Scientific
Research
Publishing

Impact of Monetary Policy Changes on Brazilian Banking Efficiency during Crises

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Abstract

This study investigated the effects of monetary policy changes on Brazilian banking efficiency during crises through data envelopment analysis and difference of means tests between March 2001 and June 2014. The results indicate an increase in the effectiveness of the banking sector given changes in domestic monetary policy, especially, in terms of allocative and economic efficiencies during a crisis.

Keywords

Banking Efficiency, Monetary Policy, Economic Crises, Data Envelopment Analysis, Brazilian Banking

1. Introduction

Banking activity is strongly influenced by internal and external monetary policies, in addition to shocks that affect the demand or supply of money, such as economic crises (Mishkin, 2000; Wolters et al., 2014). Many comparative studies have been conducted on the efficiency and profitability of the banking sector (Havrylchyk, 2006; Paula & Faria, 2007; Staub et al., 2010; Matias et al., 2014; Gomes et al., 2017). However, until now, no study has analyzed the efficiency of this sector in view of changes in monetary policy, whether influenced by economic and financial crises.

In the 2000s, with the Brazilian economy already stabilized, changes in the domestic monetary policy and economic crises affected the Brazilian banking system (Giambiagi et al., 2005). These crises included the crisis in Argentina in 2001, the energy crisis in Brazil in 2001, the terrorist attack on the United States of America in 2001, the 2002 electoral crisis in Brazil, and the 2008 American

crisis, which turned into a world crisis. In this context, it is crucial for the responsible authority to conduct monetary policy credibly, thereby boosting the confidence of market agents during a crisis (Mishkin, 2000). Among these market agents, banks stand out, with their role in maintaining the allocation of resources between surplus and deficit agents (Giambiagi et al., 2005). Thus, this study analyzes the impact of changes in Brazil's monetary policy on Brazilian banking efficiency during crises.

We compared Brazilian banking efficiency before and after significant changes in monetary policy in the view of political and economic crises. To this end, we selected specific periods for analysis and used the Selic (*Sistema Especial de Liquidação e de Custódia*) rate, which is the primary mechanism of monetary policy in Brazil, and data envelopment analysis (DEA) to calculate banking efficiency.

The results indicate that the Brazilian banking sector exhibits greater efficiency, in terms of allocative and economic efficiency, in times of crisis. For example, after the 2008 crisis, the sector witnessed a change in the level of technical efficiency, indicating that the banking sector became more technically efficient, minimizing the use of production factors (inputs) to obtain a certain level of product (outputs).

The rest of this article is composed of the following sections: theoretical framework (Section 2); methodology (Section 3), which presents how the DEA model is calculated, the variables used by the model, and the statistical tests used in the study; analysis of results (Section 4); and final considerations (Section 5).

2. Theoretical Framework

The literature on banking sector efficiency assumes that the main function of a bank is managing resources, acting as an intermediary between surplus agents (savers) and deficit agents (investors), relating work and capital with the products supplied to various economic agents (Hasan & Marton, 2003; Isik & Hassan, 2002; Gomes et al., 2017). Among the studies that assessed Brazilian banks' efficiency through efficient frontier analysis, we highlight those of Paula and Faria (2007), Périco et al. (2008), Staub et al., (2010), and Gomes et al. (2017).

Paula and Faria (2007) analyzed the evolution of the Brazilian banking sector efficiency from December 2000 to December 2006. The sample consisted of 38 banking institutions. The efficiency was calculated by DEA. The results obtained did not show any significant improvements in the efficiency of the Brazilian banking sector in the analyzed period.

Périco et al. (2008) evaluated the efficiency of the 12 largest commercial banks in Brazil using data from 2005. Through DEA, the authors considered equity, total assets, and deposits as inputs to the model and net income as the output. The results, based on the criteria of the Central Bank of Brazil for the classification of banking institutions, showed that the size of the banks alone does not determine the efficiency of each of them.

