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Essays on Government Interventions and Resource Misallocation in Brazil

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Denise Manfredini

Essays on Government Interventions and Resource Misallocation in Brazil

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They were arguing about something very complex and important, and neither of them could defeat the other. They did not agree with one another about anything, and because of that their argument was particularly interesting and interminable.
Mikhail Bulgakov, *The Master and Margarita*

[...] knowledge isn't the data. It's what you do with the data.
Louis Menand, *The New Yorker, November 16, 2020*

RESUMO

Esta tese consiste em três ensaios independentes sobre o impacto das intervenções governamentais na alocação ótima de recursos na economia brasileira. No primeiro capítulo, aplica-se o método de *business cycle accounting* à economia brasileira. Usando um modelo de crescimento neoclássico, as flutuações do ciclo de negócios são decompostas pela contribuição de cada fricção (*wedges*) com o objetivo de orientar as escolhas sobre onde introduzir fricções em modelos que analisam o ciclo de crescimento e recessão de 2003-2016. Os resultados mostram que a produtividade é o principal *wedges* responsável pelo comportamento do investimento, consumo e produção observados. No capítulo dois, um modelo de dinâmica de firma é calibrado com os dados brasileiros para investigar os efeitos dinâmicos da má alocação no crescimento da produtividade que podem surgir de uma expansão de crédito impulsionada pelo governo. Os principais resultados são: (i) quando apenas empresas sem restrições de crédito recebem subsídios, a heterogeneidade dentro do mesmo grupo de produtividade aumentará, o que resulta em uma produtividade agregada mais baixa; (ii) se as empresas com restrição de crédito receberem subsídios, os subsídios podem compensar parcialmente a distorção de mercado criada pela restrição de crédito e a economia pode alcançar um produto por trabalho mais elevado com menos capital; e (iii) quando a taxa de juros internacional aumenta, os custos dos subsídios são cada vez mais prejudiciais ao governo. No terceiro capítulo, é investigado se há suporte para a hipótese de que o impacto dos subsídios ao crédito sobre o crescimento e a produtividade é decrescente, ou mesmo negativo, à medida que o acesso ao crédito se torna mais generalizado. Os resultados de um VAR com parâmetros variando no tempo e volatilidade estocástica mostram que não há evidências de um impacto estatisticamente significativo dos choques de crédito subsidiado sobre a produtividade. Choques de subsídio de crédito levam a um aumento transitório no PIB per capita, sugerindo que o crédito subsidiado poderia ser considerado eficaz na promoção da atividade econômica. Por último, o PIB per capita tornou-se menos reativo aos subsídios de crédito nos últimos dez anos em relação às décadas de 1950 e 1970. Os resultados contribuem para uma possível explicação de que, com o desenvolvimento do sistema bancário, os efeitos de uma expansão do crédito direcionado têm maior probabilidade de levar a uma substituição da fonte de financiamento.

Palavras-chave: Má-alocação. Brasil. Intervenções do Governo.

RESUMO EXPANDIDO

Introdução

Esta tese é uma coleção de três ensaios sobre o impacto das intervenções governamentais na alocação ótima de recursos na economia brasileira. Entre 2014 e 2016, a economia brasileira experimentou o menor crescimento acumulado e os mais longos períodos consecutivos de recessão desde 1980, a inflação subiu e o país enfrentou grave instabilidade política que contrasta com o bom desempenho econômico dos anos 2000. Como o Brasil passou de uma das economias de crescimento mais rápido para uma profunda recessão econômica? Minha hipótese é que a intervenção do governo, por meio da política industrial, foi um fator relevante. A política industrial gera distorções idiossincráticas e a sobrevivência de firmas improdutivas, o que resulta em queda da produtividade e compromete o crescimento econômico de longo prazo.

A evidência empírica da literatura sobre crescimento econômico sugere que o desenvolvimento industrial e econômico não tem a ver com proteção; trata-se de produtividade. Controlada por diferenças na quantidade e qualidade dos fatores de produção, a produtividade é o principal fator para explicar o diferencial de crescimento econômico entre os países; veja Jones (2016); Klenow and Rodriguez-Clare (1997); Prescott (1998); Rodrik, Subramanian, and Trebbi (2004). O afastamento das tecnologias de fronteira e a difusão mais lenta das boas práticas produtivas está entre as causas apontadas em nível nacional como responsáveis pelo desequilíbrio do desenvolvimento.

O foco na microestrutura da firma oferece uma explicação alternativa e complementar para explicar as diferenças entre os países nas rendas per capita: distorções no nível da firma levam a alocação de recursos abaixo do ideal (má alocação) dentro do país, resultando em uma produtividade média e econômica mais baixa (Restuccia and Rogerson, 2017). A base empírica para essa explicação é a alta heterogeneidade observada em tamanho e produtividade entre empresas e setores, e a abordagem teórica está embutida nos modelos quantitativos de heterogeneidade da empresa.

As raízes da literatura sobre alocação de recursos no crescimento econômico são difusas, abrangendo desde os ciclos de negócios até organização industrial. Nos últimos anos, o renovado interesse pelos efeitos da alocação de recursos sobre o crescimento resultou em uma vasta literatura empírica sobre má alocação que propunha uma ideia antiga: políticas discricionárias, como subsídios e isenções tributárias, podem causar queda na produtividade.

Podemos ver a análise dos efeitos da alocação de recursos dentro das firmas por duas perspectivas; direto e indireto. Na abordagem direta, uma distorção específica que afeta a alocação de recursos é identificada e, em seguida, seu efeito na alocação de recursos e na produtividade é medido. Na abordagem indireta, podemos abstrair da origem das distorções e focar em como as distorções e fricções (*wedges*) no comportamento ótimo das firmas podem afetar a produtividade e, portanto, o crescimento econômico (Restuccia and Rogerson, 2013). Sob a abordagem indireta estão os trabalhos seminais da literatura recente de má alocação: Chari, Kehoe, and McGrattan (2007), que mede *wedges* no ciclo de negócios; Restuccia and Rogerson (2008), que avalia o impacto de distorções idiossincráticas no crescimento econômico; e Hsieh and Klenow (2009), que mede a má alocação usando dados no nível da empresa.

Objetivos

No primeiro ensaio da presente tese decompõe-se as as flutuações do ciclo de negócios da economia brasileira em *wedges* para orientar as escolhas sobre onde introduzir atritos nos modelos para melhor captar as muances da economia brasileira. O principal objetivo do segundo ensaio é identificar os efeitos do crédito subsidiado na produtividade em uma indústria competitiva. No terceiro ensaio é investigado se há suporte para a hipótese de que o impacto dos subsídios ao crédito sobre o crescimento e a produtividade é decrescente, ou mesmo negativo, à medida que o acesso ao crédito se torna mais amplo.

Metodologia

A metodologia do primeiro ensaio é um modelo de crescimento de uma pequena economia aberta com quatro tipos de *wedges*: capital, trabalho, investimento e eficiência. Em que os *wedges* medem as distorções que afetam o mercado de capital, trabalho, investimento e a eficiência produtiva.

No segundo ensaio é formulado uma versão do modelo de dinâmica das firmas que inclui política de crédito idiossincrática e dificuldades de acesso ao crédito. O modelo de dinâmica da empresa caracteriza o comportamento de uma economia povoada por empresas iguais que enfrentam choques de produtividade independentes, em linha com Hopenhayn (1992), Hopenhayn and Rogerson (1993), Restuccia and Rogerson (2008) e Samaniego (2009). O modelo incorpora três estados exógenos: produtividade, acesso ao crédito e subsídio ao crédito. Além do acesso desigual ao crédito, o modelo possui três características de extensão que partem da configuração do modelo básico de dinâmica das firmas. Primeiro, o nível de produtividade segue uma distribuição Pareto limitada. Em segundo lugar, as empresas têm saida endógena e exógena. Terceiro, existe um intermediário financeiro para contabilizar os fluxos financeiros na economia.

No terceiro ensaio a metodologia empírica segue a literatura que analisa a evolução das inter-relações entre múltiplas variáveis macroeconômicas usando modelos VAR com parâmetros variando no tempo com volatilidade estocástica (TVP-VAR), desenvolvido por Cogley and Sargent (2005) e Primiceri (2005).

Resultados e Discussão

Três resultados podem ser aprendidos com o primeiro ensaio. Em primeiro lugar, a produtividade é o principal *wedge* responsável pelo comportamento do investimento, consumo e produção observados, especialmente até 2009. Após a crise financeira global e principalmente durante a recessão de 2014-2016, o *wedge* do trabalho gradualmente ganhou importância na contabilização dos movimentos do ciclo de negócios, embora o *wedge* do trabalho nunca ultrapasse a produtividade na explicação do ciclo de negócios. Em segundo lugar, o *wedges* de trabalho é o melhor preditor dos movimentos no mercado de trabalho observados ao longo dos anos 2000 e 2010. Por último, os *wedges* de capital e títulos têm uma contribuição limitada para explicar o ciclo de negócios brasileiro entre 2003-2017.

Os resultados do segundo ensaio são três. Em primeiro lugar, quando apenas empresas sem restrições de crédito recebem subsídios, a heterogeneidade dentro do mesmo grupo de produtividade aumentará, o que resulta em uma produtividade total dos fatores mais baixa. Em segundo lugar, quando apenas as empresas com restrições de crédito recebem subsídios, a alocação de recursos na economia melhora. Os subsídios compensam parcialmente a distorção de mercado criada pela restrição de crédito, e a economia pode alcançar um produto por trabalho mais elevado com menos capital. Por último, os custos dos subsídios são responsáveis por uma carga considerável da dívida do governo quando a taxa de juros internacional aumenta.

No terceiro ensaio três descobertas principais emergem. A primeira constatação é que não há evidências de um impacto estatisticamente significativo dos choques de crédito subsidiado sobre a produtividade. Assim, não encontraram-se evidências de que um aumento no crédito subsidiado seja responsável por uma menor produtividade agregada. Em segundo lugar, os choques de subsídios de crédito levam a um aumento no PIB per capita, sugerindo que o crédito subsidiado poderia ser considerado eficaz na promoção da atividade econômica. A terceira descoberta é que o crescimento se tornou menos reativo a um aumento nos subsídios ao crédito. De acordo com a mediana das funções impulso-resposta, um choque positivo de crédito subsidiado leva a um aumento transitório do PIB per capita igual a 0,85 % em 1959 e 0,5 % em 1977, por outro lado, em 2012 a resposta é inferior a 0,3 %. Isso sugere que o PIB per capita se tornou menos reativo aos subsídios de crédito nos últimos dez anos em relação às décadas de 1950 e 1970. Uma hipótese plausível para essas evidências é que, uma vez que o sistema bancário se tornou mais desenvolvido, os efeitos de uma expansão do crédito direcionado têm maior probabilidade de levar a uma substituição da fonte financiamento, com o crédito direcionado substituindo outras fontes de financiamento.

Considerações Finais

A retração brasileira na década de 2010 teve várias causas. A mais óbvia foi a queda no preço das commodities que causou um choque econômico negativo para os países latino-americanos; em 2016, o preço das commodities caiu um quarto em relação ao nível de 2011. Mas as políticas governamentais intervencionistas e o declínio da credibilidade da política também desempenharam um papel proeminente na desaceleração econômica (Cuevas et al., 2019). As políticas governamentais intervencionistas estão englobadas principalmente pela política industrial implementada no país desde o final dos anos 2000 até meados dos anos 2010. As medidas de política incluíram um aumento nas operações de crédito com alocação compulsória, barreiras técnicas ao comércio, reduções de impostos, requisitos de conteúdo nacional e bens e serviços nacionais preferenciais nas compras

governamentais. Embora essas medidas visassem aumentar a produtividade e impulsionar o crescimento industrial, a produtividade brasileira se matém estável, em baixos níveis, desde a década de 1980.

Palavras-chave: Má-alocação. Brasil. Intervenções do Governo.

ABSTRACT

This thesis consists of three independent essays on the impact of government interventions in the optimal allocations of resources within the Brazilian economy. In the first chapter, I apply the Business Cycle Accounting method to the Brazilian economy. Using a neoclassical growth model for a small open economy, I decompose the business cycle fluctuations into contributing frictions (wedges) to guide the choices about where to introduce frictions into models to better fit the boom-bust cycle of 2003-2016. Results show that productivity is the main wedge accounting for the behavior of the observed investment, consumption, and output. In chapter two, I formulate a firm dynamics model with heterogeneous firms and calibrate to the Brazilian data to investigate the dynamic effects of misallocation on productivity growth that can arise from a government-driven credit expansion. The main results are: (i) when only credit-unconstrained firms receive subsidies the heterogeneity within the same productivity group will increase, which results in lower total factor productivity; (ii) if credit-constrained firms receive subsidies, the subsidies may partially offset the market distortion create by the credit constraint and the economy can achieve a higher output per labor with less capital; and (iii) when the international interest rate increases the subsidy costs are increasingly harmful to the government. In the third chapter, I investigate if there is support for the hypothesis that the impact of credit subsidies on growth and productivity is decreasing, or even negative, when credit access became more widespread. My results from a VAR with time-varying parameters and stochastic volatility show that there is no evidence of a statistically significant impact of the subsidized credit shocks on productivity. Credit subsidy shocks lead to a transitory increase in per capita GDP, suggesting that subsidized credit could be indeed considered effective in promoting economic activity. Last, per capita GDP has become less reactive to credit subsidies over the last ten years with respect to the 1950s and 1970s. The results contribute to a potential explanation that once the banking system became more developed, the effects of an expansion in the earmarked credit are more likely to lead to a funding substitution.

Keywords: Misallocation, Brazil, Government Interventions

List of Figures

List of Tables

Acronyms

BCA Business Cycle Accounting.

BNDES Brazilian Development Bank.

CCS Credit-constrained subsidy.

CODACE Brazilian Dating Committee of Economic Cycles.

CUS Credit-unconstrained subsidy.

GDP Gross Domestic Product.

GFCF Gross Fixed Capital Formation.

IBGE Brazilian Institute of Geography and Statistics.

II PND Second National Development Plan.

PAEG Plan of Government Economic Action.

PBM Brasil Maior Plan.

PDP Productive Development Policy.

PITCE Industrial, Technological, and Foreign Trade Policy.

PSI Investment Maintenance Program.

TFP Total factor productivity.

TJLP (Brazilian) Long term interest rate.

TVP-VAR Time-varyig parameter vector autoregressive model.

VAR Vector autoregression.

Contents

INTRODUCTION

This thesis is a collection of three essays about the impact of government interventions in the optimal allocations of resources within the Brazilian economy. Between 2014 and 2016, the Brazilian economy experienced the lowest cumulative growth and longest consecutive periods of recession since 1980, the inflation rose and the country faced severe political instability that contrasts with the good economic performance in the 2000s. How did Brazil go from one of the fastest-growing economies to a deep economic recession? I hypothesize that the government interventions, through industrial policy, were a relevant factor. The industrial policy generates idiosyncratic distortions and the survival of unproductive firms, which results in a productivity fall and compromise long-term economic growth.

In Gudin's 1954 paper, *Produtividade*, the author describes the faulty logic behind industrial protection. I will borrow his explanation using ties instead of door locks. Suppose that in our developing country ties are a good only available through importation, and we decided to create a domestic ties company. Being a new industry, the government offers protection to the ties sector, ties imports are heavily taxed and subsidies are granted to the domestic producers. Now we can buy ties made in domestic territory that cost two times more than the duty-free ties with the same quality. The ties industry can pay higher wages than the sectors facing direct foreign competition, and resources are reallocated to the brand new tie sector.

We could conclude that now we have the same country, but with a higher domestic income and more domestic firms. Therefore, industrial progress is a necessary and sufficient condition for development. So, is industrial protection the key to development? Unfortunately, one argument invalidates this assumption: the reasoning was made in terms of nominal prices. The higher wages paid in the domestic ties company do not result from higher labor productivity, but from the higher nominal prices paid by the population that wears ties. With the domestic ties company we achieve income distribution - other sectors are funding the ties sector - and not boosting development. Our country remains a developing country, and our aggregate living standards remain the same.

The industrial protection argument criticized by Gudin in 1954 bears similarities to arguments still being used in the Brazilian industrial policies. In 2011, for example, the *Plano Brasil Maior* (PBM) instituted several local content measures and target firms in the sector considered strategic for development. Brazil has a low degree of openness when compared with economies of similar size and considering the influence of variables such as territory size, population, and degree of urbanization (Canuto, Fleischhaker, and Schellekens, 2015). Brazil is also among the five countries with the lowest trade/GDP ratio in the world, has high average tariff rates, and non-tariff barriers are widely used; the average tariff applied by Brazil in 2008 on ties was 33.5 percent, in Portugal 1.8.

Empirical evidence from the economic growth literature suggests that industrial and economic development is not about protection; it is about productivity. Controlling by differences in quantity and quality of factors of production, productivity is the key factor in explaining the economic growth differential across countries; see Jones (2016); Klenow and Rodriguez-Clare (1997); Prescott (1998); Rodrik, Subramanian, and Trebbi (2004). Distance from the frontier technologies and slower diffusion of good production practices are among the causes described at the national level as responsible for the development imbalance.

Focusing on the firm microstructure gives an alternative and complementary explanation to elucidate the cross-country differences in per capita incomes: distortions in the firm-level lead to suboptimal resource allocation (misallocation) within the country, resulting in lower average productivity and economic growth (Restuccia and Rogerson, 2017). The empirical foundation for this explanation is the observed high heterogeneity in size and productivity across firms and sectors, and the theoretical approach is embedded in the quantitative models of firm heterogeneity.

The roots of the literature on resource allocation in economic growth are diffuse, ranging from business cycles to industrial organization. In recent years, the renewed interest in the effects of resources allocation on growth has resulted in a vast empirical literature on misallocation that put forward an old idea: discretionary policies, such as subsidies and tax exemptions, can cause lower productivity.

We can see the analysis of the effects of resource allocation within firms from two perspectives; direct and indirect. In the direct approach, a specific distortion that affects resource allocation is identified, and then its effect on resource allocation and productivity is measured. In the indirect approach, we can abstract from the origin of distortions and focus on how wedges in the firms' optimal behavior can affect productivity, and therefore, economic growth (Restuccia and Rogerson, 2013). Under the indirect approach are the seminal works of the recent misallocation literature: Chari, Kehoe, and McGrattan (2007), which measures wedges in the business cycle; Restuccia and Rogerson (2008), that evaluate the impact of idiosyncratic distortions on economic growth; and Hsieh and Klenow (2009), that measure misallocation using firm-level data.

Using the misallocation literature framework, I investigate the sources of the recent boom and bust cycle in the Brazilian economy and analyze the relative importance of idiosyncratic distortion in the recent period of slow economic growth. Specifically, I use macro and micro-level distortions to identify and quantify how large are the aggregate productivity losses from the misallocation of resources within the economy.

The Brazilian downturn in the 2010s had multiple causes. The most obvious being the fall in the commodities prices that caused a negative economic shock for the Latin American countries; in 2016, the commodities price was down by a quarter from their level of 2011. But interventionist government policies and declining policy credibility also played a prominent role in the economic downturn (Cuevas et al., 2019). The interventionist government policies are encompassed mainly by the industrial policy that the country has undergone from the late-2000s to the mid-2010s. The policy measures included an increase in credit operations with compulsory allocation, technical barriers to trade, tax rebates, national content requirements, and preferred domestic goods and services in government purchasing. Although these measures aimed to enhance productivity and boost industrial growth, Brazilian productivity decreased by 6.2 percent between 2004 and 2015 (Feenstra, Inklaar, and Timmer, 2015).[1]

In the first chapter, I apply the Business Cycle Accounting method to the Brazilian economy. Using a neoclassical growth model for a small open economy with time-varying wedges – that could emerge from shocks to productivity and frictions in the labor, bonds, and capital markets – I decompose the business cycle fluctuations into contributing frictions (wedges) to guide the choices about where to introduce frictions into models to better fit the boom-bust cycle of 2003-2016. I find that the productivity wedge is the main wedge accounting for the behavior of the observed investment, consumption, and output,

[1]TFP at constant national prices (2011=1) from the Penn World Table version 9.1

especially until 2009. After the Global Financial Crisis and mainly during the 2014–2016 recession, the labor wedge gradually gained importance in accounting for the movements in the observed data. I also find that the labor wedge is the best predictor of the observed labor movements throughout the 2000s and 2010s.

For the second chapter, I formulate a firm dynamics model with heterogeneous firms and calibrate it to the Brazilian Data. Using this model, I investigate the dynamic effects of misallocation on productivity growth that can arise from a government-driven credit expansion. In particular, I argue that the misallocation induced by the credit policy is a contributing factor to the dismal performance of the Brazilian economy in the 2010s. Three conclusions can be drawn from the results. First, when only credit-unconstrained firms receive subsidies, the heterogeneity within the same productivity group will increase, which results in lower total factor productivity. Second, when only credit-constrained firms receive subsidies, the resources allocation within the economy will improve. The subsidies partially offset the market distortion create by the credit constraint, and the economy can achieve a higher output per labor with less capital. Last, when the international interest rate increases, the subsidy costs are responsible for a sizeable government debt burden.

In the third chapter, I investigate if there is support for the hypothesis that the impact of credit subsidies on growth and productivity is decreasing, or even negative, when credit access became more widespread. To that end, use Brazilian data from the late 1950s to 2010s to identify and estimate the effects of a credit subsidy shock in the economy using a VAR with time-varying parameters and stochastic volatility. My results show that there is no evidence of a statistically significant impact of the subsidized credit shocks on productivity. Thus, I could find no evidence to suggest that an increase in the subsidized credit is responsible for lower aggregate productivity. I also find that credit subsidy shocks lead to a transitory increase in per capita GDP, suggesting that subsidized credit could be indeed considered effective in promoting economic activity. Last, per capita GDP has become less reactive to credit subsidies over the last ten years with respect to the 1950s and 1970s. The results contribute to a potential explanation that once the banking system became more developed, the effects of an expansion in the earmarked credit are more likely to lead to a funding substitution, with earmarked credit taking the place of other capital sources.

Essay 1

SOURCES OF ECONOMIC GROWTH IN THE BRAZILIAN BOOM AND BUST CYCLE

1.1 INTRODUCTION

I apply the Business Cycle Accounting (BCA) method to the boom-bust cycle of 2003-2016 in Brazil. My goal with the method is to guide the choices about where to introduce frictions into models to better grasp the complexity of the empirical world. Specifically, I focus on the accounting procedure of the BCA, which is the decomposition of the business cycle fluctuations into contributing frictions. Thus, using a standard neoclassical growth model with time-varying wedges – distortions to the equilibrium decisions of agents operating in otherwise competitive markets – I measure the relative importance of each wedge to understanding the drivers of short-run movements in the business cycle.

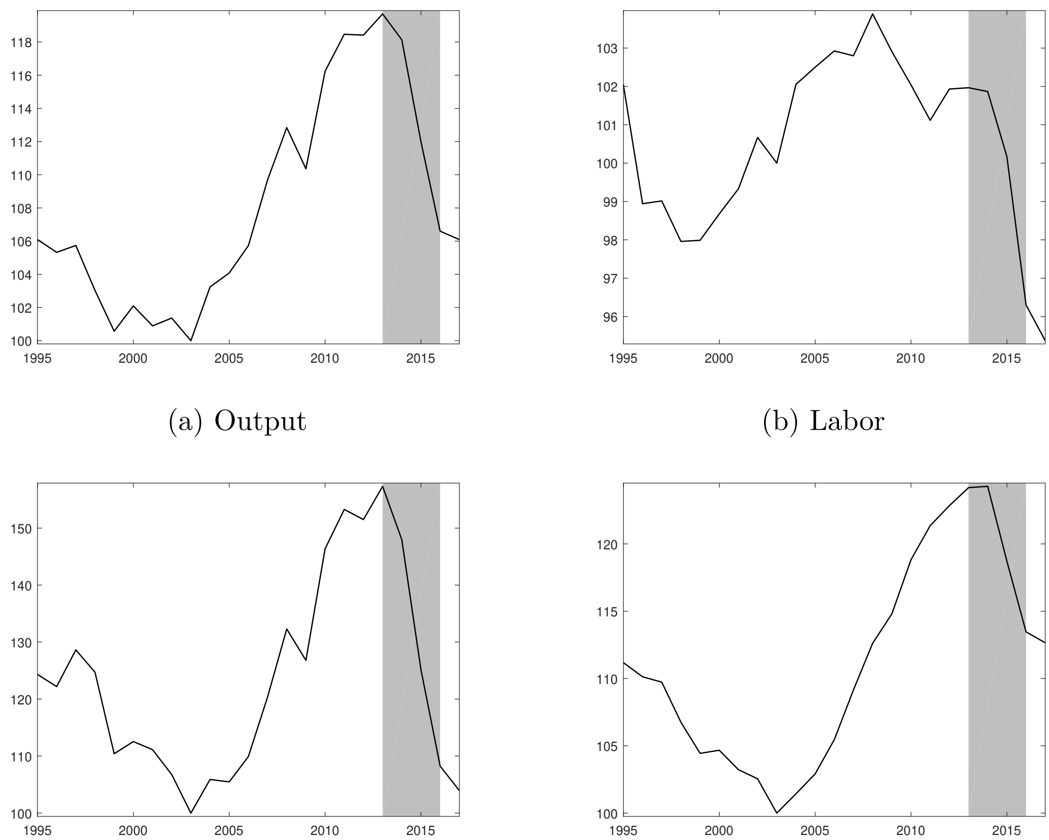
Note that the point of this kind of exercise is not to tell what are the underline mechanisms that drive the business cycle in the economy. It is, rather, to narrow down the class of models that should be considered while analyzing the potential mechanism that leads to economic fluctuations (Brinca et al., 2016).

Between 2014 and 2016, Brazil experienced an economic crisis that resulted in the lowest cumulative growth and longest consecutive periods of recession since 1980; -8,6% over 11 quarters.[1] Growth collapsed, inflation rose, and the country faced severe political instability that contrast with the economic performance in the 2000s. From 2000 to 2010 the annual average GDP growth was 3.7%, the market share of global exports of agricultural commodities increased from around 4 percent in 2002–2004 to 7 in 2012, and the terms of trade increased significantly; rising by 24.6 percent between 2000 and 2010.

Although the fall in commodities price by half from 2011 to 2016 has negatively affected all Latin American countries, the economic downturn was particularly strong in

[1]Brazilian Dating Committee of Economic Cycles (CODACE)

Brazil resulting in one of the worst economic crises in the country's recent history. In 2015, annual investment contracted 14% and the consumer confidence index plunged from 80 in January to 65 in December. [2] By May 2017, the unemployment rate had peaked at 16% in the Metropolitan Region of São Paulo, the highest value since the series started in 1985. [3] The deterioration of the macroeconomic situation during the 2014–16 crisis is evident in Figure 1.1.



(a) Output (b) Labor

(c) Investment (d) Consumption

Note: aggregate per capita annual data over the 1995–2017 period detrended by the average growth rate. All values are normalized to equal 100 in 2003, and the shaded areas in the figure correspond to the recession period between 2014–2016.

Figure 1.1: Observed variables (2003=100)
Source: Own Elaboration (2019)

The economic instability highlighted the structural fragilities that prevent productivity growth such as low trade openness, poor infrastructure, impaired credit market and inefficiencies in the tax system, regulation, labor markets, and credit policies (Spilimbergo and Srinivasan, 2019). The lower economic growth also exposed the vulnerability of

[2] seasonally adjusted data from Fundação Getulio Vargas (FGV)
[3] Fundação Sistema Estadual de Análise de Dados, Pesquisa de Emprego e Desemprego (Seade/PED)

inflexible public spending, with mandatory expenses representing the main share of public expenditure (around 80% in 2017). The fiscal imbalance accelerated when growth began to falter, and previous pressures in the government budget combined with low revenue resulted in a nominal deficit of around 9 percent of GDP in 2015. [4]

Structural reforms are the key to improving Brazil's long-term growth prospects. But reform involves selecting policy priorities because of capital and political constraints. By decomposing business cycle fluctuations into contributing factors, we can identify the patterns in Brazilian economic volatility and shed light on the main obstacles to economic recovery. From the business cycle model, we can also map the wedges to a detailed model and draw policies to tackle economic frictions that result in higher economic efficiency.

To guide empirical work, I use the neoclassical growth model for a small open economy of Lama (2011) for estimation and historical decomposition. In the model, time-varying wedges are introduced in an open-economy version of the neoclassical growth model. The wedges could emerge from shocks to productivity and frictions in the labor, bonds, and capital markets.

The paper is related to the macroeconomic literature on business cycles and resource misallocation, especially the works based on the Business Cycle Account methodology, developed by Chari, Kehoe, and McGrattan (2007). Important contributions to this literature include Simonovska and Söderling (2015), Chakraborty and Otsu (2013), Kersting (2008), and Kobayashi and Inaba (2006). My work is most related to Chakraborty and Otsu (2013) and Simonovska and Söderling (2015). Chakraborty and Otsu (2013) analyze the growth period in the developing economies of Brazil, Russia, and India that occurred during the 2000s. Simonovska and Söderling (2015) measure the most important wedges of the business cycle fluctuations in Chile between 1998–2007 and propose policy recommendations based on the empirical findings.

For most of the 2000s, I find that productivity is the main wedge accounting for the behavior of the observed investment, consumption, and output. The same result is drawn for the 2010s, although the labor wedge gradually gained importance in accounting for the movements in the observed data in that period, especially in the 2014–2016 recession. The labor wedge is the most useful for explaining the share of worked hours. While the capital

[4] consolidated fiscal balance from BACEN — Central Bank of Brazil

and bond wedges play a minor role in explaining the Brazilian business cycle between 2003—2017.

1.2 SMALL OPEN ECONOMY MODEL

The framework described below is designed to estimate the importance of the wedges, which can be mapped to market distortions, in explaining the volatility in output, labor, investment, and consumption. I consider a small open economy growth model with four types of wedges, as in Lama (2011). Four types of wedges include capital, labor, investment, and efficiency that measures distortions in each of these markets.

The model includes optimizing households and firms, a government that follows a balanced budget policy, and households hold international bonds. Firms have access to a constant returns to scale technology, and households supply labor and own the capital stock that is rent it to firms. Fluctuations in the aggregates are induced by wedges. Therefore, I create a historical decomposition of the business cycle by turning on and off the individual wedges. Using the historical decomposition, I was able to quantify the importance of each wedge in explaining economic fluctuations in Brazil.

1.2.1 Households

There is a large (measure one) population of infinitely lived households. The preferences over streams of consumption and leisure are given by

$$E_0 \sum_{t=0}^{\infty} N_t \beta^t U\left(c_t, l_t\right) \qquad \beta \in (0,1), \tag{1.1}$$

where β is the discount factor, c_t is the per capita consumption, l_t the per capita labor supply, and N_t is the population size.

