Public banks and monetary policy: An empirical analysis based on dependent local projections for Brazilian Economy (2000-2018)

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Abstract

We test the hypothesis that public banks reduce monetary policy power for Brazilian economy, during the 2000-2018 period. Previous studies have shown that companies with access to government driven credit present smaller fall in investment and production after a contractionary monetary policy shock. Nevertheless, these studies are based on microeconomic data and ignore cost-push effects of monetary policy. We employ state dependent local projections (Jordà, 2005) to compare monetary policy power (defined as the sensibility of inflation to changes in basic interest rate) between periods of high credit of public banks and periods of high credit of private banks. We do not find evidence that monetary policy is less powerful in periods of high credit of public banks. Even though periods of high credit of public banks present a lower effect over output, those periods present less persistent price puzzles than periods of high private credit. We conduct several robustness tests to confirm our results. We attribute those results to lower flexibility in interest rates of credit from public banks, what leads to lower transmission in financial costs, lower reduction in capital stock and lower puzzle in exchange rate.

Keywords: **public banks; monetary policy; local projections; credit-channel**
JEL: **E 5; E 51; E 58; E 63**
Area: **4 – Macroeconomia, Economia Monetária e Finanças**

Resumo

Testamos a hipótese de que os bancos públicos reduzem a potência da política monetária no Brasil, entre os anos de 2000 e 20187. Estudos anteriores mostraram que as empresas com acesso ao crédito dirigido pelo governo apresentam menor queda no investimento e na produção após um choque contracionista na política monetária. No entanto, esses trabalho são baseados em dados microeconômicos e ignoram as pressões de custo da política monetária. Empregamos projeções locais dependentes do estado (Jordà, 2005) para comparar a potência da política monetária (definida como a sensibilidade da inflação às mudanças na taxa básica de juros) entre períodos de alto crédito de bancos públicos e períodos de alto crédito de bancos privados. Não encontramos evidências de que a política monetária seja menos potente em períodos de alto crédito de bancos públicos. Embora nos períodos de alto crédito de bancos públicos apresentem um efeito menor sobre a produção, esses períodos apresentam *price puzzles* menos persistentes do que em períodos de alto crédito privado. Realizamos vários testes de robustez para confirmar nossos resultados. Atribuímos esses resultados à menor flexibilidade nas taxas de juros de crédito dos bancos públicos, o que leva a menor transmissão nos custos financeiros, menor redução no estoque de capital e menor *price puzzle* na taxa de câmbio.

Palavras-chave: **bancos públicos; política monetária; projeções locais; canal do crédito**
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1 – Introduction

Contemporary macroeconomic regimes surveilled by strong and independent Central Banks targeting only price stability, resulted in strong and highly flexible financial markets (Blyth, Mathijs, 2017). More flexible financial markets are usually associated with stronger impacts of monetary policy on economic activity (Borio, 1996; Garriga et al., 2017). In countries where companies and households are indebted in flexible rate loans, increases in interest rates are expected to further reduce the aggregate demand. Therefore, the credit-channel of monetary policy (Bernanke, 1995) is stronger in economies with more flexible financial markets.

Nevertheless, the flexibility of credit rates may have undesirable outcomes for investment and financial stability. Given the uncertain character of investment decisions, which requires long-term, committed and patient finance, especially in innovation intensive sectors (Mazzucato and Penna, 2016). A financial system subject to highly volatile interest rates may harm investment planning and increase financial instability (Minsky, 2008, p 239). When balance sheets are filled with short-term and flexible rate debts, the effects of monetary policy over activity may enhance financial instability (Fazzari and Minsky, 1984, p.112).

In this sense, it could be argued that the flexibility of credit rates divergently affects two goals of contemporary Central Banks, namely, the control of inflation and the promotion of financial stability. On the one side, Central Banks are expected to affect credit markets and economic activity in order to comply with inflation targets. On the other, Central Banks are required to promote financial stability, which can be achieved through stable credit sources. The two diverging social purposes should be conciliated in order to design desirable macroeconomic regimes (Baker, 2018).

In Brazil, a broad network of public banks has sought to maintain low credit rates and lengthen credit terms, especially for agriculture, housing and capital goods (Torres Filho, 2009; Pazarbasioglu-Dutz et al., 2017). The intervention also protects real economy from exogenous shocks, such as international financial crisis. The response of public banks to the 2008 crisis fostered the recovery of Brazilian economy, although it was criticized for reducing monetary policy power (Bonomo et al., 2015; Segura-Ubiergo, 2012). Critics argued that, once the credit granted by public banks present a less pronounced response to monetary policy, a higher change in the policy rate is required for a desired change in output (Arida, 2005). This would imply a higher equilibrium basic interest rate (Barboza, 2015). This argument was central in recent financial reforms that reduced government intervention in credit markets. Among the reforms, the main referential rate for the Brazilian National Development Bank (BNDES) was pegged to inflation plus the spread of a government five-year bond (Palludetto and Borghi, 2020, p. 15)3. The reforms aimed to bring BNDES benchmark rate closer to market levels and more responsive to Central Bank basic rate. In 2020, during the coronavirus lockdown, Public Banks were reactivated in order to contain the liquidity crisis. The recurrent reliance on public banks to provide liquidity when private banks retract brings to forefront the necessity of coordinating financial stability policies with monetary policy.

This paper tests the hypothesis that the increased role of public banks reduces the power of monetary policy. We apply state-dependent local projections (Jordà, 2005;2019) to compare estimates between states of high-credit of public banks with states of high-credit of private banks. Our estimations contribute to the growing literature on state-dependent effects of monetary policy (Tenreyro and Thwaites, 2016; Alpanda and Zubairy, 2018; Jorda et al. 2019), by estimating the effects of monetary policy during periods of high level of indebtedness in credit cycles from public and private banks. This contribution bears in mind the recent push for coordinating diverse goals of monetary policy (Dow, 2014, Baker, 2018). Specially, we empirically analyze how financial development and stability policies interact with monetary policy goals, a pressing question for the Brazilian context

[3] Formerly, the main benchmark for BNDES loans was the Long Term Interest Rate, a rate defined by the National Monetary Council usually in lower levels than the policy rate.