Staub et al. (2010) analyzed banking efficiency in terms of the type of control between 2000 and 2007 by using DEA and concluded that foreign-owned banks are less-efficient than public and domestic, private banks. The authors found high technical inefficiency, demonstrating the need for improvements that can increase the efficiency of the Brazilian banking sector.

In a more recent analysis, covering 2006 to 2013, Gomes et al. (2017) found results similar to those of Staub et al. (2010), with domestic banks being more efficient than their foreign competitors. The authors also found that Brazilian banking efficiency decreased over the reviewed period. Partially, this reflects the global economic crisis that originated abroad, affecting foreign banks more strongly. Conversely, the scenario of uncertainties and internal crises that Brazil has been experiencing in recent years has further forced banks to be highly efficient.

The Brazilian banking sector underwent major changes over the last decades, influenced by the following political and economic issues of the time: the period of high inflation, implementation of the real plan (1994) and post-real plan (Giambiagi et al., 2005). Recently, the steady growth of the Brazilian credit market (2003 to 2008) and the economic and political crises (2002, 2008, and 2015) witnessed prominence. In the post-real plan period, the international Brazilian economic scenario and public accounts improved, and Brazil recorded higher economic growth than the other periods. However, in 2001, Brazil suffered external impacts emerging from the Argentina crisis, the terrorist attack on the United States of America, and the energy crisis (Giambiagi et al., 2005; Wolters et al., 2014). These impacts caused foreign capital outflows from the country, exchange devaluation, and initiated new inflationary pressures (Giambiagi et al., 2005; Coutinho & Amaral, 2010). During these times of crisis, the monetary authority raised the interest rate to reinforce economic containment.

The electoral crisis of 2002 was an internal crisis. During this period, there was uncertainty in the market about the electoral elections held at the time, which caused low economic growth, a rise in unemployment, an increase in public debt, capital outflow, exchange devaluation, an increase in the risk of public debt, and inflationary pressures which were suppressed through the rise in the interest rate by the economic authority (Paula & Pires, 2017).

The 2008 crisis began in 2007 in the US market and spread to the rest of the world through global inter-financial relationships. The Brazilian monetary authority responded to this crisis by increasing government consumption and establishing a countercyclical fiscal policy; this response implies that the interest rate instrument was not powerfully used in this period. However, Paula and Pires (2017) point out that the effectiveness of countercyclical policies reduced after the global financial crisis due to coordination problems in macroeconomic policies.

In this context of banking efficiency and economic and financial crises, the Brazilian monetary policy, expressed by the Selic interest rate, proved to be an

important variable for conducting the trajectory of the Brazilian economy (Giambiagi et al., 2005). As banking activities are impacted by monetary policy and internal and external shocks (Mishkin, 2000; Wolters et al., 2014), it is essential to know how the banking sector efficiency behaved given changes in monetary policies, whether influenced by economic and financial crises or not. This fact deserves to be highlighted in the Brazilian context. Because of this, the present study aims at analyzing the impact of changes in monetary policy in crisis contexts on the efficiency of the Brazilian banking sector.

3. Methodology

3.1. Efficiency Measured through Data Envelopment Analysis (DEA)

We used DEA to achieve the objective of the study. This methodology is based on linear programming problems and aims at to comparatively analyze the operational performance of independent units, such as sectors, firms, or departments, either between groups in the same period or different periods. The DEA model provides measures to assess the relative efficiency of the units analyzed. Therefore, each unit represents a set of inputs and outputs for the calculation of efficiency measures.

