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NOVA School of Business Economics

11 October 2022

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Abstract

What is behind the economic depression Brazil experienced between 2014 and 2016? A synthetic control estimation corroborates the hypothesis of a mainly domestic episode. With that in mind, we apply the business cycle accounting method and find that the episode was driven by the efficiency wedge. We find econometric evidence that public development bank outlays have a positive (negative) impact in the short-run (long-run) on the efficiency wedge. This motivates a model with financial frictions and a public development bank that is able to reproduce the dynamics of output during the crisis.

Keywords: Business Cycle Accounting, Brazil, DSGE, Financial Frictions
JEL Classification: E32, E44, E50

1 Introduction

There are repeated periods during which real GDP falls, the most dramatic instance being the early 1930s. Such periods are called recessions if they are mild and depressions if they are more severe.
Gregory N. Mankiw.[1]

After the Great Financial Crisis (GFC) the recovery in Brazil can be considered fast, given that the episode consisted of a two-quarters contraction in 2009, and in 2010 the economy was not only already back to its previous level, but also GDP increased 7,5% in 2010 relative to the previous year. However, after 2011, growth rates trended downwards. In 2014 the growth rate close-to-zero growth and marked a period of a severe recession or, as it is called in this paper, a depression. Why? Because of two dimensions: first, the length and accumulated loss of output (see Figure 1), and second due to its deep scars possibly with hysteresis in the output dynamics (see Figure **??**).
What happened between 2014-2016? The aim of this paper is to understand the drivers of the episode. With that in mind, the first step is to understand whether the roots of the episode were domestic or if the depression was a consequence of the international environment? The evidence corroborates the former. The fall in the Brazilian GDP was stronger than the one that would have occurred solely from international factors.
The second step in our investigation is to access what drove output toward a two-years depression without a major disruptive event. We apply the Business Cycles Accounting (BCA) method and find that the efficient wedge accounts for almost all the variation in output.
In possession of these results and given the importance of earmarked credit in Brazil at the time, we raise the possibility that the efficiency wedge responds to loans from the federal public development bank. We find econometric evidence in line with that hypothesis. Finally, we use a dynamic general equilibrium

[1] Mankiw (2010).

model with credit market frictions and the federal public development bank (BNDES in the Portuguese acronym) is to understand the depression in Brazil. The model can to reproduce the output dynamics (the fall and slow recovery) and the importance not only of financial frictions but also of the BNDES during the episode.

In order to account for all the aforesaid steps for understanding the depression in Brazil, this paper is organized as follows. Besides this introduction, the next section presents some characteristics of Brazilian recessions. In Section 3, we present the synthetic control estimation to address the role of the international environment to explain the fall in output in Brazil. In Section 4, we apply the BCA method to inform us about the mechanisms underlying the episode, and, given the role of the efficiency wedge as the main driver, we perform a simple econometric exercise with the distortion and BNDES' outlays in Section 5. We use the previous results as a guide/motivation for adapting a DSGE model with financial frictions to Brazil in Section 6, in order to account for the dynamics of output during the depression. Finally, the last section is dedicated to further remarks and conclusions.

2 Recessions in Brazil

According to the Brazilian business cycle dating committee (CODACE in the Portuguese acronym), Brazil has experienced nine recessions since the 1980s, besides the one related to the Covid-19 pandemic (CODACE, 2017). The duration of each recession has varied from 2 to 11 quarters. The most severe recession, when measured by the accumulated GDP fall, was the 1981Q1-1983Q1 contraction after unsuccessful stabilizing plans and the impeachment of the president elected in the first direct elections after the 1964-1985 military dictatorship, while the 2014Q2-2016Q4 depression, which was also after a presidential impeachment, is the close second most severe (GDP felt, from the peak to the through, 8.5% in the former and 8% in the latter). However, if we measure the severity of each recession by the duration in quarters, the two episodes change places. Table 1 presents some stylized facts of the CODACE-dated recessions.

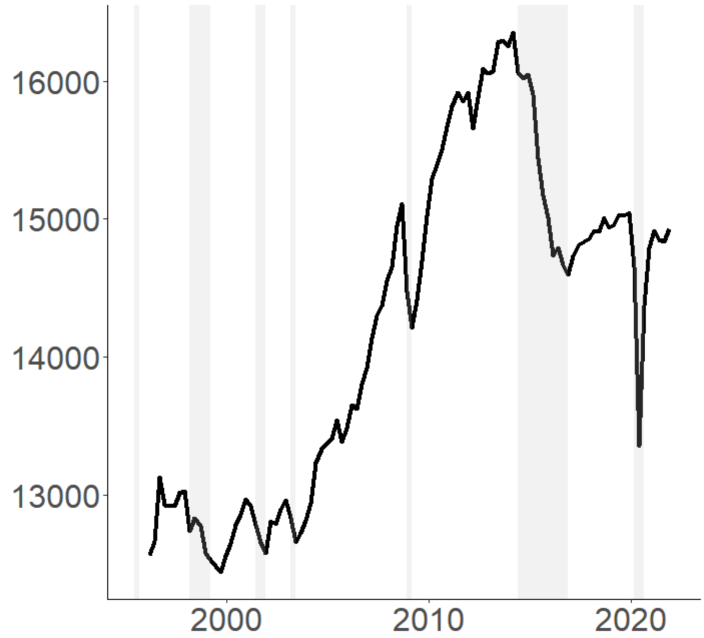
Table 1: Duration output loss in Brazilian Recessions

Period	**Duration (in quarters)**	**Accumulated growth**	**Annualized average quarterly growth**
1981Q1-1983Q1	9	-8.5%	-3.9%
1987Q1-1988Q4	6	-4.2%	-2.8%
1989Q3-1992Q1	11	-7.7%	-2.9%
1995Q2-1995Q3	2	-2.8%	-5.6%
1998Q1-1999Q1	5	-1.1%	-0.9%
2001Q2-2001Q4	3	-0.9%	-1.1%
2003Q1-2003Q2	2	-1.5%	-3.0%
2008Q4-2009Q1	2	-5.1%	-10.0%
2014Q2-2016Q4	11	-8.0%	-3.0%

Notes: Accumulated growth from peak to through. Data from CODACE.

The 2014-2016 depression is important not only due to its severity and duration but also due to its possible long-run effects. Figure 1 presents quarterly real GDP per working-age population from 1996Q1 to 2022Q2. It is interesting to note the there may be a structural break after 2014. The previous level has yet to be achieved and, until further data may challenge this claim, it was the only contraction since 1996 that may have caused a change in the output trend.

Figure 1: Per capita real GDP

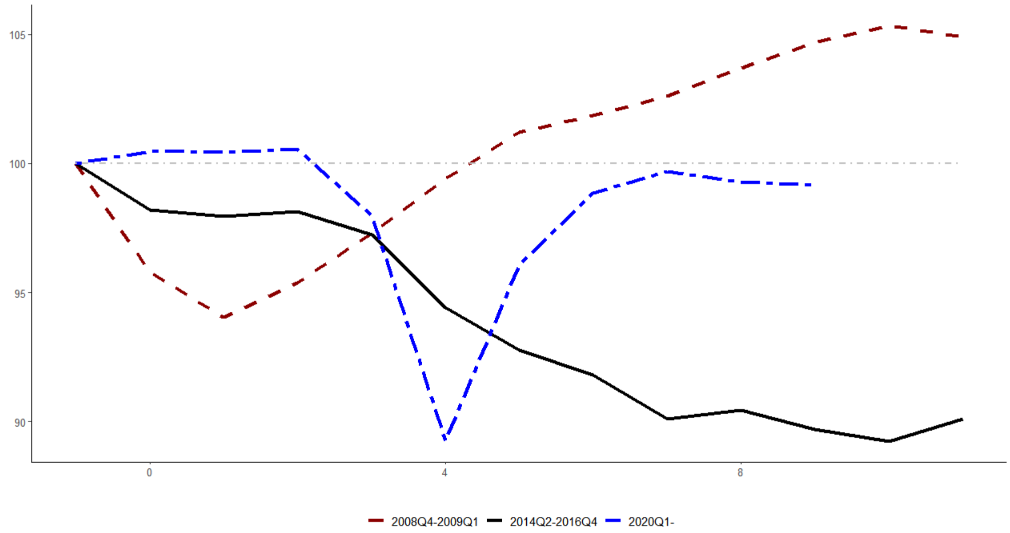


Note: GDP per working-age population (16-65 years), deflated by the GDP deflator. The data is from IBGE and OECD. Shaded areas are the recessions defined by the CODACE.