(Bonomo et al, 2015; Castro, 2019), but also relevant for other developing and developed economies (Stiglitz and Greenwald, 2015, p 227; Griffith Jones et al. 2018).

We find that in periods of high indebtedness the price puzzles are more pronounced, i.e., price levels may initially rise more after an increase in interest rates. In credit cycles led by private banks, such price puzzles are more persistent. Once the credit of private banks is more flexible, the stronger credit channel is curtailed by financial costs increases after the monetary contraction. Therefore, we conclude that policies promoted by public banks, that increase the term of loans and the stability of credit rates, may enhance overall monetary policy goals in times of financial fragility.

In addition to the introduction, this work is divided into three sections. The second section discusses the coordination issue between public banks and monetary policy, analyzing the Brazilian debate. The third section presents the methodology of state dependent local projections, explaining its usage for regimes of high credit of public and private banks. In the fourth section we present our results, showing that the estimates do not support the hypothesis that regimes of high credit of public banks compromise the power of monetary policy. Even though public banks make production more resilient to monetary policy shocks, the power of monetary policy (measured in terms of inflation) is no less in periods of high public credit when compared with periods of high private credit.

2 – Public banks and monetary policy in Brazil

Interest rates in Brazil are historically high when compared to countries with similar economic structure. Several authors suggested that such high level could be explained by government intervention in credit markets (Arida, 2005; Barboza, 2015; Bonomo et al., 2016). Persio Arida (2005), former president of both Brazilian Central Bank and Brazilian National Development Bank, has argued that public banks were responsible for reducing the power of monetary policy. Once credit rates charged by public banks were less responsive to the policy rate, borrowers from public banks would be protected from monetary tightening. Therefore, after a hike in interest rate, the expenditures of companies and households borrowing from public banks would be reduced less than if they had borrowed only at private banks. Accordingly, the Central Bank would have to further increase the policy rate in order to reduce excess demand and stabilize rising inflation (Segura-Ubiergo, 2012; Barboza, 2015).

Credit rates earmarked by government are significantly less responsive to changes in the policy rate (SELIC) (Bonomo et al., 2018). As the correlations in the Table 1 show, the average interest rates on free fund and earmarked loans are highly correlated with the policy rate (68% and 65% respectively). In contrast, the correlation with SELIC is lower with BNDES average interest rates and with earmarked credit spread (28% and 0.03% respectively). The lower responsiveness of the credit spread of earmarked credit would curtail the bank-lending channel of monetary policy (Bernanke and Gertler, 1995), requiring the Central Bank to further increase the policy rate (Bonomo et al, 2016).

Table 1: **Correlations between basic interest rate (SELIC) and average rates and spreads for free and earmarked credits in Brazil (2007-2018)**

	SELIC	Free Rates	Earmarked Rates	Free Spread	Earmarked Spread	BNDES
SELIC	1					
Free Rates	0,68	1				
Earmarked Rates	0,65	0,91	1			
Free Spread	0,47	0,96	0,88	1		
Earmarked Spread	0,03	0,6	0,75	0,72	1	
Average rate of BNDES	0,28	0,78	0,9	0,86	0,92	1

Note: Data Source: Brazilian Central Bank. Authors' own elaboration.

The lower responsiveness of earmarked spread and BNDES rates reflects governmental protection of priority sectors through the stabilization of credit rates. In the period after the crisis of 2008, the Brazilian Government intensified the action of public banks to prevent international financial instability from affecting domestic production (Barros et al., 2018; Griffith-Jones et al., 2018). Although the intervention sustained the stability of financial markets, its continuity was criticized as soon as the initial effects of the crisis ceased for hindering monetary policy power (Segura-Ubiergo, 2012, Bonomo et al., 2015).

Current empirical testing of the effects of public banks on monetary policy is limited to microeconomic studies at firm and industry level. Bonomo et al. (2016) show that after a contractionary shock, companies with access to credit from public banks present a smaller reduction in the volume of new loans and employment. In addition, these companies are less sensitive to external shocks, such as rising international risk. Corroborating such evidence, Perdigão (2018) shows that there is a lower response to monetary policy in industrial sectors with a larger share of earmarked credit to total credit.

By definition, monetary policy power is a macroeconomic phenomenon, which firm-level databases are unlikely to capture (Kashyap and Stein, 2000). Castro (2019) questions the breadth of the arguments of Bonomo et al. (2016) due to the presentation of only microeconomic evidence. In fact, aggregate effects of monetary policy are the sum of each firm's microeconomic effects plus the external effects of all firms acting simultaneously, what alters input and final goods prices. Cross-section estimates omit external effects and are not necessarily informative about inflation outcomes.

Analyzing inflation responses disregarding external effects can hide the intensification of price puzzles. Positive variations in prices following contractionary shocks - known as price puzzles - are well documented in the economic literature (Ravenna and Walsh, 2006, Ramey, 2016). Price puzzles appears in most VAR estimations in the form of an initial increase in prices after a monetary policy shock (Ramey, 2016, p. 99). The effects of financial costs were pointed as an explanation for this hump-shaped estimations in VAR models (Cristiano et al, 2005). The hump in prices would stem from increased financial costs passed on to consumers by firms setting prices as a markup on costs (Lima and Setterfield, 2010; Castro, 2019). If reductions on prices arising from demand contraction do not offset the rise in the financial cost, inflation is increased. The existence of price puzzles alters the optimal monetary policy problem because any shock implies a trade-off between stabilizing inflation and stabilizing the output gap (Cardim de Carvalho, 2005; Ravenna and Walsh, 2006).

Interestingly, the lower flexibility of credit rates, promoted by public banks, has divergent effects for the traditional credit channel of monetary policy and for the increase in financial costs4. Since interest charged on earmarked credit is less responsive to the policy rate, the cost channel is less active in firms with greater access to public banks' credit. Thus, earmarked credit would have a dubious effect on monetary policy. The access to public banks' credit results in lower output reduction following contractionary shocks. On the other hand, access to public bank credit reduces the intensity of cost shocks that could lead to price puzzles. Consequently, in the absence of public banks, output may respond more and inflation respond less to monetary policy changes (Castro, 2018; Silva et al, 2018). In this case, public banks would be beneficial both for the financial stability and for the inflation control.