3.2. Efficiency: Concept and Measurement

Among the efficiency measures, the following three measures stand out: technical efficiency (TE), allocative efficiency (AE), and cost efficiency (CE). According to Havrylchyk (2006), TE is the ability to produce maximum results (outputs) with a given level of production factors (inputs) or the ability to minimize the use of production factors to obtain a given level of results. As per Havrylchyk (2006), AE refers to the ability to select the optimal combination of inputs, based on a set of prices presented for a given level of outputs, to minimize production cost, considering that the TE has already been fully achieved. Finally, CE is the combination of TE and AE; in other words, it requires technical efficiency and implies cost minimization (Havrylchyk, 2006). TE can be assessed by considering the following two orientations: input and output orientations. Input-oriented measures are based on reducing inputs, while output-oriented measures are focused on increasing the production volume.

According to Sealey & Lindley (1977), any variable can be used as an input or output for assessing financial institutions, provided that this variable is compatible with the objective of the study. In order to allow comparison, the inputs and outputs of the different units of analysis should be the same, varying only in intensity or magnitude. In addition to relying on the literature for choosing variables, this study used the stepwise correlation analysis procedure to compose an initial pair of input vs. output, similar to what Gomes et al. (2017) did in their study. By using this methodology, we found that the variables that best explained

the production process of the selected sample were as follows:

- Inputs:

 1) Expenses arising from funding operations in the market: the expenses of financial intermediation were mainly related to funds obtained in the local market through time deposits interbank deposits, committed operations, agricultural credit lines, and financial bills.

 2) Personnel expenses: salaries, fees, benefits, and charges accrued and paid to bank employees.

 3) Total assets: the sum of all assets (current and long-term assets).

- Outputs:

 1) Revenues from credit operations: revenues from financial intermediation for credit operations includes revenues from interest on loans and financing from working capital operations through discounted trade bills, loan agreements, transfers of resources by Brazilian Development Bank (BNDES), and import financing, among others.

 2) Return on assets (ROA): it is used to measure banks' profitability. ROA was calculated based on the ratio of net income to total assets.

 3) For the calculation of allocative efficiency (AE), the relative prices or costs of the aforementioned three inputs are required. Following the procedures of Havrylchyk (2006) in his study on the Polish banking sector efficiency, we calculated the costs of market funding operations, personnel, and total assets for each decision-making unit (DMU) and for each year analyzed as follows:

- (Relative) cost of funding operations in the market = Expenditure on funding operations in the market/total amount of deposits
- (Relative) cost of personnel = personnel expenses/number of employees
- (Relative) cost of total assets = administrative expenses/total assets.

3.3. Identification and Application of the Model

The work uses DEA with input orientation. Thus, efficiency measures are intended to reflect the decrease in the input level while maintaining the same output level. With regards to the type of returns to scale between variables, we chose to use the variable returns to scale (VRS) model, which includes the possibility of variable returns to scale. This model is the most adequate for this study because increases in inputs do not occur in the same proportion as increases in outputs; in other words, the variations are not directly proportional.

We used DEAP v. 2.1 (Data Envelopment Analysis Program - Version 2.1) for the calculation of efficiency measures, and statistical tests of the difference between mean and median to observe the behavior of the efficiency variables over the analyzed periods. After the estimation of the efficiency measures, we created 11 different sub-samples for each period of analysis, as seen in Table 1. We divided the periods according to changes in the Selic rate, representing changes in the Brazilian monetary policy.

Table 1. Number of banks analyzed per period.

Comparison Period	Sample/Observations
Mar 01/Dec 01(1)	46
Dec 01/Sep 02(2)	45
Sep 02/Mar 03(3)	46
Mar 03/Jun 04(4)	43
Jun 04/Jun 05(5)	45
Jun 05/Dec 07(6)	42
Dec 07/Dec 08(7)	45
Dec 08/Dec 09(8)	43
Dec 09/Jun 11(9)	47
Jun 11/Dec 12(10)	36
Dec 12/Jun 14(11)	46

The sample comprises 50 largest banks in Brazil collected from the quarterly accounting data of banking institutions between March 2001 and June 2014, presented in the report titled "The 50 Largest Banks and the Consolidation of the National Financial System" available on Central Bank of Brazil's website. Table 1 shows the number of banks analyzed in each comparison.

