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Financial side over the real side: Effects in the Brazilian economy at last decade using hierarchical BVAR approach

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Abstract

We estimate a hierarchical Bayesian VAR (BVAR) for Brazil covering 2015–2024 to examine how financial conditions —credit, household indebtedness, FDI, bank lending rates, and default rates—propagate to real activity— unemployment, investment, and industrial capacity utilization. Impulse-response evidence indicates transmission channels, especially credit and balance-sheet effects, that extend beyond the conventional interest-rate channel emphasized in standard monetary-policy analysis.

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1 Introduction

After the Subprime crisis (2007) and the Eurozone sovereign debt crisis (2009-10), macroeconomists have become increasingly interested in understanding the relationship between the financial sphere and the real world (De Marco, 2019; Christiano, Gust, & Roldos, 2004). From a New-Keynesian perspective, the models began to incorporate more details about the communication between the two parties. This communication included how monetary and fiscal policies were conducted, as well as the use of unusual instruments. (Woodford, 2012; Badarau & Popescu, 2014).

Empirical macroeconomic literature aims to verify the role of financial variables as good predictors of future economic activity, and has found evidence in this regard. (Espinoza, Fornari, & Lombardi, 2012; Ferrara & Marsilli, 2013)

As supported by evidence, some financial variables are important for economic growth and also for the monetary policy transmission channels in developed countries. However, there is no significance for developing economies due to their small share of credit/GDP and low levels of indebtedness in these economies (Rocha, Magalhães, & Brilhante, 2022; Abbas, Afshan, & Mustifa, 2022).

This paper investigates how shocks in the financial sphere (business credit, interest rates on firm loans, debt levels, debt defaults, foreign direct investment) affect macroeconomic variables. For that, we focused on three main macroeconomic variables for the Brazilian economy: the growth rate of fixed capital, the industrial capacity utilization and the unemployment rate. To do this, three different hierarchical BVAR models are used to estimate the period from 2012 to 2024. Despite there is no conclusive result for the foreign direct investment, the other financial variables highlight the importance of these variables for the three variables of interest.

To this end, we have divided the text into four sections. The first section is the introduction, while the second briefly reviews the literature. The third section shows the econometric methodology, and the fourth and final section shows the final remarks.

2 Literature Review

Since Tobin's study on the general equilibrium approach to monetary theory (Tobin, 1969), the traditional view of monetary policy transmission has focused mostly on the interest rate channel and the substitutability of different asset classes by investors and banks.

The central bank can influence bank's reserve holdings by buying and selling assets on the open market. A tightening of reservable deposits will result in an increase in the interest rates on accounts that do not have to meet these requirements, which in turn translates into higher lending interest rates and thus affects the real economy.

Of course, we need to assume price rigidity for this channel to work. Thus, the usual view of monetary policy transmission considers financial intermediaries to be passive agents of a transmission mechanism, but not an actor in themselves.

Therefore, this paper is a further step in the discussion of the independent role of the financial sector and the effect of possible shocks from this sector on the real side of the economy, beyond the usual monetary policy shocks.

Thus, given the independent behavior of the banking sector, works such as (Gilchrist & Zakrajšek, 2011; Martins, Batista, & Ferreira-Lopes, 2019) point out how contractions in the credit supply negatively affect economic growth in the Eurozone. Similar results

are found for the BRICS (Farajnezhad, Ziaei, Choo, & Karimiyan, 2016) although there is an asymmetry of results between countries (Vieira & da Silva, 2023).

3 Methodology

For the econometric analysis, we employed the Hierarchical Bayesian VAR method (Kuschnig & Vashold, 2021). The VAR methodology is a good fit for the problem because of the endogenous relationships that are created between the variables. The Bayesian estimation method has advantages for our purpose. Frequentist VAR models suffer from the so-called curse of dimensions, since the loss of degrees of freedom for estimation increases quadratically as the size of selected variables or the lag order increases. Using such a dense parameterization often leads to inaccuracies regarding the out-of-sample forecasting and structural inference, especially for higher-dimensional models.

Thus, even if we have large time series, we cannot use VARs with too many variables or lags at the risk of over-parameterization. In the case of Bayesian VARs, this problem can be reduced by adding informative priors. The result is that we have a decrease in uncertain parameters and a significant increase in out-of-sample forecasting performance (Koop, 2013).