The households maximize expected utility over per capita consumption and leisure subject to the budget constraint

$$(1+n)b_{t+1} + c_t + i_t \leq (1-\tau_{lt})w_t l_t + (1-\tau_{kt})r_t k_t + (1+\tau_{bt})(1+r_t^*)b_t + T_t, \tag{1.2}$$

the capital accumulation law

$$(1+n)k_{t+1} = (1-\delta)k_t + i_t - \phi\left(\frac{i_t}{k_t}\right)k_t, \tag{1.3}$$

and an upward-sloping supply curve for foreign funds

$$(1+r_t^*) = (1+r^*)\left(\frac{b_t}{b^*}\right)^v. \tag{1.4}$$

where b_t denotes the international bonds, w_t the wage rate, r_t the capital rental rate, k_t the capital stock, i_t the investment, T_t the government transfers, n the population growth rate, $\delta \in (0,1)$ the depreciation rate, ϕ the capital adjustment cost, b^* the total debt, and r_t^* the foreign interest rate. The parameter ν is strictly positive and the positive correlation between r_t^* and b^* is interpreted as a risk premium for the investors resulting from the increase in the perceived probability of default when the economy has a high absolute level of foreign debt.

The households face distortions in the consumption-labor decisions caused. The distortions are represented by three wedges in the budget constraint(Equation 1.2): capital wedge, $(1+\tau_{kt})$; labor wedge, $(1-\tau_{lt})$; and bond wedge, $(1+\tau_{bt})$. The wedges reduce the households' disposable income and change the allocation of resources across within the economy, creating misallocation.

1.2.2 Firms

There is a continuum of identical firms in a perfectly competitive market that combines capital and labor using a production technology function $A_tF(k_t,(1+\gamma)^t l_t)$. The parameter A_t is the stochastic component of total factor productivity (productivity), and $(1+\gamma)$ is the labor-saving technological trend. The decision problem of a firm to hire capital and labor services is static. The maximum one period profit function π_t satisfies

$$\pi_t = \max_{n_t,k_t \geq 0} A_tF(k_t,(1+\gamma)^t l_t) - r_tk_t - w_tl_t. \tag{1.5}$$

1.2.3 Government

The government collects the capital and labor tax wedges, pays interest on the international bonds, and the surplus or deficit is redirected to the households as a lump-sum transfer, T_t. In each period the government budget constraint holds

$$T_t = \tau_{kt} r k_t + \tau_{lt} w_t l_t - \tau_{bt} \left(1 + r_t^*\right) b_t. \tag{1.6}$$

1.2.4 Equilibrium Conditions

The equilibrium is summarized by the aggregate resource constraint,

$$A_t F\left(\widehat{k}_t, l_t\right) = \widehat{c}_t + \widehat{i}_t + \left[(1+n)(1+\gamma)\widehat{b}_{t+1} - \left(1 + r_t^*\right) \widehat{b}_t\right]; \tag{1.7}$$

the first-order conditions are given by the capital Euler equation,

$$U_{ct} = \beta E_t \left[U_{ct+1} \left(1 + r_{t+1}^k\right)\right]; \tag{1.8}$$

the Euler equation for bonds,

$$U_{ct} = \beta E_t \left[U_{ct+1} \left(1 + \tau_{bt+1}\right) \left(1 + r_{t+1}^*\right)\right]; \tag{1.9}$$

and the allocation between consumption and leisure,

$$-\frac{U_{lt}}{U_{ct}} = \left(1 - \tau_{lt}\right) A_t F_{lt}, \tag{1.10}$$

where $\hat{v}_t$ denote variables detrended by the rate of technological progress, $\hat{v}_t = v_t / \left(1 + \gamma\right)^t$, and the interest rate on capital is given by

$$1 + r^k_{t+1} = \left(1 - \phi'\left(\frac{\widehat{i}_t}{\widehat{k}_t}\right)\right)\Bigg[(1 - \tau_{kt+1})A_{t+1}F_{kt+1} + \frac{1}{1 - \phi'\left(\frac{\widehat{i}_{t+1}}{k_{t+1}}\right)} \tag{1.11}$$
$$\left((1-\delta) - \phi\left(\frac{\widehat{i}_{t+1}}{\widehat{k}_{t+1}}\right) + \phi'\left(\frac{\widehat{i}_{t+1}}{\widehat{k}_{t+1}}\right)\frac{\widehat{i}_{t+1}}{\widehat{k}_{t+1}}\right)\Bigg].$$

Note that the wedges are essentially residuals from the first-order conditions that affect prices. The wedges can be mapped to specific frictions such as taxes, subsidies, market power, and trade restrictions. Particularly, the model presents four channels from which distortions can be mapped to bonds, productivity, labor, and capital wedges.

1.2.5 Measuring the Wedges

To decompose the business cycle in wedges, we need to ensure that the dynamic expectations for the agents are the same in a model with wedges and without. In the Euler equations for capital (Equation 1.8) and bonds (Equation 1.9), there are expectations about the future states of the economy, that are unobserved, so to close the model we need to specify a stochastic process for the event $s^t = \left[\log\left(\frac{A_t(s^t)}{A}\right), \log\left(\frac{1-\tau_{lt}(s^t)}{1-\tau_l}\right), \log\left(\frac{1-\tau_{kt}(s^t)}{1-\tau_k}\right), \log\left(\frac{1+\tau_{bt}(s^t)}{1+\tau_b}\right)\right]$,

$$\log(A_t) = \left(1 - \rho^A\right)\log(A) + \rho^A \log(A_{t-1}) + \varepsilon^A_t, \tag{1.12}$$

$$\log(1 - \tau_{lt}) = \left(1 - \rho^L\right)\log(1 - \tau_l) + \rho^L \log(1 - \tau_{lt-1}) + \varepsilon^L_t, \tag{1.13}$$

$$\log(1 - \tau_{kt}) = \left(1 - \rho^K\right)\log(1 - \tau_k) + \rho^K \log(1 - \tau_{kt-1}) + \varepsilon^K_t, \tag{1.14}$$

$$\log(1 + \tau_{bt}) = \left(1 - \rho^B\right)\log(1 - \tau_b) + \rho^B \log(1 + \tau_{bt-1}) + \varepsilon^B_t, \tag{1.15}$$

where the errors $\{\varepsilon^m_t; m = A, L, K, B\}$ are independent identically distributed normal with mean zero and variance σ^2_m.

1.3 SPECIFICATION AND CALIBRATION PROCEDURE

The procedures for the business cycle accounting can be summarized in four steps. First, we obtain the parameters of the model through calibration. Second, we compute a first-order approximation to the policy functions of the neoclassical model around the non-stochastic steady-state. Third, we use the data and the model results to estimate the stochastic process of the wedges by maximum likelihood[5]. Last, we access the marginal contribution to the economic fluctuations in the observed data plugging the stochastic process of the wedges into the decision rules.

To carry out an empirical analysis, we must choose functional forms and assigning parameter values. The empirical model consists of the following functional forms:

(i) utility function:

$$U(c, l) = \log c + (\psi) \log(1 - l), \tag{1.16}$$

(ii) production function:

$$A_t F(k_t, (1+\gamma)^t l_t) = A_t \left[k^\alpha (1+\gamma)^t l^{1-\alpha} - r_t k_t - w_t l_t \right], \tag{1.17}$$

and (iii) adjustment costs:

$$\phi\left(\frac{i}{k}\right) = \frac{a}{2}\left(\frac{i}{k} - \delta - \gamma - n - \gamma n\right)^2, \tag{1.18}$$

where a is a parameter for the level of the adjustment cost.

We can separate the model's structural parameters into two categories: those that can only determine dynamics and those that, in addition to influencing the dynamics, determine the steady-state. Generally speaking, most of the parameters that determine the steady-state are calibrated to match the empirical statistics so that the model equilibrium matches the chosen statistics.

The statistics to calibrate the parameters are population growth, investment–GDP

[5]The stochastic process is estimated using decision rules of the model along with observed data, so the second step is part of the third

ratio, exogenous technological progress, discount factor, and leisure weight from the System of National Accounts for the period 1995–2017. [6] The debt–GDP ratio is calibrated as the average fraction of net foreign asset in the GDP as in Lane and Milesi-Ferretti (2007), and the remaining parameters are calibrated as in Lama (2011).Table 1.1 summarizes the selected values for the calibrated parameters.

Description	**Parameter**	**Value**
discount factor	β	0.93
leisure weight	ψ	3.25
capital share	α	0.3
capital adjustment cost parameter	a	0.25
exogenous technological progress	γ	2.55
population growth	η	1.8
depreciation rate	δ	0.5
elasticity of supply funds	ν	0.0001
debt–GPD ratio	$^b/_y$	0.33
investment–GDP ratio	$^i/_y$	0.19
interest rate	r	1.04

Table 1.1: Calibration to Brazilian Data
Source: Own Elaboration (2020)

The parameters that only determine the dynamics are estimated by maximum likelihood using the yearly data on output, consumption, worked hours, and investment from 1995 to 2017. The output is the GDP, consumption is the final consumption expenditure, and investment is the gross fixed capital formation. All variables are in constant 2010 prices detrended by the rate of technological progress and divided by the working-age population (15–64) [7], the exception is labor, that is the average share of hours worked by the population between 15–64 [8].

With all the parameters determined, the model can be solved numerically. The numerical procedure used is a first-order approximation to the policy function as presented in Schmitt-Grohé and Uribe (2004). The methodology uses Taylor's theorem to find approximations to the equations of the model, and when necessary use the implicit function theorem to evaluate derivatives. One advantage of this numerical strategy is that it uses analytic derivatives which improve the computational efficiency and yield more accurate results to welfare comparisons (Farmer and Hollenhorst, 2006).

[6] *Instituto Brasileiro de Geografia e Estatística* (IBGE)
[7] World Bank World Development Indicators (WBI)
[8] International Labour Office (ILO) LABORSTA database

1.4 RESULTS

Using the calibrated model and Brazilian data for the 1995–2017 period, I compute the four wedges described in equations 1.12–1.15. Figure 1.2 plots the output and estimated stochastic process between 2003–2017 relative to the base year 2003. The red line marks the beginning of the slowdown in the growth rate of the Brazilian economy in 2011.

In the growth period (2003–2010), both the efficiency and the labor wedge rise, accounting for essentially all the movements of output. The exception is 2009 when output and productivity contract as a result of the Global Financial Crisis. The labor wedge decrease in 2010, showing a delay to adjust to the output drop. The contraction in the labor wedge is persistent until 2011, which is compatible with The Brazilian rigid formal labor market.

The bond and capital wedges display the opposite fluctuations to what we observed in the output during the growth period. Exhibiting a mild downward trend between 2003–2017, the bond wedge is unable to explain the behavior of output along the analyzed period.

Notice that during the slowdown and recession periods (2011–2016) the efficiency and the labor wedges can account for a significant portion of the downturn. The labor wedge exhibits the sharpest downfall among the wedges after 2014, which suggests that frictions in labor-leisure played a significant role in explaining the 2014–2016 crisis.

Over slowdown and recession periods, the capital wedge fluctuates, but the capital distortion τ_k is smaller between 2014–2016 than in 2003, and the capital wedge plays a minor role in explaining the output fluctuations. The capital wedge pattern suggests that financial frictions models that are mapped from the capital wedge are unable to explain the Brazilian boom to bust cycle. Note that we can map financial frictions from other wedges, for example, we can map financial shocks from labor wedge as in Jermann and Quadrini (2012).

Given the estimated wedges, which wedges better account for the bust and boom that Brazil experienced during the 2000s and 2010s? To answer that question, the wedges by themselves are insufficient to quantify their importance to account for the Brazilian business cycle. So, I plot the model predictions for one or more combinations of wedges

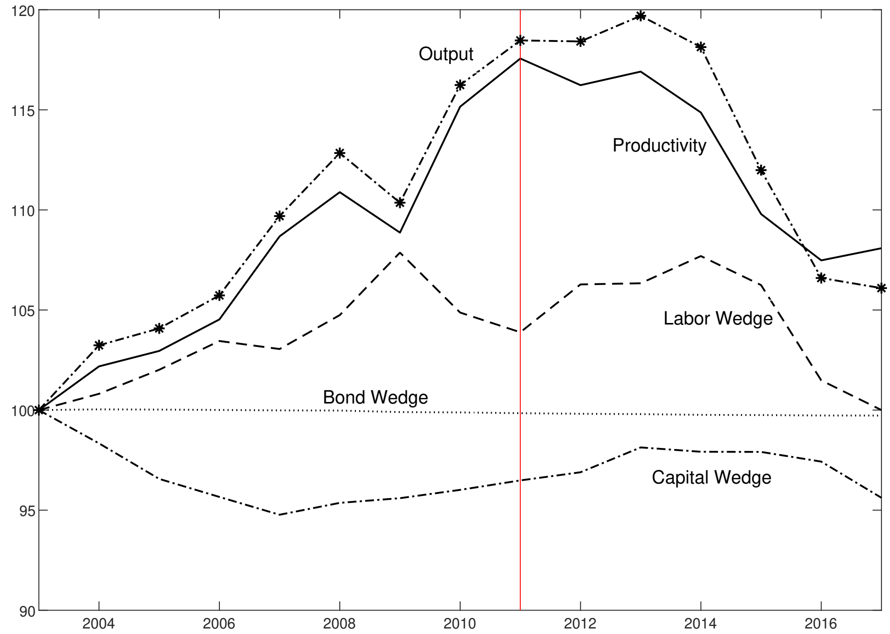


Figure 1.2: Output and Measured Wedges (annually; normalized to equal 100 in 2003.)
Source: Own Elaboration (2019)

with the observed data from 2003–2017 for Brazil.

Figure 1.3 shows the predictions of the model for the output, feeding one wedge into the model at a time. Figures 1.4, 1.5 and 1.6 show the predicted movements of the labor, consumption and investment. In all four plots, the solid line represents the actual data and the dashed line represents the predictions of the model, simulated by each of the four wedges considered in isolation. By construction, feeding all wedges to the model, we replicate the observed data. The predictions by the models with a combination of wedges are displayed in Figure 1.7.

1.4.1 Output

Starting with the top left panel of Figure 1.3, we can see that movements in the output between 2003–2017 are mainly explained by productivity. But the productivity model under-predicts the slowdown and downturn in output from 2011 through 2017. Note that the capital wedge (top right) in isolation help to explain the slowdown in the output from the early 2010s.

The labor wedge (bottom left) follows the same pattern as the observed fluctuation

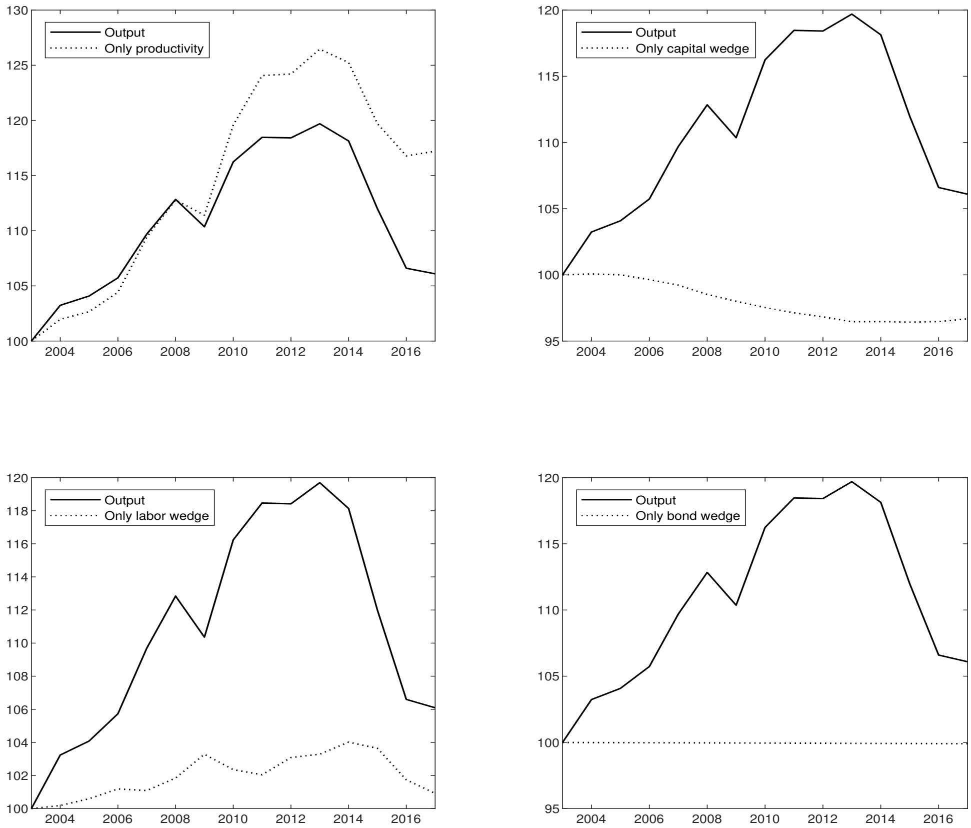


Figure 1.3: Observed and Simulated Output with a Single Wedge
Source: Own Elaboration (2019)

in the output, but predicts much lower fluctuations. For the 2014 recession, the labor wedge accounts for a share of the sharp decline in output. Further, we can see that output simulated only with a bond wedge (bottom right) is unable to explain the fluctuations observed in real output data.

1.4.2 Labor

The simulated labor data using only the labor wedge explains most of the fluctuations in hours worked (bottom right panel in Figure 1.4). But for the recession that started in 2014, all the wedges under-predict the fall in hours worked. The unemployment rate rose from 6.8% in the last quarter of 2015 to 13.7% in the first quarter of 2017, which is reflected in the observed percentage of hours worked.

Since 2008, the labor wedge over-predict the share of worked hours, a period that

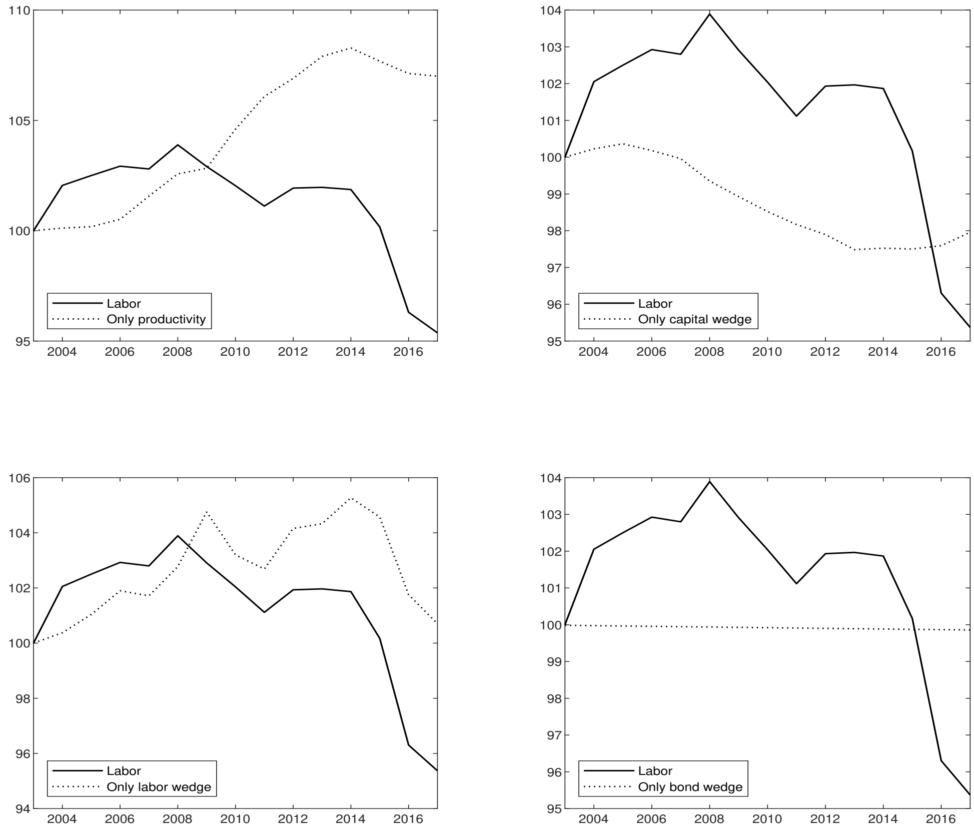


Figure 1.4: Observed and Simulated Labor with a Single Wedge
Source: Own Elaboration (2019)

coincides with the industrial policies initially adopted by the government to mitigate the Global Financial Crises, that remained in place until 2016.

It is worth noting that the government responded to the crisis with countercyclical policies, similar to several other countries. The government also increased the availability of credit with below-market interest rates, reduced the industrialized products tax, and increase the duration of unemployment insurance. In 2011, the credit expansion was further extended, and the government graded payroll taxes cut for selected industries, which, in turn, affected the labor market.

The simulated labor per capita data using only the productivity (top right) and only the capital wedge (top left) play a minor role in explaining the labor movements, exhibiting almost stable trends since 2003. The productivity predicts a higher fraction of hours worked after 2008, and the capital wedge a lower fraction of worked hours relative to 2003. The bond wedge (bottom right) is unable to explain the observed labor data.

1.4.3 Consumption

Credit availability increased household consumption in the 2000s until 2014. From 2003 to 2014 the total household debt increased almost five-fold as a result of facilitating repossess collateral by lending institution, new bankruptcy law, and a new law on payroll lending. The consumption rise was also partially caused by government programs targeting low-income households, and subsidized housing programs (Garber et al., 2018).

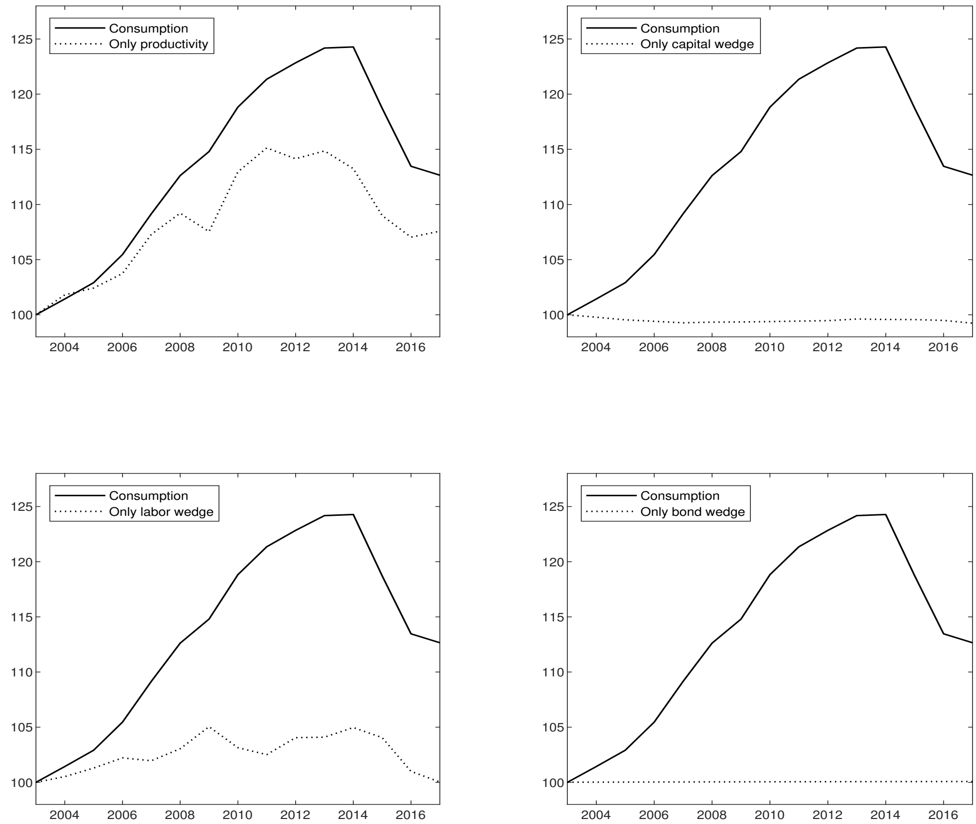


Figure 1.5: Observed and Simulated Consumption with a Single Wedge
Source: Own Elaboration (2019)

Figure 1.5 shows the path of consumption over the course of the growth slowdown and recession. I estimate that consumption was 25 percent above the trend by the mid-2010s and drop sharply after 2014. Both the bond wedge (bottom right) and the capital wedge (top right) cannot account for the movements in consumption.

The productivity in isolation (top left) provides a reasonable match for the consumption movements for a large part of the decade, however, the productivity over-predicted the consumption drop in 2009 and under-predict the drop in 2015. The labor wedge (bottom left) o helps account for the rise in consumption in 2009, and the fall in consumption in 2014. This suggests that a combination of the productivity and labor wedge are needed to account for the consumption fluctuations.

1.4.4 Investment

The investment can be accounted for without the bond wedge (bottom right panel in Figure 1.6). Note also that the capital wedge (top right) cannot account for the downturn in the investment; the capital wedge predicted a boom through the mid-2000s until 2015.

The productivity (top left) predicts the observed movements in investment particularly well but suggests higher volatility in investment than observed in the data. The labor wedge (bottom left) appears to play some role to explain the investment, although smaller than the role of the productivity. The labor wedge complements the productivity in accounting for the investment movements, especially between 2014–2017.

I summarize the one-wedge models' predictions for output, labor, consumption, and investment by presenting the predicted variation in percentage in Table 1.2. Overall, productivity does the best job predicting the movements in the output, consumption, and investment during the 2000s and 2010s. But, although the productivity tracks the direction of the movements, it over-predicts the output and investment growth between 2003–2010 and under-predicts the recession between 2011–2017. The consumption is under-predicted in the 2000s and the fall is over-predicted in the 2010s.

The productivity cannot account for the labor variation from 2003 to 2017, being the labor wedge the best predictor of the observed labor movements. The capital and bond wedge have a limited contribution in accounting for the observed data movements for the growth, and the slowdown follows by the recession period. The analysis reinforces that efficiency and labor wedges play a dominant role in explaining the fluctuations in the Brazilian business cycle.

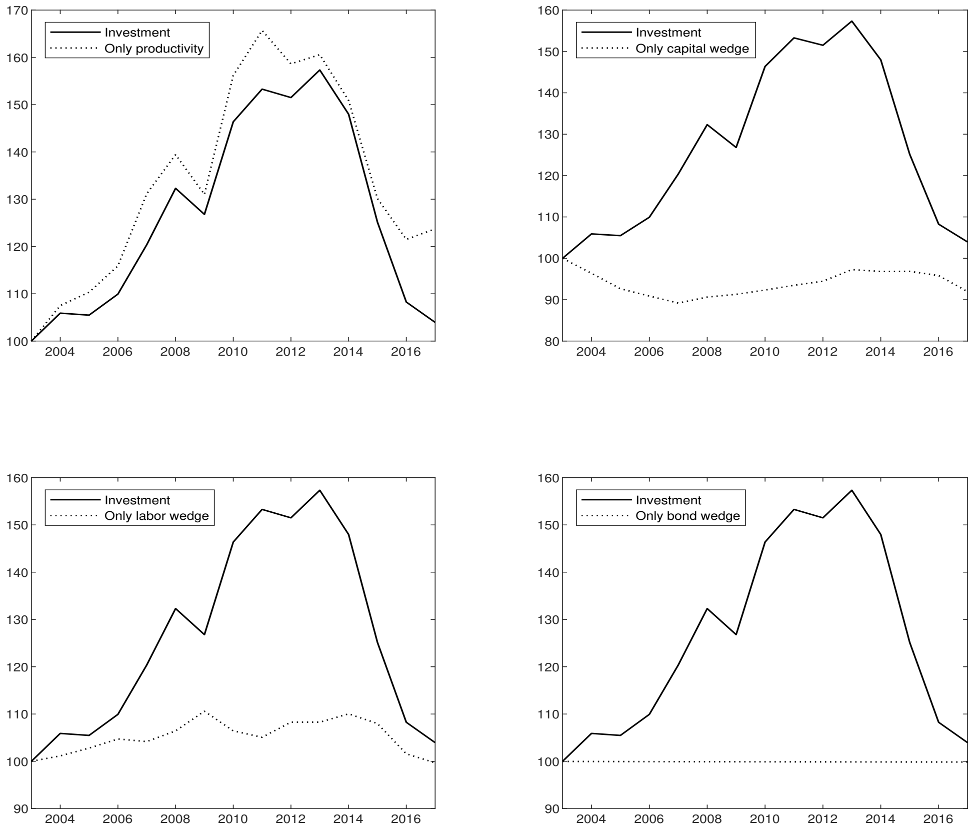


Figure 1.6: Observed and Simulated Investment with a Single Wedge
Source: Own Elaboration (2019)

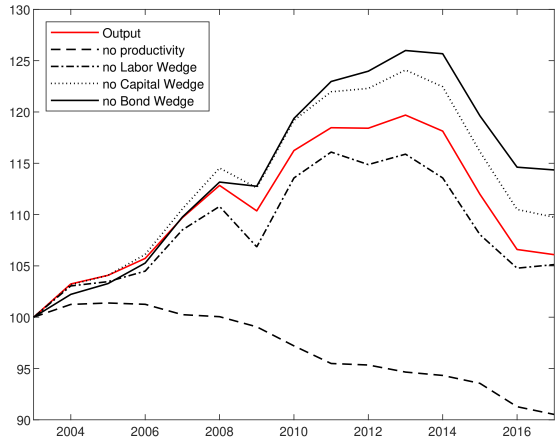
	Output	**Labor**	**Consumption**	**Investment**
		2003–2010		
Productivity	24.07	6.08	15.13	65.70
Labor Wedge	2.05	2.69	2.52	5.08
Capital Wedge	-2.87	-1.83	-0.57	-6.53
Bond Wedge	-0.05	-0.07	0.04	-0.08
Observed	18.47	1.12	21.36	53.28
		2011–2016		
Productivity	-7.28	1.04	-8.09	-44.20
Labor Wedge	-0.31	-0.93	-1.52	-3.50
Capital Wedge	-0.66	-0.58	0.06	2.35
Bond Wedge	-0.04	-0.04	0.02	-0.04
Observed	-11.87	-4.81	-7.89	-45.03

Note: All contributions are expressed in percentage variation between 2013 and 2016 observed data.

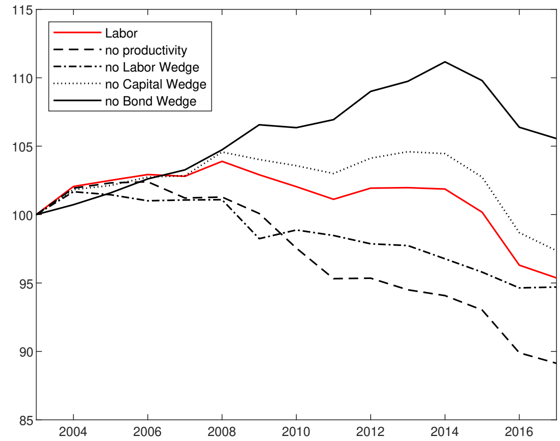
Table 1.2: Predicted Percentage Change by Wedge
Source: Own Elaboration (2019)

1.4.5 One-wedge-off economy

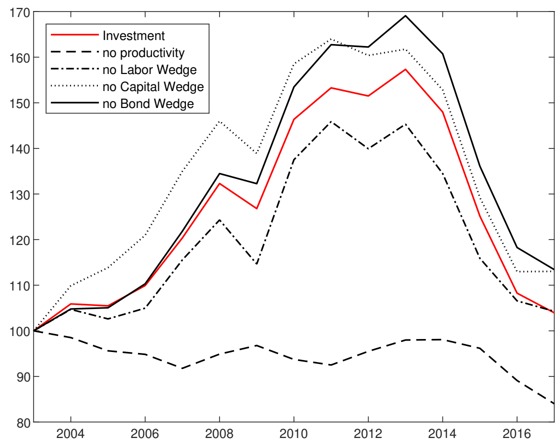
To ensure the robustness of a wedge in the model prediction, we can hold one wedge fixed at a time, and assess the importance of that particular wedge to reproducing the observed dynamics. The counterfactual exercise also helps determine which frictions must be included in a model to account for the boom to bust cycle of 2003-2016 in Brazil. Figure 1.7 shows the path of output, labor, investment, and consumption from 2003 to 2017, along with the paths predicted by the model with three wedges, holding one wedge constant to its steady-state level.