The efficiency measures were calculated for each period and all banks in the 11 sub-samples. Since this study aims to analyze the impact of changes in monetary policy on the efficiency of the Brazilian banking sector during crises, t-tests were performed to compare the means of the efficiency indices calculated for each period, that is, to determine whether the efficiency of the sector was affected by the changes in the monetary policy in different periods. Statistical tests were performed to determine whether this change was statistically significant.

4. Analysis of Results

Previously the presentation and discussion of static tests' results, we tested the difference of means using the Levene test (1960) to determine the equality of variance between the periods compared. Table 2 presents the p-value obtained in each Levene test. We used these results in the difference of mean tests performed subsequently. Table 3 shows the statistical results of the mean tests for each comparable period.

Table 3 below shows the test of differences between means between each efficiency calculated in the study.

We performed non-parametric tests for differences between medians aiming at giving robustness to the results obtained from the difference of means tests

Table 2. Levene test results.

	P-value of the variance comparison test		
Comparison Period	Technical Efficiency	Allocative Efficiency	Economic Efficiency
Mar 01/Dec 01(1)	0.0030	0.2047	1.0000
Dec 01/Sep 02(2)	0.2544	0.8408	0.9457
Sep 02/Mar 03(3)	0.5469	0.9495	0.6324
Mar 03/Jun 04(4)	0.3143	0.5748	0.8721
Jun 04/Jun 05(5)	0.5410	0.9034	0.9530
Jun 05/Dec 07(6)	0.2213	0.0437	0.0134
Dec 07/Dec 08(7)	0.6262	0.0023	0.0004
Dec 08/Dec 09(8)	0.0418	0.5617	0.1712
Dec 09/Jun 11(9)	0.0360	0.4694	0.4919
Jun 11/Dec 12(10)	0.5142	0.4158	0.2022
Dec 12/Jun 14(11)	0.1237	0.9072	0.9240

Table 3. Difference of means tests for each calculated efficiency.

	T-test of difference of means					
	Technical Efficiency		Allocative Efficiency		Economic Efficiency	
Period	Equal Variances	Different Variances	Equal Variances	Different Variances	Equal Variances	Different Variances
Mar 01/Dec 01(1)	N/A	13.133	−1.9216*	N/A	−12.308	N/A
Dec 01/Sep 02(2)	0.8570	N/A	0.2661	N/A	0.4404	N/A
Sep 02/Mar 03(3)	0.317	N/A	−2.7503***	N/A	−2.0554**	N/A
Mar 03/Jun 04(4)	−10.030	N/A	0.5057	N/A	0.1181	N/A
Jun 04/Jun 05(5)	0.4792	N/A	0.681	N/A	0.6133	N/A
Jun 05/Dec 07(6)	−0.6767	N/A	N/A	4.4924***	N/A	3.6944***
Dec 07/Dec 08(7)	0.3489	N/A	N/A	−6.0966***	N/A	−5.2016***
Dec 08/Dec 09(8)	N/A	7.7137***	−10.686	N/A	2.6663***	N/A
Dec 09/Jun 11(9)	N/A	−7.1275***	3.4154***	N/A	−0.5271	N/A
Jun 11/Dec 12(10)	11,535	N/A	0.4388	N/A	10.166	N/A
Dec 12/Jun 14(11)	−1.8309*	N/A	15.131	N/A	0.7701	N/A

Legend: N/A: not applicable; *significance level of 10%; **significance level of 5%; and ***significance level of 1%.

(Table 3). This test does not assume population distribution, and hence it is more conservative than the others. The results of the differences between medians tests are reported in Table 4. The comparison of all the 11 periods revealed heterogeneous results regarding the change in the efficiency of the banking sector, these results can be seen in Table 3 and Table 4.