In order to have a complementary visual understanding of the differences amongst the recessions in Brazil, Figure 2 compares three episodes (2008Q4-2009Q1, 2014Q2-2016Q4, and after 2020) within a 12-quarters window (for the Covid-19 crisis the sample is lower, but it does not affect our conclusion). We can see two main differences amongst the three contractions with respect to the "shape" and the number of quarters to achieve the level before the beginning of the episode. For the 2008Q4-2009Q1 recession, we have a sort of "U-shaped" dynamics, an initial fall followed by another quarter of contraction and the full recovery took four quarters. The recession during the pandemic has more of a "V-shaped" format, an intense and rapid fall, followed by a fast recovery. For the 2014Q2-2016Q4 depression, we see a "L-shaped" dynamic.

We know that TFP was the main driver of economic cycles in Brazil from 1970 to 1974 and from 1980 to 1998, whereas capital accumulation was the key factor

Figure 2: GDP Growth Rate (%)



Note: GDP per working age population (16-65 years), deflated by the GDP deflator. The value of the quarter before the beggning of the recession is set to 100. The horizontal axis measures the quarters after the recession. The data is from IBGE and OECD.

between 1974 and 1979 (Bugarin et al., 2010). Moreover, controlling for the differences between private and public investment in the 1970s and relative price dynamics (between investment and consumption goods) from the 1980s, the neoclassical growth model is able to explain the Brazilian cycles. However, the volatility in consumption, hours, and productivity is not explained by a Real Business Cycle model (Ellery Jr et al., 2002), opening room for extensions of the basic framework. But what about the short-run forces that explain the fall after 2014?

In order to answer the research question raised in the introduction, we need first to assess whether the depression is a consequence of global events or rather of domestic choices/dynamics. With that in mind, the next section addresses the source of the depression.

3 The nature of the depression

The Brazilian depression happened within a period where global GDP growth remained relatively constant. Advanced economy marginally increased its performance from 2014 to 2016, whereas emerging-market economies registered different records according to the region. Table 2 presents IMF data from its World Economic Outlook report released in October 2020.

Table 2: World GDP Growth (%)

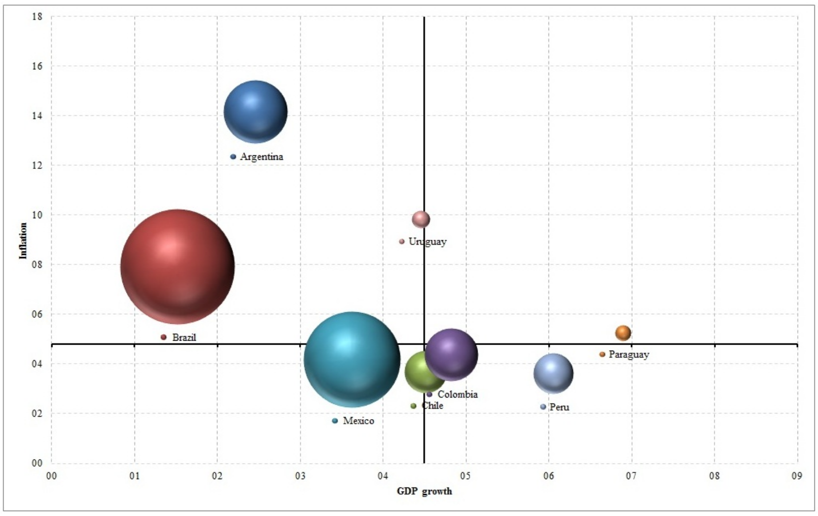
Country Group	**2014**	**2015**	**2016**
World	3.5	3.4	3.3
Advanced economies	2.1	2.4	1.8
Emerging and developing Asia	6.8	6.8	6.8
Emerging and developing Europe	1.8	1.0	2.0
Latin America and the Caribbean	1.3	0.4	-0.6
Argentina	-2.5	2.7	-2.1
Chile	1.8	2.3	1.7
Colombia	4.5	3.0	2.1
Venezuela	-3.9	-6.2	-17.0
Brazil	0.5	-3.5	-3.3

Notes: Data from International Monetary Fund, World Economic Outlook Database, October 2020.

While emerging Asia had a small decrease in growth rates, Latin America and the Caribbean countries fell from 1.3% to -0.6%. This could raise doubts regarding whether the roots of the depression are domestic or international (or regional, at least). Within Latin America, we have Chile and Colombia which kept growing (though with decreasing growth rates) and had a better performance than its neighbors, Argentina and Venezuela.

If we consider the average growth rate of the period, Brazil has the worse result. If we bring inflation also to the analysis, it has the third higher rate for the period, as can be seen in Figure 3, which shows the growth-inflation average performance for selected Latin America countries (sphere sizes are due to PPP adjusted per capita GDP).

Figure 3: Growth and inflation after the 2008 crisis



Notes: Data from International Monetary Fund, World Economic Outlook Database, April 2016; author's elaboration. Real GDP average growth from 2010 to 2016, average CPI inflation from 2010 to 2016. Spheres size is given by PPP adjusted per capita GDP.

If it was a global force holding Latin America back, one could expect a change in Brazilian growth rates similar to what happened to other countries in the region. However, since they have very distinct track records, perhaps the difference in (the change in) growth rates within countries is more of a consequence of domestic policies and shocks.

The synthetic control method may help answer the following question: is the depression a result of domestic or international dynamics? One might wonder whether there may be a combination of economic policies (domestic sources) causing the depression. If this is the case, a "treatment-control group" helps to investigate the issue. The difficulty, however, is that we cannot define a "control" group in the usual sense, since there are no "two Brazils" to work with. One approach could be to select a group of countries and use them as the control group. But which countries? Are their weight in the group the same? Instead of choosing arbitrarily the "control" group, we follow a data-driven procedure in Abadie et al. (2010) and Abadie et al. (2015).

Let us work with $j = 1, ..., J + 1$ units (countries), where $j = 1$ is the country we are studying (i.e., Brazil) and the other $j = 2$ to $j = J + 1$ are the "candidates" for comparison, at time t. We work with a balanced panel. Define T_0 as the pre-intervention period and T_1 as the post-intervention periods, with $T = T_0 + T_1$. The pre-intervention period is from 2000 to 2010 and the post-intervention period is from 2011 to 2015 since in 2011 there was an economic policy regime change with the new government.

A "synthetic Brazil" is built by averaging countries within the sample, with the vector $W = (w_2, ..., w_{J+1})'$, with $0 \leq w_j \leq 1$ representing the weight of each country.[2] Define Y_1 as the $(k \times 1)$ vector with the pre-intervention values for Brazilian characteristics (in this case: inflation, GDP growth from 2000 to 2010, government net borrowing and current account balance) and let Y_0 be the $(k \times j)$ matrix of pre-intervention values for the characteristics of the other countries in the sample. We obtain the contribution of each country (the vector W) by minimizing the difference between observed Brazilian annual GDP growth in the pre-intervention period (2000 to 2010) and the synthetic Brazilian annual GDP growth:

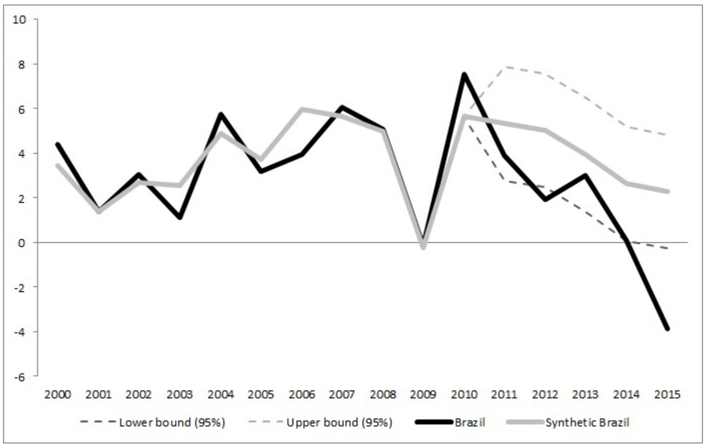
$$\min_{W} \sum_{m=1}^{k} v_m (Y_{1m} - Y_{0m})^2$$

where v_m is the relative importance of the $m - th$ variable, which is choosen as a cross-validation method following Abadie et al. (2015). Using IMF's data, the synthetic Brazil is composed by the weighted average of Belize (0.089), Ecuador (0.091), Guyana (0.178) Mexico (0.254), Peru (0.355) and Venezuela (0.033). Figure 4 presents the pre/post 2011 behavior of observed GDP growth for actual and synthetic Brazil.

