9926
	(2)			0.7806	0.7561	0.8712	0.6384	0.6193	0.7045	0.5900	0.9226
	(3)					0.0165	0.0138	0.1863	0.2293	0.1856	0.1585
	(4)								0.2413	0.2545	0.2331
	(5)									0.0302	0.0110
	(6)										0.3902
yt-q : p-value for β_q	(1)	0.5619	0.5881	0.5592	0.6044	0.5916	0.6427	0.8344	0.9432	0.5003	0.3837
	(2)		0.2001		0.1994		0.1607	0.1831	0.2604	0.4150	0.6194
	(3)							0.0263	0.0317	0.0473	0.1449
	(4)								0.0598	0.0632	0.0776
	(5)									0.0066	0.0029
	(6)										0.2727
South											
xt-p : p-value for γ_p	(0)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(1)	0.3562	0.3932	0.4040	0.3230	0.3091	0.2241	0.0938	0.0972	0.0815	0.0996
	(2)			0.4430	0.0025	0.4119	0.0020	0.0024	0.0050	0.0196	0.0220
	(3)					0.5507	0.4134	0.0237	0.0229	0.0652	0.1224
	(4)								0.9735	0.9351	0.8812
	(5)									0.3765	0.4501
	(6)										0.1472

yt-q : p-value for β_q	(1)	0.3978	0.4393	0.4351	0.6182	0.3778	0.5354	0.1927	0.1931	0.1810	0.1424
	(2)		0.0571		0.0005		0.0004	0.0002	0.0006	0.0025	0.0020
	(3)							0.0202	0.0221	0.0810	0.1311
	(4)								0.9070	0.7465	0.8550
	(5)									0.2083	0.1466
	(6)										0.0577
Southeast											
xt-p : p-value for γ_p	(0)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(1)	0.8406	0.8106	0.8584	0.8129	0.9678	0.9421	0.4279	0.2423	0.2699	0.2146
	(2)			0.6873	0.0247	0.6502	0.0260	0.0177	0.0702	0.1685	0.1694
	(3)					0.0992	0.0602	0.0006	0.0004	0.0034	0.0185
	(4)								0.1195	0.0719	0.2006
	(5)									0.1818	0.1191
	(6)										0.0947
yt-q : p-value for β_q	(1)	0.4396	0.7036	0.5684	0.7593	0.5900	0.7361	0.5442	0.2949	0.1959	0.1328
	(2)		0.0102		0.0007		0.0006	0.0008	0.0048	0.0229	0.0457
	(3)							0.0036	0.0024	0.0167	0.0662
	(4)								0.2067	0.1565	0.3160
	(5)									0.0292	0.0200
	(6)										0.1413