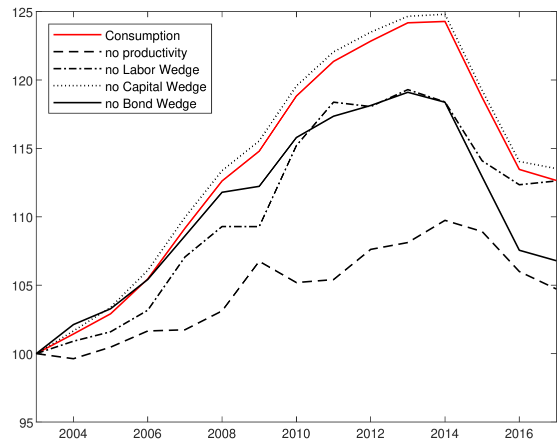
(a) Output



(b) Labor



(c) Investment



(d) Consumption

Figure 1.7: Observed and Simulated Endogenous Variables Without One Wedge
Source: Own Elaboration (2019)

The top left panel shows that holding fixed productivity generates the opposite dynamics to those observed in the Brazilian output. The movements predicted in the output by the model without productivity have an almost linear downward trend even for the growth period between 2003–2010. The output predicted by the model without labor, capital, and bond wedges match the movements in the observed data but fail to explain the amplitude of the slowdown and recession cycles. Both models without bond and capital wedge over-predict the output after 2009 and the model without the labor wedge under-predicts the output since the mid-2000s.

The explanatory power of the different wedge combinations for investment (bottom left) is similar to those for the output. The predictions by the model without capital, labor, and bonds match the movements in the observed data. In the growth period (2003–2010) the model without the bond wedge gives a better prediction for the investment, and in the slowdown and recession period (2011–2016), the model without the capital wedge yields the most accurate prediction.

The predictions for the consumption (bottom right) without the capital wedge are essentially along with the observed trend over 2003–2017. For the labor, all different wedge combinations are unable to explain the observed labor trend after 2008. We can see in the top right panel that all models predicted labor growth below trend. So, note that productivity is the main wedge accounting for the behavior of the observed data, especially during the growth period, and the capital and bond wedges were less relevant in explaining the economic fluctuations.

1.5 EQUIVALENCE BETWEEN EFFICIENCY WEDGE (TOTAL FACTOR PRODUCTIVITY) AND DETAILED THEORETICAL MODELS

My BCA exercise focus on the relative importance of each distortion to understanding the drivers of short-run movements in the business cycle, however, the hallmark of the business cycle accounting is helping mapped wedges to shocks and frictions and identify current inefficiencies that enhance the business cycle volatility. On this subject, I illustrate the equivalence between a few detailed models and the efficiency wedge.

In doing so, I intend to help clarify how the pattern of wedges in the data can help researchers to choose where to introduce friction into models that explain the Brazilian business cycle. Since my results show that the main driver of the fluctuations is the efficiency wedge, I start clearing a misconception about the wedges: the efficiency wedge is not exclusively connected to technology shocks (Brinca et al., 2016).

An equivalence result for labor and efficiency wedge is presented by Brinca et al. (2016). The detailed economy includes a law of motion for employment, no government, a modified production function, and no aggregate uncertainty. We can find the efficiency and labor wedge, solving the first-order condition for the labor-leisure allocation and manipulating the production function. The paper describes the detailed economy and the associated prototype economy.

Buera and Moll (2015) presents the mapping from an economy with heterogeneous productivity and collateral constraints to a prototype model. The detailed economy has two agents; entrepreneurs, and workers. Workers do not have access to assets, and the labor market is competitive. The entrepreneur can choose between capital and bond to split his net worth, and this decision is conditional to the entrepreneur's productivity level. They face a borrowing constraint, and the degree represents friction in the financial market. The friction parameter fluctuates deterministically and generates business cycle fluctuations. They made two changes in the prototype model to allow the mapping; a modified utility function and the investment wedge is a tax on capital income.

In Chari, Kehoe, and McGrattan (2007), they cite another model that can be an equivalence result for the efficiency wedges. The model is an economy with input-financing frictions. In this model, the firms have to pay for the intermediate inputs in advance, and there are two firms types; one pays a higher interest rate on borrowing. The financial friction induces by the differences in the interest rate act as distorting taxes that impact the consumers' budget constraint. The associated prototype economy has an investment wedge that is a tax on capital rather than a tax on income, as in Brinca et al. (2016).

Lagos (2006) presents a model with a frictional labor market, that we can mapping into a prototype economy with an efficiency wedge (Chari, Kehoe, and McGrattan (2007)). The levels of output, inputs and total factor productivity are determinate by individual decisions, which are affected by policies. The labor market follows a search and matching structure. The paper analyses the effect of employment subsidies, hiring subsidies, firing taxes, and unemployment benefits. The results show that the employment subsidies and firing taxes reduce productivity, and productivity increases with hiring subsidies and unemployment benefits.

Restuccia and Rogerson (2008) present a neoclassical growth model with establishment-level heterogeneity that we can map from a prototype economy with an efficiency wedge (Chari, Kehoe, and McGrattan, 2007). The policies analyzed are simple and abstract, and they cause idiosyncratic distortions that affect firm-level decisions. The firms have a constant productivity level, and in equilibrium the capital and labor prices are constant. A probability density function represents the tax rate and productivity of each firm, and they calibrate the probability density function using a grid of 100 points. As the tax (distortions) increases the total factor productivity reduces, even with idiosyncratic distortions uncorrelated with productivity.

1.6 CONCLUSIONS

Between 2003–2010, economic growth in Brazil averaged about 4 percent a year—a respectable rate compared to the 2.5 percent average growth in the mid-1990s. By 2011 GDP growth was falling, and in 2014 the country experienced a recession of historic proportions. From 2014 to 2016, Brazil's GDP was shrinking 2.1 percent a year, and the unemployment rate rose from 6.8% in the last quarter of 2015 to 13.7% in the first quarter of 2017.

To which kinds of macroeconomic models best explain the fluctuations in the Brazilian economy, I decompose the business cycle from 1995 to 2017 into its contributing factors. Specifically, I estimate the wedges in a business cycle model using the neoclassical growth model for a small open economy of Lama (2011). Based on the model predictions, I identify where to introduce frictions into models to better explain the output, consumption, labor, and investment fluctuations during the economic boom and the following sharp decline during the 2014–2016 economic recession.

By measuring the wedges' paths and the simulated aggregates that they predicted over time, we have a quantitative estimate of the wedges' influence in a given period. The predictions are a guide to identify the underline mechanism that leads to the fluctuations in the business cycle. When we select frictions and shocks that can be mapped to the wedge that are the main drivers in the business cycle, we enhance the potential of a model to explain the specific mechanism that results in the 2000s and 2010s business cycle.

Three results can be learned from the paper. First, productivity is the main wedge accounting for the behavior of the observed investment, consumption, and output, especially until 2009. After the Global Financial Crisis and mainly during the 2014–2016 recession, the labor wedge gradually gained importance in accounting for the movements in the observed data, although the labor wedge never surpasses the productivity in explaining the business cycle. Second, the labor wedge is the best predictor of the observed labor movements throughout the 2000s and 2010s. Last, the capital and bond wedges have a limited contribution in explaining the Brazilian business cycle between 2003–2017.

Essay 2

THE BRAZILIAN SLUMP AND THE GOVERNMENT-DRIVEN CREDIT EXPANSION

2.1 INTRODUCTION

Credit subsidies are a paradoxical kind of policy. The provision of credit subsidies is widely adopted across countries to ease credit constrain and enable firms to engage in productivity-boosting investment opportunities and ease factors misallocation. But target credit policies imply a distortion of the prices faced by different firms, which influences micro-level decisions and shapes the firm dynamics. Thus, resources will divert to subsidized firms, and depending on the underlying distribution of firms, the subsidies may enhance factors' misallocation.

To pin down the subsidized credit effects on productivity in a competitive industry, I develop and analyze a dynamic stochastic model. My model focus on the government-driven credit expansion in Brazil after the global financial crisis. Brazil experienced a large vertical industrial policy to enhance credit access for firms without achieving a higher aggregate productivity growth. Assuming heterogeneity in access to finance and subsidies, I show that subsidized credit results in productivity gains only when the subsides are correlated with idiosyncratic financial frictions.

Because of a combination of macroeconomic stability, government interventions, and good external conditions, the total credit to the Brazilian private sector increased from 44.8 percent of GDP in 2004 to 76.9 percent in 2015; the highest level in 20 years.[1] In 2015 half of the credit was directed by government interventions with compulsory allocation or predetermined interest rates or both (earmarked credit). In contrast to the sharp credit increase, productivity decreased by 6.2 percent between 2004 and 2015 (Feenstra, Inklaar, and Timmer, 2015).[2]

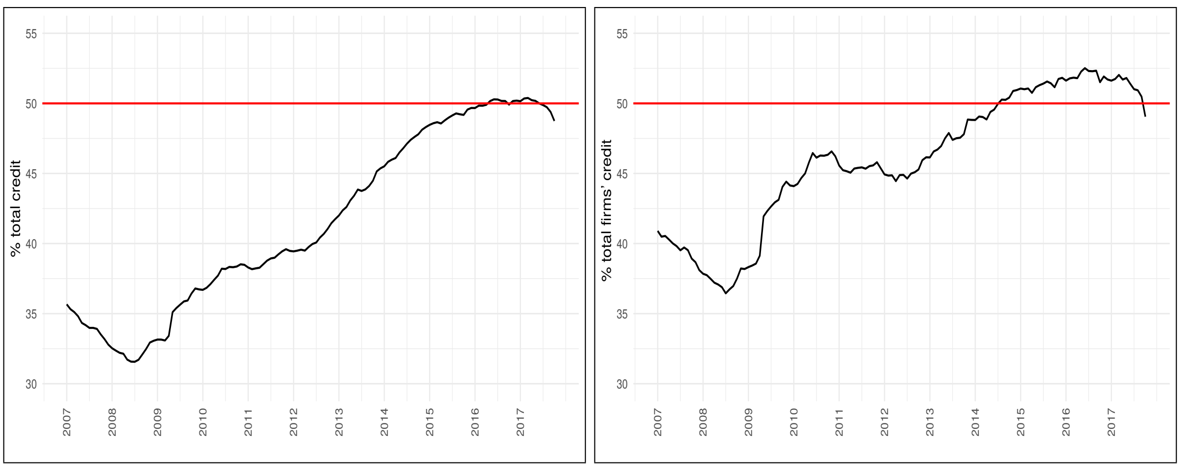
The government-subsidized credit also has a significant cost for the Treasury,

[1]BIS total credit statistics (2019) – total credit to the private non-financial sector
[2]TFP at constant national prices (2011=1) from the Penn World Table version 9.1

adding to the country's fiscal imbalance; between 2010–2018 the public domestic debt rose from around 40 percent to 65 of GDP. Pazarbasioglu-Dutz et al. (2017) shows that the estimated fiscal cost of the earmarked credit for the Brazilian economy was 3.7% of general government revenues in 2015; if we look only at the financing provided through the Brazilian development bank, the fiscal costs rose from 1 to 2.6 percent from 2009 to 2015.

Policymakers initially attributed the earmarked credit expansion to a countercyclical fiscal policy to mitigate the private credit crunch caused by the 2008 Global Financial Crisis, however, seven years after the Global Financial Crisis, the earmarked share of total credit was still increasing; see Figure 2.1. The Brazilian Development Bank disbursements are an example of the size of government-driven credit expansion: the disbursements were 77% higher than the World Bank's in 2014 and accounted for 75% of earmarked firm credit overall 2009–2014. As with the broad earmarked credit, credit from the Brazilian Development Bank is often subsidized; on average, the interest rate for the earmarked credit is one-quarter of the non-earmarked credit (Kuwer, 2016).

Looking at the firms' credit market, from the total earmarked credit, an average of 60% was designated to firms during 2008-2017. The beneficiaries firms were larger, older, and with a lower proportion of non-performing loans than the country average, and the credit was unevenly distributed between sectors: firms in the services and manufacturing sectors received the largest share of the earmarked credit (Bonomo, Brito, and Martins, 2015).



(a) Credit for Firms and Households (b) Credit for Firms

Figure 2.1: Share of the Earmarked Credit (2007–2017)
Source: Central Bank of Brazil (2019)

To analyze the effects of the government provision of target subsidized credit, I present a theoretical linkage between the distribution of credit subsidy and aggregate productivity in an economy with firm heterogeneity. We will look at two models for this. First, we will look at a two-sector neoclassical growth model in which sectors face idiosyncratic distortions to investment. The environment in the two-sector model comprises a final good and two intermediate goods: low and high-technology goods. To produce the intermediate goods, the technologies differ in terms of total factor productivity, and I introduce idiosyncratic distortions to the investment that favors the low-productivity sector. The idiosyncratic distortion reflects the interest-rate wedge between subsidized and non-subsidized firms. I show that, in equilibrium, as subsidy increases in the low productivity sector relative to the high productivity sector output and aggregate productivity decrease.

Second, I formulate a version of the firm dynamics model with idiosyncratic credit policy and credit access difficulties. The firm dynamics model characterize the behavior of an economy populated by a continuum of firms facing independent productivity shocks, in line with Hopenhayn (1992), Hopenhayn and Rogerson (1993), Restuccia and Rogerson (2008) and Samaniego (2009). I formulate a model that incorporates three exogenous states: productivity, credit access, and credit subsidy. Besides the uneven credit access, the model has three extension features that depart from the basic firm dynamics model setup. First, the level-productivity follows a bounded Pareto distribution, that closely mimics the right tail of the empirical firm size distribution. Second, firms have endogenous entry and exogenous exit. Third, I introduce a financial intermediary to account for financial flows in the economy. Appendix A is an introduction to the basic concepts of the dynamics of the distribution of firms in a general equilibrium model, which is useful to understand the general ideas of the model described in the essay.

The model description is as follows. The economy is inhabited by a continuum of competitive firms, that each period received an idiosyncratic productivity shock and differ on their access to formal credit and credit access quality. To mitigate the credit constrain faced by firms with poor credit access, the government implement a credit policy to give access to subsidized credit for selected firms and sectors, thus firms can be divided into two categories: subsidized and non-subsidized. Combining the idiosyncratic credit subsidy with heterogeneous productivity creates a shift in capital allocation within the economy - capital will be reallocated to subsidized firms, the subsidized firms also will be more likely to enter the market and less liked to exit. But the effect of the reallocation on productivity depends on the correlation between subsidized credit and level of credit access.

If credit subsidies are given mainly to firms with poor credit access, the subsidies may offset the financial friction and improve access to capital, leading to higher productivity. Otherwise, the subsidy will lower competition, increase the productivity cut-off for exiting subsidized firms, and lower the productivity cut-off for entering subsidized firms, preventing the reallocation of inputs toward more productive uses. The larger the gap between the subsidized capital and non-subsidized capital, the higher will be the impact of the credit policy on the firm dynamics, and on the aggregate productivity.

I drew three conclusions as a result of my theoretical model. First, when only credit-unconstrained firms receive subsidies, the heterogeneity within the same productivity group will increase, which results in lower total factor productivity. Second, when only credit-constrained firms receive subsidies, the resources allocation within the economy will improve. The subsidies partially offset the market distortion created by the credit constraint, and the economy can achieve a higher output per labor with less capital. Last, the subsidy costs are responsible for a sizeable government debt burden when the international interest rate increases.

The chapter is related to the macroeconomic literature on misallocation and financial markets. Particularly with a modern view of financial markets that highlight the existence of a nonlinear relation between credit and growth (Benczúr, Karagiannis, and Kvedaras, 2018; Hung, 2009), and empirical findings that episodes of rapid credit expansion are often associated with economic turbulence; see Gorton and Ordonez (2016) and Bakker et al. (2012).

In the financial markets literature, one of the channels that lead to turbulence is the borrowing constraints. In the event of a lending boom, the constraints limit the allocation of credit toward higher productivity firms and diverge the credit to unproductive ones. Several reasons can cause lending booms, such as poor regulation, bailout guarantees, and credit imperfections that increase systematic risk in the financial market (Gourinchas, Valdes, and Landerretche, 2001). To sum up: in this literature, the possible dismal effect of credit expansion on output growth may be the result of inefficient allocation of resources when financial markets are imperfect; see Reis (2013) and Gopinath et al. (2017) for empirical evidence on Euro Area countries.

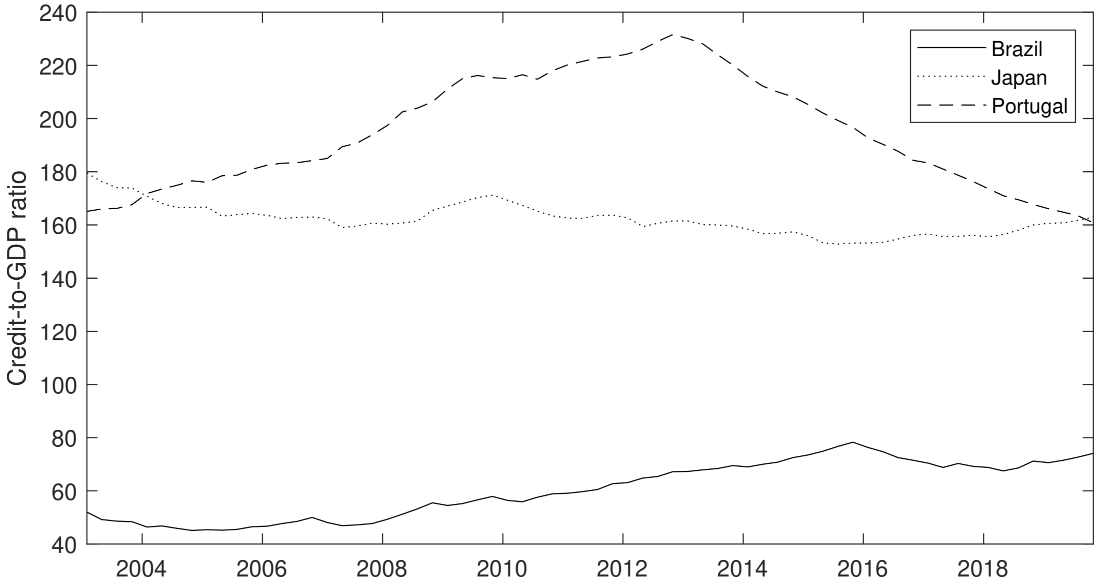


Figure 2.2: Credit-to-GDP ratios
Source: Bank for International Settlements (2020)

The current paper contrasts with Reis (2013) and Gopinath et al. (2017) in at least two areas. First, the misallocation is induced by the idiosyncratic credit policies in my model, and not by the high credit-to-GDP level. Unlike Portugal and Japan, the credit-to-GDP ratio in Brazil was below 80 percent throughout the 2010s (Figure 2.2) and the banks remained well-capitalized compared to international standards, profitable, and liquid (IMF, 2018). Therefore it is less likely that undercapitalized banks, reallocating private credit to weak firms, induce resource misallocation in Brazil. Second, the effect of subsidized credit on firm dynamics – which is crucial to understand resources reallocation through the firm entry, exit, expansion and, contraction – is not studied in those models.

2.2 OVERVIEW OF THE BRAZILIAN RECESSION AND CREDIT EXPANSION: FACTS AND A NARRATIVE

Brazil has gone from a period of sustained growth and unprecedented economic and financial stability in the 2000s to a growth slump in the subsequent decade. During 2003–2008 the country experienced a higher average investment growth than the previous decade, primary surpluses exceeding 3 percent of GDP, and an average growth above 4 percent a year. Features that contrast with the economic performance observed in the 2010s: a deep recession in 2015–2016, which lasted eleven quarters and resulted in a GDP contraction of more than 8 percent, and a decade with an average growth of less than 1 percent a year.

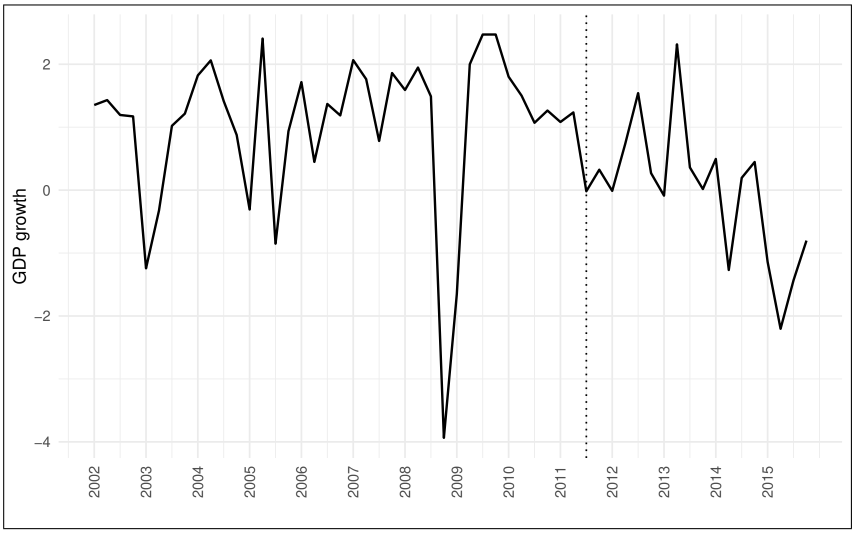


Figure 2.3: Gross Domestic Product growth (quarterly %)
Source: IBGE, Quarterly National Accounts (2019)

Many Latin American countries suffered from the decline in commodity prices that started in 2012 and crashed in 2014, alongside a fall in global trade. Brazil was not an exception – commodities constitute more than 60 percent of export value since 2009. Because of the lower terms of trade, – and thus purchasing power – coupled with low levels of domestic savings, the country had a broad transmission of external shocks on domestic demand. Therefore, the adverse external scenario limited the domestic sources of financing investment and public expending.

The adverse external scenario also resurfaced domestic structural weakness: high tariff rates, low competition, poor infrastructure, inefficiencies in the public sector, and increasing government spending. The consumption-led policies ongoing since the mid-2000s, meanwhile, became less effective to attain growth given a low employment rate. In addition, the efforts to intensify the state interventions increased the government budget imbalance and fueled the political instability.

Among the state interventions were the policies to stimulate economic growth in specific sectors that started out as a countercyclical fiscal policy after the Global Financial Crisis but remain in operation for another seven years as an industrial policy. The policies included several fiscal benefits to companies selected by the government, such as credit with subsidized interest rates for investments and tax exemptions. Even with the economic slowdown started in the third quarter of 2011, the investment rate remained above 20 percent of GDP from 2010 to 2014, the highest rate since 1995. The combination of a high rate of investment in an economic slowdown was the result of government fiscal stimulus through interventions in the credit market.

Figure 2.4 shows a wider gap between the output growth rate (measured by the IBC-Br) and the capital formation growth rate (measure by the Ipea-FBCF) after the Global Financial Crisis until 2015. One hypothesis for the capital deepening with low economic growth is that although the economic stimulus resulting from the government-driven credit expansion sustained the investment rate until 2014, the policy spurred a crowd-out effect. The idea presented within this hypothesis is that the government-driven credit expansion became a source of resource misallocation because of the inflexibility in the earmarked credit in terms of allocation and interest rate.

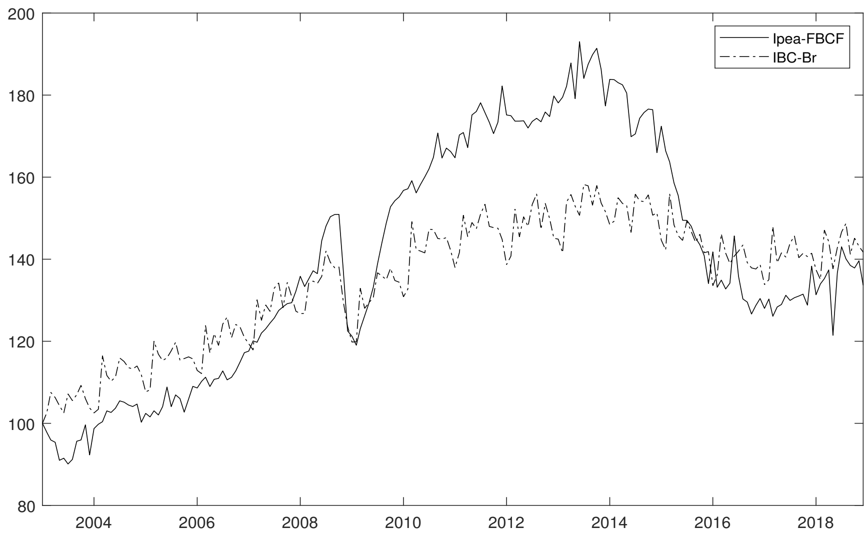
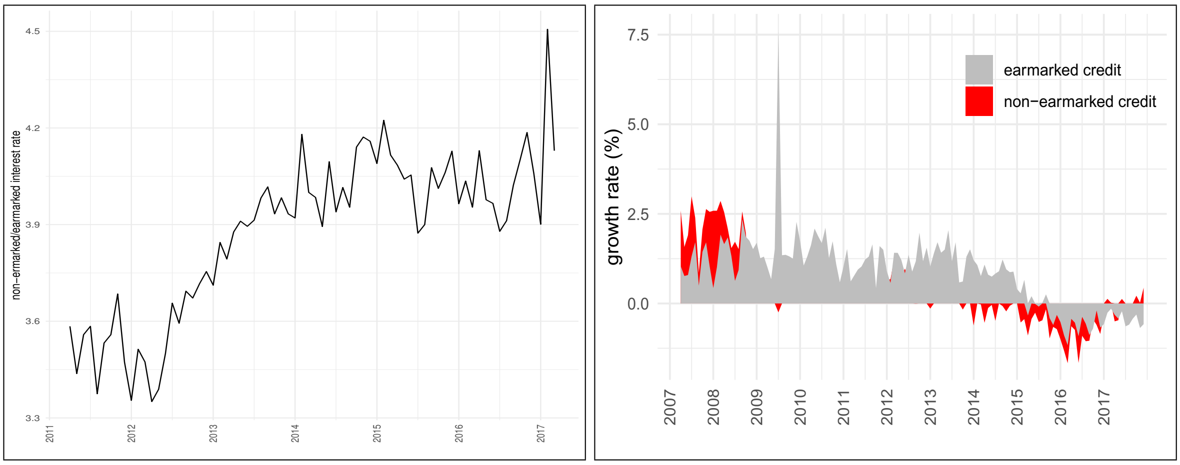


Figure 2.4: Index of Economic Activity of the Central Bank (IBC-Br) and Gross Fixed Capital Formation Ipea Index (Jan/2003=100)
Source: BCB and IPEA (2019)

After seven years with a strong government intervention in the credit market, the earmarked credit grew more than the freely allocated credit (non-earmarked credit) between 2009–2015, with average interest rates much lower than non-earmarked credit. The monthly average interest rate of earmarked credit operations was 0.75 percent in 2015 compared with 3 percent for the non-earmarked credit operations (Figure 2.5). One of the adverse implications of a large share of total credit coming from the government-funded programs of directed lending is the reduction in competition. In addition to receiving subsidized credit, the non-beneficiary firms face higher costs to access credit because of the increased marginal fund cost for the banks (Mello and Garcia, 2012).



(a) Interest Rate Gap (2011–2017) (b) Credit Operations (2007–2017)

Note: The spike in the earmarked credit operations in 2009 is caused by the loan agreement between PETROBRAS and the Brazilian National Development Bank (BNDES).

Figure 2.5: Credit Operations
Source: Central Bank of Brazil (2019)

The earmarked expansion was part of industrial policy strategy to promote national champions and foster industrial growth; more than half of total earmarked credit is directed to firms. From 2009–2015, the Brazilian Development Bank was responsible for lending 75 percent of the total credit for non-financial corporations; see Table 2.1.

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Percentage of Total Credit Operations (firms and households)								
Households	36.1	33.9	33.5	36	38.9	41.2	43.5	44.7
Firms	63.9	66.1	66.5	64	61.1	58.8	56.5	55.3
Percentage of Credit Operations for Firms								
Rural	12.8	10.7	9.1	8.9	8.5	9	9.9	8.9
Real Estate	3.1	4.1	4.8	6	7.2	7.5	8.1	8.3
BNDES	70.2	73.3	76.6	77.4	77.2	74.6	73.2	73
Others	13.9	11.9	9.5	7.7	7.1	8.9	8.8	9.8

Table 2.1: Main Types of Credit Operations (2008–2015)
Source: Central Bank of Brazil (2019)

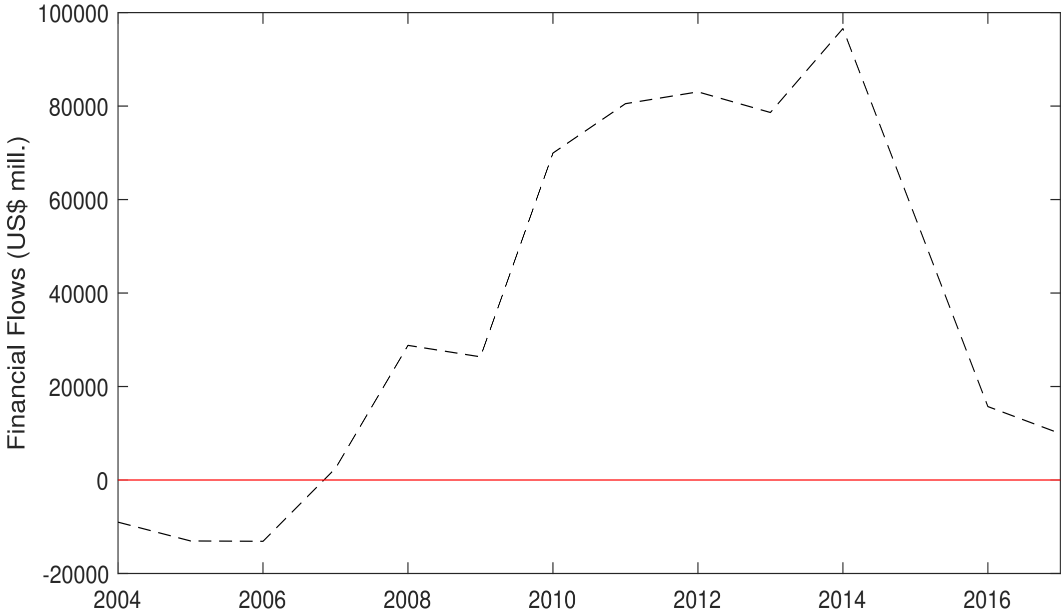
In an economy with rapid credit growth sustained by capital inflows, the allocation of the credit between firms will determine the long-run outcome for the economy. Persistent capital inflows may ease the need for structural reforms, enable investments in low-productivity projects, and unsustainable household consumption. In the long run, however, the aggregate productivity decline because of the factors misallocation, which eventually leads to a credit crunch and suppresses the economic growth (Brunnermeier and Reis, 2019).