Some of the critiques on the use of Bayesian estimation regard the subjectivity of the prior choice, since this can impact the final result of the estimation. A part of the literature addresses this point by systematizing the use of priors by hierarchical criteria. In our case, we will use the hierarchical procedure based on the Giannone procedure (Giannone, Lenza, & Primiceri, 2015). The method uses a hyperparameter adjustment that best combines the Minnesota prior, the sum-of-coefficients (SOC) prior, and the single unit-root dummy-observations (SUR) prior.

Another advantage of using BVARs is that they are suitable for estimations using I(1) and I(0) series, without causing any loss of information. The estimation procedure involves choosing the mode, standard deviation, minimum and maximum values for each prior (Minessota, SOC and SUR), adjusting the optimization of the hyperparameters, choosing the lag order of the model, as well as the settings of the Metropolis-Hasting algorithm which is used as an Markov-Chain Monte Carlo (MCMC) algorithm. All the values used in this work are shown in Table 1 and are in line with other BVAR macroeconomic papers.

An important procedure for verifying MCMC results is visual inspection of the Marginal Likelihood (ML) trace, the lambda hyperparameter, the SOC and the SUR. The results should present a convergence in the trace and a single peak in the density graph. The trace and density results for all models estimated in this paper show convergence under the model specification.

4 Results and Discussions

4.1 Dataset, Descriptive Statistics and Unit Root Tests

In this section, we present the dataset, descriptive statistics and unit root test results. This study uses monthly time series dataset from the Brazilian economy. The time span is from March 2012 to December 2024. The selected variables are – (a) fixed capital growth rate, obtained directly from Institute for Applied Economic Research (IPEA); (b)

Interbank Rate (% p.y.); (c) Foreign Direct Investment (g.r.); (d) Credit Supply to Firms (g.r.); (e) Households Debt/Disposable Income (%); (f) Average Firms Loans Interest Rate (% p.y.); (g) Default Rate in Loans (%)[1]. In addition, we used (h) the Capacity Utilization, from National Confederation of Industry (CNI); (i) Unemployment Rate (%), from Brazilian Institute of Geography and Statistics (IBGE); (j) Wage-share from GPD, calculated by the authors using monthly wage bill data and accumulated GDP over the last 12 months that also comes from IBGE; ans (k) Real Exchange Rate on the imports, also from IPEA.

It is worth mentioning that all nominal monthly data were deflated using the consumer price index and also treated for seasonality using the X-13-ARIMA-SEATS method. Table 1 shows the descriptive statistics of the series used in the BVAR models. The table displays the sample size (**n**), the minimum value (**Min**), the first and the third quintiles ($\mathbf{q_1}, \mathbf{q_3}$), the median ($\tilde{\mathbf{x}}$), the mean ($\overline{\mathbf{x}}$), the maximum value (**Max**) and the interquartile range (**IQR**). We chose to work with series that allow for direct economic interpretation. For this reason, we used series in terms of growth rate (log-difference transformation), percentage ratio and annualized interest rate. The main variables of interest (response variables) are: (a) Fixed Capital growth rate; (b) Industrial Capacity Utilization; and (c) Unemployment Rate.

Table 1: Dataset and Descriptive Statistics

Variable	**n**	**Min**	$\mathbf{q_1}$	$\tilde{\mathbf{x}}$	$\bar{\mathbf{x}}$	$\mathbf{q_3}$	**Max**	**s**	**IQR**
Fixed Capital (g.r.)	152	-2.2	-0.1	0.5	0.8	1.7	3.6	1.2	1.8
Interbank Rate (% p.y.)	152	1.8	6.4	9.8	9.2	12.7	14.6	3.7	6.2
Foreign Direct Investment (g.r.)	152	-61.5	-12.9	0.3	0.5	14.7	43.8	19.8	27.6
Credit Supply to Firms (g.r.)	152	-2.9	-0.4	0.4	0.4	1.2	4.7	1.3	1.6
Households Debt/Disposable Income (%)	152	37.2	38.3	39.8	41.7	47.6	49.8	4.4	9.3
Capacity Utilization (Industry)	152	66.8	77.5	79.0	79.1	81.0	83.4	2.4	3.5
Average Firms Loans Interest Rate (% p.y.)	152	10.6	15.4	17.0	17.3	19.7	22.3	2.9	4.3
Wage Share in GDP (%)	152	36.3	38.0	51.3	49.9	57.4	68.8	10.0	19.3
Real Effective Exchange Rate (g.r.)	152	-14.3	-2.1	0.2	0.0	2.3	10.1	4.1	4.4
Default Rate in Loans (%)	152	0.5	0.6	1.2	1.2	1.6	2.2	0.5	0.9
Unemployment Rate (%)	152	6.4	7.5	9.8	10.1	12.5	15.1	2.7	5.0