The black line represents the data for observed Brazilian GDP annual growth. The solid gray line is synthetic Brazil (the "control group"). The upper and

[2]See Table 5 for the list of the 32 countries and appendix for data details.

Figure 4: Brazilian GDP growth: actual and synthetic



Note: Data from IMF.

lower bounds (point estimations +/- 1.96 standard deviation) for the synthetic estimation are the dashed lines. As we can see, the "treated" series is below the lower bound in 2015. The results corroborate with the hypothesis that a deceleration would happen, as part of a global (or at least regional) movement, however, if this was the only (or the main) reason, it would not be as not as strong and recessive as the observed figures. It seems a domestic issue after all. After the evidence from the previous exercise, we address the issue regarding the drivers of the depression in the next section.

4 The transmission of the depression

The investigation of the dynamics of the depression imposes some challenges since there are several possible mechanisms available to explain the episode. Therefore, the BCA method may help us to understand the depression.
The starting point is the neoclassical growth model. There are four main decisions: how much to produce, how much to work, how much to consume and how to share the resources. There are optimal choices for each decision and possible deviations from the optimality. The distortions in each decision are called wedges: the efficiency wedge, the labor wedge, the investment

wedge, and the government consumption wedge, respectively.

Following Chari et al. (2007), the prescriptions of the neoclassical model are confronted with data and the wedges are estimated. The wedges are assumed to be exogenous and the four wedges account for the whole data by construction. The business cycle accounting estimates the contribution of each wedge by letting it fluctuate while remaining other wedges constant. Therefore, it is possible to identify the promise distortions driving short-run fluctuation. After that, there are mappings from the prototype economy to a class of detailed models so further analysis can be used with DSGE models that fit stylized facts.

Brinca et al. (2020) present a survey on BCA literature findings, mappings, and extensions, for instance, Šustek (2011) introduces monetary issues (inflation and interest rates). Otsu (2010b), Lama (2011) and Hevia (2014) expand BCA to a open-economy setup and the relationship between economies is addressed in Otsu (2010a).

The drivers of business cycles in Emerging Market Economies were studied using BCA in several papers.[3] For instance, Hevia (2014) and Sarabia (2008) (Mexico), Simonovska and Söderling (2008) (Chile) Hnatkovska and Koehler-Geib (2015) (Paraguay), He et al. (2009) studies China and Gao and Ljungwall (2009) compare it with India. Financial crises in Asia are analyzed in Cho and Doblas-Madrid (2013) as well as in Otsu (2010a). Study the relationship between Japan, Korea, and Taiwan, while Kolasa (2013) focuses on Central and Eastern European countries.

Lama (2011) uses the open-economy extension of BCA to see the drivers of fluctuations in Latin America. He finds that the efficiency and the labor wedges

[3]For advanced economies see, Chari et al. (2007) and Ohanian (2010) (US), Bridji (2013) (France), Kobayashi and Inaba (2006), Chakraborty (2009), Saijo (2008) (Japan), Kersting (2008) and Chadha and Warren (2012) (UK), Orsi and Turino (2014) (Italy), Cavalcanti (2007) (Portugal), López and García (2014) Spain, Sarabia (2007) (Korea); Brinca (2013) (Sweeden). More comprehensive studies in Brinca (2014), Brinca et al. (2016) and **?**

are the main ones responsible to account for output falls in Latin America. Chakraborty and Otsu (2013) uses BCA for analyzing output fluctuations in BRIC economies. For Brazil, they have concluded that the investment and the labor wedges played important roles in the 1990s, whereas the efficiency wedge was the main driver for Brazil in the 2000s. Graminho (2006) also applies BCA to Brazil. She finds that both the efficiency and the labor wedges are important for explaining the output dynamics.

This paper complements BCA analysis of Chakraborty and Otsu (2013), Graminho (2006) and Lama (2011) by not only extending the sample period but also using i) quarterly data and ii) adjusting consumption and investment data by removing durables goods from the former and adding it to the latter. Next, we present the neoclassical growth and the BCA results.

4.1 The Prototype Economy

Consider that a given state of nature, s_t, has a probability $\pi_t(s^t)$ of occurrence, at any time t, where $s^t = (s_0, ..., s_t)$ represents the history of events up to and including period t. We take the initial state, s_0, as given. Consumers maximize expected lifetime utility over per capita consumption (c_t) and labor (l_t) for each t and s^t

$$\sum_{t=0}^{\infty} \sum_{s^t} \pi_t(s^t) \beta^t U(c_t(s^t), l_t(s^t)) N_t$$

subject to the budget constraint for all t and s^t:

$$c_t(s^t) + (1 + \tau_{xt}(s^t)) x_t(s^t) = (1 - \tau_{lt}(s^t)) w_t(s^t) l_t(s^t) + r_t(s^t) k_t(s^t) + T_t(s^t)$$

Following Brinca et al. (2016), we introduce adjustment costs ($\phi(\frac{x_t(s^t)}{k_t(s^{t-1})})$) to the the law for capital (k_t) accumulation:

$$(1+\gamma)k_{t+1}(s^t) = (1-\delta)k_t(s^{t-1}) + x_t(s^t) - \phi(\frac{x_t(s^t)}{k_t(s^{t-1})})$$

where $(1-\tau_{l,t})$ is the labor wedge, $1/(1+\tau_{x,t})$ is the investment wedge, g_t is the government consumption wedge, β is the discount rate, $U(.)$ stands for the utility function, N_t is the population (with a growth rate of γ_N), x_t is per capita investment, w_t is the real wage rate, r_t is the return on capital, δ is the depreciation rate, T_t is per capita lump-sum transfers from the government to households, γ is the technological growth rate and $\phi(\frac{x_t(s^t)}{k_t(s^{t-1})}) = \frac{a}{2}(\frac{x_t(s^t)}{k_t(s^{t-1})} - b)^2$, with $b = \delta + \gamma + \gamma_n$.

Firms operate in a perfectly competitive markets and maximize profits Π_t, given the production function $F(k_t(s^{t-1}), (1+\gamma)^t l_t(s^t))$, and the efficiency wedge $(A_t(s^t))$:

$$\max_{k_t, l_t} \Pi_t(s^t) = y_t(s^t) - r_t(s^t)k_t(s^{t-1}) - w_t(s^t)l_t(s^t)$$

By combining the optimal decisions of both agents with the production technology and the resource constraint, we have the four equilibrium conditions of the model:

$$y_t(s^t) = A_t(s^t)F(k_t(s^{t-1}), (1+\gamma)^t l_t(s^t)) \tag{1}$$

$$-\frac{U_{l,t}(s^t)}{U_{c,t}(s^t)} = (1-\tau_{l,t}(s^t))A_t(s^t)(1+\gamma)F_{l,t} \tag{2}$$

$$U_{c,t}(s^t)(1+\tau_{x,t}(s^t)) =$$
$$\beta \sum_{s^{t+1}} \pi_t(s^{t+1}|s^t)[U_{c,t+1}(s^{t+1})(A_{t+1}(s^{t+1})F_{k,t} + (1-\delta)(1+\tau_{x,t+1}(s^{t+1})) + \phi_{k_{t+1}}] \tag{3}$$

$$c_t(s^t) + x_t(s^t) + g_t(s^t) = y_t(s^t) \tag{4}$$

where $U_{c,t}$, $U_{l,t}$, $F_{l,t}$, $F_{k,t}$ and $\phi_{k_{t+1}}$ are derivatives of the utility function, the production function and adjustment costs with respect to its arguments. Optimal decisions are distorted by four wedges: the efficiency wedge (A_t), the labor wedge ($1 - \tau_{l,t}$), the investment wedge ($1 + \tau_{x,t+1}$) and the government consumption wedge (g_t).