3 – Methodology and empirical strategies

3.1. Local Projections

The extent that aforementioned mechanisms hold are a matter of empirical testing. As highlighted before, former studies are incapable of studying inflation, since they deal only with microeconomic data. Time-series approaches have been the main methodological tool for understanding the effects of monetary policy over activity and inflation at once. Estimates of local projections have been increasingly used in the monetary policy literature. A recurring result of this literature is the fact that monetary shocks during periods of growth are more potent than those in periods of recession (Tenreyro and Thwaites, 2016; Santoro et al., 2014; Jordà et al., 2019). Tenreyro and Thwaites (2016, p.59) conclude that in the American economy contractionary shocks have greater effects on output than monetary easing. In stark contrast, Chen et al. (2019) conclude that in China output and inflation responses are higher after a monetary easing. This result is attributed to the presence of public companies, which would suffer less from monetary contractions and benefit more in times of loosening. Chen et al. (2019) results highlight the fact that the response of diverse government agencies is highly relevant for the conduct of monetary policy.

Beyond studies of cycles of monetary policy in depressions and recoveries, a recent literature has applied local projections to different monetary responses in a credit cycle. Jordà et al. (2019) show that the product responds more to monetary policy in periods of high credit to households, while inflation responds more in periods of low credit. Alpanda and Zubairy (2018) conclude that a monetary easing is more effective for economic activity in periods of low mortgage debt, but in these periods there is a worsening of the price puzzle (Alpanda and Zubairy, 2018, p.12).

As we can see, the literature of state-dependent local projections questions the linear relation between excess demand and inflation predicted by new-Keynesian models (Santoro et al., 2014). In fact, this relation would be subject to distinct phases in the credit cycle and also to the nature of the credit cycle, for instance, if it is held by households or by companies (Jorda et al., 2019).

Local Projections were initially proposed by Jordà (2005) as a way to avoid bias due to poor specifications in Vector Auto-Regression (VAR) models. In VAR models, if the number of lags is not equal to that of the data generating process, estimated errors of impulse response functions are accumulated at each time horizon (Ramey, 2016, p.83). As an alternative, local projections make direct

[4] In addition to lower cost shocks, the existence of public banks could lead to less pronounced reductions in capital stock following increases in interest rates (Feijó and Sousa, 2012; Modenesi and Modenesi, 2012; Castro, 2018). Through this channel, the short-term impacts of targeted credit on the power of monetary policy could be offset by allowing potential output to expand, reducing the impact of demand pressures on inflation.

predictions from a specific regression for each time horizon. Instead of iterating one step further from a previously estimated model as in VAR models, local projections predict values of a variable using a direct forecast for a specific horizon (Ramey, 2016, p.84). For instance, a linear local projection can be estimated by Ordinary Least Squares (OLS), according to the equation (1):

$$y_{t+h} = \beta_{t+h}\, shock_t + \theta_{t+h} x_t + u_t \quad (1)$$

The coefficient β estimates the average effect of an exogenous shock on the variable y over the time horizon t+h. The matrix θ contains the coefficients of the control variables x_t. Therefore, an OLS estimate is generated for each time horizon h after the shock. Control variables ensure that the effects of the shock on the variable of interest are only caused by the shock itself. Controls may include trends, shock-correlated variables, y-lags, and seasonal dummies, for example. The method is robust to non-stationary or cointegration in the data (Ahmed and Cassou, 2016). Nevertheless, the u_t error terms are serially correlated, requiring the usage of Newey-West corrections in standard errors (Jordà, 2005).

In order to identify contemporary causal relationships between the variable of interest y_{t+h} and shocks, one has to adopt one of the identification options shared with the VAR literature. The most common identification methods include Cholesky decompositions, structural identifications, narrative methods, high frequency identification, instrumental variables, signal restrictions. In our estimates, we employ Cholesky decompositions for the estimation of shocks, that are subsequently adopted in the local projections. Such a specification is commonly used in monetary policy studies (Christiano et al., 1999; Jordà, 2005; Ramey, 2016) and has presented similar results to narrative methods (Alpanda and Zubairy, 2018).

In small sample estimations or where the number of lags is poorly specified, local projections are a viable alternative to VAR impulse-response function estimates (Brugnolini, 2018; Barnichon and Brownlees, 2019). Even though estimations from local projections may in some cases be less accurate than VAR estimates (Kilian and Kim, 2011; Ramey, 2016), it presents several advantages for the question at hand. Firstly, local projections can be estimated by OLS, not requiring more complex methods used in high order VARs (Jordà, 2005). Secondly, local projections are robust to the poor specification of the actual data generating process. Since it is not necessary to define a priori the functional form of the data generating process, the estimates are reliable even if the equation system that best describes the interactions of variables is not known (Jordà, 2005). Thirdly, estimates with local projections may allow to save parameters and increase degrees of freedom (Tenreyro and Thwaites, 2016, p. 47).

3.2. Local Projections for High Credit States

Monetary policy studies with linear local projections may analyze the average response of output and inflation to a monetary shock, regardless of the credit conditions of an economy (see for instance Carcel et al. 2017). As a hypothesis of this work, we test if different credit state influences the response of inflation and output to monetary policy. Moreover, we test whether the states have different outcomes for monetary policy in the cases where the credit cycle is led by public or private banks[5].

Local projections are adopted because they allow the simple incorporation of different states. We can investigate the effects of exogenous shocks under different credit states without a priori

[5] Analogously, Jorda et al. (2019) compares the credit cycles defined by different debtors, whether households or companies. Authors conclude that cycles led by household debt are more influent for monetary policy interventions.

defining how the economy moves from one state to another (Ramey and Zubairy, 2018). Estimations are performed following the specification in equation (2):[6]

$$y_{t+h} = F(z_{t-1})(\beta^{H}_{t+h}\, shock_t + \theta^{H}_{h} x_t) + \big(1 - F(z_{t-1})\big)(\beta^{L}_{t+h}\, shock_t + \theta^{L}_{h} x_t) + u_t \qquad (2)$$

As in the linear model, the coefficients βh estimate the average effect of a shock on the variable y for the time t+h. In a state dependent local projection, the coefficient β^{i} depends on the credit state, defined by the function $F(z_{t-1})$ and indicated by the upper index for high (H) or low (L). Following Auerbach and Gorodnichenko (2012) the state variable is lagged, so there is no contemporary feedback between the state and the shocks. The $F(z_{t-1})$ function returns a regime definition representing the probability of the economy to be in a high or low credit state. To obtain non-discrete probabilities as values of the function $F(z_{t-1})$, the difference between the state variable and its trend is transformed according to the following logistic function:[7]

$$F(z_t) = \frac{e^{-\gamma z_t}}{(1 + e^{-\gamma z_t})} \qquad (3)$$

Function (3) approaches 1 when the economy is most likely to be in a high credit regime. Alternatively, it approaches 0 when the regime is more likely to be low-credit. The logistic function smoothes state changes to prevent that slight variations in zt result in a sudden (and discrete) regime change. The parameter γ defines the intensity of the smoothing: higher values of γ mean that $F(z_t)$ stays longer near the limits [0,1], bringing the model closer to a discrete setting.