The expansion in the earmarked credit may also affect the monetary policy power since the earmarked credit rates are regulated and independent of the short-term interest rates set by the Central Bank. Thus, changes in the base interest rate have to be larger in order to achieve monetary policy objectives. In 2013, the annual base interest rate rose systematically from 7.25 percent in January to 10 percent in December as a response to inflationary pressures, however, the larger share of earmarked credit suppressed the efficiency of the monetary policy:

> [...], earmarked credit is basically influenced by administrative decisions, i.e. credit policies settled by the federal government, which can directly stimulate credit growth (earmarked credit) irrespective of how loose or tight the monetary policy stance may be [...]. In this scenario, policy inconsistencies may emerge if monetary and credit policy stances differ, as seen in 2013 when public credit expanded and monetary policy tightened (López Vicente and Serena, 2014, p.25).

This view is corroborated by Bonomo and Martins (2016). Using an unbalanced panel of almost 300,000 non-financial firms from 2006 to 2012, they estimate that a 1 percent increase in the Brazilian short-term interest rate (Selic) increases by 1.15 percent the interest rate of firms without access to earmarked credit and by 0.64 percent for firms with access. Thus, the credit channel of monetary policy is less effective for firms with government-driven loan access, and earmarked loans seem to impact the transmission of monetary policy to private loan markets.

Before 2014, Brazil was receiving a wave of capital inflows that started in 2007 and intensified after 2009. The capital inflows resulted from strong demand for its export commodities and structural factors (including political stability, sound macroeconomic fundamentals, and high interest rates), which led to a strong economic growth prospects for Brazil and attract foreign investment. These inflows kept sovereign and corporate spreads low and provide liquidity to banks, which in combination with the development of the domestic capital market fueled the supply of credit; as seen in Figure 2.5b until 2012, except for July 2009, the earmarked and non-earmarked credit operations had a positive growth rate (IMF, 2012).



Note: Inflows are positive, whereas outflows are negative. From late 2009 to mid-2011, Brazil imposed further controls on capital inflows, a 2 percent tax on fixed-income and equity inflows was reintroduced in October 2009. The tax was further increased to 6 percent in October 2010 but then reduced back down to 2 percent in January 2011, however consistent measures to loosen the capital restrictions were adopted only in March 2012.

Figure 2.6: Financial Flows (1995–2019)
Source: Brazilian Central Bank, Balance of Payments, BPM6 (2020)

The increasing inflow of capital to Brazil reversed after 2014, as seen in Figure 2.6. A conjunction of external and domestic factors caused these changes. In 2013 the US Federal Reserve announced the gradual reversal of a quantitative easing policy, which generated an outflow of capital from emerging market economies with high external and fiscal imbalances, such as Brazil. The outflow of capital and the broader collapse of commodity prices that occurred after mid-2014 further intensified the fiscal policy and political difficulties within the Brazilian economy, and resulted in the downgrade of Brazil's sovereign credit in 2014 (European Central Bank, 2016).

Capital inflows are often considered to be a driver of credit growth. During the inflows of capitals between 2009–2012, the non-earmarked and earmarked credit have a positive growth rate, and in the non-earmarked credit market that growth was accompanied by a decreasing interest rate. In 2013, with the international uncertainty and the Brazilian economy slowdown, the Brazilian Central bank increased the basic interest rate which led to a contraction in the non-earmarked credit operations in 2013 and a negative growth have after 2014 (see Figure 2.5b).

Until 2018, the rates for loans to specific sectors and BNDES loans were the discretionarily set TJLP (Long Term Interest Rate). The rate was regulated by the National Monetary Council, defined in an ad hoc manner, and was kept persistently below the Brazilian federal funds rate (Selic). Since the earmarked credit has its interest rates tied to the TJLP, that type of credit reaming with a positive growth since 2014. The supply of earmarked credit in a scenario of economic instability, low capital inflow, and higher international interest rates may have contributed to worsening the fiscal situation of the country.

2.3 TWO-SECTOR MODEL WITH CREDIT MISALLOCATION

To illustrate the mechanism behind the quantitative exercise with a target credit policy, I present a simpler model, namely a two-sector neoclassical model, with similar features to the firm dynamics model. I base my empirical analysis on a general equilibrium model with idiosyncratic productivity shocks and capital distortions to individual firms. The model is consistent with important features of the Brazilian economy and suggests negative effects of the government-driven credit expansion on economic growth, namely that an increase in the credit subsidies leads to a fall in the aggregate total factor productivity and output.

In the two-sector neoclassical growth model, the economy is inhabited by many identical households and the production takes place in two stages. In the first stage, there are intermediate firms that produce two goods: high-technology good, $y_{h,t}$, and a low-technology good, $y_{l,t}$. In the second stage, a firm in a perfectly competitive market produces a final good combining high and low-technology goods.

The representative infinitely lived household has preferences over stochastic sequences of consumption, c_t, written as:

$$\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma} - 1}{1-\sigma}, \qquad \sigma \neq 1, \quad 0 < \beta < 1, \tag{2.1}$$

where β is the discount factor rate and σ is the coefficient of relative risk aversion.

The final good is produced by a representative firm that combines $y_{l,t}$ and $y_{h,t}$ using a Cobb-Douglas technology:

$$y_t = y_{h,t}^{\varpi} y_{l,t}^{1-\varpi}. \tag{2.2}$$

Cost minimization implies that industry shares, ϖ and $(1-\varpi)$, are given by

$$\varpi = \frac{p_{h,t} y_{h,t}}{y_t p_t} \qquad (1-\varpi) = \frac{p_{l,t} y_{l,t}}{y_t p_t}, \tag{2.3}$$

where the price for the final good is set to $p_t = 1$.

In the first stage, the output for each technology is given by a Cobb–Douglas production function using capital as an input, $k_{i,t}$:

$$y_{i,t} = a_i k_{i,t}^{\alpha}, \qquad i \in \{h, l\}, \quad \alpha \in (0,1). \tag{2.4}$$

Notice that the output elasticity of capital, α, is the same across technologies and constant over time. The total factor productivities are different between technologies, in particular $a_l < a_h$.

I introduce idiosyncratic distortions to the investment in the low-technology sector (ψ_l) e and in the high-technology sector (ψ_h), that reflect the interest-rate wedge between favored and non-favored industries. Capital accumulation follows:

$$k_{h,t+1} - k_{h,t} = i_{h,t}/(1+\psi_h) - \delta k_{h,t}, \tag{2.5}$$

$$k_{l,t+1} - k_{l,t} = i_{l,t}/(1+\psi_l) - \delta k_{l,t}. \tag{2.6}$$

where i_t is the gross investment in capital, and δ is the depreciation rate. Capital is fully employed at each point in time $k_t = k_{h,t} + k_{l,t}$ and the goods market clear $c_t + i_t = y_t$,

The abstract distortions ψ_l and ψ_h create heterogeneity in the individual factor demands:

$$(1+\psi_h)r = \varpi \frac{\alpha y_t}{k_{h,t}}, \qquad (1+\psi_l)r = (1+\varpi)\frac{\alpha y_t}{k_{l,t}}. \tag{2.7}$$

The idiosyncratic distortions parameter affect the sectorial capital accumulation, a policy that subsidizes the low-technology sector will increase the share of resources allocated to low-technology firms compared to the efficient allocation, the same occurs if the policy increases the taxes for high-productivity firms.

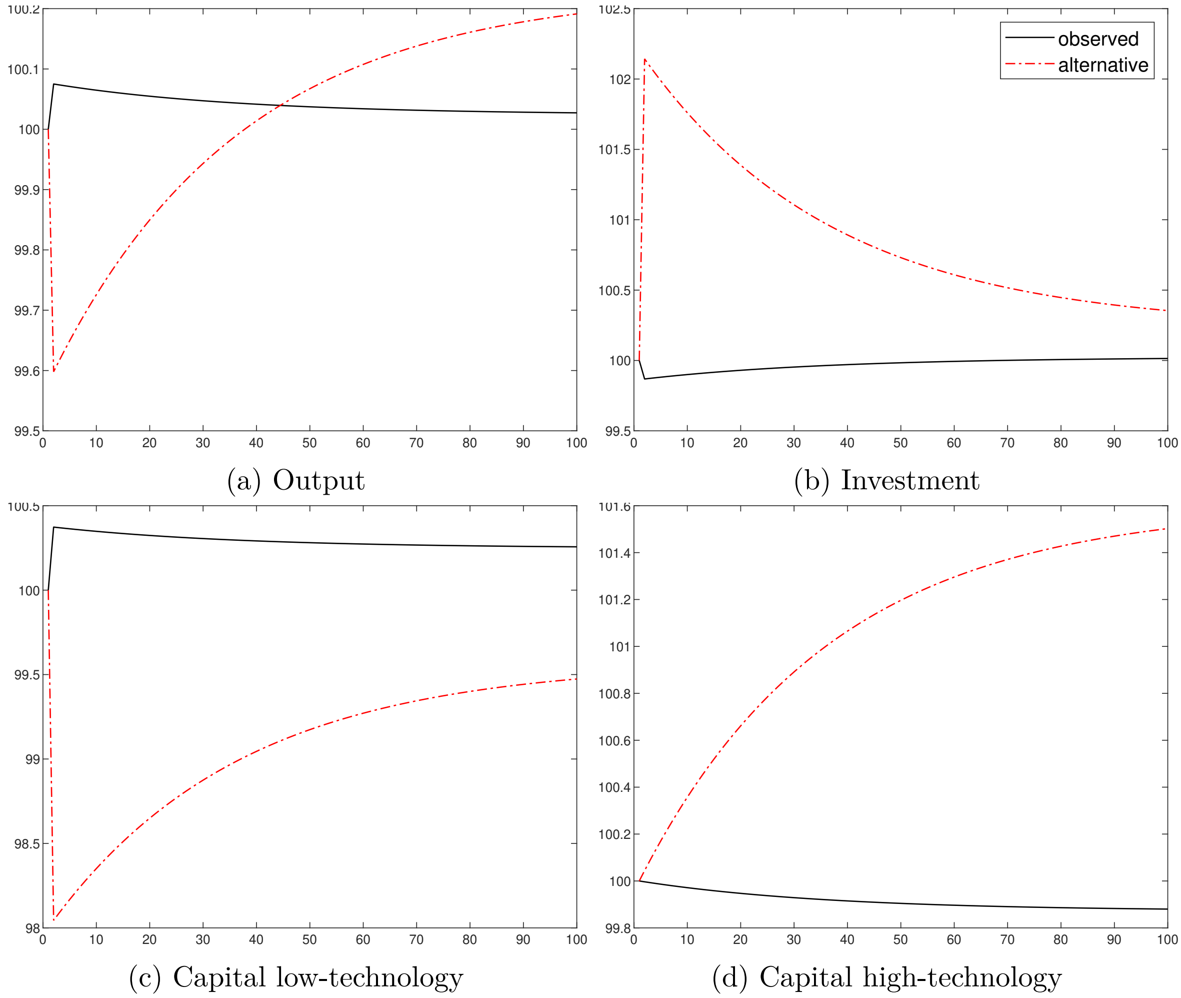
The following analytical expression for the steady-state output illustrates the main implications of the model:

$$\overline{y} = (a_l^{\varpi} a_h^{1-\varpi}) \left[\left(\frac{(1+\psi_h)}{(1+\psi_l)} \right) \left(\frac{1-\varpi}{\varpi} \right) \right]^{\alpha(1-\varpi)} \overline{k_h}^{\alpha}. \tag{2.8}$$

The aggregate per worker output (Equation 2.8) depends on: (i) the productivity of the low and high-technology firms weighted by the goods share in the total output; (ii) the high-technology capital; and (iii) the distortion of individual firms weighted by the industry share in the total output. The higher the relative credit subsidy that the low-technology good receives (ψ_h/ψ_l) and the share of the high-technology good in the total output (ϖ), the lower is the aggregate total factor productivity. For ψ_h/ψ_l close to 1, the economy is undistorted, and as the subsidy increases in the low productivity sector, (ψ_h/ψ_l) < 1, the larger is the resulting reduction in output and aggregate productivity.

Note that with $\psi_h/\psi_l = 1$ the economy is undistorted across firms and does not imply an efficiency of the allocation of savings and investment in the economy. From a welfare perspective, the efficient solution is $\psi_h, \psi_l = 0$, and subsidies, while increasing output, would still be welfare reducing.

Next, I show an example based on the Brazilian economy to understand the impact of target credit on aggregate productivity and output: I compare two numerical simulations of the transition path from a calibrated version of the preceding model. In simulation entitled *observed*, the interest rate for the earmarked and non-earmarked credit matches the observed values in the third quarter of 2009, and in the simulation entitled *alternative* I hold the same interest rate for the earmarked and non-earmarked credit, set as the 2013 value for the non-earmarked credit. This example helps to understand the effects



(a) Output (b) Investment

(c) Capital low-technology (d) Capital high-technology

Note: Values for the discount factor and the depreciation rate are set $\beta = 0.9798$ and $\delta = 0.0125$. The coefficient for the risk aversion is $\sigma = 0.63$. In the production functions, the capital share is $\alpha = 0.399$, and the share of the high-technology good in the total output is $\varpi = 0.5$. TFP in the high-technology ($a_l = 2.75$) and low-technology ($a_l = 1$) sectors are chosen to match the upper and lower bound for the total numbers employed by firms in the year 2009 in Brazil. I discuss in detail the chosen values for the calibrated parameters in section B.1.

Figure 2.7: Two-Sector Model
Source: Own Elaboration (2021)

of misallocation and is useful in the subsequent section when I introduce an additional distortion - the quality of credit access - that interacts with target credit in a larger model with entry and exit.

Figure 2.7 displays the transition paths produced by distinct credit policies in the model. The policies are implemented at $t = 0$. Before this instant, the capital wedges are $(1 + \psi_l) = 1.0287$ and $(1 + \psi_h) = 1.0497$, which is compatible with the average interest for the earmarked and non-earmarked credit operations in the third quarter of 2009. I consider the transition path to a new equilibrium following a permanent shock under two scenarios: (i) a rise in $(1+\psi_h)$ to 1.0513 and rise in $(1+\psi_l)$ to 1.0264 (final scenario); and (ii) a 1.0356 capital wedge for both sectors (alternative scenario). The values for the first scenario reproduce the average interest rates for the earmarked and non-earmarked credit operations in the third quarter of 2014, and the interest rate for the second scenario reproduces the lowest non-earmarked rate during the 2010s; 15% per year in December 2013 [3].

Since the policies have two distinct roles, variables behave in an opposite manner for each scenario: the observed policy enhances the gap between the low-technology and high-technology wedges and, the alternative policy equalizes ψ_h and ψ_l. The new policy changes the individual consumption and saving decisions, and hence, aggregate prices, which induce dynamics away from the initial steady-state towards the new one.

A larger fraction ψ_h/ψ_l (black line) increases the consumption in $t=0$ since the cost of investment increases, which leads to a drop in the investment. Further, the households expand the consumption of low-technology capital relative to the high-technology capital. As time passes, shifting capital towards the low-technology sector reduces the aggregate total factor productivity and results in a fall in output. In contrast, both output and investment rise towards the new steady-state in the alternative policy (red line).

When I extend the model to include an exogenous cross-sectional heterogeneity, namely heterogeneous agents with idiosyncratic uncertainty in the productivity and credit taxes level (section 2.4), the responses to an increase in the tax subsidies are qualitatively the same as in the simpler model. In particular, an increase in the credit subsidies leads to a fall in the aggregate total factor productivity and output, even when the credit distortions are uncorrelated with productivity. But, when all subsidized firms are credit constrained, credit subsidies have a positive direct effect on the allocation of the input, which leads to positive effects on aggregate productivity.

2.4 FIRM DYNAMICS MODEL WITH CREDIT MISALLOCATION

The model is designed for studying the linkage between aggregate productivity and credit subsidies. I consider a producer heterogeneity model with firm dynamics, such as those in Hopenhayn and Rogerson (1993), and Restuccia and Rogerson (2008), extended

[3] Further information on the calibration can be found in Appendix B and Appendix D

to consider the presence of international capital flows and uneven credit access.

The extensions yield important insights into the impact of subsidized credit on the cross-sectional distribution of firms across productivity. First, including international capital flows illustrates the role that foreign capital plays in allowing the existence of the non-earmarked sector. Second, I assume that only a fraction of firms have unconstrained access to credit (good credit access). Since tighter access to credit makes it more difficult for firms to invest, relaxing credit constraints allows firms to expand their input endowment with a positive long-run effect on productivity. In doing so, there is a departure from the assumptions that subsidized credit policies always result in lower aggregate productivity.

Time is discrete and is indexed by the subscript $t = 1, 2, \ldots$. Each period a positive mass of price-taking firms produces a homogeneous good by hiring labor and renting capital; that is a mixture of both domestic and foreign capital. All firms use the same decreasing returns to scale technology and face individual productivity shocks, s_t. The rent for the domestic capital can be subsidized by the government with a low interest rate (subsidized capital) or rented using the market interest rate (non-subsidized capital) – receiving the subsidy is indexed by an idiosyncratic exogenous state ψ. Some firms also have a poor credit market access τ, and as a result they face an access fee c_τ to rent capital. Therefore, the exogenous states for the productivity and credit subsidy, and the net capital inflows affect the capital allocation in the economy and aggregate productivity.

2.4.1 Households

There is a continuum of infinitely lived households normalized to unit mass. The period utility function is continuous and twice differentiable. The households choose a sequence of consumption, $\{c_t\}_{t=0}^{\infty}$, and domestic capital stock, $\{k_{t+1}^H\}_{t=0}^{\infty}$, to maximize the present value of utility discounted by β, and do not value leisure.[4]

Households own all domestic firms, and the representative household is endowed with n_t^H units of labor, and k_t^H units of domestic capital. The household also receives the flow of profits from the firms Π_t, lump-sum transfers from the financial intermediary, T_t^{nfa}, and pays a lump-sum tax imposed by the government, T_t^G. Income can be used either for

[4]Because I solve the model only for the steady-state, there is no need to specify the utility function.

consumption or investment, following the budget constraint:

$$c_t + k^H_{t+1} - (1-\delta)k^H_t = r^H_t k^H_t + w_t n_t + \Pi_t - T^G_t - T^{nfa}_t, \tag{2.9}$$

Domestic capital depreciates at the constant rate δ, and the household take as given the product price (p_t), wage rate (w_t), and domestic capital rent (r^H_t). In the stationary equilibrium, first-order conditions then yield for the domestic capital rent $r^H = {}^1\!/\!_\beta - 1 + \delta$.

2.4.2 Incumbent firm

In a perfectly competitive market, a continuum of firms produces a homogeneous good by hiring n_t units of labor and renting k_t units of capital.

In each period t, an individual firm total factor productivity is the parameter $s \in S \subset \mathbb{R}_+$, where $S := [\overline{s}, \underline{s}]$. Firms may also receive a credit subsidy $\psi \in \Psi \equiv \{0, 1\}$, and have a poor credit market access $\tau \in T \equiv \{0, 1\}$, which affects the individual firm budget constraint. I abstract from time-series variation in ψ and τ, therefore a firm that receives subsidies will always be subsidized, and the same for the credit access [5].

The exogenous states of an agent is the set $z = \{s, \psi, \tau\}$, where $z \in Z = S \times \Psi$ and follows a Markov-chain with transition function Γ mapping from Z to Z adjusted to endogenous and exogenous exits. In addition to the rent r_t and wage costs w_t. If a firm employs n_t workers and rent k_t units of capital in period t, when the output price is p_t the firm has the following profit function, $\pi_t(z, k)$,

$$\pi_t(k, z) = p_t\left(s_t k^\alpha_t n^\gamma_t\right) - w_t n_t - \left[\tau c_\tau + \psi r^\psi + (1-\psi) r^{market}_t\right] k_t - g(k_t, k_{t-1})\mathbb{1}_{(k_t=0)}, \tag{2.10}$$

where firms operate with a decreasing return to scale technology, $0 < \gamma + \alpha < 1$, with $\alpha, \gamma \in (0, 1)$. There is a capital adjustment cost $g(k_t, k_{t-1})$, and the rent paid by the firms can be defined by an exogenous subsidized interest rate r^ψ ('earmarked credit') or by the market interest rate r^{market}_t. The firm-level productivity s_t is independent across firms and follows a Markov chain with $\pi^s_{ij} \equiv \Pr\left(s' = s_j \mid s = s_i\right) \geq 0$ and $\sum_{j=1}^{s} \pi^s_{ij} = 1 \quad \forall i =$

[5] The invariant ψ and τ are assumptions to simplify the model.

$1, 2, \ldots, n_s$ as in Jo and Senga (2019).

After realizing the productivity, credit subsidy shock, and the access fee (s_t, ψ_t, τ), each firm decides how much to produce by hiring labor and renting capital based on the policy denoted by n' and k'.

Formally, the value of an incumbent firm before drawing the pair of exogenous states z is:

$$W^0(k, z) = p_\xi W_\xi(k, z) + p_\eta W_\eta(k, z) + p_X W_X(k, z), \tag{2.11}$$

where $P_\lambda = \{p_\xi, p_\eta, p_X\}$ are the probabilities associates with the three status of exit $\lambda = \{\lambda_\xi, \lambda_\eta, \lambda_X\} \equiv \{\text{exogenous exit, endogenous exit, no exit}\}$. With the exogenous exit assumption, the model can reproduce the empirical distribution of firm size by capturing the fact that big firms also exit from the economy. If we considered just the endogenous exit decision, only small firms would leave the market since the size is correlated with productivity. But empirically, large firms also exit; in 2018, 0.38 percent of firms with more than 1000 employees exit from the US market (Business Dynamics Statistics database).

After realizing z and the status of exit λ, the value of an incumbent for each λ is:

(i) with exogenous exit (λ_ξ)

$$W_\xi(k, z) = \max_{k', n' \geq 0} \{\pi(k', z)\}. \tag{2.12}$$

(ii) with endogenous exit (λ_η)

$$W_\eta(k, z) = \max_{\substack{\chi \in \{0,1\} \\ k', n' \geq 0}} \left\{\pi(k', z) + \chi \left[\beta \int W(z, k') d\Gamma(z', z) - \phi\right]\right\}; \tag{2.13}$$

where ϕ is the continuation cost, and χ is the optimal decision to stay $(\chi = 1)$ or exit the market $(\chi = 0)$.

(iii) with no exit (λ_X)

$$W_X(k, z) = \max_{k', n' \geq 0} \left\{\pi(k', z) + \beta \int W(z, k') d\Gamma(z', z)\right\}. \tag{2.14}$$

2.4.3 Entering firm

The decision to enter the market has two steps. First, firms will observe the potential gains to enter the market before observing their individual pair z, and the firms that decide to engage in production unconditionally to z go to the next step. In the second step, firms draw z and decide to engage in production or cancel entry conditional to z. The conditional entry decision in the second step is denoted by $\bar{e}(z)\exists(0,1)$, where if the potential entrant chooses to engage in production $\bar{e} = 1$.

The firm draws the states (s, ψ, τ) from the joint distribution over productivity and subsidies $G(k, z) = P_k \otimes P_s \otimes P_{\psi\tau}$. P_s is the randomly drawn from the ergotic distribution $s \in S$, $P_{\psi\tau}$ the joint exogenous probability of receiving a credit subsidy and an access fee, and P_k is the entrant capital distribution. The next step will be paying a fixed cost $c_e > 0$ to enter the market, which is nonrecoverable. From the next period, conditional on surviving, the firm becomes an incumbent.

Every period there is a flow of m new potential entrants that are ex-ante identical and the value of a prospective entrant is given by,

$$W^e = \int \max_{\bar{e}\in\{0,1\}} \left\{ \bar{e}(z)W^0(k,z)dG(k,z) - c_e \right\}. \tag{2.15}$$

Since the fixed cost affects the present discounted value of a potential entrant, firms only enter the market if $W^e \geq 0$. In equilibrium, free entry will guarantee that $W^e = 0$, called the free-entry condition. If the free-entry condition did not hold, additional firms would enter the market.

2.4.4 Timing within period

The timing of individual decisions for firms that are considering entering the market and incumbents are summarized in Figure 2.8, and can be described as follows:

Incumbents: At the beginning of each period, an incumbent decides to exit the market if it is unprofitable to stay. Firms that stay have to pay a continuation cost ϕ and choose their optimal production level.

Potential entrants: After drawing the exogenous state z, potential entrants face a two-step decision process to enter the market: (i) decide to enter the market or not based on the expected market gains; and (ii) if decide to engage in production, the potential entrant will observe their individual expected gains to produce, and decide to cancel or confirm their entry. Firms that enter the market pay a fixed cost of entry c_e, and draw their current states from $G(k, z)$. For all entering firms, the endogenous state k is zero, thus there is no production carry on by entering firms.

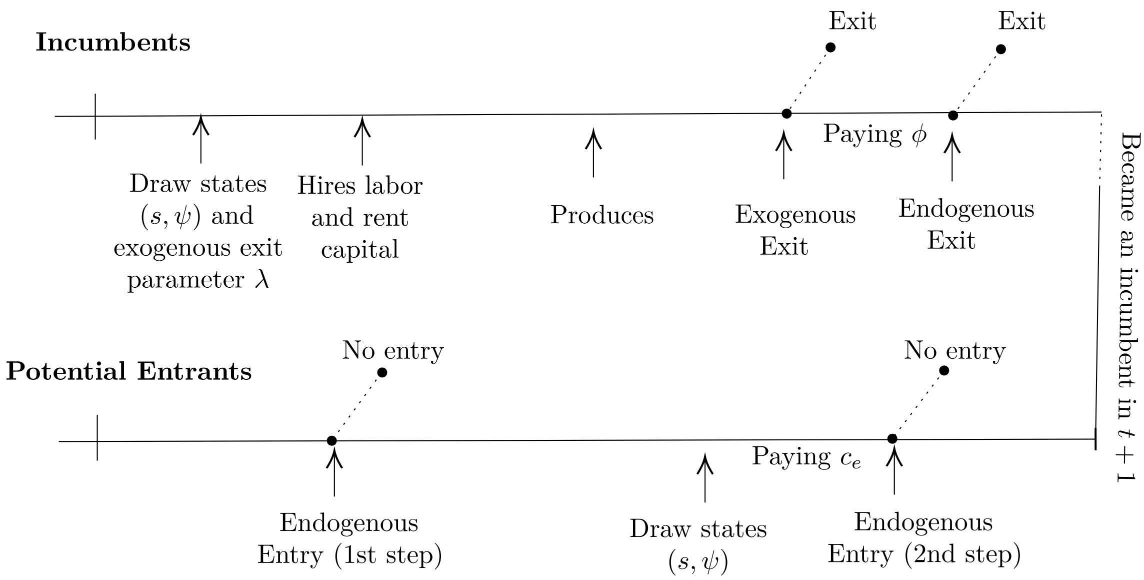


Figure 2.8: Timing within a Period
Source: Own Elaboration (2021)

2.4.5 Firms Dynamics Distribution

The current realization of the states (k, z) across entrants, the exogenous exit shock, and the endogenous exit decision imply a law of motion for the distribution of firms over the states (k, z). Note that because of the conditional entry decision, the entrants' distribution is a combination of the conditional entry decision $e(z)$ and an exogenous distribution of potential entrants $G(k, z)$ over the states (k, z). That is, entering firms make their first step entry decision knowing that they face the distribution $G(k, z)$ and the conditional entry decision (second step entry decision) is the optimal entry decision after the firm drew the pair (k, z).

The law of motion depends on the following individual decision: (i) an incumbent firm enters the current period with the states (k, z) determined at the beginning of the period and may exit with probability p^{exit} given by χ, incumbents can also grow or shrink based on the amount of labor and capital they choose to use in production; (ii) firms that exit the market are replaced by new entrants that find it optimal to pay a sunk entry cost of c_e and become incumbents in the next period.

The evolution of the distribution of agents over time, $\mu_t(k,z)$, is defined by: [6]

$$\mu_t(k',z') = \underbrace{\int\int \left[\tilde{\Gamma}(z',z)\right] \mathbb{1}_{[k'=g(k,z)]} d\mu_{t-1}(k,z)}_{\text{Surviving Incumbents}} + \underbrace{N_t^e G(k',z')\bar{e}(z')}_{\text{Surviving Entrants}} \tag{2.17}$$

where $\tilde{\Gamma}(z',z) = p_\xi \Gamma + p_\eta \chi \Gamma$ is the transition matrix for the exogenous states with endogenous and exogenous exit, $g_{p,\theta}$ is the optimal policy function with parameters vector θ, $\mu_t(k,z)$ denote the mass of firms with exogenous state variables (s,ψ) and endogenous state k at period t.

2.4.6 Government

The total cost of subsidizing capital is paid by the government and given by $c(K^\psi)$,

$$c(K^\psi) = \int\int \psi(r^{market} - r^\psi)k_t d\mu(k,z), \qquad r_t^{market} > r^\psi \quad \forall t. \tag{2.18}$$

The government pays the cost of subsidies granted to firms, and the deficit is redirected to the households as a lump-sum tax, T_t^G. In each period the government budget constraint holds

$$T_t^G - c(K^\psi) = 0. \tag{2.19}$$

[6]The probability density function of the agent over the states (k,z) is defined by

$$\int\int [\Gamma(z',z)] \mathbb{1}_{[k'=g(k,z)] d\mu_{t-1}(k,z)} + \frac{N_t^e}{N_t} G(k',z')\bar{e}(z'), \tag{2.16}$$

where the mass of agents evolve as $N_t = N_t^e + (1 - P^{exit})N_{t-1}$.

2.4.7 Financial Intermediary

The financial intermediary is an abstract representation of unmodeled flows of capital and frictions in the capital market. In the model, the financial intermediary allows an imbalance between the market interest rate and the household domestic rate. The imbalance is caused by uneven access to the foreign market; households only access the domestic capital market, and firms rent foreign and domestic capital from the financial intermediary. Thus, the financial intermediary trade capital in the global market and hold the net foreign assets within the economy.

Figure 2.9 illustrates how the financial intermediary agent interacts with firms, households, government, and foreign economy. Given the current state of the international and domestic interest rate, the financial intermediary rents capital from households and the foreign economy, and leases capital to firms, governments, and the foreign economy. The net value of the transitions allows us to compute the net foreign assets within the economy – the sum of foreign capital held by domestic agents, minus the value of the domestic assets owned by foreigners.

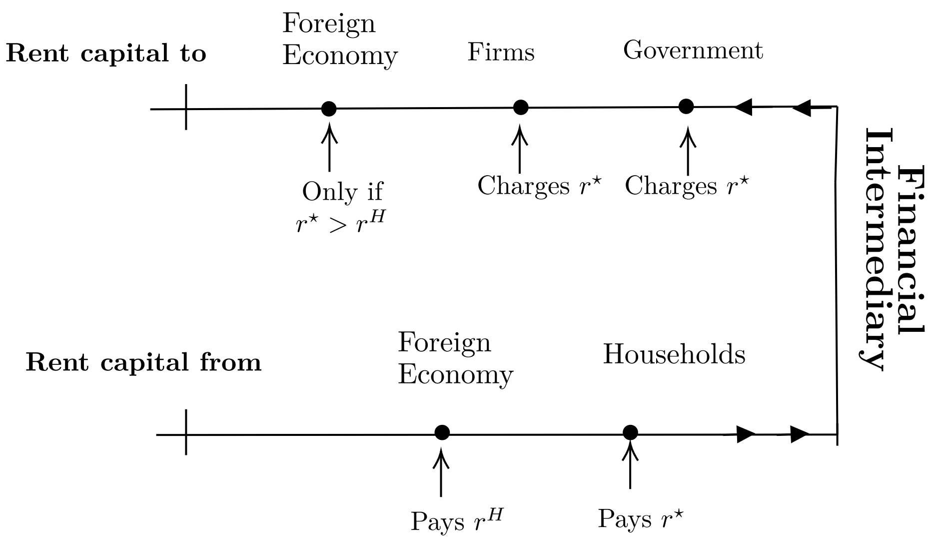


Figure 2.9: Capital Flows
Source: Own Elaboration (2021)

Non-subsidized Capital

The financial intermediary is the only agent with access to domestic and foreign capital. Households rent the domestic capital k_t^H to a financial intermediary, and firms rent the capital from the financial intermediary paying r_t^{market}.