4.2 Accounting for business cycles in Brazil

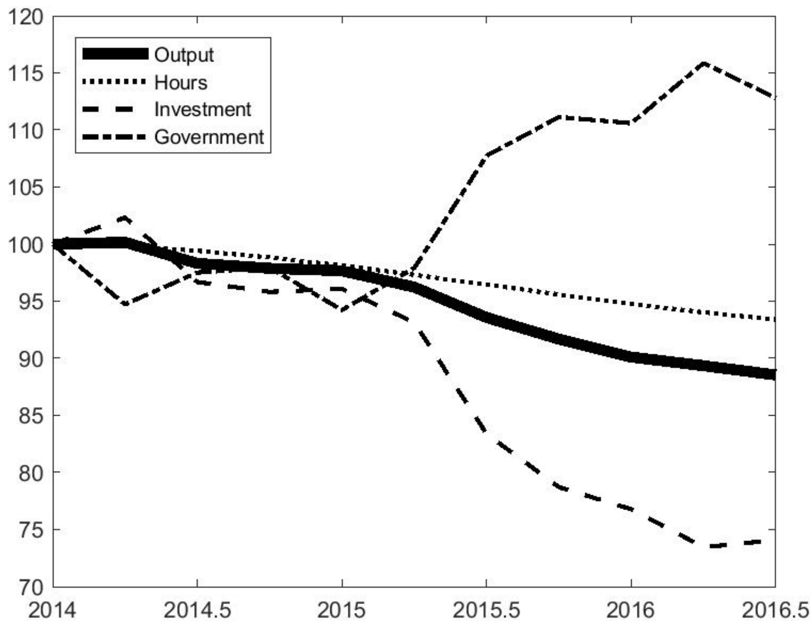
The BCA exercises used data from the first quarter of 1996 to the second quarter of 2016.[4] Figure 5 presents per worker output, investment, government consumption plus net exports and hours of work for the depression period. There seems to be two different moments: in the first (2014-2015), the behavior of macroeconomic variables are similar. Output falls as well as hours of work, investment and government consumption plus net exports. This seems to corroborate with the synthetic estimation in which for the aforesaid period there was a more generalized deceleration, i.e. domestic and international drivers for the GDP fall in Brazil and other Latin America countries (materialized in the prescribed GDP fall for the synthetic Brazil).

In the second moment (2015-2016), however, even though hours of work kept declining at the same rhythm, the output trajectory became steeper, investment more depressed and government consumption plus net exports increased.[5] Figure 6 presents all wedges. We can see that both the efficiency and the labor wedges felt during the depression, while the investment wedge, as well as the government consumption wedge rose.

[4] See the appendix for more details.

[5] Net exports tend to be counter-cyclical and follow exchange rate depreciation, whereas in some cases fiscal policy may also be counter-cyclical. See Frankel et al. (2013) for a discussion of fiscal policy in emerging markets.

Figure 5: Macroeconomic variables (2014Q1=100)

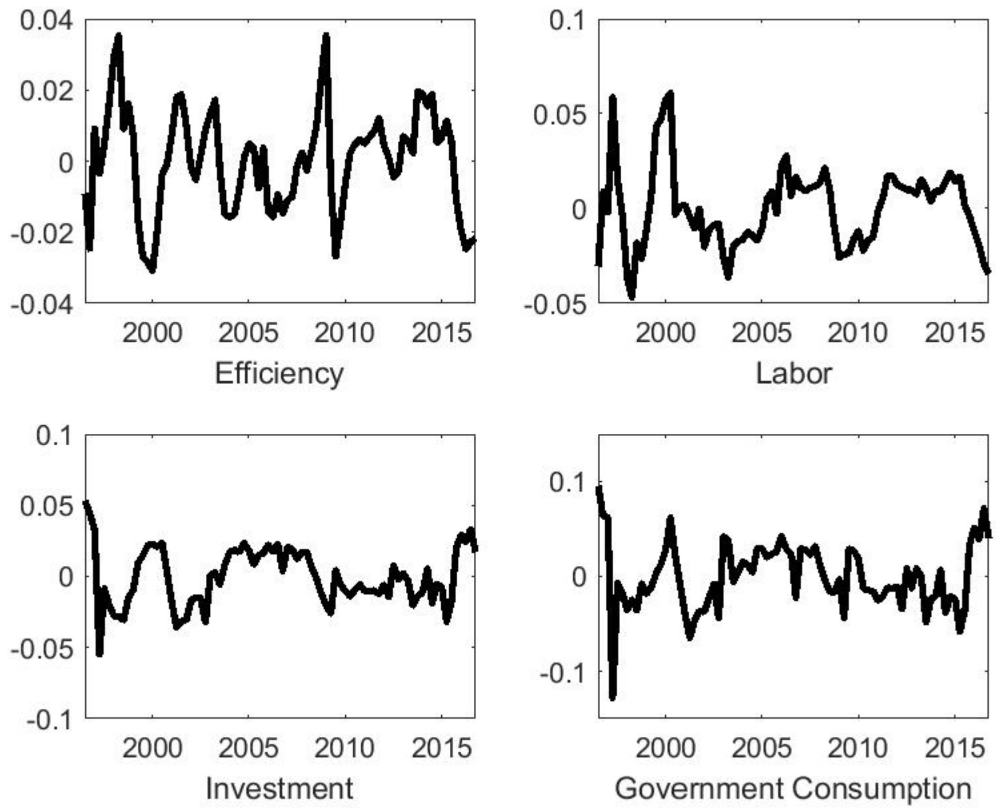


After estimating the wedges, the trajectory of output is simulated. Figure 7 presents two sets of simulations. In the top graphs there are the “one wedge economies", in which economies are simulated by allowing one wedge to fluctuate, while the others remain constant. In the bottom graphs there are the “one wedge off economies", in which economies are simulated by holding one wedge constant and allowing the other to fluctuate.

As we can see, the simulated output path with the efficiency wedge accounts for almost the whole production dynamics during the 2014-2016 depression. The model with only a labor wedge prescribes a delayed (and softer) recession and the model with only an investment wedge, even though accounts for the initial fall, presents a faster output recovery. Finally, output does not fall in the model with only the government consumption wedge.

Regarding the “one wedge off" simulations, the performance after removing the efficiency wedge is the worst among the four cases. The other three follow the observed output fall, even though the accuracy changes among them. Both one

Figure 6: Estimated HP-filtered wedges for the Brazilian economy



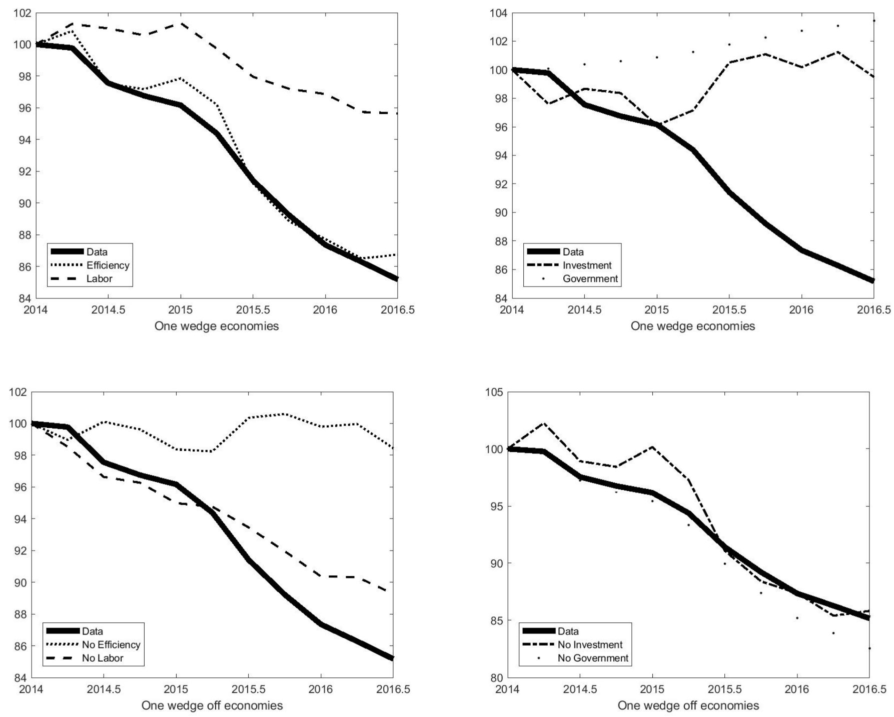
wedge and one wedge off simulations seem to corroborate the hypothesis of a TFP depression. Formally, we can test it with some statistics. Table 3 presents four of them: success ratio, linear correlation, root mean-square error (RMSE) and a ϕ statistic following Brinca et al. (2016), defined as follows:

$$\phi_i^y = \frac{1/\sum_t (y_t - y_{i,t})^2}{\sum_j (1/\sum_t (y_t - y_{i,t})^2)}$$

where i is the subscript for output prescribed by each model and j is the total of models considered. The statistics lies between 0 and 1 and the closest the value is to 1, the better. Therefore, the value is the contribution of each wedge for explaining output movements.