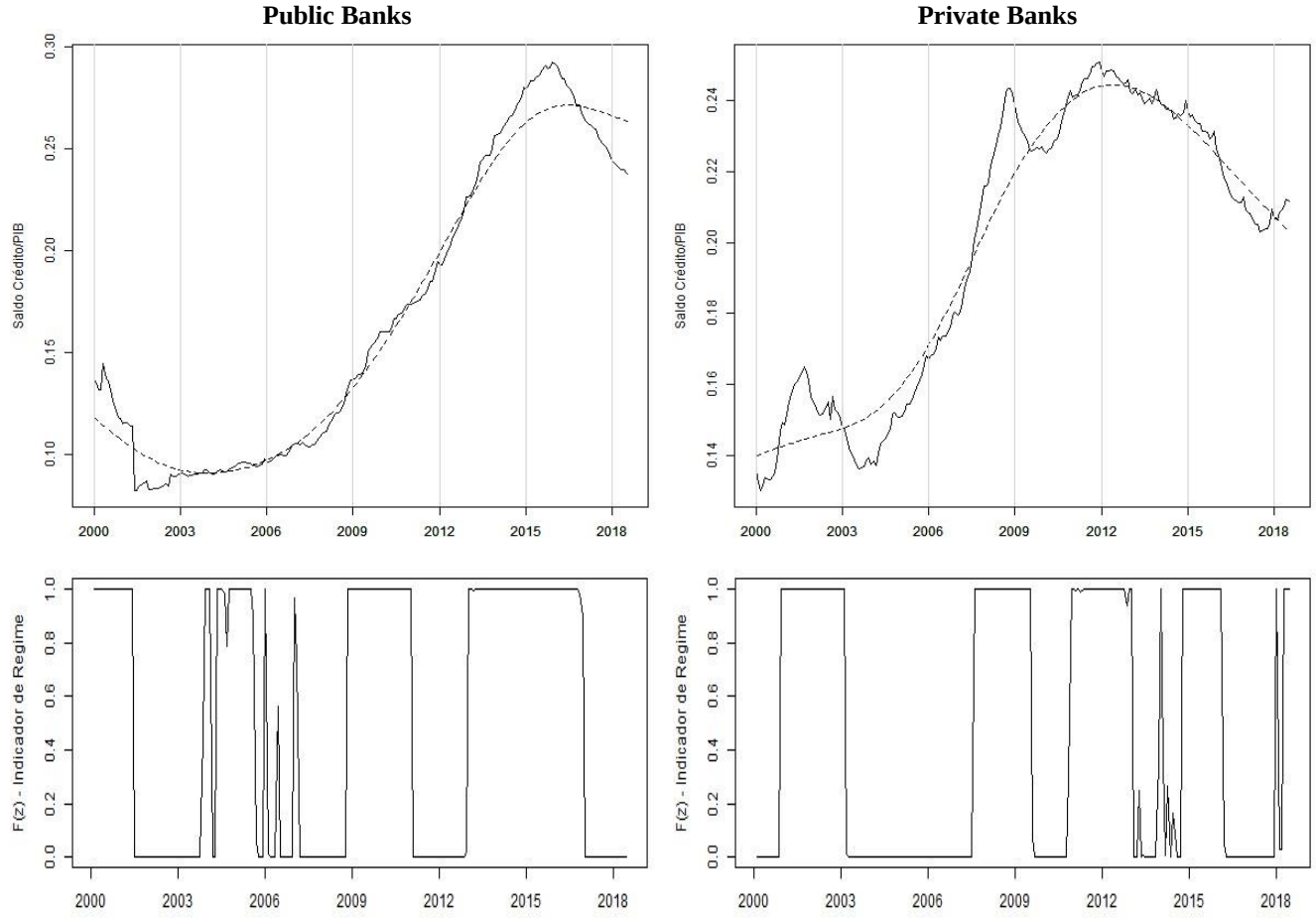
Credit states are identified following the financial literature on the "credit gap" (Drehmann and Tsatsaronis, 2014). Accordingly, high credit states are defined as those in which the credit balance to GDP is larger than its long term trend. By using the credit series as a ratio of GDP, we intend to control for changes in price levels and changes in economic conditions (Alpanda and Zubairy, 2018). Thus, the difference between Credit / GDP and its trend defines regimes in local projections represented by the zt in Equation (2).

The credit gap has been recommended by the Bank for international settlements as an indicator of macroeconomic financial instability. Periods where the credit gap is positive are characterized by banking stress and are good predictors of financial crises (Jordà et al., 2016). Drehmann and Tsatsaronis (2014, p. 58) argue that, conceptually, the credit gap synthesizes financial instability in line with the work of Minsky (2008). High credit periods are thus prime episodes to investigate the effects of the monetary policy credit channel. In these periods, interest rate shocks are more likely to affect investing and spending decisions, given the greater commitment of income to loan repayments.

As we argue, credit cycles of public banks are assumed to soften this effect as there is lower response of borrowing costs to movements in basic rate. Therefore, adopting the credit gap, we can test whether in periods of high credit of public banks the monetary policy has lower power in comparison with periods of high credit of private banks. The two upper graphs in figure 1 show the credit state variable of public and private banks (% GDP), as well as their dotted trend. The periods in which the credit stock is superior to the trend is considered a high credit state. The lower graphs show the state indicator, where value 1 is assigned to periods when the credit balance is greater than trend. In this indicator there is no smoothing, so we can note sudden breaks when the credit level is above the trend.