Assuming perfect capital mobility, the interest rate in small open economy equals the international interest rate $r^\star$, therefore, the financial intermediary receives $r_t^{market} = r^\star$. The surplus or deficit is redirected to the households as a lump-sum transfer, T_t^{nfa}. The financial intermediary budget constraint is given by,

$$\int\int (1-\psi)(r_t^H - r^{market})k_t d\mu(k,z) + T_t^{nfa} = 0, \qquad r^{market} = r^\star. \tag{2.20}$$

Subsidized Capital

In addition to renting capital from the financial intermediary, the firms can receive subsidized capital from the government. If a firm receives a credit subsidy (ψ=1), the rental price for capital is a fixed value of r^ψ. The firms without subsidies ($\psi = 0$) have to rent capital paying the market value, r_t^{market}. r^ψ being a subsidized price, the market interest rate is higher than the r^ψ in every t.

Net Foreign Assets

Suppose that only the households hold capital in the economy, then they would be willing to buy any level of capital for renting as long as the rental rate was $r_t^H = {}^1/_\beta - (1-\delta)$ - solution for the optimization problem of the household in the steady-state. But with an intermediary agent that access domestic and foreign capital, - the financial intermediary - firms can rent capital paying r_t^{market}. Thus, to solve the partial equilibrium problem of the capital market we need to find the net foreign assets that clear the market by solving the imbalance between the domestic and foreign capital supply.

From the total capital stock, we can compute the net foreign assets, K^{nfa}, by

$$K^{nfa} = K_t - K_t^H, \tag{2.21}$$

where K_t^H is the aggregate optimal capital level that firm would choose if the rent rate was r_t^H, $\int\int g_{p,r^H}(z)d\mu_t(k,z)$, and K_t the aggregate optimal capital level that firm effectively choose with r_t^{market} as the interest rate, $\int\int g_{p,r^{market}}(z)d\mu_t(k,z)$.

2.4.8 Stationary Competitive Equilibrium

A competitive stationary equilibrium for the economy is a set of prices $\{p, r, w\}$, a lump-sum tax T^G, a lump-sum transfer T^{nfa} a set of decision rules $\{W, W_e\}$, policy functions χ', k', n' for individual firms, a mass of entry ${}^{N^e}/{}_{N}$, distribution of firms μ, and aggregate levels of consumption (C) and capital (K). Labor is supplied inelastically and exit is endogenous.

(i) (Consumer optimization)

$$\begin{gathered}\max_{c_t, k^H_{t+1}} \quad E_t \sum_{t=0}^{\infty} \beta^t \left(u(.)\right) \\ \text{s.t.} \\ c_t + k^H_{t+1} - (1-\delta)k^H_t = r^H_t k^H_t + w_t n_t + \Pi_t - T^G_t - T^{nfa}_t\end{gathered} \tag{2.22}$$

(ii) (Firms optimization) Give prices (p, r, w), the equations π (Equation 2.10), W^ξ (Equation 2.12), W^η (Equation 2.13), W^X (Equation 2.14), W^e (Equation 2.15) solve incumbent and entering firms' problems and k', n', χ' are optimal policy functions.

(iii) (Free-entry)

$$W_e = 0 \tag{2.23}$$

(iv) (Market clearing)

$$K = \int\int k'(z) d\mu(k, z) \tag{2.24}$$

$$1 = \int\int n'(z) d\mu(k, z), \tag{2.25}$$

$$C + \delta K + N c_f + N_e c_e = p \int\int s k'^{\alpha} n'^{\gamma} d\mu(k, z) \tag{2.26}$$

(v) (Financial Intermediary budget balance)

$$T^{nfa} - \int\int (1-\psi)(r^H - r^\star) k' d\mu(k, z) = 0 \tag{2.27}$$

(vi) (Government budget balance)

$$T^G - \int\int \psi r^{\psi} k' d\mu(k,z) = 0 \tag{2.28}$$

(vii) (Stationary Firms' distribution)

$$\mu_t(k',z') = \int\int \left[\tilde{\Gamma}(z',z)\right] \mathbb{1}_{[k'=g(k,z)]} d\mu_{t-1}(k,z) + N_t^e G(k',z')\bar{e}(z') \tag{2.29}$$

2.5 CALIBRATION AND BENCHMARK MODEL

2.5.1 Calibration

I set calibration on a quarterly basis and summarize the assigned values for the calibrated parameters in Table 2.2. The calibration aims to reproduce the distribution of firm sizes along with firms' entry and exit statistics for the Brazilian economy.

I set the exogenous exit rate in the model at 0.017 and the endogenous exit rate at 0.044 to reproduce the average share of firms that leave the market between 2007–2017; 18.59%. The parameter values of the fixed cost of production, 0.155, the entry cost, 0.25, and the continuation cost, 0.25, are calibrated to reproduce the observed size of firms. The discount factor is 0.9798, consistent with a yearly interest rate of 8.35%.

To calibrate the model I assume a functional form for the capital adjustment cost given by

$$g\left(k_t, k_{t-1}\right) = \begin{cases} \frac{a_k}{2}\left[\frac{i_t}{k_{t-1}} - \delta\right]^2 & \text{if } k_{t-1} > 0, \\ 0 & \text{otherwise.} \end{cases} \tag{2.30}$$

where i_t is the investment in t and the parameter for the level of the adjustment cost is set to $a_k = 3.21$, as in Lama (2011).

I calibrate the capital depreciation parameter, $\delta = 0.025$, as in Pereira (2019), which is consistent with an annual depreciation of capital stock close to 10 percent. I also calibrate the model so that it matches the labor income share adjusted to the income of self-employed workers and employers as in Gomes, Bugarin, and Ellery-Jr (2005). The labor share is set to 0.67 and I follow Restuccia and Rogerson (2008) assumption that $\alpha + \gamma = 0.89$. [7]

Parameter	**Value**	**Description**
β	0.9798	discount factor
α	0.22	capital share
γ	0.67	labor share
δ	0.025	depreciation rate
λ_ξ	0.017	exogenous exit rate
λ_η	0.044	endogenous exit rate
ϕ	0.25	continuation cost
a_k	3.210	adjustment cost parameter
s range	$[0.4, 1.2]$	relative productivity range
k range	$[1, 1900000]$	relative capital range
c_e	0.25	entry cost
c_f	0.155	fixed cost of production
ρ_s	0.9426	persistence parameter
χ_s	9.5	shape parameter

Table 2.2: Calibrated Parameters
Source: Own Elaboration (2021)

The capital range is chosen to match the 2009 Brazilian firm-level data from World Bank (2009). I use the relative current cost of machinery, vehicles, and equipment for the capital range and consider a log-spaced grid with 201 points, which results in a range of capital for incumbent firms from 1 to 1,900,000.

Firm-level productivity follows a bounded Pareto distribution with a shape parameter $\chi_s = 9.5$ and bounded to $(0.4, 1.2)$, which is discretize using 14 points. Following Jo and Senga (2019), a firm retains its previous level of individual productivity with a fixed probability per year of 0.75. The bounds of the Pareto distribution and the shape parameter are chosen to resemble the establishments and labor share reported in the Demography of Enterprises and Statistics of Entrepreneurship (IBGE) from 2010.

2.5.2 Benchmark Stationary Equilibrium

My benchmark economy is calibrated as described in subsection 2.5.1, and the credit policy parameters – interest rates for earmarked and non-earmarked credit operations and

[7] Based on estimates of firm-level production functions and different calibration techniques, including the calibration procedures for the U.S. data in Veracierto (2001).

the share of subsidized firms – are calibrated to fit the features of the Brazilian economy in the early 2010s. Specifically, the benchmark steady-state is compatible with the values for the third quarter of 2009. The market tax rate is set to 5.17 percent per quarter (22.34% per year). The subsidized rate is set to 2.87 percent per quarter, that is equivalent to an annual rate of 12%, and 42.9 percent of the firms with credit operations had access to subsidized interest rates. The model is solved with the VFI toolkit (Kirkby, 2017) using a value function iteration with the discretization of the state space (z, k) .

For the correlation between the subsidized credit and poor market access, I use the percentage of BNDES's disbursement to small and medium enterprises (SMEs) in 2010–2014: 32% (Menezes Barboza, Furtado, and Gabrielli, 2019). I selected SMEs as a proxy to poor access to the credit market since these firms are unlike to have access to external finance and are more constrained in their access to financial services than large establishments, since the former have more information to share with potential investors, more assets to be used as collateral, and more options to signal their performance (Andrieu, Staglianò, and Van Der Zwan, 2018). In the calibration, firms with poor credit access pay an additional cost to access credit equivalent to an increase of 0.0210 in the interest rate.

Brazilian Data in 2010		
Number of Employees	**Share of establishments**	**Share of labor**
less than 5	41.03	3.35
5 to 49	51.59	26.42
50 or more	7.38	70.24
Benchmark Model		
Number of Employees	**Share of establishments**	**Share of labor**
less than 5	41.88	1.04
5 to 49	50.08	27.61
50 or more	8.04	71.36

Note:The empirical firm size are calculated from the annual tables in the the Demography of Enterprises and Statistics of Entrepreneurship (IBGE) from 2010.

Table 2.3: Distribution of Firm Size
Source: Own Elaboration and IBGE (2020)

Table 2.3 reports the distribution statistics predicted by the benchmark steady-state and the observed values for the Brazilian economy in 2010 from the annual survey of industrial companies (PIA-Enterprise) (IBGE, 2020). As is well known in the literature, the firm-size distribution is very skewed. Around 70% of total employment is accounted for less than 7.5% of establishments, and more than 40% of firms have less than 5 employees. That feature was well captured by the distribution statistics implied by the benchmark model, meaning a heavy right tail of the size distribution of firm size.

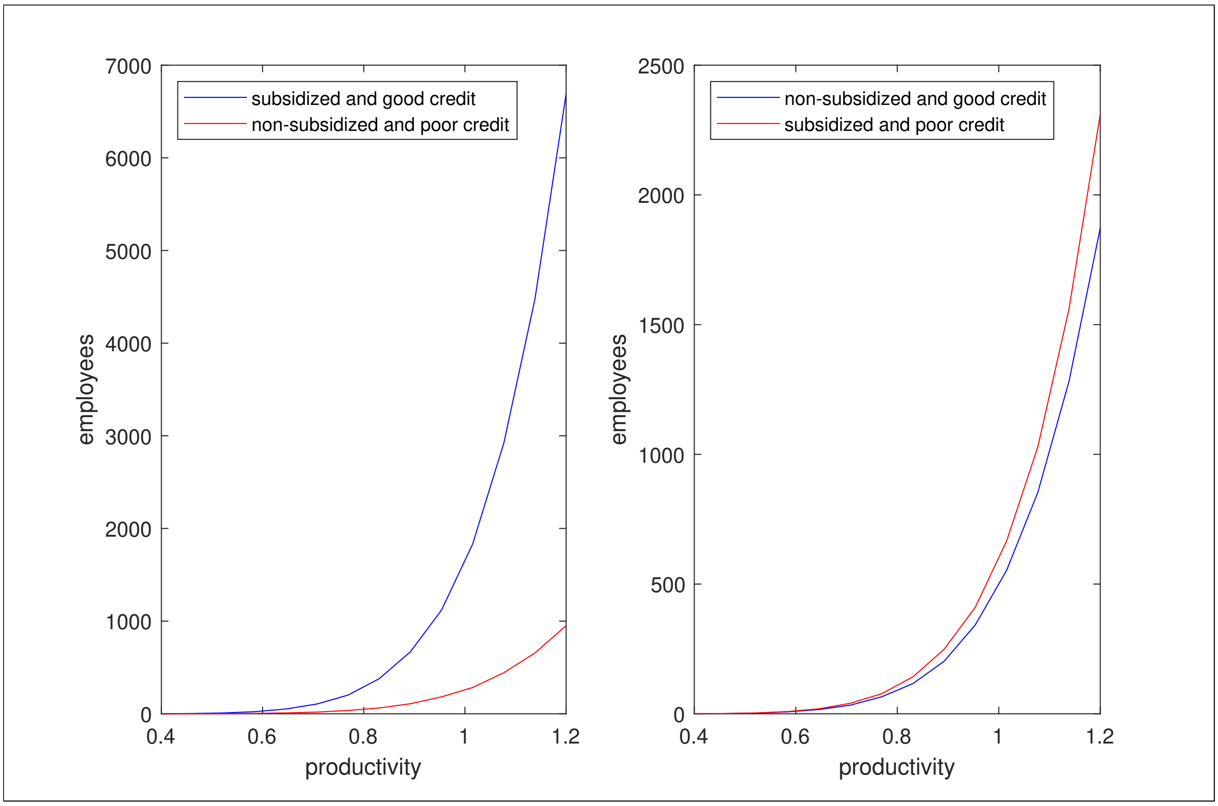


Figure 2.10: Firm-Size Distribution - benchmark
Source: Own Elaboration (2021)

In the benchmark stationary equilibrium we can see the difference between subsidize constraint firms (right-side panel in Figure 2.10) and unconstrained firms (left-side panel in Figure 2.10). When credit constraint firms received subsidies, they will display a behavior close to credit-unconstrained firms, because in that case subsidies are correcting a market imperfection. But subsidizing unconstrained-firms has the opposite effect. Subsidized unconstrained-firms cause a market distortion since resources will diverge to the subsidized firms, that already display good access to credit. Thus, considering their productivity, subsidized unconstrained-firms will be larger than they should be.

In the model, financial frictions distort entry and the firms' optimal production choices. If we decrease the relative cost of capital for a group of firms, the inputs will move to these firms regardless of their productivity. Low-productivity entrants also will enter the market if they receive the credit subsidy. In the aggregate capital swift away from the optimal allocation and the economy faces productivity losses caused by misallocation. This dismal effect is offset if the firms that received the subsidy were credit constraint, in that case, credit subsidies resolve misallocation of resources and may enhance aggregate productivity.

2.6 QUANTITATIVE ANALYSIS

In this section, I examine the aggregate consequences of credit policies on TFP and growth. Three sets of results are presented, in which the primary goal is to identify channels for productivity losses and gains caused by a government-driven credit expansion.

First, I analyze the impact of an expansionary credit policy when all non-subsidized firms are credit constrained. Second, I analyze the impact of an expansionary credit policy when only firms with poor accesses to credit receive subsidies. Third, I design an experiment to access how an increase in the international interest rate affects the aggregates. Thus, for all models, the credit policy is based on the Brazilian interest rates for earmarked and non-earmarked credit operations in 2014, except for the third experiment where I consider an 0.32 points increase in the international interest rate, which is compatible with the decline of the commodities prices and the reversal of capital inflows to developing countries.

I design the model to consider the effect of subsidies in a model with financial friction besides subsidies, in opposition to the two-sector growth model presented in section 2.3 that has only one type of friction. In the first two sets of results, subsection 2.6.1 and subsection 2.6.2, I explore the cases where the correlation between subsidies and credit access in the stationary equilibria are independent of the percentage of endogenous exit firms; corner cases. Therefore, I can establish key theoretical results regarding subsidies that are less sensitive to the exit choices made by firms.

The credit-constrained subsidy only (CCS) and credit-unconstrained subsidy only (CUS) stationary equilibria capture the main characteristics of the government-driven credit policy during the 2010s, namely a higher probability of receiving the government subsidy and almost constant low-interest rate, which contrasts with a tight monetary policy. The market and subsidy interest rates are set to their value in the third quarter

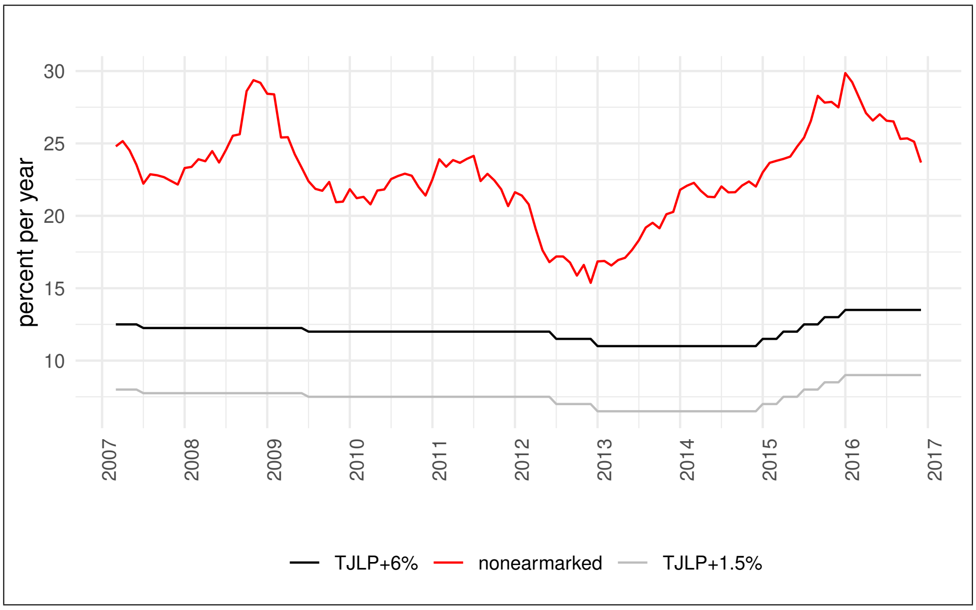


Figure 2.11: Long Term Interest Rate and Non-earmarked Interest Rate for Working Capital

Source: Central Bank of Brazil (2019)

of 2014; with a yearly interest rate of 11% for the earmarked credit and 22.16% for the non-earmarked. By 2014, in the third quarter, 50.3 percent of the total credit allocated to firms was subsidized.

The earmarked and non-earmarked average values are available only back to the second quarter of 2011; however, the interest rate of working capital loans and the TJLP (*Taxa de Juros de Longo Prazo*) – a below-market rate set quarterly by the government – can be used as good proxies for the non-earmarked and earmarked interest rates (see Appendix D for comparisons). For this reason, the TJPL with a spread of 6% a year and the interest rate of working capital loans are employed to evaluate the credit policies. Figure 2.11 shows display the evolution of the TJPL with a 1.5% and 6% spread and the non-earmarked interest rate between March 2007 and December 2016.

2.6.1 Credit-Unconstrained Subsidy (CUS)

In this subsection, I introduce credit subsidies only for firms that are credit unconstrained (have good credit access). Such a configuration of distortions will cause a reallocation of capital to subsidized firms, and even high-productivity firms will choose to leave the market if they are not beneficiaries.

CUS Stationary Equilibrium	
Relative productivity	0.92
Relative subsidy cost	2.06
Relative Y/L	0.99
Relative K/L	1.37
Net foreign assets	0.13

Note: The valuers are relative to the benchmark economy presented in subsection 2.5.2. CUS denotes the credit-unconstrained subsidy model.

Table 2.4: Relative effects of idiosyncratic distortions - CUS
Source: Own Elaboration (2021)

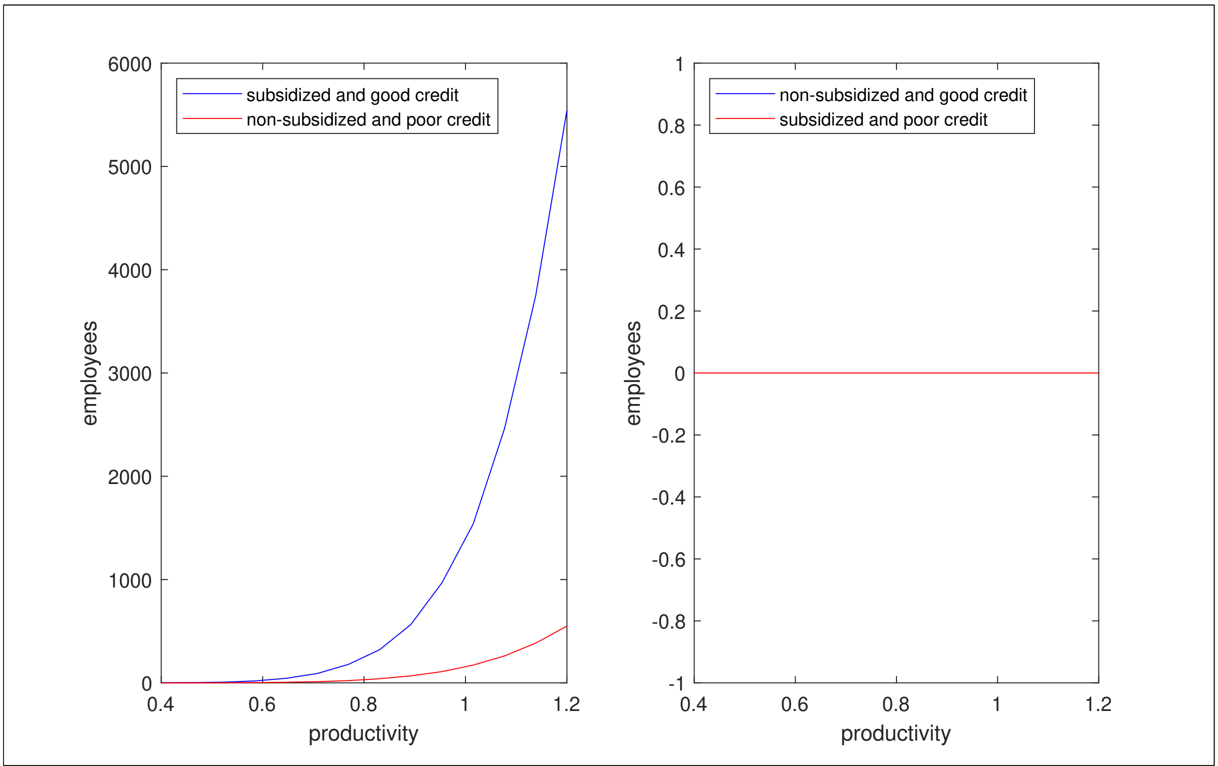


Figure 2.12: Firm-Size Distribution - CUS
Source: Own Elaboration (2021)

Table 2.4 summarizes the effects of the distortions on several variables of interest in the CUS stationary equilibrium relative to the benchmark economy. Three major features are apparent. First, the productivity is around 8 percent lower. Second, the output per worker is 1 percent lower while the capital per worker is 37 percent higher. Thus, the government-driven credit policy focused on unconstrained firms results in a combination of low productivity with strong capital deepening. Last, the subsidy costs are increasingly harmful to the government with an expansion of the subsidized credit. The cost for the government increases two times with a 0.3 percent lower quarterly interest rate and a 7 percent increase in subsidized firms,

The source of inefficiency in the model, that results in lower aggregate productivity is twofold. First, firms with lower productivity that receive the subsidized credit will enter the market, which implies that the productivity cut for entering the market is lower for subsidized firms. Second, capital is reallocated to firms that received the subsidy and the optimal firm sizes will be distorted.

CUS Stationary Equilibrium			
	Subsidized Credit	**Non-subsidized Credit**	**Aggregate**
Total Factor Productivity	0.45	0.49	0.47
Aggregate output	0.92	0.09	1.00
Aggregate labor	0.93	0.08	1.00
Aggregate capital	0.97	0.03	1.00

Note: The aggregate values are relative to the total aggregate in the CUS model. CUS denotes subsidized credit-unconstrained, meaning that only firms with good credit access receive credit subsidies. For the aggregate production function, the capital share is 0.22 and the labor share is 0.67.

Table 2.5: Share of Subsidized and Non-subsidized Firms - CUS
Source: Own Elaboration (2021)

The left-side panel in Table 2.5 shows the number of employees by productivity level for credit-unconstrained subsidy firms (blue line) and non-subsidized credit-constrained firms (red line). Subsidized firms are larger than their optimal size, given by the productivity level, and inputs diverge from non-earmarked firms since they face a higher interest rate and compete with the subsidized firms.

In the stationary equilibrium, non-subsidized firms have a higher TFP than the subsidized firms (Table 2.5). The source of the TFP differences is that subsidized firms become larger, which implies that firms will display heterogeneity in size within the same productivity class. As expected the earmarked firms are responsible for a higher share of inputs and output. Note that this strong imbalance between earmarked and non-earmarked firms reflects the reallocation of capital towards the subsidized firms.

The misallocation of resources caused by the CUS credit policy results in a higher dispersion in firm-level productivity, lower productivity, and lower welfare. To boost economic growth, capital needs to be directed toward efficient projects. When the productivity rises, the firms will demand more capital and investment increase, thus, the increase in capital regardless of the firm level-productivity is insufficient to drive long-term growth.

2.6.2 Credit-Constrained Subsidy (CCS)

The distortions considered in the last subsection were adding noise to the competitive market. Now I consider the case when only firms that are credit-constraint receive subsidies. In particular, I show that if a firm faces binding collateral constraints, then the credit subsidizing policy helps it to achieve the optimal level of capital stock.

Table 2.6 illustrates that reallocation within the economy. The first row reports the total factor productivity for the subsidized and non-subsidized firms and the aggregate. The final three rows report the proportion of output, labor and capital for subsidized and non-subsidized firms compare to the model's aggregate values.

CCS Stationary Equilibrium			
	Subsidized Credit	**Non-subsidized Credit**	**Aggregate**
Total Factor Productivity	0.50	0.50	0.54
Aggregate output	0.54	0.46	1.00
Aggregate labor	0.54	0.46	1.00
Aggregate capital	0.56	0.44	1.00

Note: The aggregate values are relative to the total aggregate in the CCS model. CCS denotes subsidized credit-constrained, meaning that only firms with good credit access receive credit subsidies. For the aggregate production function, the capital share is 0.22 and the labor share is 0.67.

Table 2.6: Share of Subsidized and Non-subsidized Firms - CCS
Source: Own Elaboration (2021)

CCS Stationary Equilibrium	
Relative productivity	1.08
Relative subsidy cost	0.68
Relative Y/L	1.02
Relative K/L	0.77
Net foreign assets	1.86

Note: The valuers are relative to the benchmark economy presented in subsection 2.5.2. CCS denotes the subsidized credit-constrained model.

Table 2.7: Relative effects of idiosyncratic distortions - CCS
Source: Own Elaboration (2021)

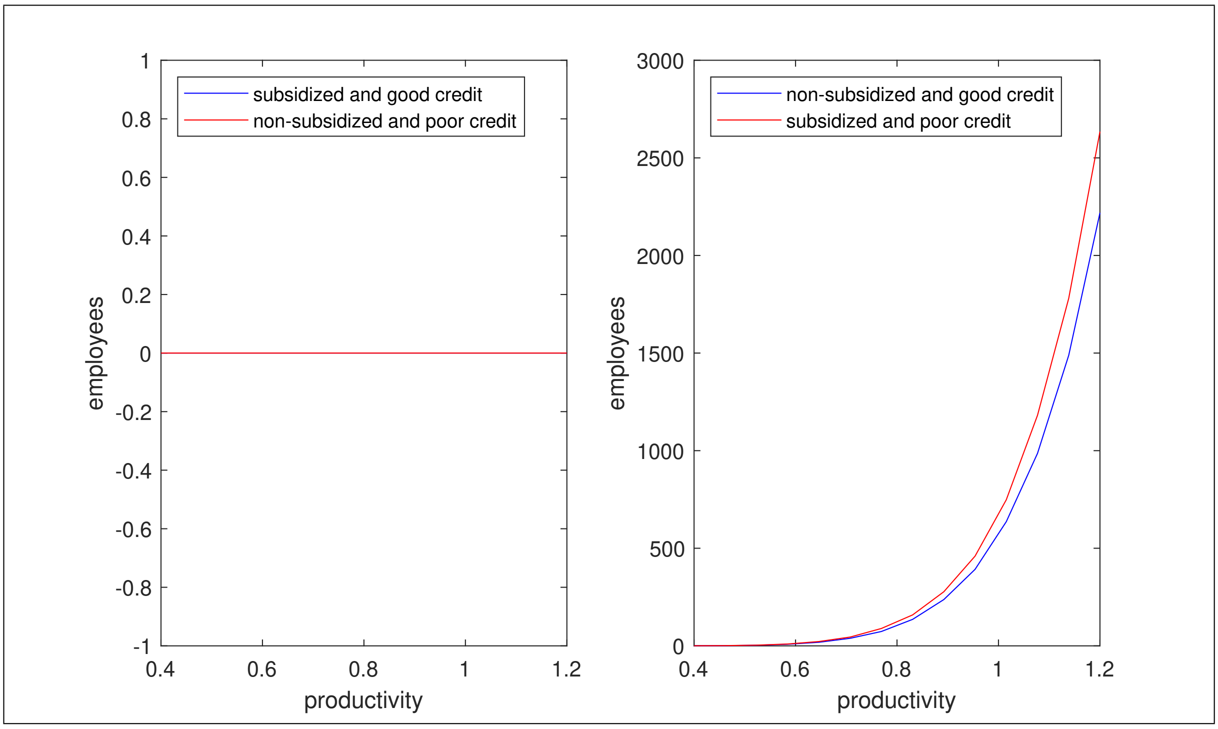


Figure 2.13: Firm-Size Distribution - CCS
Source: Own Elaboration (2021)

As shown in the first row of the table, the subsidized and non-subsidized firms have the same TFP, and the aggregate TFP is higher than the CUS model. We further observe that the proportion of subsidized and non-subsidized firms in the total output, labor, and capital are similar. The results in the CCS model show a more balanced distribution of credit-unconstrained and credit-constrained firms than the CUS model, which is caused by the entry and exit dynamics and a smaller dispersion in the capital allocation within the same productivity group, regardless of the financial constraint each firm faces.

In the model, a firm's degree of credit constraint changes its optimal capital and labor allocation. The constraints generate a large dispersion in firm size, and limit the constraint-firms' sizes, thus, by reducing the credit constraint, subsidies reduce misallocation. This point is wheel illustrate by the right-side panel in Table 2.7. We can see that, because of the subsidy, the distribution of firms sizes for non-credit-unconstrained subsidy firms and subsidized credit-constrained firms display similar patterns.

The above aggregate improvements in the firm's allocation lead to an improvement in the economy's performance. As we can see in Table 2.7 the average TFP by firm size in the CCS steady-state is higher for all firms when compared to the benchmark economy. The output per worker is 2 percent higher, while the capital per worker is 23 percent lower, resulting in an improvement in the aggregate TFP of 8 percent. Since the competition is fair among firms, non-subsidized firms with small and medium productivity will also remain in the market, and with a balanced distribution of subsidized and non-subsidized firms, the relative subsidy costs became lower in this scenario.

2.6.3 Capital Flows

In this subsection, I examine how a higher international interest rate affects the government's ability to sustain the subsidized credit policy. In particular, I increase the international interest rate from 4.97 to 5.13 percent while keeping all other parameters as in the benchmark calibration. This exercise also illustrates the role that foreign capital plays in allowing the existence of the subsidized sector.