The efficiency wedge accounts for 72.1% of output movements in the full sample and its role increases to 98% in the depression. Moreover, even if

Figure 7: Simulated economies during the depression



previous business cycles might have been driven by a secondary role of other wedges (each account for around 9% of output movements), the Brazilian depression is driven by the efficiency wedge.

5 The Brazilian Quantitative Easing

From the synthetic control results, data seems to indicate that any attempt to model the Brazilian depressions should encompass mainly domestics features. The business cycle accounting results favor the efficiency wedge as the main driver of the depression.

One important feature of the last decade in Brazil is the growing participation of earmarked credit in total credit. Figure 8 presents the share of earmarked over total amount of credit.

Earmarked credit represented 36% of total credit at the end of the first quarter of 2007. In the second quarter of 2016, the share achieved 50%. A great part of

Table 3: BCA decomposition statistics

Statistic	Efficiency	Labor	Investment	Government
One wedge economies - full sample				
Success Ratio	0.790	0.457	0.420	0.185
Correlation	0.858	0.539	-0.406	-0.753
RMSE	0.028	0.078	0.078	0.079
ϕ_i^y	0.721	0.094	0.094	0.092
One wedge off economies - full sample				
Success Ratio	0.407	0.864	0.765	0.963
Correlation	-0.230	0.661	0.836	0.992
RMSE	0.077	0.031	0.046	0.009
$1-\phi_i^y$	0.279	0.906	0.906	0.908
One wedge economies - 2014 depression				
Success Ratio	0.727	0.818	0.455	0.000
Correlation	0.989	0.949	-0.589	-0.977
RMSE	0.008	0.131	0.074	0.115
ϕ_i^y	0.980	0.004	0.012	0.005
One wedge off economies - 2014 depression				
Success Ratio	0.545	0.909	0.727	1.000
Correlation	-0.089	0.983	0.979	1.000
RMSE	0.104	0.037	0.052	0.010
$1-\phi_i^y$	0.020	0.996	0.988	0.995

Success ratio: relative frequency when simulated and observed data had the same sign; Linear correlations between simulated and observed data; RMSE: root of the mean-square error; ϕ statistic following Brinca et al. (2016).

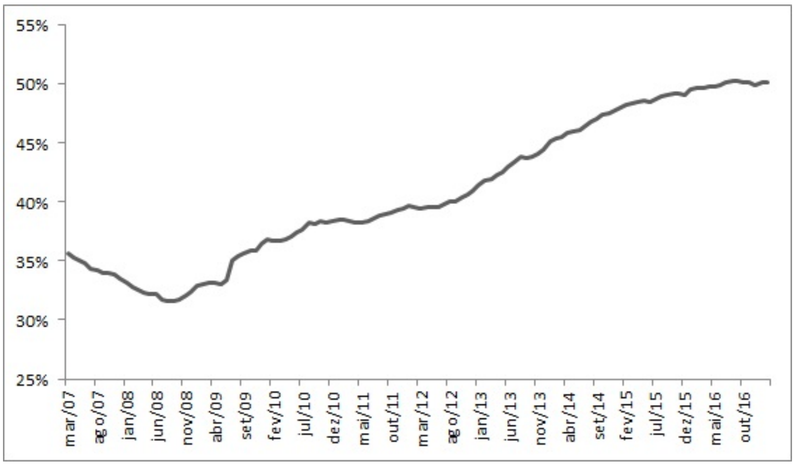
this is issued by the BNDES (*Banco Nacional de Desenvolvimento Econômico e Social* in the Portuguese acronym).[6] The public bank share in 2007 was 33.1% of total credit, whereas its participation rose to 41.5% at the beginning of 2015, diminishing marginally to 39.1% at the end of the sample.

Due to importance of BNDES credit in the Brazilian economy and the role of the efficiency wedge in the Brazilian depression, a question emerges: what is the relation between the efficiency wedge and BNDES outlays? We rely on two sources for answering this question: the equivalence in a very simple and stylzed model and an econometric exercise.

A simple model. Let us work within a two-period, perfectly competitive framework. The economy has two sectors: a totally privately-funded, sector A,

[6] BNDES credit outlays are mostly with earmarked resources.

Figure 8: Earmarked credit share share



Source: Brazilian Central Bank.

and a totally publicly-funded, sector B. In the first period, agents choose the optimal allocation of resources and, after that, the efficiency MIT shocks will manifest themselves in the second period. Final goods output (Y_t) is obtained by combining production of each sector ($y_{i,t}, i \in \{A, B\}$) as follows:

$$Y_t = (y_{A,t})^{\mu}(y_{B,t})^{1-\mu}. \tag{5}$$

Each sector combines capital per unit of effective labor ($k_{i,t}, i \in \{A, B\}$) according to the following production technologies

$$y_{A,t} = A_{A,t}k_{A,t}^{\alpha}, \tag{6}$$

$$y_{B,t} = A_{B,t}k_{B,t}^{\theta\alpha}, \tag{7}$$

where α stands for the capital per unit of effective labor share in the procution of each sector. For sector B, this share is multiplied by θ, allowing a different marginal productivity of capital. All markets are perfectly competitive. Firms in sector A maximize profits ($\Pi_{A,t}$) and finance capital accumulation with private funds:

$$\max_{k_{A,t}} \Pi_{A,t} = y_{A,t} - r_t k_{A,t}. \tag{8}$$

Firms in sector A maximize profits ($\Pi_{A,t}$) and finance capital accumulation with public funds:

$$\max_{k_{B,t}} \Pi_{B,t} = y_{B,t} - r_t k_{B,t}. \tag{9}$$

In perfectly competitive markets the marginal product of capital must be equal in both sectors. Using this result we may rewrite aggregate output as follows

$$Y_t = A k_{B,t}^{\alpha}, \tag{10}$$

where

$$A = A_A^{\mu - \frac{\mu}{\alpha-1}} A_B^{\frac{\mu}{\alpha-1}+1-\mu} k_{B,t},$$

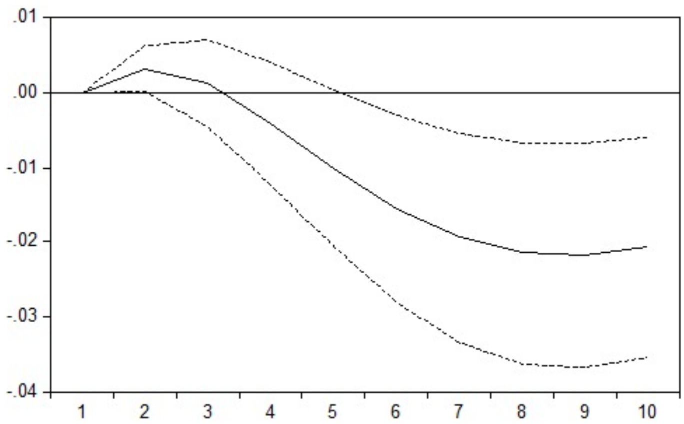
is the efficiency wedge. This provides the intuition for the relationship between the efficiency wedge and BNDES outlays. By accumulating more capital in sector B, the efficiency wedge would rise, holding everything else constant. Of course, we do not know how other variables (e.g. productivity in the other sector) would respond in the second period. The long-run effects of earmarked outlays are out of the scope of this paper, though.