Along with the analysis of the statistical tests, a graphical analysis was performed to demonstrate better how the mean of each type of banking efficiency behaved given the changes in the Selic rate by the Brazilian monetary authority. Figure 1 illustrates this analysis. The bank efficiency indices are represented by the central axis (left), while the second axis represents the Selic interest rate. It is worth noting that the efficiency indices and the interest rate are on different scales.

Figure 1 shows that allocative efficiency and economic efficiency increase with an increase in the Selic rate since the beginning of the period analyzed until the end of 2008. Thus, this suggests that banks tend to be more efficient in the context of currency contraction, crisis, or economic difficulty. The opposite is also exact; in other words, when the monetary authority reduces the Selic level, these efficiencies also fall. This behavior was observed in the technical efficiency index for the period analyzed. Thus, an increase in the Selic level in the macroeconomic scenario is accompanied by a reduction or stagnation of technical efficiency.

Table 4. Difference between medians tests for each efficiency calculated.

Median difference test			
Comparison Period	Technical Efficiency	Allocative Efficiency	Economic Efficiency
Mar 01/Dec 01(1)	0.694994	−2.29973**	1.72577*
Dec 01/Sep 02(2)	0.6012	1.60184	1.36781
Sep 02/Mar 03(3)	0.343593	−3.20166***	−2.65503***
Mar 03/Jun 04(4)	−1.0149	0.738463	0.14251
Jun 04/Jun 05(5)	0.661715	0.919946	1.04099
Jun 05/Dec 07(6)	−0.465195	5.35869***	4.93375***
Dec 07/Dec 08(7)	0.4116	−5.49547***	−5.30583***
Dec 08/Dec 09(8)	5.71337***	−0.807559	−1.67126*
Dec 09/Jun 11(9)	−5.30845***	3.44823***	−0.412124
Jun 11/Dec 12(10)	0.900983	0.185828	0.456123
Dec 12/Jun 14(11)	−1.21038	2.28802**	1.85852*

Legend: *significance level of 10%; **significance level of 5%; ***significance level of 1%.
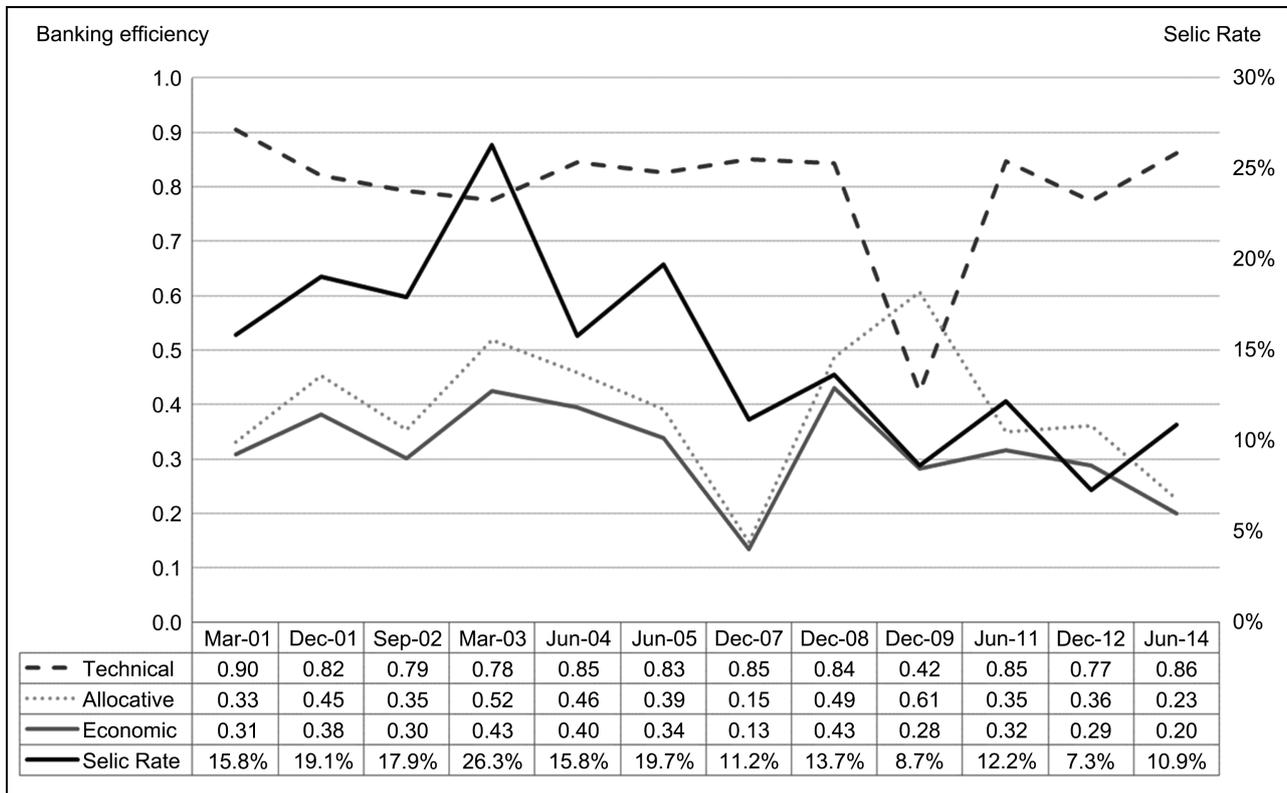
Figure 1. Evolution of banking efficiency measures and the Selic interest rate for each period compared to the previous year.