As previously mentioned, correctly specifying the priors (via Minnesota prior), allows us to address the $I(1)$ and $I(0)$ series in the BVAR model. Thus, to identify all the series within this order of integration, we use the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests on the variables in level (or log) and first difference (or log-diff) to report the order of integration. Table 2 shows that the models contain both $I(1)$ and $I(0)$ series.

4.2 Hierarchical BVAR Estimation and Impulse-Response Results

A single model could not be used because the model containing all the variables in table 1 revealed a high correlation (multicollinearity issues) between the variables. Therefore, we created three different models to circumvent the problem. The selected models are shown in Table 4. The values of the hyperparameters used are shown in Table 3.

[1]All these coming from Brazilian Central Bank dataset.

Table 2: Unit Root Tests

Series/Tests	**ADF**	**PP**	**KPSS**	**Results**
Fixed Capital (g.r.)	-1.944 *	-2.441 ***	1.050	$I(1)$
Interbank Rate (% p.y.)	0.142 *	-1.190	0.365 *	$I(0)$
Foreign Direct Investment (g.r.)	-12.423 ***	-26.640 ***	0.025 *	$I(0)$
Credit Supply to Firms (g.r.)	-3.697 ***	-5.273 ***	0.427 *	$I(0)$
Households Debt/Disposable Income (%)	-2.998	-0.325	2.363	$I(1)$
Capacity Utilization (Industry)	-2.857 *	-2.887 **	0.636 *	$I(0)$
Average Firms Loans Interest Rate (% p.y.)	0.357	-1.247	0.289 *	$I(0)$
Wage Share in GDP (%)	-2.360	-1.703	3.070	$I(1)$
Real Effective Exchange Rate (g.r.)	-13.546 ***	-22.698 ***	0.025 *	$I(0)$
Default Rate in Loans (%)	-0.052	-1.643	1.168	$I(1)$
Unemployment Rate (%)	-0.438	-0.226	0.652	$I(1)$

Note: *** p $<$ 0.01, ** p$<$ 0.05, * p $<$ 0.1.

Table 3: Hyperparameters Priors Setup

Prior	**Parameter**	**Mode**	**SD**	**Max**	**Min**
Minnesota	λ	0.2	0.4	5	$1e^{-4}$
-	α	2			
-	σ^2	$1e^{-7}$			
SOC		1	1	50	$1e^{-4}$
SUR		1	1	50	$1e^{-4}$

The three models were estimated using 50,000 draws and 25,000 burn-in samples. The Metropolis-Hasting algorithm was used for the Monte Carlo Markov Chain (MCMC). The model for the growth rate of the capital stock was estimated using 5 lags because it had the best trace convergence. The models for capacity utilization and the unemployment rate were estimated using 3 lags for the same reason.

Given the multicollinearity relationship between some variables, we parsimoniously separated the models between the variables of interest and those for which we already have the traditional channels explained. For example, fixed capital (g.r) was tested alongside FDI, credit supply, average loan interest rates, and wage share. This analysis revealed the variables that ultimately affect investment, identified FDI as a suspected important variable, and functional distribution as a variable that can both boost demand or generate profit squeeze.

Furthermore, the models were tested with two possible interest rates: short-term and long-term. Since the long-term results were similar to the short-term results, the latter were used for all models. The level of household debt variable was more related to aggregate demand (and thus the unemployment rate) as a whole than to capital accumulation. Therefore, the three models were chosen based on economic relationships and separation of multicollinearity.

In the subsequent figures presenting the impulse response functions, the solid black line denotes the median, and the light- and dark-shaded areas indicate the 95th percentile and 70th percentile confidence bands, respectively. In order to analyze the results obtained from these calculations, the median, its trajectory, peak (maximum or minimum), and potential dissipation must be examined. This must be done in conjunction with their associated confidence bands. To ascertain the nature of the effect, the 70th and 95th

confidence intervals are evaluated to ascertain whether they lie entirely in the positive or negative quadrant, that is, above or below zero, respectively.