Econometric analysis. In order to answer the question of which scenario describes better what happened in Brazil, a unrestricted VAR was estimated with the efficiency wedge from the BCA (A_t^c) and the log of BNDES outlays (B_t^c; HP filtered and seasonally adjusted). Both original series were multiplied by a 1999-crisis dummy (δ_{1999}), which assumes a value equals to two between the first quarter of 1996 and the last quarter of 2001, and a value equals to one from the first quarter of 2002 to the second quarter of 2016.

$$\begin{bmatrix} A_t^c \cdot \delta_{1999} \\ B_t^c \cdot \delta_{1999} \end{bmatrix} = \beta_0 + \beta_1 \cdot \begin{bmatrix} A_{t-1}^c \cdot \delta_{1999} \\ B_{t-1}^c \cdot \delta_{1999} \end{bmatrix} + \beta_2 \cdot \begin{bmatrix} A_{t-2}^c \cdot \delta_{1999} \\ B_{t-2}^c \cdot \delta_{1999} \end{bmatrix} + \begin{bmatrix} \epsilon_t^A \\ \epsilon_t^B \end{bmatrix}$$

where β_0 is the vector of constants, β_1 and β_2 are matrices of coefficients and ϵ_t^A and ϵ_t^B stand for the errors. The Schwarz and Hannan-Quinn information criteria favor the model with two lags. Figure 9 presents the ten-period accumulated response of the efficiency wedge to a one standard deviation shock on BNDES outlays using the Cholesky decomposition (results are robust to changes in variables order) with 95% confidence intervals (doted lines).

Figure 9: Response of the efficiency wedge to BNDES outlays



The point estimation for the response of the efficiency wedge initially rises, in line with the intution from the simple model. However, the accumulated effect is negative (and statistically significant) from the sixth quarter onwards. We present an intution for this result based on our simple model in the appendix C, since we do not want to loose focus on the research question we are interested in.

This corroborates with the idea of a “bad news case" as described before. By choosing projects with low efficiency, the long run effects may be negative. During the sample period, this long run effects may have been offset by new outlays, whereas de depression may also be a combination of too much credit and a fall in this “Brazilian Quantitative Easing", in a sort of balance-sheet recession for both public and private agents.

The results are in line with the evidence that government-driven credit expansion in Brazil, since they have been destined to larger and older firms, may have served as counter-cyclical measure, but its continuity may have distorted resources allocation (Bonomo et al., 2015). Moreover, the subsidies seem to have no impact on market valuation and investment, only on the cost of funding, at least for publicly-traded companies (Lazzarini et al., 2015).

6 The model

The importance of the public bank in the credit market justifies a model that not only i) has a domestic trigger for the depression, ii) has an efficiency wedge as the main driver of economic fluctuations, but also encompasses the role of the BNDES in the Brazilian economy. With all that in mind, the model from Gertler and Karadi (2011) is adapted to analyze to depressions. The model was originally used to evaluate quantitative easing policies (QE). In some sense, the BNDES is responsible for a sort of Brazilian QE.

Households

A continuum of identical households save, consume and supply labor. A fraction f of the households members is composed by bankers. The probability of staying as a banker in the next period is given by θ. Households solve the following maximization problem:

$$\max_{C_t, L_t} E_t \sum_{t=0}^{\infty} \beta^t [\ln(C_t - hC_{t-1}) - \frac{\chi}{1+\varphi} L_t^{1+\varphi}], \tag{11}$$

subject to a budget constraint given by

$$C_t = W_t L_t + \Pi_t - T_t + R_t B_t - B_{t+1} \tag{12}$$

where C_t is consumption, L_t stands for labor, B_{t+1} and R_t are the short term debt and its gross real return; Π_t is the transfer from households to those entering in the banking business and T_t are lump-sum taxes. The first order conditions are:

$$(C_t - hC_{t-1})^{-1} - \beta h(C_{t+1} - hC_t)^{-1} = \lambda_t, \tag{13}$$

$$\lambda_t W_t = \chi L_t^{\varphi}, \tag{14}$$

$$\beta E_t R_{t+1} \frac{\lambda_{t+1}}{\lambda_t} = 1. \tag{15}$$

Financial intermediaries

The financial firm j obtains funds from households' savings in bonds and its stock of wealth, $N_{j,t}$. Given the relative price (Q_t) on financial claims, the total lend to non-financial companies ($S_{j,t}$) evolves according to the following balance sheet dynamics:

$$Q_t S_{j,t} = N_{j,t} + B_{j,t+1}. \tag{16}$$

The evolution of banker's capital is given by:

$$N_{j,t+1} = R_{k,t+1} Q_t S_{j,t} - R_{t+1} B_{j,t+1}. \tag{17}$$

Replacing the balance sheet dynamics into the previous equations yields:

$$N_{j,t+1} = Q_t S_{j,t}(R_{k,t+1} - R_{t+1}) + R_{t+1} N_{j,t}. \tag{18}$$

Let $\Lambda_{t,t+1} = \lambda_{t+1}/\lambda_t$ and define $\beta^t \Lambda_{t,t+1}$ as the stochastic discount factor for each banker. The risk-adjusted premium is thus

$E_t\beta^t\Lambda_{t,t+1}(R_{k,t+1} - R_{t+1}) \geq 0, \forall t$. Financial intermediates maximize expected wealth ($V_{j,t}$) and to to avoid an indefinitely expansion of assets (moral hazard problem), funds will flow to the banker if

$$V_{j,t} \geq \Omega Q_t S_{j,t}, \tag{19}$$

where Ω is the fraction of funds the banker diverts instead of transferring them back to households. Therefore, the expected wealth is equal to:

$$V_{j,t} = v_t Q_t S_{j,t} + \eta_t N_{j,t}, \tag{20}$$

with

$$v_t = E_t[(1-\theta)\beta\Lambda_{t,t+1}(R_{k,t+1} - R_{t+1}) + \beta\Lambda_{t,t+1}\theta x_{t,t+1} v_{t+1}], \tag{21}$$

$$\eta_t = E_t[(1-\theta) + \beta\Lambda_{t,t+1}\theta z_{t,t+1}\eta_{t+1}], \tag{22}$$

$$x_{t,t+1} = \frac{Q_{t+1}S_{j,t+1}}{Q_t S_{j,t}}, \tag{23}$$

$$z_{t,t+1} = \frac{N_{j,t+1}}{N_{j,t}}, \tag{24}$$

where v_t is the expected discounted marginal gain of expanding assets and η_t is the expected discounted gain of marginal wealth given the amount of assets. The incentive constraint is thus

$$Q_t S_{j,t} = \frac{\eta_t}{\Omega - v_t} N_{j,t} = \phi_t N_{j,t}, \tag{25}$$

where ϕ_t is the leverage ratio. Assume it is the the same for each firm and we have:

$$Q_t S_t = \phi_t N_t. \tag{26}$$

Banker's net wealth evolves according the following dynamics:

$$N_{j,t+1} = (\phi_t (R_{k,t+1} - R_{t+1}) + R_{t+1}) N_{j,t}. \tag{27}$$

Total net wealth (N_t) is a combination of the net wealth of existing bankers ($N_{e,t}$)

$$N_{e,t} = \theta[(R_{k,t} - R_t)\phi_{t-1} + R_t] N_{t-1}, \tag{28}$$

and the net wealth of new bankers ($N_{n,t}$), financed with "start up" money from households. The resources are a fraction (ω) of end-of-period assets of existing bankers:

$$N_{n,t} = \omega Q_t S_{t-1}. \tag{29}$$

The law of motion of N_t may be rewritten as follows:

$$N_t = \theta[(R_{k,t} - R_t)\phi_{t-1} + R_t] N_{t-1} + \omega Q_t S_{t-1}. \tag{30}$$

Credit Policy

The government issues debt to households to fund its credit policy. The cost of debt is the riskless interest rate and it lends to non-financial firms at market lending rates. However, government intermediation occurs inefficiently, bearing costs (τ) per unit of government loan ($Q_t S_{g,t}$). Public debt ($B_{g,t}$) will fund a fraction (ψ_t) of fund, i.e.:

$$Q_t S_{g,t} = \psi_t Q_t S_t, \tag{31}$$

$$B_{g,t} = \psi_t Q_t S_t, \tag{32}$$

Therefore, total amount of credit is the sum of private loans ($S_{p,t}$) and public loans:

$$Q_t S_t = Q_t S_{p,t} + Q_t S_{g,t}, \tag{33}$$

where $\phi_{c,t} = 1/(1-\psi_t)$.