[6] Estimations are performed with the *lpirfs* package, implemented in R by Adämmer (2018).
[7] Function implemented by Adämmer (2018), and originally suggested by Granger et al. (1993).

Figure 1: **State Variable: Credit Stock of public and Private Banks as a proportion of GDP**



In the estimations, we consider separately the state variables for public and private banks, and then compare the results by examining the monetary policy multipliers. Thus, first we analyze how monetary policy behaves during high and low credit states led by public banks. Then we move on to the the credit cycles led by private banks. Finally, monetary policy multipliers inspired by Jordá et al. (2019) are calculated in order to compare monetary policy power in the two different cycles.

3.3 – Data

The basic estimates of this work include output, inflation and interest rate variables, as well as the credit state variable of public and private banks. For inflation data, we use the series of the National Consumer Price Index (IPCA), the index used for Central Bank's inflation target. For Gross Domestic Product data, we use Getúlio Vargas Foundation (FGV) monthly series, which is compatible with Brazilian Institute of Geography and Statistics (IBGE) quarterly GDP estimates. For monetary policy shocks, we employ the policy rate series (Selic), published by the Central Bank. For state variables, we use the Balances of Credit Operations of Financial Institutions under Public Control and Private Control, both disclosed by the Central Bank. The main estimates are made for the period between January 2000 and July 2018, resulting in 223 monthly observations. The lower limit of January 2000 is given by the availability of data from the FGV GDP Monitor. As the inflation targeting regime was adopted in Brazil in June 1999, the sample covers the entire period, except for the initial six months, due to the unavailability of monthly GDP data for the period.

4 – Results and discussion

4.1. Credit regimes of public banks

In the next two sections, we present the estimations of the local projections first for public banks and then to private banks credit cycles. Later on, we compare the responses by looking to the monetary policy multipliers. For calculating the local projections, we adopted 12 lags, as recommended by the AIC criterion. Additionally, we added a monthly dummy to prevent the effects captured from reflecting seasonality.

Figure 2 presents the impulse response functions for a one standard deviation policy rate shock, depending on the credit state of public banks. The first column presents the response of inflation, output and of policy rates itself. We can compare the responses during high credit state represented by the solid black line with the low credit state represented by the dotted red line. The confidence intervals (95%) for high state is represented by the solid thin lines and for the low state by red shaded area.

Inflation's response presents a remarkable price puzzle by the fifth month. This price puzzle is more relevant in the period of high credit than low credit. From the sixth month onwards, monetary policy has a significant negative effect on inflation in the high credit regime, which is maintained until the 15th month. In the low credit regime, however, monetary policy has no significant negative effect on prices. In this regime, after the 6th month the shock remains not significant in practically all periods.

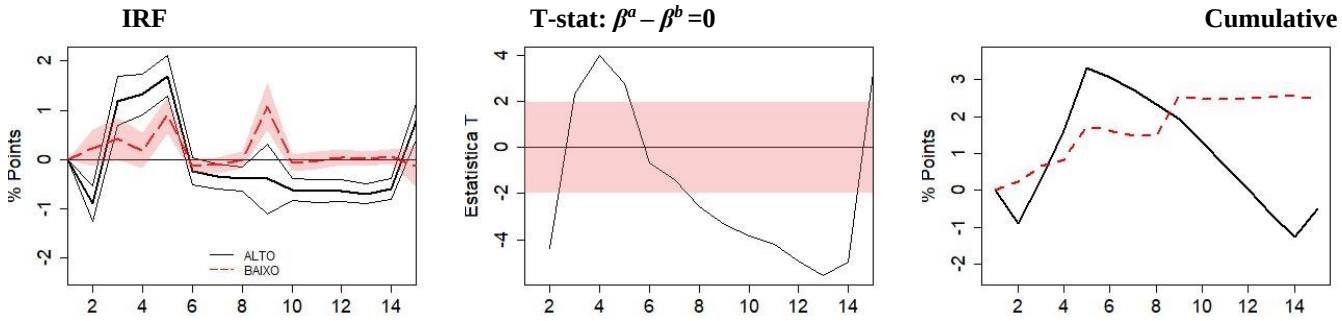
The effects on GDP are in line with the hypothesis that in the period of higher indebtedness the effects of monetary policy are stronger. The negative effect on the product occurs from the first month and intensifies in the following months. Until the eighth month, the trajectories of high and low credit remain close. From the eighth month, there is a greater distance between the two estimates, with the product having larger losses in the state of high credit. Note that the effects on the product do not dissipate until the 15th month. Effects of monetary policy over periods of more than two years are also noted by Jordà et al. (2019); Tenreyro and Thwaites (2016).

In both regimes, positive monetary policy shocks are followed by successive increases in basic rates. In the high credit regime, successive increases are greater than those of the low credit regime. In the high credit regime, although the shocks decay, they do not converge to zero within the presented 15-month horizon. Under the low credit regime, basic interest rate stops increasing after one year.

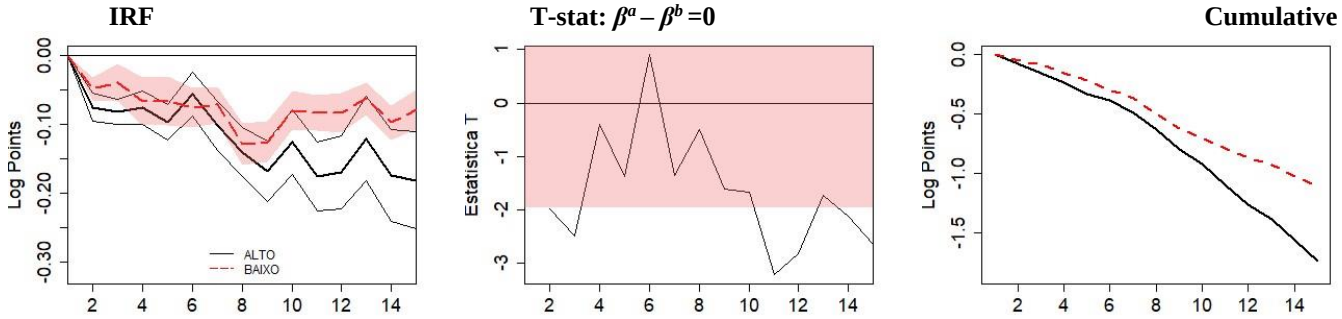
Interestingly, for the three variables, the high credit regime has greater confidence intervals than the low credit. This reflects the fact that in addition to the more intense effects on the high credit regime the effects are less predictable.