To check the results' robustness, we tested lags from 1 to 12. We verified the convergence of lambda, SOC, SUR, and ML, as well as the possibility of changing the qualitative signs of the impulse response functions. We also tested restricted models and found that the qualitative results did not change[2].

Table 4: Selected Models

Series/Models	**Model 1**	**Model 2**	**Model 3**
Fixed Capital (g.r.)	x		
Interbank Rate (% p.y.)			
Foreign Direct Investment (g.r.)	x	x	x
Credit Supply to Firms (g.r.)	x	x	x
Households Debt/Disposable Income		x	
Capacity Utilization (Industry)		x	
Average Firms Loans Interest Rate (% p.y.)	x	x	x
Wage Share in GDP (%)	x	x	x
Real Effective Exchange Rate (g.r.)		x	x
Default Rate in Loans (%)			x
Unemployment Rate (%)			x

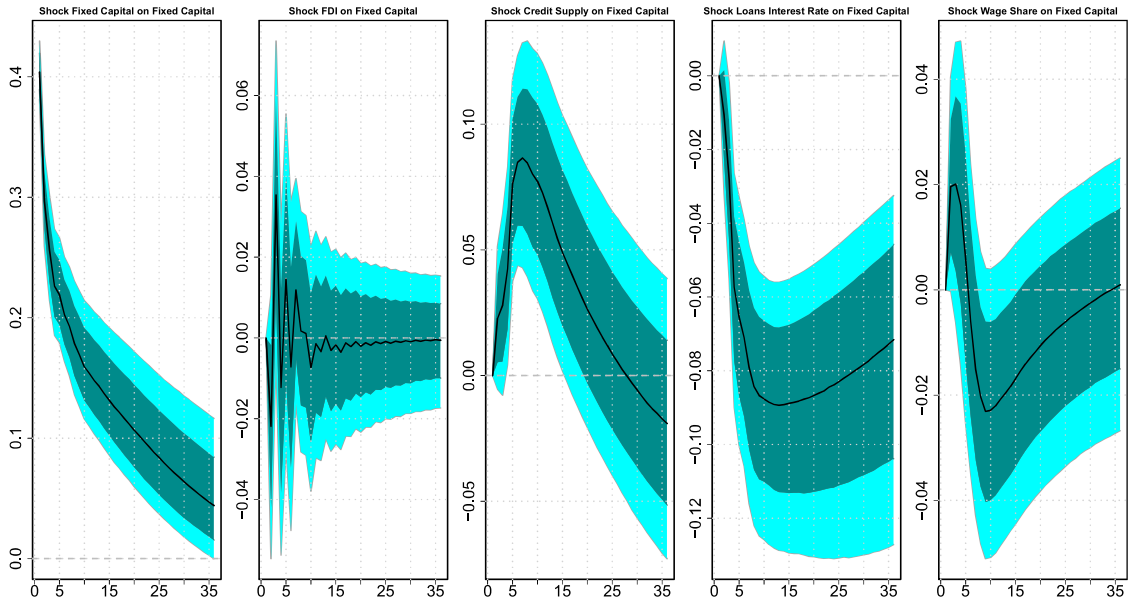
The results obtained by the impulse response function (and confirmed by robustness tests) for 36 months indicate that the rate of capital accumulation has a high autoregressive effect, since even after three years the effect has not completely dissipated. As Figure 1 shows, a shock increase in the FDI growth rate has an inconclusive effect. Since part of the literature points out that FDI is a channel through which new investments can occur (Buckley, Cross, Tan, Xin, & Voss, 2008; de Castro, Fernandes, & Campos, 2013), we expected it to increase the rate of capital accumulation in the short term. An increase in the growth rate of credit supplied to firms increases the accumulation rate by up to 10% within the first 6 months, but this effect dissipates completely after two years. And although credit supply is a variable linked to monetary policy transmission channels, Brazil's credit supply is segmented and dependent on other funding sources. In some cases, the reaction of public credit supply, via the National Development Bank (BNDES), is of paramount importance (De Menezes Barboza & Vasconcelos, 2019). Therefore, we can infer that the result of credit expansion is partly autonomous and sometimes countercyclical. Since investment requires prior financing to materialize, a significant effect was expected.