6.0.1 Intermediate goods firms

Value of capital acquired should be equal to the value of the claims to acquire capital:

$$Q_t K_{t+1} = Q_t S_t. \tag{34}$$

Firms produce intermediate goods (Y_t) according to the following technology:

$$Y_t = A_t (K_t \xi_t U_t)^{\alpha} L_t^{1-\alpha}, \tag{35}$$

where A_t is, K_t is the stock of capital, U_t stands for the utilization of capital and ξ_t is the shock in the value of capital, which is assumed to follow an AR process. Producers maximize profits taking the price of intermediate goods as given and accounting for the costs of replacing capital ($\delta(U_t) = U_t^{1+\zeta}/(1+\zeta)$). The first order conditions are

$$\alpha \frac{P_{m,t} Y_t}{U_t} = U_t^{\zeta} K_t \xi_t, \tag{36}$$

$$(1-\alpha) \frac{P_{m,t} Y_t}{L_t} = W_t. \tag{37}$$

Zero profits condition imply

$$R_{k,t} = \frac{\alpha \frac{P_{m,t+1}Y_{t+1}}{K_{t+1}\xi_{t+1}} + Q_{t+1} - \delta(U_t)}{Q_t}\xi_{t+1}. \tag{38}$$

Capital producing firms

Capital producing firms also maximize profits by choosing net investment ($I_{n,t}$) subject to adjustment costs ($f(I_{n,t}, I_{n,t-1})$). Optimal choice is given by

$$Q_t = 1 + \eta_i(I_{n,t}, I_{n,t-1}) - E_t\beta\Lambda_{t,t+1}\eta_i(I_{n,t+1}, I_{n,t}). \tag{39}$$

Final goods producers

From a cost minimization problem each the demand for each input ($Y_{f,t}$) is given by

$$Y_{f,t} = (\frac{P_{f,t}}{P_t})^{-\epsilon}Y_t, \tag{40}$$

which depends of each input's price ($P_{f,t}$), relative to total price index (P_t), given the parameter for preferences, ϵ. Define the price index as follows:

$$P_t = [\int_0^1 P_{f,t}^{1-\epsilon}df]^{\frac{1}{1-\epsilon}}. \tag{41}$$

Final goods producers set prices in a la Calvo, maximizing expected profits and only a fraction resets prices. Under this set up, inflation (π) is given by Therefore

$$\pi_t^* = \frac{\epsilon}{\epsilon - 1}\frac{F_t}{Z_t}\pi_t, \tag{42}$$

where $\pi_t^* = \frac{P*_t}{P_{t-1}}$ and

$$F_t = Y_t P_{m,t} + E_t \gamma \beta \Lambda_{t,t+1} (\frac{\pi_{t+1}}{\pi_t^{\gamma_p}})^{\epsilon} F_{t+1}, \tag{43}$$

$$Z_t = Y_t + E_t \gamma \beta \Lambda_{t,t+1} (\frac{\pi_{t+1}}{\pi_t^{\gamma_p}})^{\epsilon - 1} Z_{t+1}. \tag{44}$$

Government and Central Bank

Differently from Gertler and Karadi (2011), government spending (G_t) is not constant. It is assumed evolve according to the following dynamics:

$$G_t = G_{t-1} + \epsilon_t^G, \tag{45}$$

where ϵ_t^G represents a fiscal policy shock and it is assumed to follow an $AR(1)$ process. The economy's resource constraint thus becomes:

$$Y_t = C_t + I_t + \frac{\eta_i}{2} (\frac{I_{n,t} + I_{ss}}{I_{n,t-1} + I_{ss}} - 1)^2 (I_{n,t} + I_{ss}) + G + \tau \psi_t Q_t K_{t+1}. \tag{46}$$

The government expenditure is financed via lump-sum taxes and government financial intermediation

$$G + \tau \psi_t Q_t K_{t+1} = T_t + (R_{k,t} - R_t) B_{g,t-1}. \tag{47}$$

Monetary policy decisions are emulated by a Taylor rule (in this paper, a modified version than the one used in Gertler and Karadi (2011)):[7]

$$i_t = (1 - \rho)(r_t^N + \kappa_\pi E_t \pi_{t+1} + \kappa_y (\ln Y_t - \ln Y)) + \rho i_{t-1} + \epsilon i_t, \tag{48}$$

where $lnY_t - \ln Y$ is the output gap and r_t^N is the natural real interest rate that would prevail within a flexible prices context (equals to the marginal product

[7]Gertler and Karadi (2011) use minus the price markup as a proxy for the output gap; moreover, they assume a slightly differente functional form.

of capital). The real interest rate is obtained by the Fisher equation:

$$1 + i_t = R_{t+1} E_t \frac{P_{t+1}}{P_t}. \tag{49}$$

Finally, the dynamics of the public development, BNDES. The idea is that the bank injects resources on the economy considering its sensitivity to credit spreads and an exogenous shock (ϵ_t^{ψ}), which can encompass other determinants of the loans that are not technical, such as political will.

$$\psi_t = \psi + \nu E_t[(\log R_{k,t+1} - \log R_{t+1}) - (\log R_k - \log R_t)] + \epsilon_t^{\psi}. \tag{50}$$

After describing the model, the next section presents the output dynamics prescribed by the model, as well as the observed data.

6.0.2 Calibration and simulation

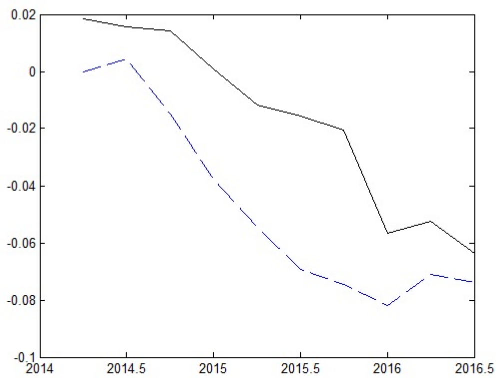
The model was calibrated following mainly Gertler and Karadi (2011), with a few exceptions for adjusting it to the Brazilian reality. For instance, the authors set the leverage ratio in the steady state equals to 4, whereas in this paper it set to 1.5, more suitable to a greater debt intolerance within emerging markets. Table 4 presents the other parameters:

Table 4: Parameters

Parameter		Value	Source
Households			
Discount factor	β	0.99	Gertler and Karadi (2011)
Habit parameter	h	0.815	Gertler and Karadi (2011)
Relative utility weight of labor	χ	3.409	Gertler and Karadi (2011)
Inverse Frisch elasticity of labor supply	φ	0.276	Gertler and Karadi (2011)
Financial Intermediaries			
Fraction of capital that can be diverted	Ω	0.381	Gertler and Karadi (2011)
Proportional transfer to the entering bankers	ω	0.002	Gertler and Karadi (2011)
Survival rate of the bankers	θ	0.972	Gertler and Karadi (2011)
Intermediate good firms			
Capital share	α	0.4	Ferreira et al. (2008)
Steady state depreciation rate	$\delta(U)$	0.05	Ferreira et al. (2008)
Elasticity of marginal depreciation with respect to utilization rate	ζ	7.200	Gertler and Karadi (2011)
AR coefficient of ξ	ρ_ξ	0.9	Gertler and Karadi (2011)
Capital Producing Firms			
Inverse elasticity of net investment to the price of capital	η_i	1.728	Gertler and Karadi (2011)
Final goods producers			
Elasticity of substitution	ϵ	4.167	Gertler and Karadi (2011)
Probability of keeping prices fixed	γ	0.779	Gertler and Karadi (2011)
Price indexation	γ_p	0.241	Gertler and Karadi (2011)
Public sector			
Inflation coefficient of the Taylor rule	κ_π	1.5	Gertler and Karadi (2011)
Output gap coefficient of the Taylor rule	κ_y	0.50/4	Gertler and Karadi (2011)
Smoothing parameter of the Taylor rule	ρ	0.8	Gertler and Karadi (2011)
Steady state proportion of government expenditures	$\frac{G}{Y}$	0.2	Gertler and Karadi (2011)

By assigning to the model the aforesaid parameters, one is able to see what would be the prescribed path of output during the Brazilian depression. Figure 10 presents the outcome of the log-linearized version of the model with HP-filtered observed output data.