At the end of 2008, technical efficiency started to follow the movement of the Selic rate, while allocative efficiency has begun to develop the direction opposite to that of the Selic rate. Following graphical analysis, Table 5 was constructed to statistically analyze whether the changes between the periods are statistically significant.

Table 5 and Figure 1 show that the technical efficiency remained, on average, unchanged until the end of December 2008. Therefore, we can conclude that changes in monetary policy had no impact on technical efficiency. Hence, disregarding the production costs, changes in the Selic rate did not change the capacity of the banks to minimize the use of production factors to obtain a certain level of results. Gomes et al. (2017) also reported levels of technical efficiency that did not exhibit significant changes until 2008.

The global financial crisis was the most significant of the crises mentioned in this study in terms of technical efficiency, as it imposed restructuring in the global banking sector and, consequently, additional costs to banks (Wolters et al., 2014; Gomes et al., 2017). After 2008, the mean technical efficiency of the sector started to change given the changes made in the Selic rate, notably, in times of high Selic rate, the technical efficiency increases. Therefore, from 2008, in times of high Selic rate, technical efficiency also increased, as seen in Table 5. This implies that banks tend to be technically more efficient during a currency contraction or a massive crisis like that of 2008.

Table 5. Effect of the changes on the calculated efficiency indices.

Comparison Period	Interest Rate-Selic	Crisis	Technical Efficiency	Allocative Efficiency	Economic Efficiency
Mar 01/Dec 01(1)	Increased	Energy crisis; Argentina crisis; Terrorist attack on United Sates.	Not Significant	Increased	Not Significant
Dec 01/Sep 02(2)	Reduced		Not Significant	Not Significant	Not Significant
Sep 02/Mar 03(3)	Increased	Electoral Crisis	Not Significant	Increased	Increased
Mar 03/Jun 04(4)	Reduced		Not Significant	Not Significant	Not Significant
Jun 04/Jun 05(5)	Increased		Not Significant	Not Significant	Not Significant
Jun 05/Dec 07(6)	Reduced		Not Significant	Reduced	Reduced
Dec 07/Dec 08(7)	Increased	2008 Crisis	Not Significant	Increased	Increased
Dec 08/Dec 09(8)	Reduced		Reduced	Not Significant	Reduced
Dec 09/Jun 11(9)	Increased		Increased	Reduced	Not Significant
Jun 11/Dec 12(10)	Reduced		Not Significant	Not Significant	Not Significant
Dec 12/Jun 14(11)	Increased		Increased	Not Significant	Not Significant