Regarding a shock from an increase in the interest rate on business loans, the maximum retraction of capital accumulation occurs within 1 year, resulting in a reduction of around 8%. Then, there is a slow dissipation that lasts up to 3 years. For the income wage-share shock, the effect was inconclusive (the IRF shows a very sharp rise in the early months, followed by a negative effect; ultimately, however, the effect offset each other).

Regarding shocks to the degree of capacity utilization in the industrial sector [Figure 2], the persistence effect is quite long, suggesting hysteresis for this variable. An increase in the FDI growth rate or in the supply of credit has an inconclusive effect. This suggests

[2]In numerical terms, the values obtained in the impulse-response function change, but there is no change in the qualitative response.

Figure 1: Impulse Response Functions - Fixed Capital Growth Rate

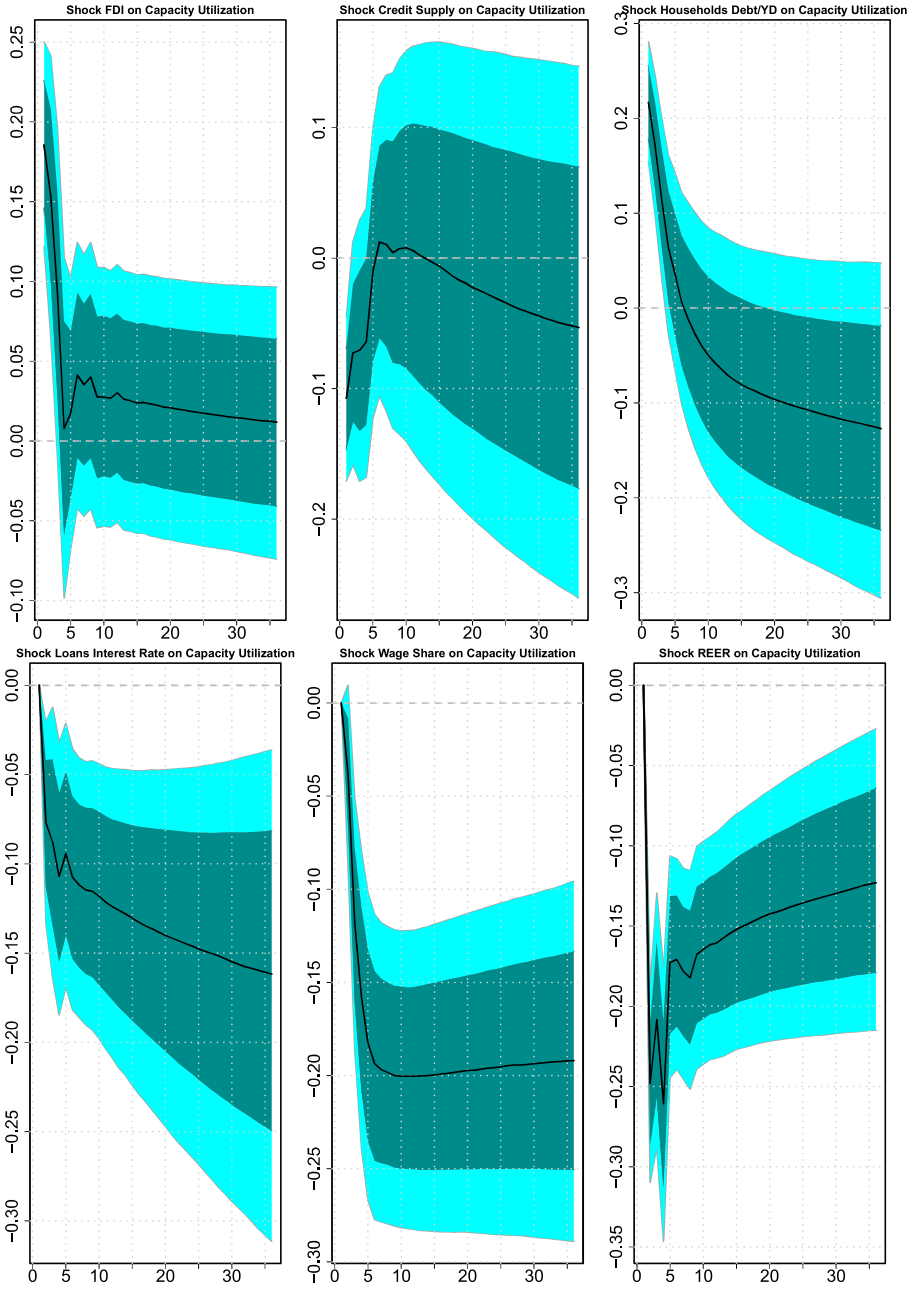


that credit expansion in the Brazilian economy is more closely tied to internal funding channels than external ones. Although an increase in the household debt-to-disposable income ratio initially has a positive effect, it soon turns negative and persistent, failing to return even after 36 months. Increasing the interest rate on business loans has a negative and persistent effect, reducing capacity utilization by up to 17% during the shock.