Figure 2: **Basic Estimations with Public Banks credit as state variable**

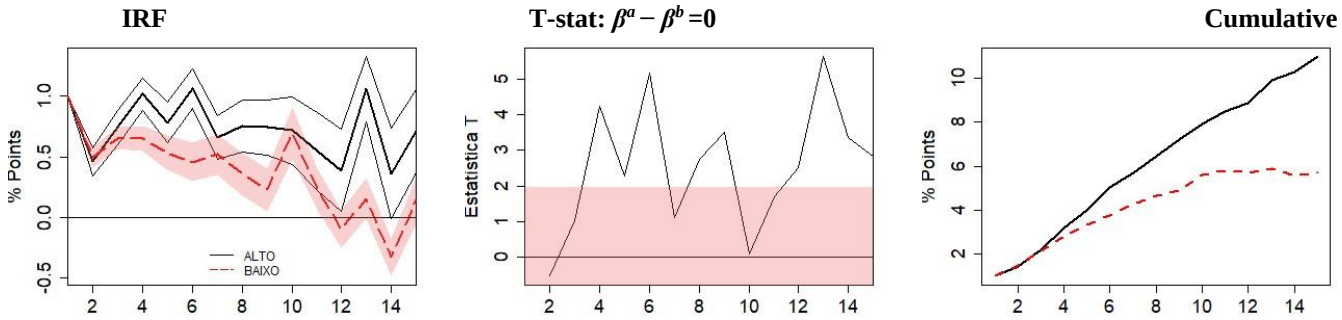
(a) **Interest Rates on inflation**



(b) **Interest rates on Output**



(c) **Interest Rates on Interest Rates**



Note: The first column shows the impulse response functions in the high credit (solid black) and low credit (dashed red) states, the respective confidence intervals (95%) are represented by the solid line and shaded area. The second column presents T statistics for the hypothesis that the difference between the coefficients in the two states is equal to 0, the shaded area marks the range of ± 1.96. The third column presents the cumulative impulse-response function for the state of high credit (solid) and low credit (dotted).

The second column of Figure 2 presents the T statistic for the null hypothesis that $(\beta_h^a - \beta_h^b) = 0$, with the shaded confidence interval of ± 1.96. Thus, if the line is below the shaded area on some time horizon, we can reject the null hypothesis that the answer on that horizon is equal, in favor of the alternative that is more negative in high credit states, under the 5% significance level. Therefore, regarding the inflation results, the difference between the two regimes is significant for the initial price puzzle and for the larger drop in inflation from the 7th month on. For the output, the high credit period has more significant effects in the first months after the shock and in the months after the 11th. Regarding basic rates, after the fourth period, successive rate increases are generally significantly higher in the high credit period.

The third column of Figure 2 presents the accumulated result of the impulse response functions, calculated by the sum of all shocks up to a certain horizon h. For inflation, it is noted that the negative net effect only becomes relevant after the 12th month of the high credit regime. For the product, there is a similar response in both regimes until the eighth month, when the monetary policy starts to have increasing effects on the high credit regime. The high credit regime does not indicate a stabilization of increases in basic interest rates, while in the low credit regime such stabilization is already noted from the 11th month.

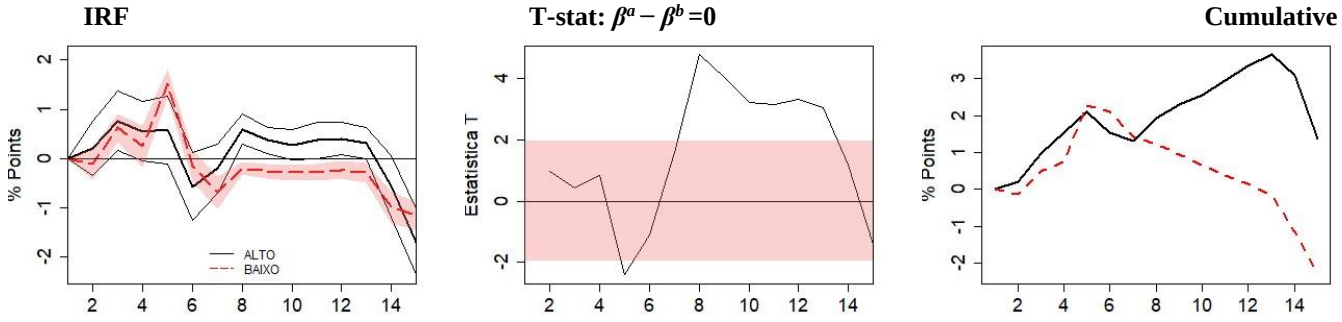
From the public banks estimates alone, we can conclude that in a high credit state, the initial price puzzle is higher, the effects of monetary policy over activity is stronger and the cycle of increases in policy rates last longer. Without comparing with cycles led by private banks, we could get to the conclusion that higher public bank activity worsens monetary policy power. When public banks are more active, an increase of interest rate would have higher effects over activity, but an undesirable effect over inflation, what would lead to additional increases in interest rates. In the next section, we compare these results with the credit cycles of private banks, where we note that those results are even more intense.