Qualitatively the patterns are similar to those of the benchmark model: the size distribution of firms remains unchanged, as seen in Figure 2.14, which implies small changes in the resources allocation within the economy (around 1% for output and capital). A key difference is that in this case, the government pays a much higher subsidy cost to fund the credit policy.

A higher gap between the market and the subsidized interest rate puts further pressure on the existing fiscal framework and makes the policy less sustainable as illustrated in Equation 2.18. With a mild expansion in the interest rate, 0.32 percent, the cost for the government increases 13 percent (Table 2.8). To keep the economy stable, the capital inflows should increase, implying that the economy needs to further increase the capital flows (assuming no restrictions on capital flow). Thus, reversions in the liquidity of international financial markets may have strong implications for the budget of a government that keeps a credit expansion through target subsidized credit.

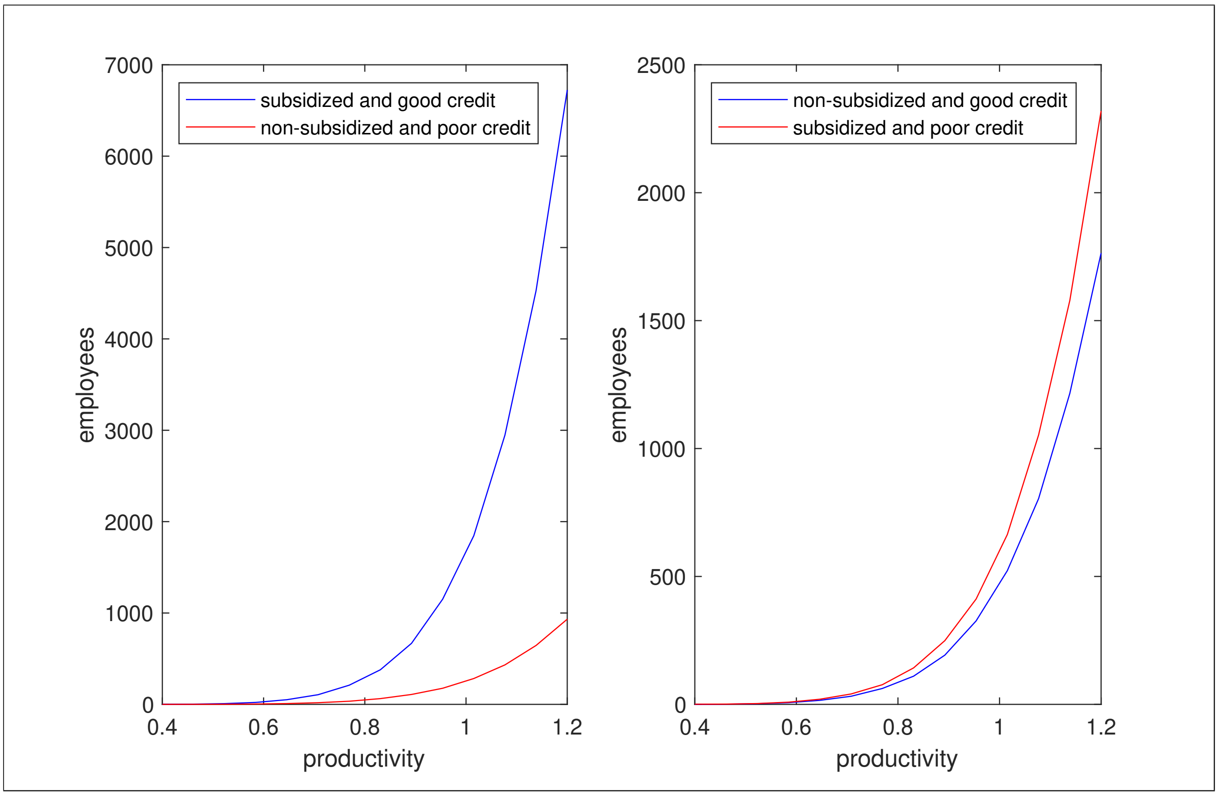


Figure 2.14: Firm-Size Distribution - Capital Flows
Source: Own Elaboration (2021)

Capital Flows model	
Relative productivity	1.01
Relative subsidy cost	1.13
Relative Y/L	1.01
Relative K/L	1.01
Net foreign assets	1.09

Note: The valuers are relative to the benchmark economy presented in subsection 2.5.2.

Table 2.8: Relative effects of idiosyncratic distortions - Capital Flows
Source: Own Elaboration (2021)

2.7 CONCLUDING REMARKS

I develop a two-sector neoclassical model where a single good can be produced with a low-technology and a high-technology sector. By idiosyncratic distortions to the investment, I change the sectorial capital accumulation in the low-technology and high-technology sectors. A policy that subsidizes the low-technology sector will increase the share of resources allocated to low-technology firms compared to the efficient allocation, the same occurs if the policy increases the taxes for high-productivity firms. In addition, from a welfare perspective, the efficient solution is to remove the subsidies since the model is absent from financial frictions. Thus, even if the subsidies increase output, they would still be welfare-reducing.

Further, I develop a model to consider financial frictions and heterogeneity among firms. From this model, I have reached three main conclusions:

First, when only credit-unconstrained firms receive subsidies the heterogeneity within the same productivity group will increase, which results in a lower TFP. Also, subsidized establishments become larger since they face a lower interest rate, and the aggregate capital required will be higher as well, thus, this case creates a combination of higher capital per worker with a lower output per worker.

Second, when only credit-constrained firms receive subsidies the resources allocation within the economy will improve. The subsidies partially offset the market distortion create by the credit constraint, and the economy can achieve a higher output per labor with less capital.

Third, when the international interest rate increases the subsidy costs are increasingly harmful to the government. With a mild expansion in the international interest rate, 3.2 percent, the cost for the government increases 13 percent and requires an increase in the inflow of foreign capital.

Appendix A

AN INTRODUCTION TO FIRM DYNAMICS MODELS

Microeconomic foundations are a standard feature in modern macroeconomic models. Using a single representative agent is the most simple and direct way to use microeconomic theory to derive the behavioral equations of a macroeconomic model. The intuition behind a representative agent model is that we consider that a continuum of homogeneous agents, that share the same optimizing behavior, can represent the average macro pattern.

Yet many important questions in economics require us to consider heterogeneous agent models. For instance, a standard representative firm model could not be used to study the capital allocation among firms, because by definition a single firm has all capital. Besides, representative firms models cannot mimic some of the patterns finding in the empirical data, as the right-skewed size distribution of firms, and the correlated entry and exit rates.

Firm dynamics models are an example of micro-funded models of size distribution that aim to overcome the representative agent model deficiencies, caused by cross-sectional heterogeneity. These models constitute a flexible framework for modeling firm heterogeneity and are used in a wide range of fields, including growth and productivity, trade, industrial organization, and resource misallocation. One of the most important versions of the firm dynamics models has been Hopenhayn (1992), which is an industry equilibrium model with entry and exit, but stationary firm distribution.

I present a simplification of Hopenhayn (1992), that embodies two of the most defining characteristics in the firm dynamics models, firm-specific shocks, and firm entry and exit. The theory behind the toy model is simple; there is no capital accumulation, only one state variable, and no aggregate risk.

Static Environment: Assume a mass m of firms that produce a homogeneous product. Each firms is described by the same technology of production sk^{α} that uses only capital as input, and exhibit decreasing returns to scale $\alpha \in (0, 1)$. Productivity is idiosyncratic and let $s \in S \coloneqq [\underline{s}, \overline{s}] \subset \mathbb{R}_+$. An important aspect of the framework is that all firms are *identical ex-ante*, but because they receive different productivity shocks, they will be *different ex-post*.

The maximum one period profit function for an individual firms with productivity level s and price p is given by:

$$\pi_i(s, p) = \max_{k \geq 0} \{psk^\alpha - k\}. \tag{A.1}$$

The first-order condition implies that the optimal factor demand k^* is

$$k^* = (ps\alpha)^{1/1-\alpha}, \tag{A.2}$$

where k^* is an increase function of price and productivity $k^*(s, p)$. Note that the rent rate has been normalized to one and hence does not appear explicitly.

Let $\mu(s)$ be the cross sectional distribution of firms across productivity. Then, we can define the aggregate supply as,

$$Y(p) = \sum_{s \in S} s(k^*)^\alpha \mu(s) \tag{A.3}$$

So far: to theoretically model heterogeneous firms we use cross-sectional distribution in a static analysis. As seen in Equation A.3 the aggregate results will depend only on the individual optimal decisions and the initial cross-sectional distribution of firms across productivity.

The primary shortcoming of this static analysis is the absence of entry and exit. Including entry and exit in the model allows the analysis of a wide range of phenomena, including the role of entrepreneurship in economic growth and the implications of policies that create zombie firms. In the theoretical model, entry and exit (endogenous and exogenous) affect the value function, law-of-motion for agent distribution, and general equilibrium conditions.

Dynamic Environment: Now I extend the static toy model to a dynamic framework with endogenous entry and exogenous exit. Time is discrete and is indexed by the subscript $t = 1, 2, \ldots$. In $t = 0$ firms receive a productivity shock $s \in S$ with distribution μ_0. After the benchmark shock, firm-level productivity is constant over time, which implies that the transition probabilities of the productivity process are an identity matrix.

The discounted present value of an incumbent firm is given by,

$$\begin{aligned} V(s,p) &= \sum_{t=0}^{\infty} \beta \left(1-\lambda\right)^{t} \pi(s,p) \\ &= \left(\frac{1}{\beta(1-\lambda)}\right) \pi(s,p). \end{aligned} \tag{A.4}$$

Each period only $(1-\lambda)$ firms remain in the market. Thus, to ensure stationary equilibrium we need to allow the entry of new firms. To introduce an economic mechanism that justifies the existence of firms that are kept out from the market, potential entrants, we introduce a fixed cost of entry $c_e > 0$.

Potential entering firms face distribution $\gamma(s)$ over potential draws for s, and they pay c_e before observing their realized draw of s. The present discounted value of a potential entrant is given by

$$V^E = \sum_{s \in S} V(s,p)\gamma(S) - c^E \tag{A.5}$$

Potential entrants enter the market if $V^E > 0$ and decide not to enter if this value is less than zero. In equilibrium, V^E must be non-positive since entry is not restricted beyond the cost of entry, and entry must be zero when $V^E < 0$. As a result, stationarity occurs when $V^E = 0$ (free-entry condition).

With exogenous exit and endogenous entry and outside the stationary equilibrium, the distribution of firms across productivity change thought time. The description of how the entry and exit shape the next period's distribution of producers over s is given by the law of motion for μ_{t+1},

$$\mu_{t+1} = (1-\lambda)\mu_t + m_{t+1}\gamma(S), \tag{A.6}$$

Equation A.6 shows that the distribution of firms in $t+1$ is determinate by the distribution of the mass of entering firms in m and the fraction of incumbents that remain in the market, namely, that avoid the exogenous exit shock.

In the stationary equilibrium, the distribution of firms over productivity will be constant over time, therefore we are interested in finding the fixed point of this mapping. Specifically, assume that mapping T is defined by $T\mu = (1-\lambda)\mu\gamma(S)$, we need to find μ^* with $T\mu^* = \mu^*$, thus the invariant distribution μ^* is

$$\mu^*(s) = \frac{m}{\delta}\gamma(S). \tag{A.7}$$

Equation A.7 shows that with exogenous exit and endogenous entry μ^* is completely determined by the probability distribution of productivity faced by potential entrants, $\gamma(S)$. In the stationary steady-state firms still exit and enter the market, however the distribution of firms over productivity remain unchanged. An μ invariant distribution implies that the aggregate values in the economy remain constant, but in the firm-level they change according to the exogenous productivity shock receive by the firm in each period.

Suppose that the demand of the market is described by a function $Y(p)^d$. Then, a stationary equilibrium consist of (p^*, m^*, μ^*) that satisfy:

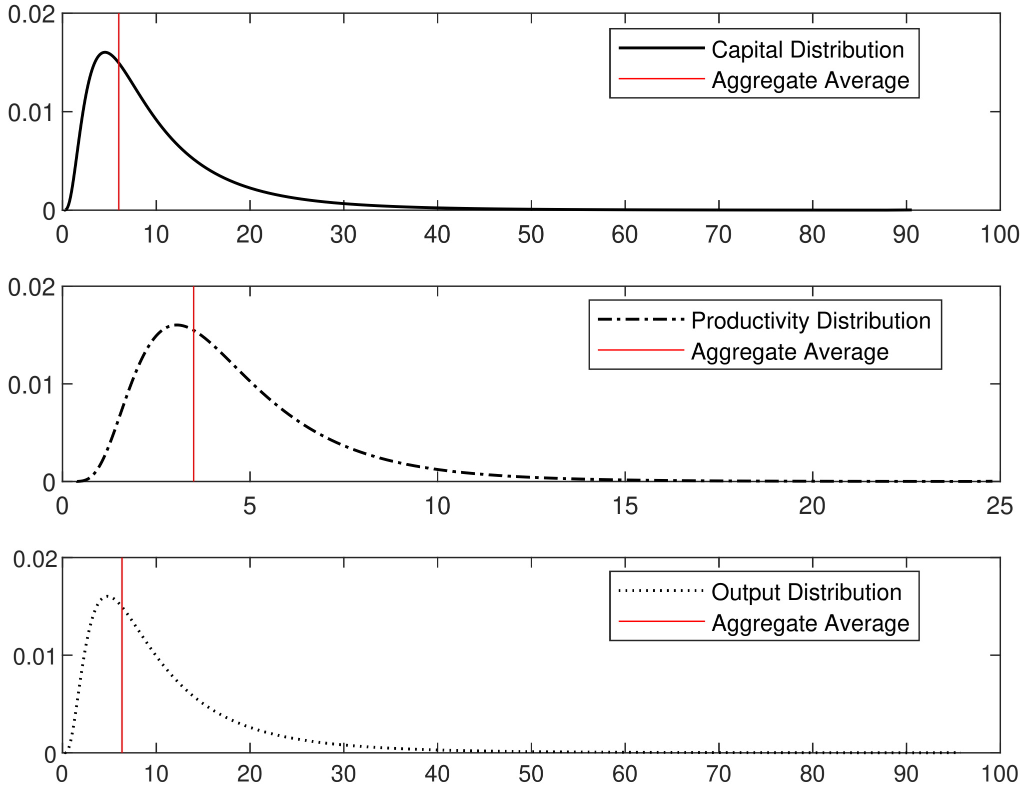
1. (Free-entry) $\sum_{s\in S} V(s,p)\gamma(S) - c^E = 0$;
2. (Market clearing) $Y(p)^d = \sum_{s\in S} s(k^*)^\alpha \mu^*$; and
3. (μ is an invariant distribution) $\mu = \frac{m}{\delta}\gamma(S)$.

Numerical Example:

Figure A.1 illustrates the effects of cross-sectional firm heterogeneity on capital, productivity, and output. The results allow us to display the profile of the average firm and the distribution of resources among firms.

Nevertheless, heterogeneity is not sufficient to affect the macro results, it needs to be combined with frictions. In the absence of idiosyncratic frictions, the model yields the same results as a representative agent model, since firms still share the same policy function. In this case, if we replaced the heterogeneous agents' framework for a representative agent, the result would be compatible with the average per capita values even in the presence of heterogeneity.

When firm-level frictions interact with heterogeneity, the firm optimal decision is influenced by the friction. Using a state-space representation of the economy, macro outcomes (points in the space) are a function of idiosyncratic frictions (states), and so, the macro values respond to changes in the idiosyncratic frictions. In this case, we need to keep track of the states to measure the macro elasticities, and the representative agent is unable to measure the aggregate response to a policy change in the economy.



Note: Values for the discount factor and the capital share are set $\beta = .8$ and $\alpha = 0.3$. The cost for enter is $c^E = 40$ and the exogenous demand curve is $Y(p)^d = {}^{400}/_{p}$. The distribution $\gamma(S)$ is calibrate as the stationary distribution of the AR(1) process $\log s_{t+1} = 0.078 \log \bar{a} + 0.98 \log a_t + \epsilon, \quad \epsilon \sim N(0, 0.53)$, approximate with a Markov chain on 200 nodes.

Figure A.1: Probability Density Functions for the Heterogeneous Firms Model
Source: Own Elaboration (2021)

Appendix B

A TWO-SECTOR MODEL

Preferences: Households choose a sequence of consumption to maximize a lifetime utility function, with discount factor β:

$$\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma} - 1}{1-\sigma}, \qquad \sigma \neq 1, \quad \beta \in (0,1), \tag{B.1}$$

Technology There is a single representative firm that combines low-technology goods and the high-technology goods to produce the final output of y_t. The production function is given by:

$$y_t = \left(y_{h,t}^{\varpi} y_{l,t}^{1-\varpi} \right). \tag{B.2}$$

The production structure of the high-technology and low-technology sectors is standard. Competitive firms operate a Cobb-Douglas technology with capital and an exogenous productivity level a:

$$y_{i,t} = a_i k_{i,t}^{\alpha}, \qquad i \in \{h, l\}, \quad \alpha \in (0,1). \tag{B.3}$$

Capital accumulates according to:

$$k_{h,t+1} - k_{h,t} = i_{h,t}/(1+\psi_h) - \delta k_{h,t}, \tag{B.4}$$

$$k_{l,t+1} - k_{l,t} = i_{l,t}/(1+\psi_l) - \delta k_{l,t}. \tag{B.5}$$

Market clearing: The final output can be either consumed or invested in new capital goods

$$c_t + i_t = y_t, \tag{B.6}$$

and the capital market clears

$$k_t = k_{l,t} + k_{h,t} \tag{B.7}$$

Social planner's problem: The social planner's problem yield the Pareto-optimal allocation in the economy and can be solved as a Lagrangian problem give by:

$$\begin{aligned}\mathcal{L} = \sum_{t=0}^{\infty} \beta^t \Bigg\{ \frac{c_t^{1-\sigma} - 1}{1-\sigma} + \lambda_t \Big[(a_h k_{h,t}^{\alpha})^{\varpi} (a_l k_{l,t}^{\alpha})^{1-\varpi} - c_t - \\ (1+\psi_l)[k_{l,t+1} - (1-\delta)k_{l,t}] - (1+\psi_h)[k_{h,t+1} - (1-\delta)k_{h,t}] \Big] \Bigg\}\end{aligned} \tag{B.8}$$

The Lagrangian yield the following first-order conditions:

$$\frac{\partial \mathcal{L}}{\partial c_t} = 0 \Leftrightarrow c_t^{-\sigma} = \lambda_t \tag{B.9}$$

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial k_{h,t+1} k_{l,t+1}} = 0 \Leftrightarrow [(1+\psi_l) + (1+\psi_h)](-\lambda_t) + \beta E_t \lambda_{t+1} \Big[\varpi a_h^{\varpi} \alpha k_{h,t+1}^{\varpi\alpha - 1} \\ (a_l k_{l,t+1}^{\alpha})^{1-\varpi} + (a_h k_{h,t+1}^{\alpha})^{\varpi} \alpha (1-\varpi) a_l^{1-\varpi} k_{l,t+1}^{\alpha(1-\varpi)-1} + \\ [(1+\psi_h) + (1+\psi_l)](1-\delta) \Big] = 0\end{aligned} \tag{B.10}$$

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial \lambda_t} = 0 \Leftrightarrow (1+\psi_h) k_{h,t+1} + (1+\psi_l) k_{l,t+1} = (a_h k_{h,t})^{\varpi} (a_l k_{l,t})^{1-\varpi} - \\ c_t + (1+\psi_h)(1-\delta) k_{h,t} + (1+\psi_l)(1-\delta) k_{l,t} = 0\end{aligned} \tag{B.11}$$

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial k_{l,t+1}} = 0 \Leftrightarrow (1+\psi_l)\lambda_t + \beta E_t \lambda_{t+1} \Big[(a_h k_{h,t+1}^{\alpha})^{\varpi} \alpha (1-\varpi) a_l^{1-\varpi} k_{l,t+1}^{\alpha(1-\varpi)-1} + \\ (1+\psi_l)(1-\delta) \Big] = 0\end{aligned} \tag{B.12}$$

$$\begin{aligned}\frac{\partial \mathcal{L}}{\partial k_{h,t+1}} = 0 \Leftrightarrow (1+\psi_h)\lambda_t + \beta E_t \lambda_{t+1} \Big[\alpha \varpi a_h^{\varpi} k_{h,t+1}^{\alpha\varpi - 1} (a_l k_{l,t+1}^{\alpha})^{1-\varpi} + \\ (1+\psi_h)(1-\delta) \Big] = 0\end{aligned} \tag{B.13}$$

The equilibrium can be characterized by the Euler equation,

$$
\begin{aligned}
c_t^{-\sigma} =& \beta c_{t+1}^{-\sigma}\left[\frac{\varpi\alpha}{[(1+\psi_h)+(1+\psi_l)]}\frac{y_{t+1}}{k_{h,t+1}}+\right.\\
&\left.\frac{(1-\varpi)\alpha}{[(1+\psi_h)+(1+\psi_l)]}\frac{y_{t+1}}{k_{l,t+1}}+(1-\delta)\right]
\end{aligned}
\tag{B.14}
$$

the economy constraint,

$$
c_t = y_t - (1+\psi_l)[k_{l,t+1}-(1-\delta)k_{l,t}] - (1+\psi_h)[k_{h,t+1}-(1-\delta)k_{h,t}], \tag{B.15}
$$

and

$$
k_{l,t+1} = \left[\left(\frac{(1+\psi_h)}{(1+\psi_l)}\right)\left(\frac{(1-\varpi)}{\varpi}\right)\right]k_{h,t+1}. \tag{B.16}
$$

Steady-State Equilibrium: The steady-state is defined as an equilibrium path in which capital, consumption and output are constant. Equations (B.17)–(B.19) characterize the model's steady-state:

$$
\overline{k_h} = \left\{(a_l^{\varpi}a_h^{1-\varpi})\left[\left(\frac{(1+\psi_h)}{(1+\psi_l)}\right)\left(\frac{(1-\varpi)}{\varpi}\right)\right]^{\alpha(1-\varpi)}\left[\frac{\alpha\varpi}{(1/\beta-1+\delta)(1+\psi_h)}\right]\right\}^{\frac{1}{1-\alpha}} \tag{B.17}
$$

$$
\overline{y} = (a_l^{\varpi}a_h^{1-\varpi})\left[\left(\frac{(1+\psi_h)}{(1+\psi_l)}\right)\left(\frac{(1-\varpi)}{\varpi}\right)\right]^{\alpha(1-\varpi)}\overline{k_h}^{\alpha} \tag{B.18}
$$

$$
\begin{aligned}
\overline{c} =& (a_l^{\varpi}a_h^{1-\varpi})\left[\left(\frac{(1+\psi_h)}{(1+\psi_l)}\right)\left(\frac{(1-\varpi)}{\varpi}\right)\right]\overline{k_h}^{\alpha} - \overline{k_h}\left\{(1+\psi_l)\delta\left[\left(\frac{(1+\psi_h)}{(1+\psi_l)}\right)\right.\right.\\
&\left.\left.\left(\frac{(1-\varpi)}{\varpi}\right)\right]+(1+\psi_h)\delta\right\}
\end{aligned}
\tag{B.19}
$$

B.1 CALIBRATION OF THE TWO-SECTOR MODEL

The parameters are calibrated to match the main features of the Brazilian economy using a quarter as one period. When data is unavailable, I follow the standard parameter values used for Brazil. The parameter δ is set to 0.025, which is consistent with an annual depreciation of capital stock close to 10 percent. Following Castro et al. (2015), the capital share in the production function is set to 0.448, and the risk aversion is $\gamma = 0.63$ as in Gandelman and Hernandez-Murillo (2014). The discount factor is 0.9798, consistent with a yearly interest rate of 8.35%. To calibrate the TFP for the high-technology and low-technology sectors, I use the mapping between firm-level productivity and employment from the undistorted version of the model presented in section 2.4. The relative demand for labor between two distinct firms i and j is given by

$$\frac{n_i}{n_j} = \frac{\left(\frac{s_i \gamma}{w}\right)^{\frac{1}{1-\gamma}} k_i^{\frac{\alpha}{1-\gamma}}}{\left(\frac{s_j \gamma}{w}\right)^{\frac{1}{1-\gamma}} k_i^{\frac{\alpha}{1-\gamma}}} = \frac{\left(\frac{s_i \gamma}{w}\right)^{\frac{1}{1-\gamma}} \left[\left(\frac{\alpha}{r}\right)^{\frac{1-\gamma}{1-\gamma-\alpha}} \left(\frac{\gamma}{w}\right)^{\frac{\gamma}{1-\alpha-\gamma}} s_i^{\frac{1}{1-\alpha-\gamma}}\right]^{\frac{\alpha}{1-\gamma}}}{\left(\frac{s_j \gamma}{w}\right)^{\frac{1}{1-\gamma}} \left[\left(\frac{\alpha}{r}\right)^{\frac{1-\gamma}{1-\gamma-\alpha}} \left(\frac{\gamma}{w}\right)^{\frac{\gamma}{1-\alpha-\gamma}} s_i^{\frac{1}{1-\alpha-\gamma}}\right]^{\frac{\alpha}{1-\gamma}}}$$

$$= \frac{(s_i)^{\frac{1}{1-\gamma}} \left[s_i^{\frac{1}{1-\alpha-\gamma}}\right]^{\frac{\alpha}{1-\gamma}}}{(s_j)^{\frac{1}{1-\gamma}} \left[s_j^{\frac{1}{1-\alpha-\gamma}}\right]^{\frac{\alpha}{1-\gamma}}} = \left(\frac{s_i}{s_j}\right)^{\frac{1}{(1-\gamma-\alpha)}}.$$

I use the 2009 Brazilian firm-level data from World Bank (2009) for the number of employees, which ranges from 1 to 9716, implying an upper-bound of 2.75 for the firm-level productivity, and a lower-bound of 1. Table B.1 summarize the calibrated parameter values for the two-sector model presented in section 2.3.

Parameter	**Distribution**	**Description**
σ	0.63	risk aversion
β	0.9798	discount factor
α	0.399	capital share
δ	0.0125	depreciation rate
a_l	1	low-technology level
a_h	2.75	high-technology level

Table B.1: Calibration of the Two-Sector Model
Source: Own Elaboration (2021)

Appendix C

A MODEL OF INDUSTRY DYNAMICS

Household sector: There is a continuum of households of mass one with identical preferences. The household's lifetime utility is given by:

$$\sum_{t=0}^{\infty} \beta^t u\left(c_t\right), \qquad 0 \leq \beta \geq 1, \quad c > 0, \tag{C.1}$$

where c_t is consumption in period t and β is the discount factor.

Firm-level production technology: Industry is composed of a continuum of firms (measure not necessarily one) which produces a homogeneous good y. In the production, each firm uses capital k and labor n with technology:

$$f(k_t, n_t, s_t) = s_t k_t^{\alpha} n_t^{\gamma}, \quad \alpha, \gamma \in (0,1), \quad 0 < \gamma + \alpha < 1. \tag{C.2}$$

The term $s \in S$ denotes the firm-level idiosyncratic productivity shock that follows a Markov process independent across firms.

Consumer's problem: Households are endowment with one unit of labor each period, k_t^H units of domestic capital, government transfers T_t^G, lump-sum transfers from the financial intermediary T_t^{nfa}, and equal shares of all plants profits, π_t. The household's problem is to choose a sequence (a stochastic process) c_t to maximize the lifetime utility (Equation C.1) subject to the constraint:

$$c_t + k_{t+1}^H - (1-\delta)k_t^H = r_t^H k_t^H + w_t n_t + \pi_t - T_t^G - T_t^{nfa}, \tag{C.3}$$

where p_t is the product price, w_t the wage rate and r_t^H the domestic capital rent.

The household's optimal solution yield the intertemporal optimality conditions for capital accumulation:

$$\frac{u'(c_t)}{\beta u'(c_{t+1})} = (1-\delta) + r^H_{t+1}. \tag{C.4}$$

Problem of an incumbent firm: Firms producing in the current period choose how many workers to hire and how much capital to rent, given its productivity and credit tax. Firms face the exogenous for the productivity and credit subsidy represented by the pair $(s, \psi) = z \in Z = S \times \Psi$, with $s \in S \equiv [\bar{s}, \underline{s}]$ and $\psi \in \Psi \equiv \{0, 1\}$. The exogenous states follow a Markov-chain with transition function Γ mapping from Z to Z.

Taking prices $\{p_t, r_t, w_t\}$ as given, the maximum one period profit function is

$$\pi_t(k, z) = p_t\left(s_t k_t^{\alpha} n_t^{\gamma}\right) - w_t n_t - \left[\psi r^{\psi} + (1-\psi) r_t^{market}\right] k_t - g(k_t, k_{t-1}) \mathbb{1}_{(k_t=0)}, \tag{C.5}$$

where the function $g(k_t, k_{t-1})$ captures the adjustment costs for capital. The rent paid by the firms can be defined by a exogenous subsidized interest rate r^{ψ} (if $\psi = 1$) or by the market interest rate r_t^{market} (if $\psi = 0$). The adjustment-cost function is represented by

$$g(k_t, k_{t-1}) = \begin{cases} \dfrac{a_k}{2}\left[\dfrac{k_t - k_{t-1}}{k_t}\right]^2 & \text{if } k_{t-1} > 0, \\ 0 & \text{if } k_{t-1} = 0. \end{cases} \tag{C.6}$$

Every period, after realizing the productivity and credit tax shock (s_t, ψ_t), each individual firm decides how much to produce by hiring labor and renting capital. Formally, the value of an incumbent firm before drawing the pair of exogenous states z is:

$$W^0(k, z) = p_{\xi} W_{\xi}(k, z) + p_{\eta} W_{\eta}(k, z) + p_X W_X(k, z), \tag{C.7}$$

where $P_{\lambda} = \{p_{\xi}, p_{\eta}, p_X\}$ are the probabilities associates with the three status of exit $\lambda = \{\lambda_{\xi}, \lambda_{\eta}, \lambda_X\} \equiv \{\text{exogenous exit, endogenous exit, no exit}\}$.

After realizing z and the status of exit λ, the value of an incumbent for each λ is:

(i) Exogenous exit (λ_ξ)

$$W^{\xi}(k,z) = \max_{k',n' \geq 0} \left\{ \pi(k',z) \right\}. \tag{C.8}$$

(ii) Endogenous exit (λ_η)

$$W^{\eta}(k,z) = \max_{\substack{\chi \in \{0,1\} \\ k',n' \geq 0}} \left\{ \pi(k',z) + \chi \left[\beta \int W(z,k') d\Gamma(z',z) - \phi \right] \right\}; \tag{C.9}$$

where ϕ is the continuation cost, and χ is the optimal decision to stay ($\chi = 1$) or exit the market ($\chi = 0$).

(iii) No exit (λ_X)

$$W^{X}(k,z) = \max_{k',n' \geq 0} \left\{ \pi(k',z) + \beta \int W(z,k') d\Gamma(z',z) \right\}. \tag{C.10}$$

Problem of an entrant firm: Considering that the value $W(k,z)$ is known, the expected value of a potential entrant can be computed by

$$W^{e} = \int \max_{\bar{e} \in \{0,1\}} \left\{ \bar{e}(z) W(k,z) dG(k,z) - c_e \right\}. \tag{C.11}$$

The decision to enter the market is conditional on the fact that the potential entrant will optimally decide to consider or dismiss engage in production after observing their realized draw of z. The decision to consider engage in production is denote by $\bar{e}(z)$.