Thus, although the change in wage-share was inconclusive for capital accumulation, it was negative for the degree of capacity utilization, with a drop in activity level of up to 20% in the first year. This may be related to profit-led growth, as described in the literature. Also, during this period the devaluation of the real effective exchange rate also had a contractionary effect on industrial activity. One possible explanation is that, due to the high proportion of imported intermediate inputs in Brazilian industrial production, devaluation of the real effective exchange rate makes manufactured goods in Brazil more expensive rather than more competitive in terms of price.

Finally, Figure 3 illustrates the outcomes of variable shocks to the unemployment rate. First, the estimates for the unemployment rate demonstrate a greater degree of uncertainty compared to those pertaining to the capital accumulation rate and the degree of capacity utilization. This finding indicates the presence of oscillatory trajectories and notably broader confidence intervals.

Figure 2: Impulse Response Functions - Capacity Utilization



In the other shocks, a positive credit-supply shock has been demonstrated to raise the unemployment rate over the initial six months. Thereafter, at the 70% credibility level, the effect turns negative, with peak reduction of approximately 5% in the unemployment rate at the 24-month mark.

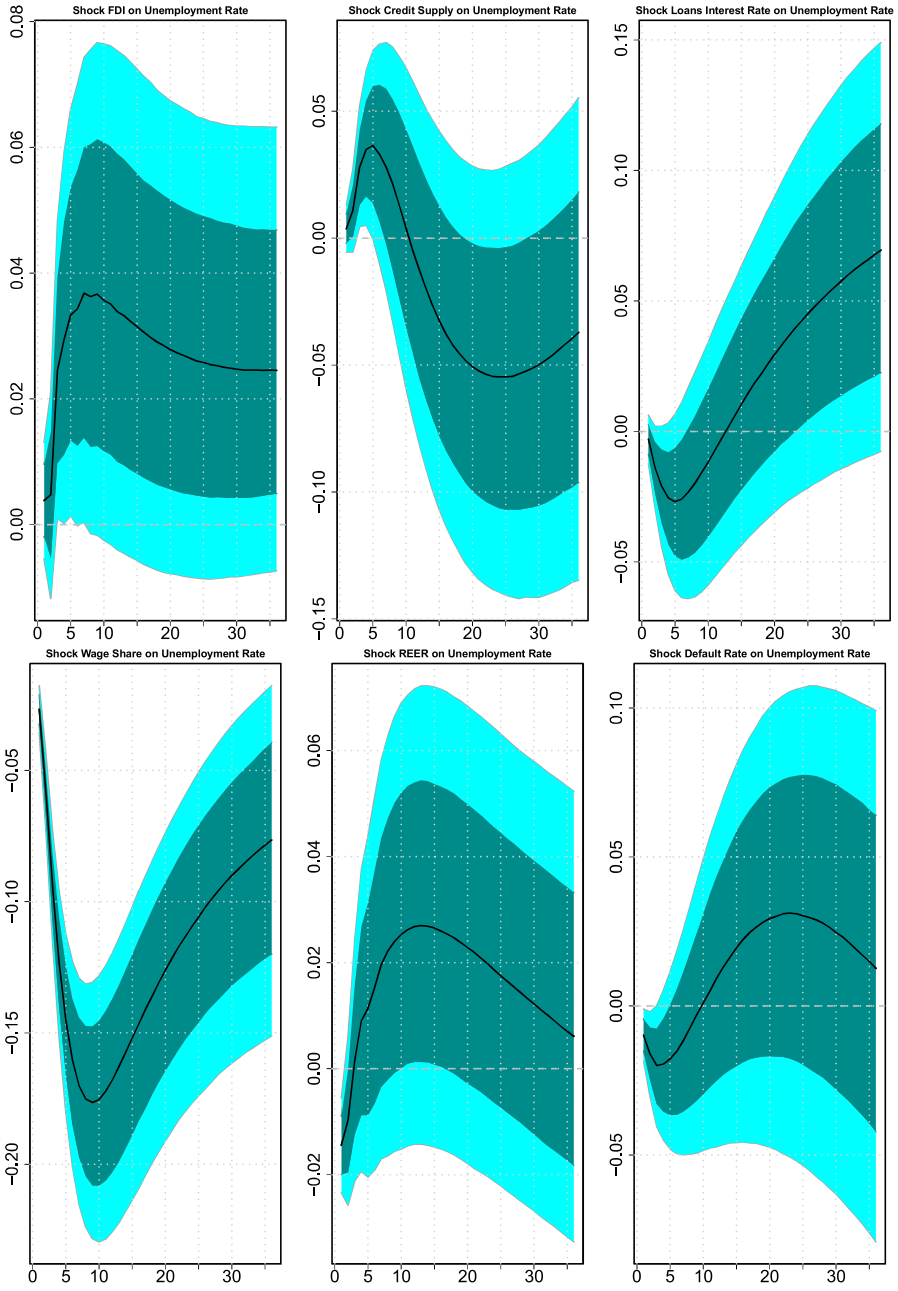
Due to the BNDES participation, the supply of credit to firms is only partially autonomous. We can infer that the expansion of credit can expand investment rate and, through this channel, aggregate demand, thereby reducing the unemployment rate.