4.2. Credit regimes of private banks

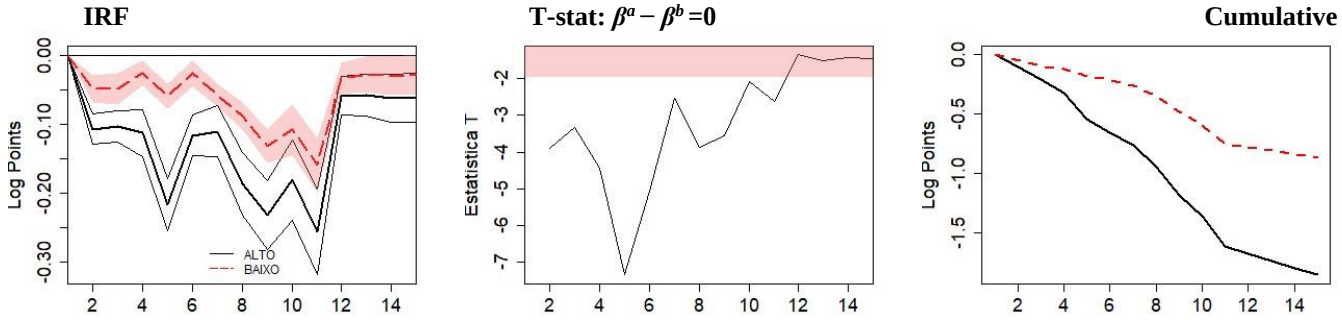
We repeat the above estimates using the private banks' credit gap as a state variable. Figure 3 presents the basic results for a standard deviation shock on policy rate over the three variables of interest, conditioned by the private bank credit regime. Although a similar price puzzle in both states is noted until the 6th month, inflation presents a stronger and longer-lasting price puzzle in periods of high credit. From the 6th month on, there is an opposite effect to that perceived in the credit cycle of public banks: periods of low private credit have a negative inflation response and periods of high credit have a positive response. The product is significantly more responsive in the high credit period. Interest rate, in turn, presents the expected downward trajectory in both states. In the high credit period, there is a higher persistence of interest rate hikes, which does not stabilize until the 15th month.

Figure 3: **Basic Estimations with Private Banks credit as state variable**

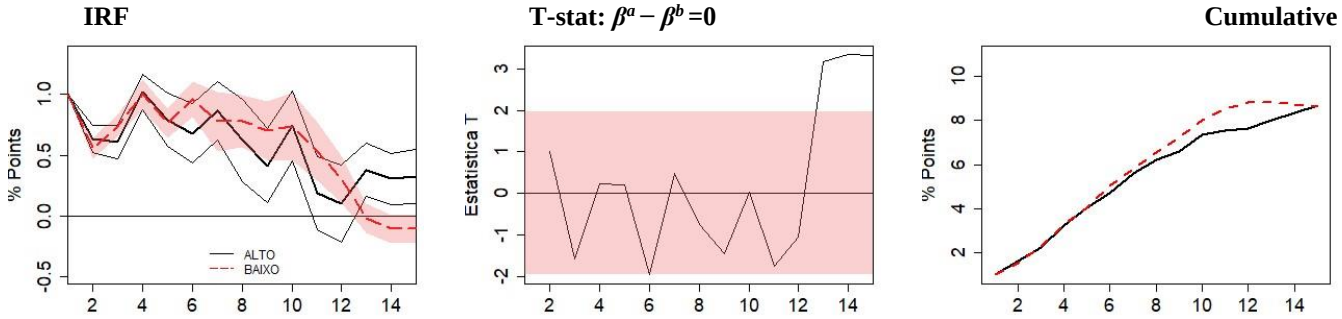
(a) **Interest rate on inflation**



(b) **Interest Rate on Output**



(c) **Interest rate on interest rate**



Note: The first column shows the impulse response functions in the high credit (solid black) and low credit (dashed red) states, the respective confidence intervals (95%) are represented by the solid line and shaded area. The second column presents T statistics for the hypothesis that the difference between the coefficients in the two states is equal to 0, the shaded area marks the range of ± 1.96. The third column presents the cumulative impulse-response function for the state of high credit (solid) and low credit (dotted).

In the second column of Figure 3 we note that the differences pointed out between the states are significant. In particular, the larger price puzzle, the larger drop in output and the persistence of interest rate increases during periods of high credit are significant. The effects are also exposed in the cumulative charts in the third column, where inflation is reversed only after the 13th month, the large accumulated difference in output response, and interest rate's indistinct behavior, with the difference that in the low credit period stabilization of policy rate increases is already noted in the 12th month.

4.3. Monetary Policy Multipliers

To compare estimates between public bank and private bank estimates, we calculated cumulative multipliers of the impulse-response functions, based on Jordà et al. (2019). Multipliers are calculated as the ratio of the average GDP and inflation response to the average interest rate response. Interest rate normalization removes differences between states that may stem from differences in the interest rate path in each state.

We can understand the multipliers as the required average variation of output (or inflation) to obtain the impulse response functions of Figures (2) and (3). The multiplier thus gives us the percentage of cumulative change in output (or percentage points in the case of inflation), given a 1 percentage point shock on interest rate in monthly values. Table (2) presents the results for the estimates based on the credit status variables of the public and private banks.

Table 2: **Monetary policy multipliers**

Public Banks	High Credit	Low Credit
Inflation	- 0,05	0,43
Output	- 0,16	- 0,19
Private Banks	High Credit	Low Credit
Inflation	0,16	- 0,27
Output	- 0,21	- 0,10

Note: Reported values can be interpreted as how much output (or inflation) changes in percentage (percentage points) on average over the 15 months considered to construct the impulse response functions reported in Figures (2) and (3).

Regarding the output, the four scenarios have negative answers. In the period of high public credit, an increase of one percentage point in the (monthly) interest rate reduces the product growth rate by 16% over the 15-month period[8]. The largest response of the output is in the period of high private credit, which is approximately double the period of low private credit, and 30% higher than the period of high public credit. This confirms the thesis that in periods of high public banks credit, output is shielded from monetary policy shocks, partially confirming the findings of Bonomo and Martins (2016).

Negative inflation multipliers only occur in periods of high public credit and low private credit, with the most significant effect on the latter. In the period of high public banks credit, an increase of one percentage point in the (monthly) interest rate reduces the inflation rate by 0.05 percentage points over the 15-month period. In turn, in the high private bank credit regimes, the price puzzle remains throughout the period. This challenges the hypothesis that the monetary policy is more effective to contain inflation in case the private banks led the credit cycle. It confirms the hypothesis that price puzzles are more related to periods in which there is higher credit rates flexibility (Castro, 2019).

To corroborate our results, we performed robustness tests that consider: (i) alternative lags selection criteria, (ii) greater smoothing in regimes, (iii) exclusion of recessive periods, (iv) inclusion of open economy variables and (v) alternative state variables, considering free and earmarked credit stocks, instead of public and private banks. The detailed results of each test are presented in the annex.