If the potential entrant considers engaging in production $\bar{e} = 1$, the next step will be paying a fixed cost c_e to enter the market. Firms only choose to enter if $W^e \geq 0$, and in equilibrium free entry will guarantee that $W^e = 0$.

Distribution of firms: The distribution of active (producing) firms is denoted by μ and evolves as

$$\mu_t(k',z') = \int \int \left[\tilde{\Gamma}(z',z) \right] \mathbb{1}_{[k'=g(k,z)]} d\mu_{t-1}(k,z) + N_t^e G(k',z') \bar{e}(z') \tag{C.12}$$

where N_t^e is the total mass of new entrants firms in t, and $\tilde{\Gamma}(z', z) = p_\xi \Gamma + p_\eta \chi \Gamma$ is the transition matrix for the exogenous states with endogenous and exogenous exit.

Financial Intermediary

There is an intermediary agent that accesses the domestic and foreign capital market - the financial intermediary. The financial intermediary rents capital from the domestic and foreign households and sublet the capital to the firms for a r^{market} interest rate. Assuming perfect capital mobility, the interest rate in small open economy equals fixed world rate $r^\star$, therefore $r^{market} = r^\star$.

The financial intermediary budget constrain is given by,

$$\int\int (1-\psi)(r_t^H - r^\star) k_t d\mu(k,z) + T_t^{nfa} = 0. \tag{C.13}$$

The financial intermediary also sublet the capital for the government. The government offers that capital to the firms for a subsidized rate of r^ψ. The total cost of subsidizing capital paid by the government and given by

$$c(K^\psi) = \int\int \psi(r^\star - r^\psi) k_t d\mu(k,z), \qquad r_t^\star > r^\psi \quad \forall t. \tag{C.14}$$

To ensure that the capital market clear, the financial intermediary holds foreign assets. The net foreign assets are given by

$$K^{nfa} = K_t - K_t^H, \tag{C.15}$$

where K_t^H is the aggregate optimal capital level that firm would choose if the rent rate was r_t^H, $\int\int g_{p,r^H}(z) d\mu_t(k,z)$, and K_t the aggregate optimal capital level that firm effectively choose with r_t^{market} as the interest rate, $\int\int g_{p,r^{market}}(z) d\mu_t(k,z)$.

Equilibrium: A competitive stationary equilibrium for the economy is a set of prices $\{p, r, w\}$, a lump-sum tax T^G, a lump-sum transfer T^{nfa} a set of decision rules $\{W, W_e\}$, policy functions χ', k', n' for individual firms, a mass of entry $^{N^e}/_N$, distribution of firms μ, and aggregate levels of consumption (C) and capital (K). Labor is supplied inelastically and exit is endogenous.

(i) (*Consumer optimization*) $r = 1/\beta - (1-\delta)$.

(ii) (*Firms optimization*) Give prices (p, r, w), the equations $\pi, W^{\xi}, W^{\eta}, W^{X}, W^{e}$ solve incumbent and entering firm's problems.

(iii) (*Free-entry*) $W_e = 0$

(iv) (*Market clearing*)

$$K = \int\int k'(z) d\mu'$$
$$1 = \int\int n'(z) d\mu',$$
$$C + \delta K + N c_f + N_e c_e = p \int\int s k'^{\alpha} n'^{\gamma} d\mu'$$

(v) (*Financial Intermediary budge balance*) $T^{nfa} - \int\int (1-\psi)(r^H - r^{\star})k' d\mu' = 0$;

(vi) (*Government budget balance*) $T^G - \int\int \psi r^{\psi} k' d\mu' = 0$;

(vii) (*Stationary Firms' distribution*)

$$\mu_t(k', z') = \int\int \left[\tilde{\Gamma}(z', z)\right] \mathbb{1}_{[k'=g(k,z)]} d\mu_{t-1}(k, z) + N_t^e G(k', z')\bar{e}(z')$$

C.1 SOLUTION METHOD

In the stationary equilibrium, since there are no aggregate shocks aggregate variables stay constant over time. Therefore, we can normalize the wage to unity without loss of generality. The solution algorithm for the model can be described as:

(1) benchmark with a guess for the product price p_0 and the mass of new entrants N_E;

(2) Solve the Bellman equations (Equations 2.12, 2.14, and 2.13) using the *value function iteration method*; this step include describing the functional form for the return function (Equation 2.10), discretizing the state and control variables, and compute the value function by backward iteration. The solution results in decision rule for capital levels;

(3) Calculate the stationary distribution. In the stationary equilibrium, the mass of entering firms is equal to the mass of exiting firms;

(4) Evaluate the free-entry condition ($W_e = 0$) and the goods market clearing (Equation 2.26) and update the guess for p and N_e ;

(5) Repeat steps (1)–(4) until $|p^{n+1} - p^n| < \epsilon$ and $|N_e^{n+1} - N_e^n| < \epsilon$.

Appendix D

EARMARKED AND NON-EARMARKED INTEREST RATES

As the aim is comprehensive coverage of the interest rate dynamics for earmarked and non-earmarked credit, a proxies measure needs to the 2000s, since the average non-earmarked and earmarked interest rates series start only in 2011.

The proxies adopted for our model calibration are the non-earmarked interest rate for working capital, for the non-earmarked interest rate, and the long-term interest (TJLP) rate with a bank spread, for the earmarked interest rate. In Figure D.1 we can see that the non-earmarked interest rate for working capital is virtually the same thought the 2010s, and the average earmarked interest rate is within the bands for the TJLP with 1.5 and 6 percent bank spread (Figure D.2).

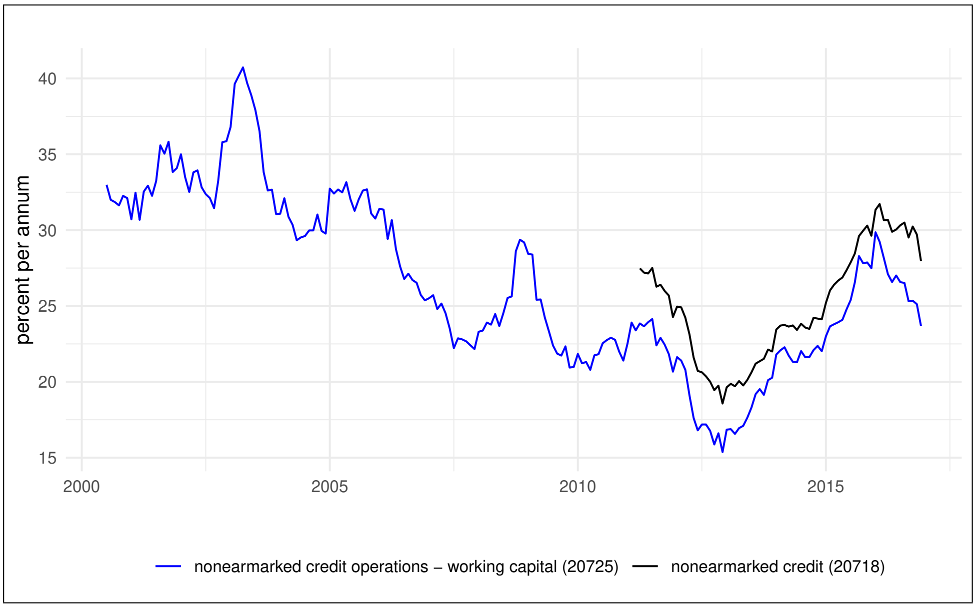


Figure D.1: Non-earmarked Interest Rate for Working Capital and Average Non-earmarked Interest Rate

Source: Central Bank of Brazil (2019)

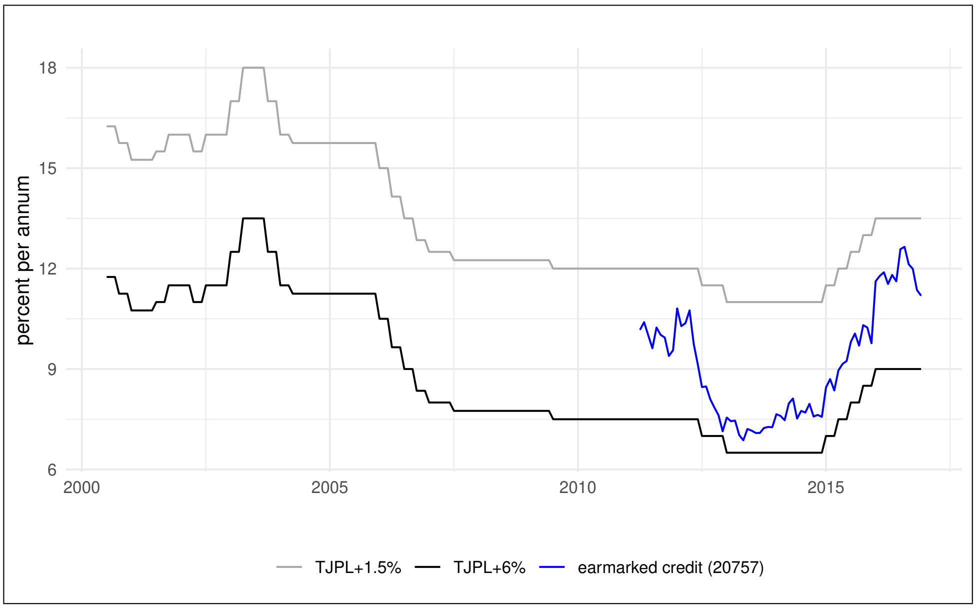


Figure D.2: Long Term Interest Rate and Average Earmarked Interest Rate

Source: Central Bank of Brazil (2019)

Essay 3

THE EVOLVING TRANSMISSION OF GOVERNMENT SUBSIDIZED CREDIT TO GROWTH IN BRAZIL

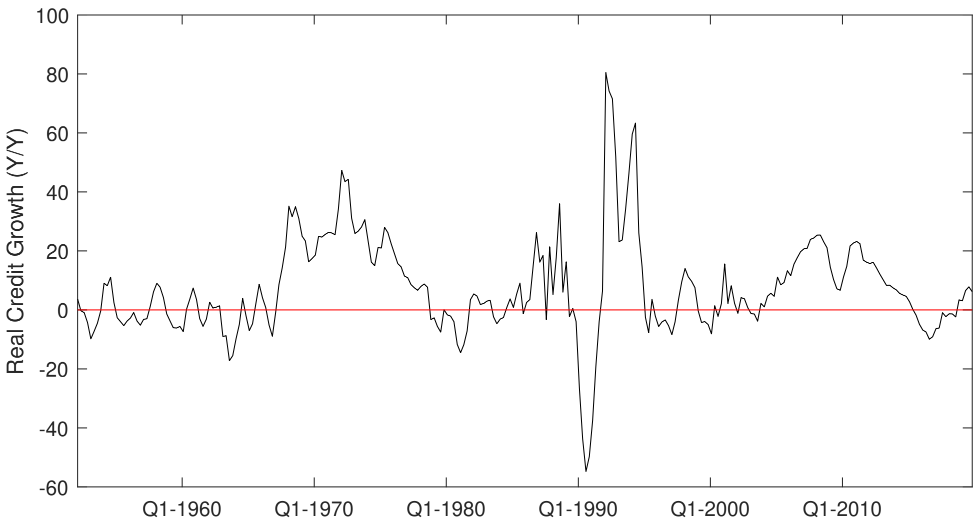
3.1 INTRODUCTION

The long-term effects of target industrial policy have been a subject of vast and controversial empirical and theoretical research since the 1950s. Within that discussion, whether credit allocation and preferential interest rate policies are good or bad for economic development and efficiency also has been long debated in economical circles. One hypothesis is that if we assume that most firms face binding collateral constraints, then the credit subsidizing policy helps them to achieve the optimal level of capital stock. But, when most firms being subsidized are credit unconstrained, subsidies will cause firms with lower productivity that receive the subsidized credit to enter the market, and capital will be reallocated to firms that received the subsidy and the optimal firm sizes will be distorted.

My goal in this essay is to investigate if there is support for the hypothesis that the impact of credit subsidies on growth and productivity is decreasing, or even negative, when the credit access became more widespread. In order to evaluate this hypothesis, I identify and estimate the effects of a credit subsidy shock in the Brazilian economy using a VAR with time-varying parameters and stochastic volatility, estimated with Bayesian simulations.

I use Brazilian data from the late 1950s to 2010s to carry out the empirical analyses, which include three main credit cycles induced by the government, each one with specific measures and a particular structure of the banking sector. Thus, we can infer there were changes in the amount of credit constraint firms. I also exploit the role of the Brazilian Development Bank in Brazil's industrialization process during the 1950s, 1960s, and 1970s, and its ongoing importance in the federal government's investment policy; the bank was the major supplier of long-term financing and corresponds to three-quarters of earmarked credit to firms in 2018 (Byskov, 2019).

Figure 3.1 displays the real credit since 1952. More specifically, it shows the growth rate in the same quarter of the previous year of bank credit to the private non-financial sector (excluding foreign credit and credit from other institutional sectors). The figure shows two long cycles of credit expansion, 1967–1978 and 2004–2014. Note that for the period before 1967 the credit growth rate is less than 15 percent, even though the period is within the first phase of the import-substitution industrialization.



Note: The peaks in 1989 and 1993 are caused by the hyperinflation that afflicted Brazil in the 1980s and early 1990. The valley in the first quarter of 1990 is caused by the Collor plan (March 1990) that set an 18-month freeze on savings accounts of more than $1200, and limited withdrawals from money market funds to $600, or 20% of an account, whichever was greater.

Figure 3.1: Credit to Private non-financial sector from Banks, Percentage change, previous period (1952–2019)

Source: Own elaboration based on Monnet and Puy (2019)

In 1964, the Brazilian government introduced the Plan of Government Economic Action (PAEG), which include a set of financial reforms. Among the measures adopted was a banking reform that segmented the financial system, created Central Bank, and some measures aiming at stimulating capital markets. The development of a private financial system contributed to financing of the economy, however, the long-term firms' financing relied on a combination of self-financing, public credit, and foreign capital (Paula, 2011).

Another important banking sector reform occurred in the mid-1990s. After decades of chronic high inflationary banks had become overly dependent on inflationary gains made on the distorted spreads between the interest and indexation on assets, when the Brazilian economy experienced a successful stabilization, it results in banking distress. To overcome this problem the Brazilian government implemented banking restructuring programs in 1995. The programs aim to stimulate acquisitions of private banks and state-owned banks in trouble, including stimulus to a regulated entrance of foreign banks that would strengthen the domestic financial system. Both banking sector reforms undertaken in Brazil were important for the evolution of the Brazilian bank-based financial system and represented an increased in the supply of credit (Camargo, 2009).

Looking at the volume of subsidized credit, to encompass the diversity of credit subsidies given by the government during the major development programs within a simple and historically consistent metric is no easy matter. That is why I limit the analysis to disbursements of the Brazilian development bank, since the bank is the largest intermediary of earmarked credit and has historical data back to the 1950s, when the bank was created. In the beginning, the Brazilian Development Bank focused on long-term credit for infrastructure projects, but gradually BNDES became a central venue for channeling foreign finance into the industry. Until 1980, BNDES played a fundamental role in financing the Brazilian industrialization process. In 1968, BNDES accounted for four-fifths of industrial lending, and between 1974–1979 its disbursements represented 8 percent of the gross fixed capital formation (Frieden, 1987; Rigolon, 1996; Torres Filho and Costa, 2012). With the revival of industrial policies in the mid-2000s, BNDES was again in the center of policies of development and investment support (Hanley et al., 2016).

My results show that there is no evidence of a statistically significant impact of the subsidized credit shocks on productivity. Thus, I could find no evidence to suggest that an increase in the subsidized credit is responsible for lower aggregate productivity. I also find that credit subsidy shocks lead to a transitory increase in per capita GDP, suggesting that subsidized credit could be indeed considered effective in promoting economic activity. Last, per capita GDP has become less reactive to credit subsidies over the last ten years with respect to the 1950s and 1970s. The results contribute to a potential explanation that once the banking system became more developed, the effects of an expansion in the earmarked credit are more likely to lead to a funding substitution, with earmarked credit taking the place of other capital sources.

The present case study complements a number of empirical studies that attempt to quantify the relationship between economic growth and financial development (see Hassan, Sanchez, and Yu, 2011; Matos and Santos, 2020; Sassi and Gasmi, 2014). The paper also generally relates to a larger literature on the impact of BNDES credit programs. I refer the reader to Hanley et al. (2016) and Barboza et al. (2020)[1] for a comprehensive literature review on BNDES economic impacts.

3.2 HISTORICAL BACKGROUND

The first requirement for a study such as this is to establish an overview of the patterns of state-led development in Brazil. Therefore, I provide a historical description of each cycle of national developments policies, which were divided into three periods: (1) the golden age of import substitution, from 1950 to mid-1960s; (2) the military national developmentalism, from the mid-1970s to 1980; and (3) the new developmental state (*novo desenvolvimentismo*), from late-2000s to mid-2010s.

A common feature in these development projects is the use of BNDES as a tool to promote the industrial sector. Development Banks were a typical feature of developing countries during the rapid industrialization process of the 1950s, but that changed in the 1980s. In the 1980s over 250 state-owned banks were privatized (Torres and Zeidan, 2016), however, BNDES did not share the same fate. The bank survived the wave of privatization and resume its role as a player in the Brazilian development policies in the 2000s, a period of industrial policy revival in Latin America.

3.2.1 The Golden Age of Import Substitution (1930–1964)

Between the 1950s and 1980s, Latin American countries used interventionist industrial policies intending to accelerate their economic development by encouraging domestic industries. This development strategy became known as the import substitution process. Although import substitution policies were used by most developing countries in the early stages of industrialization, large countries, such as Brazil, overemphasized import substitution policies and kept them in place for an extended period. In Brazil, the import substitution started after the Great Depression (1929—39) and continued until the end of the 1970s, with the conclusion of the Second National Development Plan (II PND) in 1979,

[1]Most recent up-to-date survey of BNDES, but available only in Portuguese

that marks the end of the cycle of major state-led development policies in the country.

The import substitution's main objective was economic development, with the overcoming of poverty in the middle and low-income countries. The explanation for the low degree of development in these countries, and their income gap from high-income countries, was generally identified as being caused by the domestic production structure (Bruton, 1998). Among the main objectives of the import substitution development strategy was to reduce the external dependence on the domestic economy, through the creation of an industrial park.

To guarantee the necessary protection, import substitution policies that generated distortions in the allocation of resources within the economy were adopted. The strategy to protect and develop the domestic industrial sector included a set of policies: (i) subsidized credit; (ii) tax advantages; and (iii) high levels of protection for domestic producers. The economic plan for the creation of a complex industrial park was carried out by the State and was supported by the predominance of the developmentalist ideology, which defended a process of growth and structural transformation associated with the industry and with state support (Bielschowsky and Mussi, 2013).

The long-term investment financing for the industrial policies was a combination of self-financing, external capital (bank loans and direct investments), and government credit. Throughout the 1950s–1980s, the credit was mainly provided by the Brazilian public banks, Banco do Brasil and Caixa Economica Federal, and the Brazilian Development Bank, currently know as BNDES [2] (Hermann, 2005).

The origin of BNDES intersects with the disruption of all forms of international commerce and financial flows that occurred between the First and Second World Wars and led to a return to protectionist policies (Hanley et al., 2016). To financing the industrialization process and give preferential credit access to target sectors, the Brazilian development bank was created in 1952 during the second presidency of Getulio Vargas, who had been committed to rapid industrial expansion since his Estado Novo dictatorship (1937-45) (Love, 1990).

The BNDES was a suggestion of the Joint Brazil-United States Economic Develop-

[2]The bank changed its name from BNDE to BNDES in 1982, to emphasize the objective of social development (Decree-Law 1.940 of 25 May 1982)

ment Commission (CMBEU) and aimed to provide long-term funds for heavy industries and infrastructure investment projects. Until 1959, the bank disbursements were directed to freight railroads and energy infrastructure; 41.4 percent of the disbursements were direct to railroads and 26.8 percent to the electric power sector between 1952–1960 (BNDES, 1992; Menezes Barboza, Furtado, and Gabrielli, 2019). The heavy investment in public infrastructure projects last until 1961 and are within a period of high average economic growth (8% per year) and optimism about the Brazilian developmentalist state policies.

After 1961, during an economic slowdown that resulted in negative growth rates of gross fixed capital formation, the bank shifts its aim from infrastructure to the industrial sector. From 1961 to 1965 the disbursements to industry went from 35.3 percent to 96.1 percent of total disbursements, and during the 1960s the weight of industry in the total disbursements reached 70.6 percent (agriculture and services remained receiving fewer resources and the infrastructure plunged its weight in the bank's financing distribution) (Menezes Barboza, Furtado, and Gabrielli, 2019).

March 1964, in the midst of a political turmoil, armed forces overthrew President Joao Goulart. This date marks the end of the developmentalist thought and the beginning of an military developmentalist ideology carry out by the military government, however, note that there is no defined political line throughout military governments (Bielschowsky, 1988). Getulio Vargas second term (1937–1946) and Juscelino Kubitschek's presidency (1956–1961) are the apexes of developmentalism policies in Brazil, and during the 21 years of military dictatorship the only economic plan clearly influenced by the developmentalism thought is the Second National Plan during Ernesto Geisel's presidency (1974–1979).

3.2.2 The Military National Developmentalism (1974-1979)

In 1974, the fourth President under the military dictatorship, launched the Second National Development Plan (II PND), an ambitious program of import substitution with an emphasis on the sectors of capital goods and basic inputs, that last until 1979. The II PND represented a long-term alternative in reducing the country's external dependence and is the last stage of the import substitution process, which has lasted for approximately five decades in Brazil.

The II PND was created as a response to the 1973 oil crisis, which raised the price of a barrel by 78.5 percent from 1972 to 1974 and had a strong impact on the Brazilian economy (in the 1970s Brazil imported 80 percent of the oil consumed domestically). Also, the Brazilian economy was already facing vulnerability caused by the exhaustion of idle capacity. The low industrial capacity utilization rate, which had enabled economic growth with low inflationary pressure during 1968–1972, expanded to 89.75 percent in 1973. Thus, to maintain the high growth rates of the late 1960s and early 1970s with low inflationary pressure was necessary to increase industrial investment.

The plan had two key characteristics, the geographical dispersion of investments, and the importance of state-owned companies in industrial projects. The II PND also resulted in a strong government intervention in the economy not only through state-owned companies but also by financing target projects to private companies. In that context, BNDES financing managed new capitalization of private companies (Brasil, 1974).

Note that in the 1970s BNDES was the only agency that provided long-term financing, which was indispensable to enable the projects within the plan. That resulted in a large increase of the BNDES resources, which grew 21 percent per year between 1974–1979. In comparison, during 1969–1974 the resources grew only 3.6 percent per year. To expand the BNDES' resources, the Federal Government directed the Treasury to increase the bank's available resources and the investments of public funds (PIS/PASEP) have been redirected for funding to BNDES (Prochnik, 1995).

Summarizing some of the economic indicators of the period, the annual output growth, between 1974-1979, was 6.7 percent, reaching the greatest value in 1976 (10.3 percent), and inflation reached the average of 37.8 percent per year. While the investment rate was 22.4 percent and gross external debt grew by more than 400 percent from 1965 to 1975 (Hermann, 2005). Still, the number of II PND projects - Table 3.1 - makes clear the importance of this investment plan. In 1977 the disbursements of the BNDES, that fueled the II PND projects, were equivalent to 11 percent of the gross fixed capital formation.

Despite having a moderate success in reducing the fragility of the Brazilian trade balance, the II PND's projects also demand foreign credit, which was cheap in the mid-1970s. But in the late 1970s that scenario changed, the interest on foreign loans started to generate pressures on the capital account, and that became one of the aspects that are generally pointed out as contributing factors of the 1980s Brazilian crisis. Thus, the

Table 3.1: Economic Indicators (1974-1979)

Year	GDP growth	Investment (%GDP)	II PND projects (number)	Imports (%GDP)	Exports (%GDP)
1974	8.2	21.8	1977	13.3	7.7
1975	5.2	23.3	871	11.0	7.2
1976	10.3	22.4	284	9.4	7.0
1977	4.9	21.3	203	7.9	7.3
1978	5.0	22.3	199	7.9	6.7
1979	6.8	23.4	130	9.3	7.2
(1974–1979)	6.7	22.4	611	9.8	7.2

Boarati (2003) e IBGE/SCN

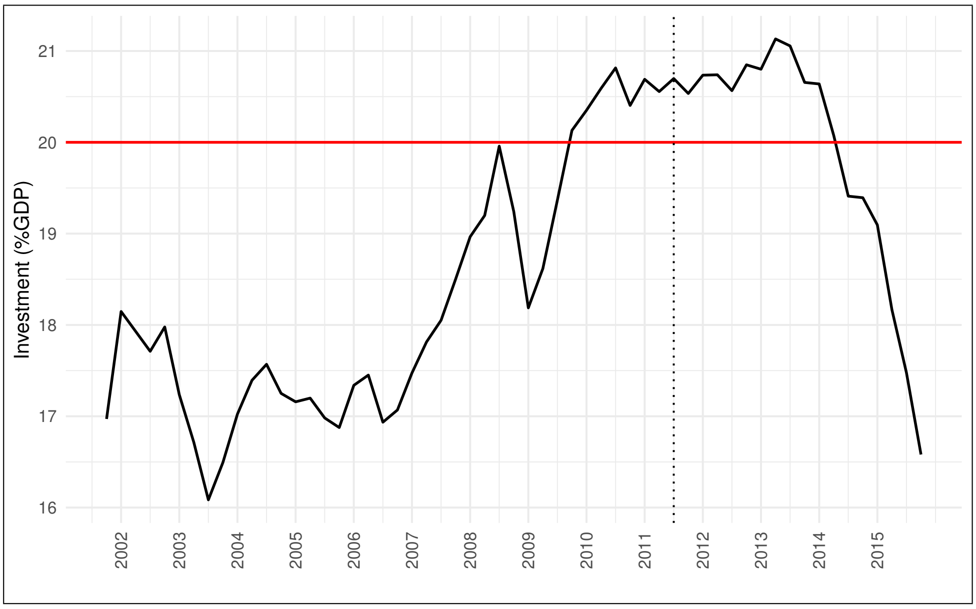
poor economic outlook in the late 1970s, flaws in the policy execution, and changes in the external scenario culminated at the end of the major development plan led by the state in twentieth-century Brazil.

3.2.3 New Developmental State (2008-2015)

The revival of industrial policy in Brazil since the early 2000s, and its deepening after the Global Financial Crisis, had as goals the diversification of the productive structure and foster innovation, however, much of the effort appeared to have focused on vertical industrial policies. These policies promoted traditional sectors and specific companies, as during the import-substitution process, and the adopted measures focused on the technology-intensive sectors in an economy led by medium and low-technology sectors (Almeida, 2009).

The policies included several fiscal benefits to companies selected by the government, such as credit with subsidized interest rates for investments and tax exemptions. Even though the economic slowdown started in the third quarter of 2011, the investment rate remained above 20 percent of GDP from 2010 to 2014, the highest rate since 1995, as a response to the fiscal stimulus and credit market interventions; see Figure 3.2.

At the center of implemented industrial policy was the explicit sectorial protection, which promoted substitution of import goods and fostered inward-looking industrialization growth. Beginning in the early 2000s, we can present three major plans launched to promote industrial development: the Industrial, Technological and Foreign Trade Policy



Note: The dotted line denote the year 2011, the start of the economic slowdown that has culminated in 2014-2015 recession. The red line marks the threshold of 20 percent of investment.

Figure 3.2: Investment (2001Q4–2015Q4)
Source: IBGE, Quarterly National Accounts (2019)

(PITCE), from 2003 to 2007; the Productive Development Policy (PDP), from 2008 to 2010; and the Brasil Maior Plan (PBM), from 2011 to 2014. The two plans launched after 2007 were part of the countercyclical economic measures adopted in the lead-up to the Global Financial Crisis. The PDP measures include tax reduction for investment goods, expanded the special tax regime for small businesses elimination of a payroll tax on employment for labor-intensive sectors (clothing, furniture, footwear, software), tax incentives for the automotive sector, and established a higher state debt limit (Cagnin et al., 2013).

Similarly, most of the PMD measures focus on labor-intensive sectors and the automotive sector. From the 293 measures included in the plan, 77 were directed to the agribusiness, 58 to healthcare and automotive sectors, 27 to the defense and aerospace, 24 to the capital goods sector, 23 for the information technology and electronics sectors, and 17 for renewable-energy industry; the remain measures were distributed between other 12 different sectors (Frassão, 2017). The main goal of the PDP was to bolster national champions in industries that the government considered strategic, such as mining, steel, aerospace, and biofuels. Covering 19 industry sectors, the PBM extended and enhanced the policies adopted in the PDP and PITCE. We can classify the measures implemented by the PBM as systematic, – horizontal measures for trade protection and productivity growth – and vertical – design for specific sectors for councils with selected private-sector members (Menezes-Filho et al., 2014).

Subsidized credit from BNDES was channeled to selected industries and large national companies, which resulted in an increase in the bank disbursements from 1.5 percent of the GDP in 1995–1999 to 3.5 in 2010–2014 (Ayres et al., 2019). To put them in perspective, Italy and France received less than 2.5 of their GDP from the US during the Marshall Plan between 1948–1951 (Crafts et al., 2011). In 2014, BNDES was responsible for lending 73 percent of the total earmarked credit for non-financial corporations, and the use of subsidized Treasury financing increased from 6 percent to 46 of the total sources of the bank from 2007 to 2010 (Torres Filho and Costa, 2012).

In the mid-2010s a sharp fall in commodity prices and slow global economic growth created additional pressure to the Brazilian fiscal imbalance that occurred alongside a political crisis, which further harmed the country's growth prospects. The combination of domestic and external factors lead to a severe economic crisis that lasted until 2016 and resulted in a contraction of 8.6 percent GDP. Between the years 2000-2010, the growth of the Brazilian output per capita was 0.8 percent lower than the world growth, however, the average growth in gross fixed capital formation was 3.1 percent higher in Brazil than in the world.

3.3 CONTRIBUTION OF GOVERNMENT CREDIT TO ECONOMIC GROWTH

3.3.1 Choice of Model

The empirical methodology follows the literature analyzing the evolving interrelationships between multiple macroeconomic variables using time-varying parameter VARs (TVP-VARs) with stochastic volatility, developed by Cogley and Sargent (2005) and Primiceri (2005). For an overview of the empirical applications of TVP-VAR models, see Nakajima (2011).

TVP-VAR models have become increasingly popular in macroeconomic literature because they offer a systematic way of capturing dynamics in multivariate time series. Although TVP-VAR models were first used for monetary policy analyses, the method has broad application. For example, Mumtaz and Zanetti (2015) study the changes in the pattern of behavior in the labor market and Baumeister and Peersman (2013) the changes in the economy's responses to oil shocks.