A rise in the lending rate on corporate (business) loans has been shown to initially induce a modest decline in the unemployment rate, with this effect observable up to month 5. Subsequently, the response undergoes a reversal after approximately 12 months,

transitioning to a positive phase, characterized by elevated levels of unemployment. This positive phase persists through month 36, exhibiting no indication of dissipation. The 70% credible intervals substantiate this pattern.

The increase in wage-share reduces unemployment, in which case it may indicate a bidirectional relationship, since the literature reports a negative relationship between the unemployment rate and wage-share.

Figure 3: Impulse Response Functions - Unemployment Rate



The REER shock on the unemployment rate does not yield a clear-cut contractionary versus expansionary pattern. The currency's depreciation during the initial three-month period indicates an expansionary effect. However, beyond this initial period, the median

response exhibits a contractionary tendency, reaching its peak around months 11 and 12. However, the confidence intervals are sufficiently wide to preclude a categorical conclusion regarding the sign of the effect. On the other hand, the default rate on business loans exhibits an inconclusive effect due to the confidence interval's proximity to both axes.

In Brazil, financial shocks are typically manifested initially in capital accumulation and capacity utilization, rather than in unemployment. A significant factor contributing to this dynamic is the segmentation of the credit market, particularly the considerable proportion of earmarked credit. This segmentation serves to insulate borrowing costs from the policy rate while facilitating the transmission of monetary shocks through bank lending supply to firms' investment (da Silva Castro, 2019; Gonzalez, Mahadeva, Rodriguez Guzman, & Rojas, 2009).

Concurrently, elevated levels of informality have been shown to weaken Okun-type relationships, thereby resulting in employment adjustments that are less responsive to output and financial shocks when compared to advanced economies—a phenomenon that serves to attenuate the measured effects on unemployment (Bizimana & Arzoumanian, 2023). The Central Bank has documented a persistent correlation between capacity utilization (NUCI) and capital-goods output, suggesting that financing and demand conditions are rapidly reflected in utilization and investment metrics.

5 Final Remarks

A hierarchical Bayesian vector autoregression (BVAR) spanning 2012–2024 was employed to detect clear and timely transmission from financial conditions to real activity along the investment/capacity margins. Positive credit-supply shocks have been shown to increase capital accumulation and capacity utilization in the short term. However, higher lending rates to firms have been demonstrated to decrease both variables over time, with this effect lasting beyond one year. The accumulation of debt does not inherently constitute a contractionary phenomenon; its deleterious effects manifest only with a temporal lag. Conversely, FDI shocks exhibit minimal signal in our context, and the unemployment responses are comparatively imprecise, with credible bands being more extensive and several effects manifesting only at the 70th percentile.