Figure 10: Output: data vs model



Notes: The outcome of a log-linearized model and the HP-filtered output data.

As can be seen, the model is able to account for the fall in output. Moreover, it also produces a brief marginal increase in 2016, followed by another marginal fall. This corroborates with the idea that the credit market is important to understand the transmission of the depression.

7 Final remarks

The Brazilian economy was able to recover fast from its two-quarters recession, in 2009, after the GFC, with a high growth rate in 2010. But not only it returned to its usual low growth rates (for an emerging market economy), a pattern since the 1980s, but also experienced a downward trend leading to stagnation in 2014. With a rare two-year GDP contraction in 2015 and 2016, a depression in the Brazilian economy arouse mainly due to domestic factors, even though some fall in GDP might be attributed to the international environment.

We saw that distortions in the accumulation of production factors, the efficiency wedge, is the driver of output dynamics within 2014-2016. Due to the structure of the credit market in Brazil at the time, with a great role for earmarked credit, we investigated how the efficiency wedge responds to BNDES' lending. This was motivated by the fact that the public development bank change its modus operand from the usual consistently positive net outlays throughout time.

In a simple econometric exercise, we find that the efficiency wedge has a positive initial response from an increase in BNDES' outlays. It does, however, vanish shortly afterward and the accumulated effect is negative. The medium and long-run effects of public lending are outside of the scope of this paper and the result opens room for future research. Nevertheless, we sketch an analysis to get the intuition behind this result. We raise the hypothesis (again, to be investigated in a future work) that subsidized credit at the time in Brazil might have been poorly allocated, a hypothesis we raised from the econometric evidence and systematized with a very simple model.

We also considered the role of the public development bank in a more complete setup, embedding not only the dynamics of government spending, a central bank, and households, but also the dynamics of credit market frictions. The model is able to account for output dynamics and the response of the economy to BNDES' outlays, as well as the importance of the indebtedness of other agents during the Brazilian depression.

By changing the behavior of public lending, the negative exogenous shocks from the withdrawal of public lending towards a more privately-oriented credit market had negative effects on the economy.

We acknowledge that there were other sources for the depression at the time, but we think this paper contributes with one channel and opens room for future research on the long-run effects of public lending on the efficient use of production factors.

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A Data description

The data from CODACE can be accessed in this report (in Portuguese).

Data for the BCA exercises in detailed below:

- GDP: Gross domestic product in current values for the first quarter of 1996. For the second quarter onwards real growth was applied. Source: IBGE.
- Consumption: Household consumption in current values for the first quarter of 1996. For the second quarter onwards real growth was applied. Source: IBGE
- Durables goods consumption: Household consumption multiplied by durables goods consumption share. Author's calculation.
- Durables goods consumption share: using Brazilian input-output matrices from IBGE for years 2000 and 2005, the share was calculate following Ellery Jr et al. (2002); from 2006 to 2015, only a random shock was considered (using excel, a pseudo random number from a Normal distribution with mean equals to zero and variance equals to the series variance - seed: 13).
- Investment: Investment in current values for the first quarter of 1996. For the second quarter onwards real growth was applied. Source: IBGE.
- Exports: Exports in current values for the first quarter of 1996. For the second quarter onwards real growth was applied. Source: IBGE.
- Imports: Exports in current values for the first quarter of 1996. For the second quarter onwards real growth was applied. Source: IBGE.
- National accounts growth: Quarterly real growth. Source: OECD Statistics.

- Hours of Work: Average Annual Hours Worked by Persons Engaged for Brazil. For 2015 the same value of 2014 was used. Source: Penn World Table.
- Population: Working age population (15-64). For 2013, 2014 and 2015, the values were estimated using the average growth between 2012 and 1992. Source: OECD Statistics.
- Total earmarked credit: Data from the Brazilian Central Bank.
- Total non-earmarked credit: Data from the Brazilian Central Bank.
- BNDES outlays: Data from the Brazilian Central Bank.

B Synthetic control

The sample used in the synthetic control estimation and the weights for the the synthetic Brazil are given by Tables 5 and 6 below.

Table 5: Full sample

Antigua and Barbuda	Argentina	The Bahamas	Barbados
Belize	Bolivia	Brazil	Chile
Colombia	Costa Rica	Dominica	Dominican Republic
Ecuador	El Salvador	Grenada	Guatemala
Guyana	Haiti	Honduras	Jamaica
Mexico	Nicaragua	Panama	Paraguay
Peru	St. Kitts and Nevis	St. Lucia	St. Vincent and the Grenadines
Suriname	Trinidad and Tobago	Uruguay	Venezuela

Table 6: Country weights

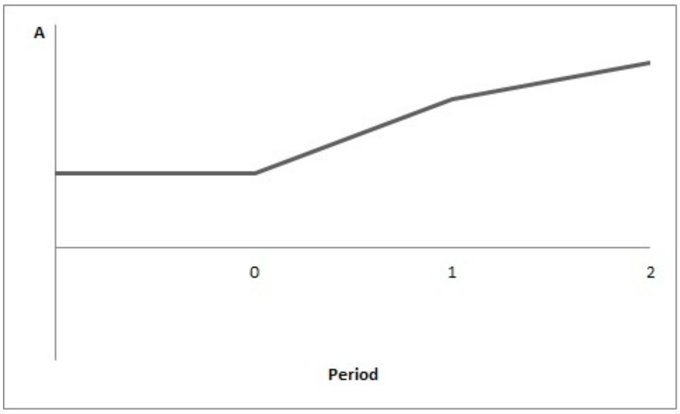
Country	Weight
Belize	0.089
Ecuador	0.091
Guyana	0.178
Mexico	0.254
Peru	0.355
Venezuela	0.033

C Good or bad news?

Good News Scenario

One hypothesis is that the public bank targeted projects with high social returns. If this is the case, let us assume that after the increase in efficiency wedge in the first period, positive spillovers would manifest in the second period, increasing productivity in both sectors, augmenting the efficiency wedge even more. Figure 11 provides a representation of the dynamics of the efficiency wedge throughout time under the good news scenario.

Figure 11: Efficiency wedge with positive social returns

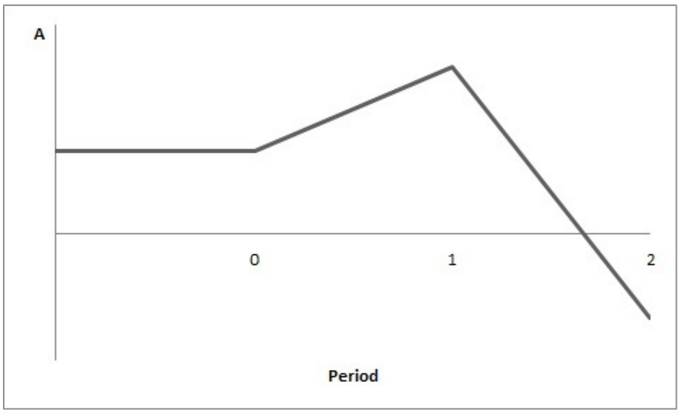


This would allow the economy to grow faster than dictated by factor accumulation.

Bad News Scenario

What if public sector investments were made poorly? For instance, the subsidized interest rate in public lending might induce an adverse selection problem through the selection of low-return projects – that would not occur in the first place if the interest rate was higher. If this was the case, in the second period, a negative shock on the productivity of sector B would produce negative spillovers on sector A. Therefore, the efficiency wedge would fall at $t = 2$, as is represented in Figure 12.

Figure 12: Efficiency wedge with negative social returns



What does the data tell us?

The results corroborate with the idea of a “bad news case" as described before. By choosing projects with low efficiency, the long run effects may be negative. During the sample period, this long run effects may have been offset by new outlays, whereas de depression may also be a combination of too much credit and a fall in this “Brazilian Quantitative Easing", in a sort of balance-sheet recession for both public and private agents.

The results are in line with the evidence that government-driven credit expansion in Brazil, since they have been destined to larger and older firms, may have served as counter-cyclical measure, but its continuity may have distorted resources allocation (Bonomo et al., 2015). Moreover, the subsidies seem to have no impact on market valuation and investment, only on the cost of funding, at least for publicly-traded companies