Allocative and economic efficiencies behaved similarly from December 2001 to December 2008. In the period of the electoral crisis, increases in the Selic interest rate resulted in improvements in both efficiencies, as seen in Table 5. Consequently, during the 2008 crisis, AE and economic efficiency accompanied both reductions and increases in the Selic rate. We observed that banks were more efficient when the Selic rate increased both in terms of allocative efficiency and economic efficiency during the 2001 and 2002 crises. In the 2008 crisis, the monetary authority reduced the Selic level during two different periods, and allocative and economic efficiencies accompanied this reduction.

The results indicate that banks respond to changes in monetary policies by increasing their ability to select the optimal combination of inputs, based on a set of prices for a given level of output, to minimize the cost of production. This occurs mainly during crises, that is when changes are more abrupt, and uncertainties are high. Consequently, the banking sector is required to adapt quickly to these changes to overcome the difficulties arising from the crises.

Although studies report that the Brazilian banking sector has not evolved in terms of efficiency (Paula & Faria, 2007; Staub et al., 2010; Gomes et al., 2017), and the results presented in this study agree with this statement, the banks have been increasing the level of efficiency when facing a contractionary monetary policy during crises. A likely explanation for this behavior is that the high control over banks' input prices causes them to reduce costs more efficiently or more quickly in periods of high uncertainty. Studying bank efficiency is essential because an efficient banking system acts as a lever for the country's economy.

5. Conclusion

This study aimed to analyze the impact of monetary policy changes on the efficiency of the Brazilian banking sector during crises between March 2001 and June 2014, through efficiency measures, by using DEA for the 50 largest banks in Brazil during 11 periods.

The results reveal that changes in the Selic interest rate affect banking efficiency depending on the type of efficiency. This is because a comparison of all the 11 periods revealed heterogeneous results regarding the change in the efficiency of the banking sector. First, we observed that in the period prior to the 2008 crisis, changes in the economy's primary interest rate did not significantly influence the technical efficiency of the banking sector. In the period following the 2008 crisis, when the rate was high, the banks had better technical efficiency indices. This behavior demonstrates a change in the behavior of the banking sector after a global crisis.

With regards to the other two types of efficiency, allocative and economic, they follow the same direction from December 2001 to December 2008. During the crisis of 2002 (electoral crisis), in which the monetary policy was characterized as being contractionary, therefore, an increase in the Selic rate led to an improvement in both efficiencies in the banking sector. Thus, in 2002, when there was an outflow of foreign capital from the country and increased uncertainties about the future policy that was to be implemented by the government, the banking sector tended to be more efficient regardless of these adversities.

With regards to the 2008 crisis, in relation to the two efficiency indices, the Brazilian monetary authority reduced the Selic rate to implement countercyclical policies, and it was expected that the banking sector's efficiency would either remain constant or exhibit an improvement. However, this was not observed once its efficiency index fell. Finally, both allocative and in terms of economic efficiency, banks seem to increase efficiency quicker in times of crisis.

This article opens a new perspective for the existing literature on the impacts of monetary policy via interest rates on the banking sector efficiency, and how such impacts occur, that is, what are the mechanisms of this relationship? These issues can be addressed in further studies. With the results presented in this study, regulators (central banks) will be able to understand the average behavior of the main Brazilian banks and this will help in the definition of monetary policies. In addition, the study provides a picture of banks' behavior in the face of crises.

The results of this study are limited to the Brazilian context (50 largest banks in Brazil) between the analyzed periods. Moreover, future studies can also focus on the use of a linear methodology that captures the mean effect of the impact of the change in the interest rate on the mean efficiency of the banking sector.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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