These patterns are consistent with institutional features that shape transmission. The segmentation of corporate finance channels exerts a primary influence on firms' investment decisions and utilization. In contrast, labor-market quantities exhibit more diffuse adjustments through hours, participation, and formality margins, thereby dampening the reaction to unemployment. Distributional shocks, characterized by an increase in the wage share, have been observed to exhibit a mixture of outcomes across various economic metrics. These shocks have been found to be pro-employment, yet not distinctly expansionary with respect to utilization or investment in the samples examined. The real exchange rate does not yield a robust expansionary or contractionary effect in our estimates; results vary across specifications and credibility levels, so we treat its short-run impact as inconclusive.

Two conclusions can be drawn from this analysis. First, for Brazil, investment and utilization serve as leading and more precisely measured margins through which financial shocks map into activity. Conversely, unemployment provides weaker, slower-moving signals. Secondly, policy evaluation should prioritize indicators of financing conditions and firms' balance-sheet stress alongside real-side metrics. Future research could refine

the identification of the exchange-rate channel, elucidate the mechanisms of labor-market adjustment (hours, participation, formality), and incorporate sectoral heterogeneity in credit dependence to test the mechanisms suggested by our results.

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Appendix

Figure 4: Model 1 - Trace of ML, Lambda, SOC and SUR

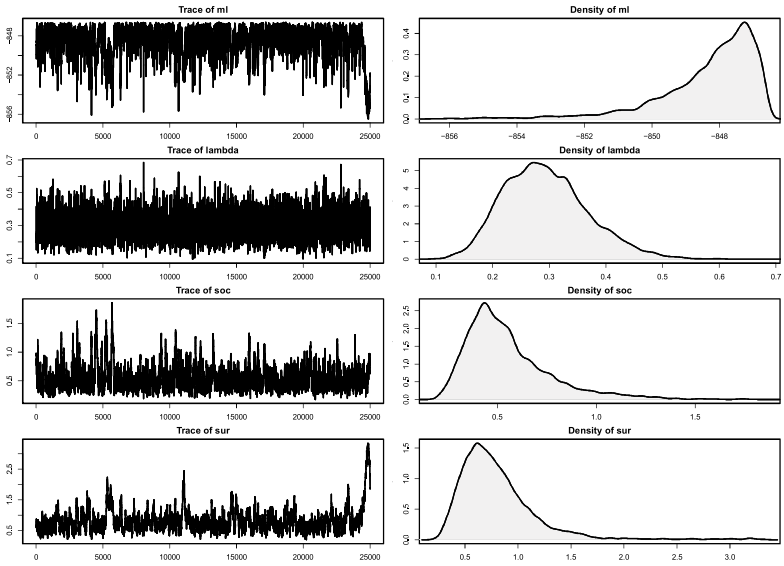

Figure 5: Model 2 - Trace of ML, Lambda, SOC and SUR

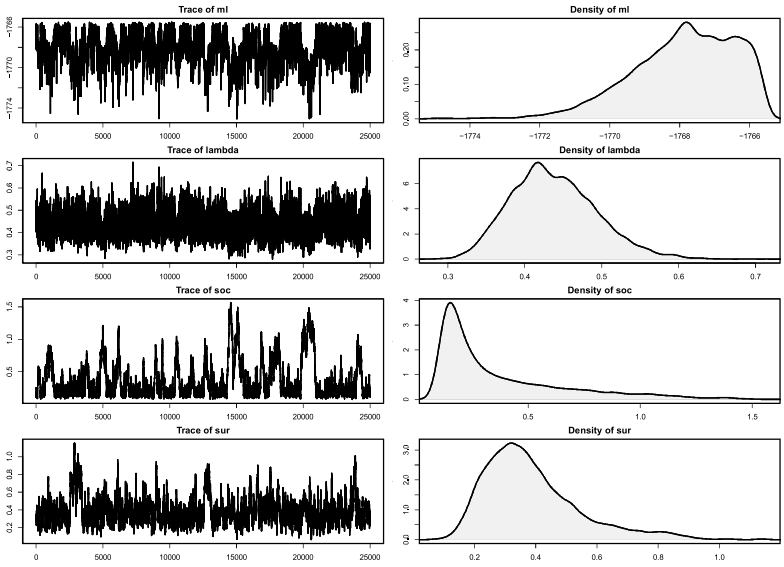

Figure 6: Model 3 - Trace of ML, Lambda, SOC and SUR