Inflation results are not as robust as output results to different specifications, but we conclude that in high credit periods price puzzles are more likely and durable. As we noted in the impulse response functions, price puzzles are considerably persistent during periods of high private credit. The periods of high public credit presented higher initial price puzzle, which reduced earlier than those in periods of high private credit. The periods of high private credit also showed the largest reductions in output, after rising interest rates. The periods of low private credit behave more closely than expected by new-Keynesian models, with smaller negative output responses and higher inflation responses.

5 – Discussion of Results

The monetary policy multipliers reveal diverging dynamics between inflation and output in periods of high and low credit. The steeper fall in production does not necessarily reflect a steeper fall in inflation, as would be expected from a traditional Phillips curve. The stronger negative effect of interest rates on inflation occurred in periods of low private credit, the same period with the lowest drop in

[8] These effects is lower than that of the period of low credit of public banks, what seems to be at odds with the impulse response functions. Nevertheless, this is the case because the increases in interest rates during the period of high credit of public banks is higher. Thus, considering the higher interest rates increase in the high public credit state, the product is more resilient to the monetary policy in the high public banks credit regime than in the low public credit regime.

output. On the other hand, in the period of high private credit, the stronger response of the product was accompanied by persistent price puzzle.

The output response confirms the hypothesis that periods of high credit from public banks show greater resilience to monetary policy than periods of high credit from private banks. We attribute this result to the higher interest rate response of private banks to basic interest rates. These results corroborate, in a macroeconomic viewpoint, the micro hypotheses tested in Bonomo et al. (2016) and Perdigão (2018).

The vast literature on asymmetries in the transmission of monetary policy in times of recession and expansion is unable to deal simultaneously with diverging output and inflation outcomes (Santoro et al., 2014, p. 20). In general, models that apply Bernanke and Gertler's (1995) theory of financial accelerator predict analogous product and inflation asymmetries in times of recession and expansion of economic activity. Santoro et al. (2014) suggests that not only the IS curve, but also the Phillips curve would have its parameters changed over the economic cycle. In a monetary contraction, during a recessive period, there would be a simultaneous movement of supply and aggregate demand that could even lead to a price puzzle, depending on the magnitude of the changes.

In the context of Brazilian monetary policy, Castro (2019) provides an explanation for such divergence based on the rise in financial costs, given the rise in interest rates. The greater flexibility of loan terms can lead to both a contraction of the product and a sharpening of the price puzzle. Another hypothesis for the diverging results may derive from the fact that in periods of higher credit restriction, interest rate increases may result in an exchange rate devaluation, what leads to price increases (Kohlscheen, 2014). The fact that in periods of higher financial instability, interest rate increases may lead to increased market fears and devaluation may ultimately cause an increase in prices. This possibility is corroborated by the robustness test that include international variables. In that test, the periods of high indebtedness are marked by devaluations following a contractionary shock, confirming the hypothesis suggested by Aghion et al (2001) and Kohlscheen (2014).

6 – Final Remarks

The effects of monetary policy on real variables and inflation are generally described on a linear fashion, where effect over aggregate demand are transmitted to prices regardless of economic states. Still, the effect of interest rates on inflation is not only mediated by demand but also by financial costs. If costs increase after a policy shock, higher output reductions do not necessarily imply a higher fall in prices. Estimates with state-dependent local projections empirically reveal this apparent paradox of monetary policy (Santoro et al., 2014; Alpanda and Zubairy, 2018; Jordà et al., 2019). Our estimates are in line with this literature, which highlights the need to incorporate nonlinearities in monetary policy transmission mechanisms.

The work provides the first macroeconomic test of the effects of public banks on monetary policy power in Brazil. The results obtained in this work do not show that the existence of public banks reduces the power of monetary policy. We do not observe that the high credit periods of public banks show a lower inflation response to monetary policy than the high credit periods of private banks. In fact, high credit periods presented a volatile inflation response, subject to relevant price puzzles. Moreover, in periods of high credit of private banks, the price puzzle was more persistent.

From the point of view of the effects of interest rate shocks on demand, previous literature is practically consensual in arguing that there is greater resilience of investment to interest rate shocks, due to the existence of earmarked credit and public banks. Less responsive credit rates allow companies and households to keep expenditure levels after monetary shocks. Confirming this fact, we find that during periods of high credit of private banks the output was more responsive than in periods of high credit of public banks. This result corroborates those presented by Bonomo et al. (2016) and Perdigão (2018). However, it is important to emphasize that the power of monetary policy is defined in terms of

inflation, the determination of which does not depend solely on demand variations. In addition, the effects on output are also likely to apply to international shocks, i.e., government participation in the credit market also mitigates the effects of external shocks (Bonomo et al., 2016). Considering that the economic costs of financial crises rise when the public sector does not pursue macroeconomic stabilization (Jordà et al., 2016), public banks offer an important countercyclical alternative.

These results are relevant for recent debate on how public banks have been central in the treatment of financial crisis and for greener development (Griffith-Jones et al., 2018). The benefits provided by the patient finance of public banks will necessarily interact with other macroeconomic goals, and could be of concern to Central Banks that bear clear mandates of inflation stabilization. In this sense, a calming conclusion arises from this work, since it finds that patient finance may help to conciliate apparently diverging mandates of Central Banks. Public banks finance may stabilize credit conditions leading to reduced price puzzles.

At least three factors may contribute to the divergent dynamics of price puzzle dynamics between cycles led by public and private banks. As we argued, after a contractionary monetary shock, lending by public banks imply lower financial cost, lower capital stock reduction and lower exchange rate puzzle. Given these factors, public banks could in fact contribute to monetary policy power.

In line with the work of Castro (2019), additional studies should formalize such hypotheses, detailing the interaction between the various mechanisms listed. Further empirical tests could provide fine grained investigation of effects over various components of demand, for understanding whether public banks are able to protect investment.

Finally, this paper provides strong evidence that the power of monetary policy depends on the credit state of the economy. High credit periods showed higher price puzzle and stronger output outcomes. In turn, periods of low credit presented lower product response, but larger declines in inflation. It is essential that such evidence, also corroborated by the international literature, be taken into account by the Central Bank for the definition of monetary policy.

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