In order to estimate the impact of subsidized loans on growth, I use a structural VAR(p) model with time-varying coefficients. The benchmark model is defined as

$$\begin{aligned} y_t &= X_t'\beta_t + \varepsilon_t \quad \varepsilon_t \sim N(0, \Omega_t^{-1}) \quad t = p+1, \ldots, T \\ X_t' &= I_n \otimes [1, y_{t-1}', \ldots, y_{t-p}'], \end{aligned} \tag{3.1}$$

where y_t is a matrix of endogenous variables that includes the real GDP growth, productivity and the disbursements of the Brazilian Development Bank as a percentage of gross fixed capital formation.

The covariance matrix of the innovations in the observation equation is an unconditionally heteroskedastic disturbance term that is normally distributed with a zero mean and a Ω_t^{-1} time-varying covariance matrix factored as $\Sigma_t\Sigma_t' = A_t\Omega_t A_t'$. The elements in the time-varying lower triangular matrix A_t are the contemporaneous interactions between the endogenous variables, and the elements in the diagonal matrix Σ_t are the stochastic volatilities. We denote the matrix A_t and Σ_t as:

$$\mathbf{A}_t = \begin{bmatrix} 1 & 0 & 0 & 0 \\ \alpha_{21,t} & 1 & 0 & 0 \\ \alpha_{31,t} & \alpha_{32,t} & 1 & 0 \\ \alpha_{41,t} & \alpha_{42,t} & \alpha_{43,t} & 1 \end{bmatrix} \quad \mathbf{\Sigma}_t = \begin{bmatrix} \sigma_{1,t} & 0 & 0 & 0 \\ 0 & \sigma_{2,t} & 0 & 0 \\ 0 & 0 & \sigma_{3,t} & 0 \\ 0 & 0 & 0 & \sigma_{4,t} \end{bmatrix} \tag{3.2}$$

Following Primiceri (2005) and Nakajima, Kasuya, and Watanabe (2011), the law of motion for the VAR coefficients is given by a random walk process:

$$\beta_t = \beta_{t-1} + u(t), \quad u(t) \sim N(0, Q), \tag{3.3}$$

$$a_t = a_{t-1} + \zeta(t), \quad \zeta(t) \sim N(0, S), \tag{3.4}$$

$$\log \sigma_t = \log \sigma_{t-1} + \eta(t), \quad \eta(t) \sim N(0, W). \tag{3.5}$$

I assume that the coefficients that represent the contemporaneous relations among the variables are independent in each equation, since independent errors simplify the model and increase the efficiency of the estimation algorithm (Primiceri, 2005). The variance-covariance matrix of the model's innovations is represented as a block-diagonal structure given by:

$$\begin{bmatrix} \varepsilon_t \\ u_t \\ \zeta_t \\ \eta_t \end{bmatrix} \sim N \left(0, \begin{bmatrix} I_n & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & W \end{bmatrix} \right), \tag{3.6}$$

where Q, S, and W are positive definite matrices and I_n is a n dimensional identity matrix.

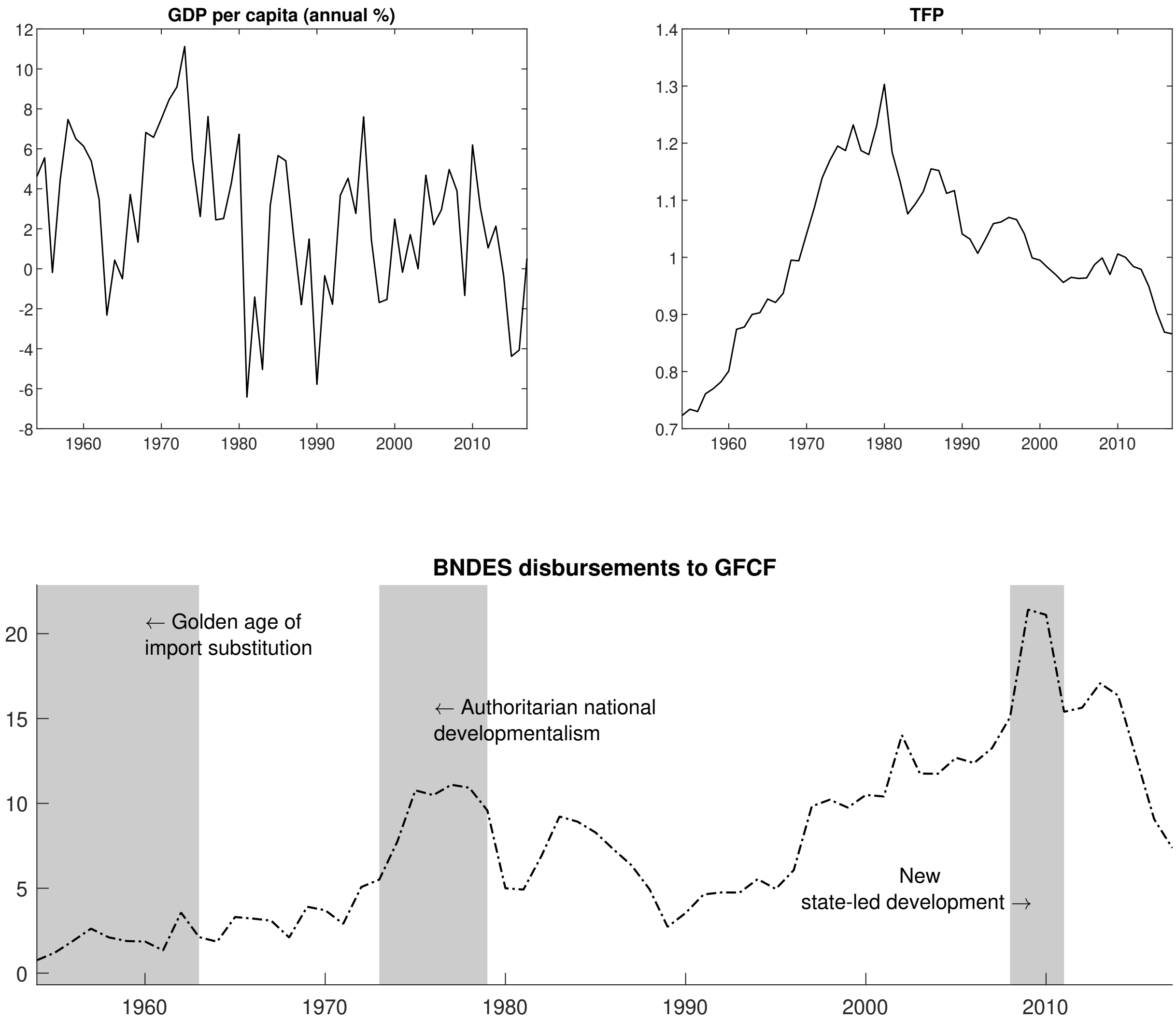
Following Koop and Korobilis (2010), I adopt a Bayesian approach to estimate the model. See section E.2 and section E.1 for details on the sampling method (Gibbs sampling algorithm) and the prior distributions. This approach was chosen for two main reasons. First, with the introduction of stochastic volatility, the model becomes a Gaussian non-linear state-space model, thus, computing the likelihood function of the model using the Kalman filter, as in a homoscedastic model, is not possible. Second, priors are a way to introduce shrinkage to deal with the problem of over-parameterization in VAR models (Canova and Ciccarelli, 2009; Jebabli, Arouri, and Teulon, 2014).

3.3.2 Choice of Metric

Credit subsidies have been standard policy fare for addressing market imperfections in advanced countries, despite questions about capital misallocation and distorted entry decisions; (see Buera, Moll, and Shin, 2013; Hsieh and Klenow, 2009). This feature also applies to Brazil, the historical records suggest that developmental state policies are a recurrent feature of Brazilian government policy during different historical times.

To evaluate the time variation and the potential effects of government-subsidized credit, I compile a dataset of annual time series spanning a period of 1954–2017. GDP per capita and GFCF were sourced from the Barbosa (2020) and Instituto Brasileiro de Geografia e Estatística (IBGE), while data for the productivity is from the Penn

World Table version 9.1, and the BNDES' disbursements are derived from three sources: Barboza et al. (2020), BNDES (1992), and BNDES stats. To interpret the dynamics induced by subsidized credit shocks, I applied the standard recursive approach (Cholesky decomposition) and assume that unexpected variations in the disbursements from the BNDES are exogenous relative to the contemporaneous values of the remaining variables included in the VAR.



Note: Total Factor Productivity is obtained from the Penn World Table 9.1 (PWT) and the annual data on GDP per capita is from Barbosa (2020). The GFCF is from Instituto Brasileiro de Geografia e Estatística (IBGE) and the BNDES series is from BNDES (1992) and Neto (2006). Both series are deflated using the IGP-DI. Shaded areas represent the Golden age of import substitution, the military developmental state, and the new developmental state.

Figure 3.3: Data series used in the TVP-VAR. Brazil, 1954–2017
Source: Own elaboration based on BNDES (1992), Neto (2006), Feenstra, Inklaar, and Timmer (2015) and Barbosa (2020)

The Brazilian macroeconomic data within context is provided in Figure 3.3. The military national developmentalism (that encapsulates the II PND) and the new developmental state (that include economic programs as PBM and PSI) are associated with the increase of the BNDES' disbursements to GFCF ratio. Yet, in the 2010–2014 period the BNDES' disbursements grew more than ever before, reaching 4.3 percent of the GDP in 2010 compared to 1.9 in 1974–1978 and 0.2 in 1952–1956 (Menezes Barboza, Furtado, and Gabrielli, 2019).

Brazil faced two deepest economic declines since the late 1970s, a recession in the early 1980s and another in the mid-2010s. Statistics also show that since the mid-1970s the productivity start deteriorating steadily, therefore a positive association is apparent between the two series. In particular, the GDP growth slump since 1980 is accompanied by a similar collapse of total factor productivity; between 2001–2017, the TFP decrease on average 0.8 percent each year.

3.4 RESULTS AND DISCUSSION

Given the functional form of the model, there is no need to test for structural breaks or unit-roots (see Equation 3.1). I choose a lag length of one based on the SIC criterion applied to a VAR with constant parameters over time.

In my estimation, I use an informative prior (exact specification details are provided in section E.1). To evaluate the robustness of the chosen priors, I present a sensitivity analysis in Appendix F and for approximating the posterior distribution I use the Gibbs sampler algorithm with 200,000 draws and a burn-in period of 40,000.

3.4.1 Volatility and Coefficients

The inclusion of stochastic volatility is used to solve the problem of identifying the source of the shock in the parameters. With a homoscedastic model, the constant variance refers to the average level of volatility for the entire period under analysis, therefore, in the presence of changes in the conditional variance of innovations over time there will be a poor specification of the autoregressive components and imprecision in the covariance matrix. Summarizing the time-varying volatility identifies the structural shock with the appropriate variance of the shock size, contributing to the estimation of the VAR (Nakajima, Kasuya, and Watanabe, 2011).

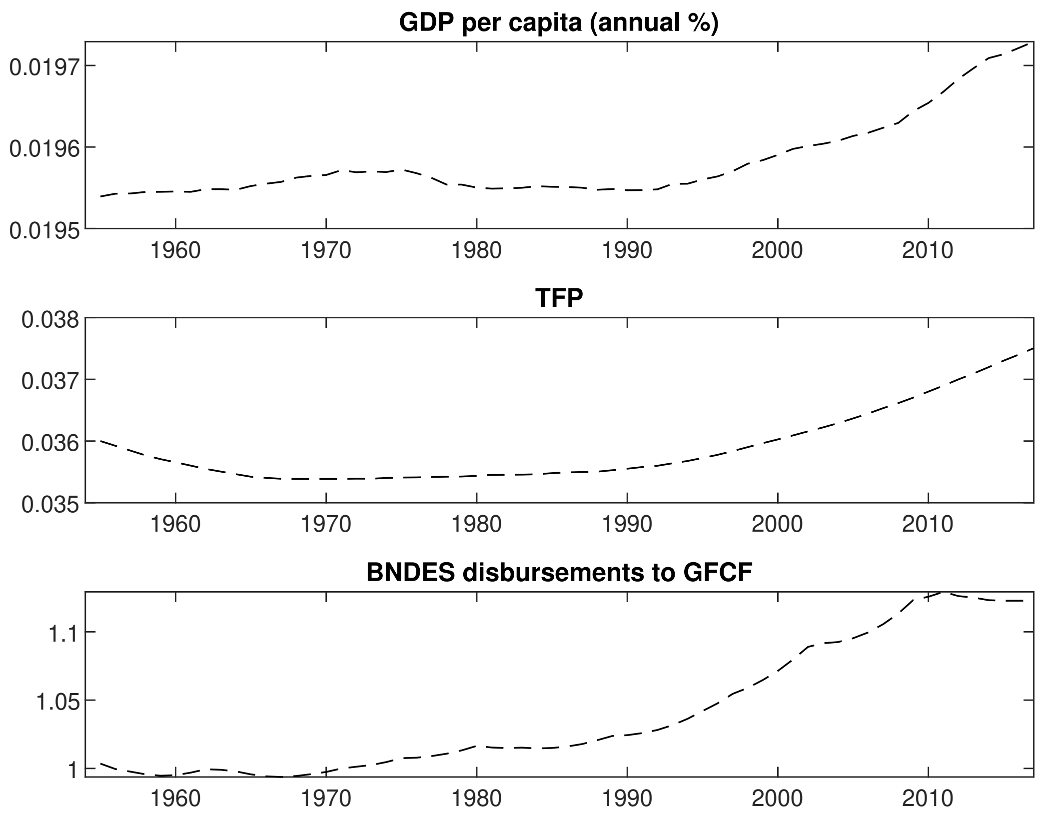
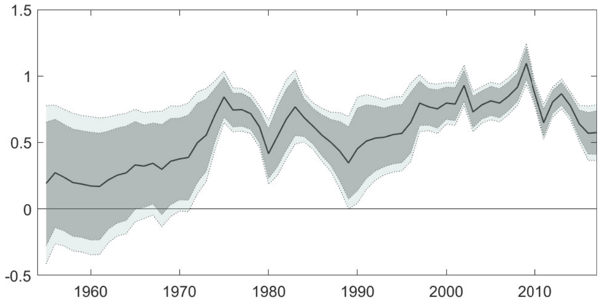


Figure 3.4: Median of Estimated Volatilities for All Variables, 1954–2017
Source: Own elaboration (2021)

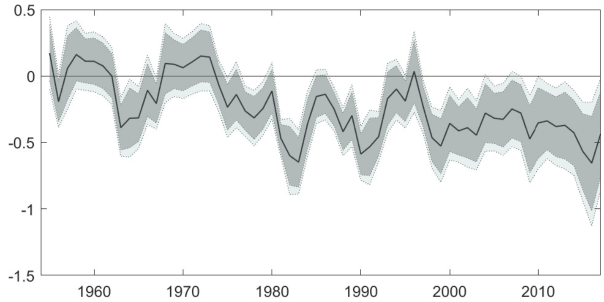
I plot the time-varying series for the estimated volatilities of the structural shocks on my variables based on the median of the posterior draws in Figure 3.4. Initially, we can observe that there is a considerable temporal oscillation in the error variance for the three variables.

The volatility of BNDES' disbursements to GFCF remains at the levels of the mid-1960s until the early 1970s and presents a sharp increase after the 1990s. The increase in the volatility is compatible with the climbing in the BNDES' disbursements since the 1990s; BNDES assumed the role as the major financier of large-scale privatizations in 1990 and was an important tool in the revival of industrial policy in the mid-2000s and early 2010s (John, 2020). By contrast, the volatility of GDP per capita and the TFP remain roughly at the same levels throughout the sample with a slight increase after the 2000s.

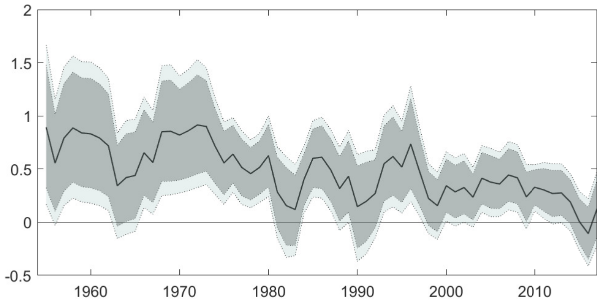
Figure 3.5 shows the selected quantiles of posterior estimates for selected coefficients. I report both posterior median values, 84th–16th and 90th–10th percentiles intervals. Some coefficients change more than others, but even considering the confidence intervals we can observe a significant instability over time in the coefficients. The coefficients drifting



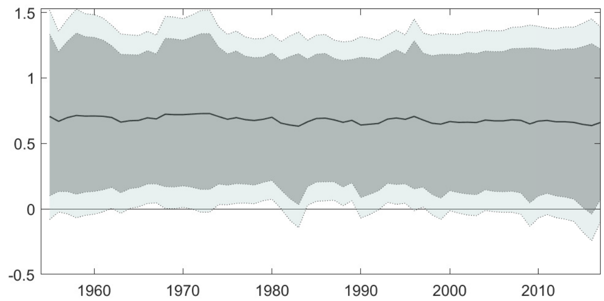
(a) First lag of subsidized credit in the subsidized credit equation



(c) First lag of subsidized credit in the growth equation



(b) First lag of growth in the productivity equation



(d) First lag of subsidized credit in the productivity equation

Note: The solid line indicates the estimated posterior median (50th percentile) and the gray-shaded areas represents the 16th and 84th percentiles (dark grey) and the 10th and 90th percentiles (light grey) of the standard deviation of residuals of the growth (panel a) and productivity (panel b) equations.

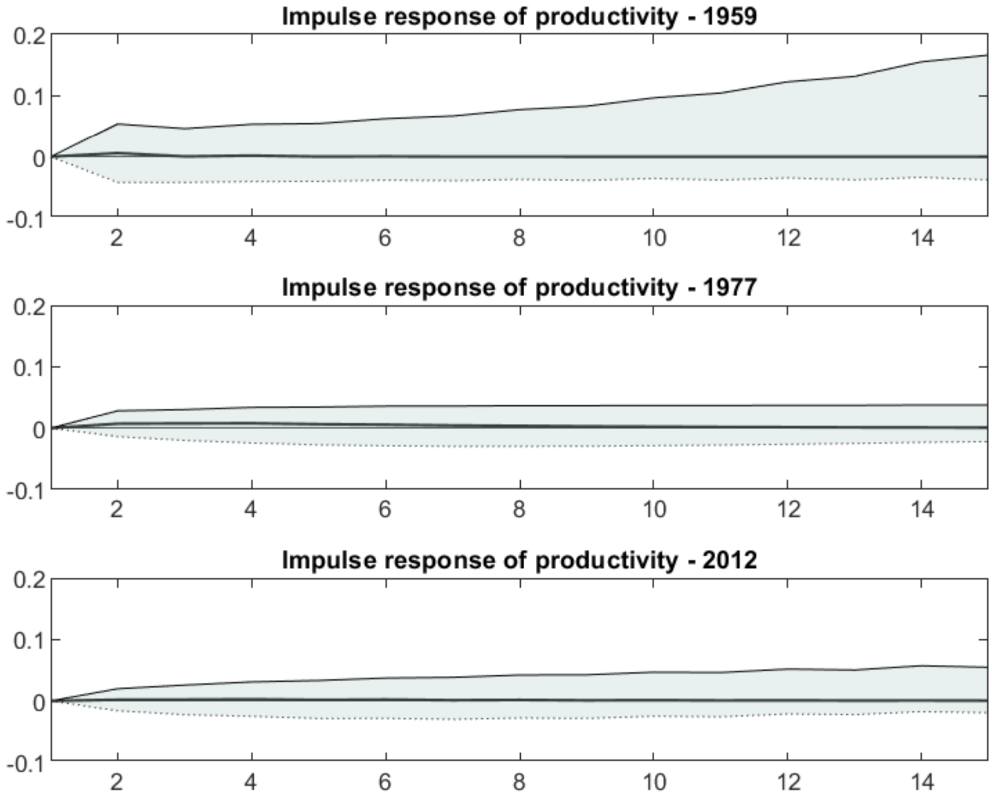
Figure 3.5: Posterior Median for Selected Coefficients
Source: Own Elaboration (2021).

over time can be translated as possible evidence that the dynamic structure among the variables changed over time.

3.4.2 Impulse Response Functions

To investigate the evolution of a structural shock, I examine the response over time of growth and productivity to a change in the credit subsidies. Since the coefficients of the VAR parameters potentially changes at every data point in the case of a TVP-VAR, there is a different impulse-response function for each year. Thus, an additional dimension corresponding to time is added to the impulse-response functions (IRFs), which allows to check responses at different points in time.

Figures 3.6 and 3.7 plot the impulse responses of productivity and growth to a subsidized credit shock in three different dates of the sample with the 16th and 84th

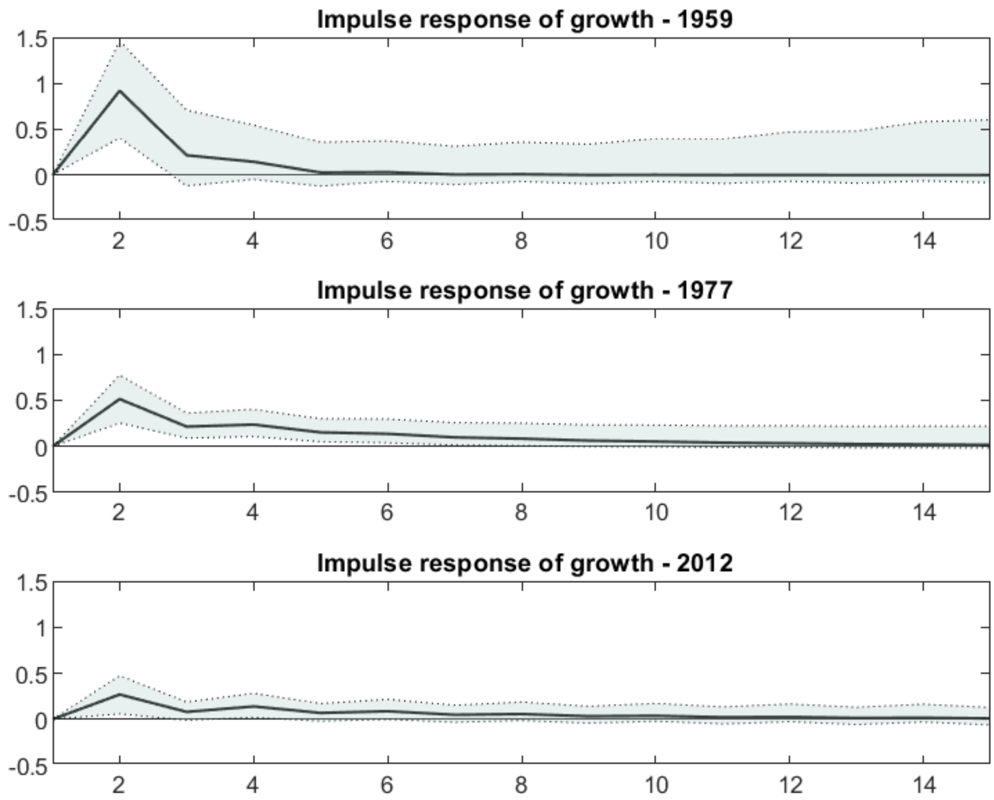


Note: The solid line indicates the estimated posterior median (50th percentile) and the gray-shaded areas represents the 16th and 84th percentiles (light grey) of the standard deviation of residuals.

Figure 3.6: Impulse Responses Functions of Productivity – 1959, 1977 and 2012
Source: Own Elaboration (2021).

percentiles. The dates chosen for the comparison are 1959, 1977, and 2012. They are somehow representative of the main state-led developmental plans implement in Brazil since they all mark the end of the first half of each major development plan, namely, the golden age of import substitution, military national developmentalism, and the new developmental state (*novo desenvolvimentismo*).

Three major findings emerge. The first finding is that there is no evidence of a statistically significant impact of the subsidized credit shocks on productivity. Thus, I could find no evidence to suggest that an increase in the subsidized credit is responsible for lower aggregate productivity. Second, credit subsidy shocks lead to an increase in per capita GDP, suggesting that subsidized credit could be indeed considered effective in promoting economic activity. But, my third finding is that growth has become less reactive to an increase in credit subsidies. According to the IRFs median, a positive subsided



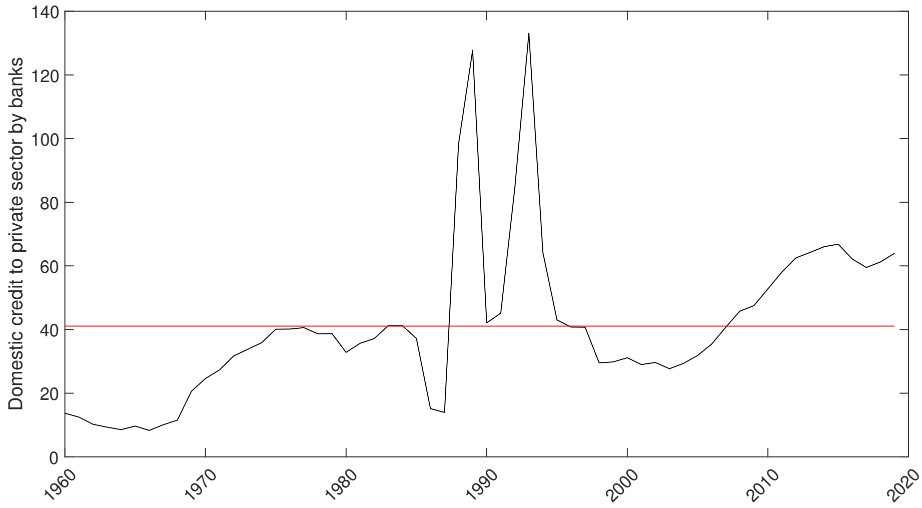
Note: The solid line indicates the estimated posterior median (50th percentile) and the gray-shaded areas represents the 16th and 84th percentiles (light grey) of the standard deviation of residuals.

Figure 3.7: Impulse Responses Functions of Growth – 1959, 1977 and 2012
Source: Own Elaboration (2021).

credit shock leads to a transitory increase of the per capita GDP equal to 0.85 % in 1959 and 0.5% in 1977, by contrast, in 2012 the response is less than 0.3%. This suggests that per capita GDP has become less reactive to credit subsidies over the last ten years with respect to the 1950s and 1970s.

The lack of statistically significant impact of the subsidized credit shocks on productivity implies that I was not able to find evidence of credit misallocation. Also, the low credit-to-GDP in the Brazilian economy is not compatible with the hypotheses that the country reached the point where more banking and more credit are associated with lower growth. Figure 3.1 displays the financial resources provided to the private sector by banks since 1960. The figure shows that overall the credit-to-GDP rate increase throughout the time, however, except from the volatility in the late 1980 and early 1990s, the credit-to-GDP never reached over 80 percent [3].

[3]According to Chong, Mody, and Sandoval (2017) the turning point at which the marginal impact of



Note: The red line is the average domestic credit to private sector by banks during the 1960–2019 period. The valley in the first quarter of 1990 is caused by the Collor plan (March 1990) that set an 18-month freeze on savings accounts of more than $1200, and limited withdrawals from money market funds to $600, or 20% of an account, whichever was greater. The peaks in 1989 and 1993 are caused by the hyperinflation that afflicted Brazil in the 1980s and early 1990.

Figure 3.8: Domestic credit to private sector by banks (% of GDP) (1960–2019)
Source: World Bank Global Financial Development Database (2021)

A plausible hypothesis for the evidence previously presented is that, once the banking system became more developed, the effects of an expansion in the earmarked credit are more likely to lead to a funding substitution, with earmarked credit taking the place of other capital sources. When the earmarked loans are distributed by private banks, banks select larger firms and especially borrowers with an existing credit relationship. Since banks servicing an earmarked loan bear part of their credit risk, they reduce risk by selecting borrowers that are ex-ante less risky. Evidence of this effect is present by Ornelas et al. (2021) that shows that bank connection matters for whether a firm can access earmarked loans.

My evidence is also compatible with Menezes Barboza and Vasconcelos (2019). They show that the Brazilian Development Bank (BNDES) has positive and statistically significant effects on gross fixed capital formation - which would reflect on a higher growth rate. Their evidence also shows a less than 1 to 1 magnitude of the BNDES effect on investment, that some degree of funding substitution could be causing.

finance on growth becomes negative appears around a credit-to-GDP ratio of close to 95%

3.5 CONCLUSIONS

I have reached three main conclusions. First, there is no evidence of a statistically significant impact of the subsidized credit shocks on productivity. Second, credit subsidy shocks lead to a transitory increase in per capita GDP. Last, per capita GDP has become less reactive to credit subsidies over the last ten years with respect to the 50s and 70s.

A plausible hypothesis for the evidence presented in this essay is that, once the banking system became more developed, the effects of an expansion in the earmarked credit are more likely to lead to a funding substitution, with earmarked credit taking the place of other capital sources. But, this essay is not without limitations. Since I had a small data sample my results could reflect the prior specification instead of the data. In addition, more structural analysis is required to distinguish between different factors affecting the transmission mechanism of target credit shocks.

Appendix E

BAYESIAN INFERENCE

E.1 PRIORS

The priors for the initial states of the time-varying parameters β_0, α_0, and h_0 are normally distributed independent from each other and the hyperparameters. I use uninformative priors, thus, no information out of the sample was introduced.

Table E.1 presents the prior choice for parameters and innovations. The priors for the error covariance Q, S, and W follow the inverse-Wishart prior distribution. The degrees of freedom is set to one plus the dimension of the matrix β, α, and h, respectively, and the scale is a fraction of the β, α, and $\log \sigma$ variances in the constant-coefficient VAR. The hyperparameters k_Q, k_S, and k_W specify the uncertainty surrounding the variances of the estimates. In our estimates they are set to $k_Q = 0.01, k_S = 0.1$ e $k_W = 0.01$ that results in diffuse priors (Primiceri, 2005).

Parameter	**Prior**
β_0	$N(0, 4I_{n_\beta})$
l_0	$N(0, 4I_{n_t})$
h_0	$N(\kappa, 4I_{n_h})$
Q	$IW(1 + n_\beta, ((k_Q)^2(1 + n_\beta)I_{n_\beta})$
S	$IW(1 + n_t, ((k_S)^2(1 + n_\beta)I_{n_t})$
W	$IW(1 + n_h, ((k_w)^2)(1 + n_h)I_{n_h})$

[a] where $\kappa = [-8; -6; 1]$, $n_\beta = KM$, $n_\alpha = \frac{M(M-1)}{2}$ $n_\sigma = M$ and e I_m is a $(M \times M)$ identity matrix

Table E.1: Prior Distributions
Source: Own Elaboration (2021)

E.2 GIBBS SAMPLE

I used Gibbs sampling to estimate the model, which is a Markov chain Monte Carlo (MCMC) method for sampling from posterior distributions and computing posterior quantities. Specifically, the Gibbs sampling allows us to simulate the posterior distribution of the parameters of interest given the conditional posteriors, and the data.

The blocks of the Gibbs sampler for the model can be described as:

(1) Initialize A^T, V, and B^T;

(2) Draw the β coefficients from $p\left(B^T|y^T, A^T, \Sigma^T, V\right)$ using the Carter and Kohn (1994) algorithm, and draw the covariance of B^T, Q, from the inverse-Wishart prior;

(3) Draw A^T from $p\left(A^T|y^T, B^T, \Sigma^T, V\right)$, and draw the covariance of A_t, S, from the inverse-Wishart prior;

(4) Draw the VAR covariance matrix Σ^T;

(5) Repeat (2) for $S = 1, \ldots, s$ draws,

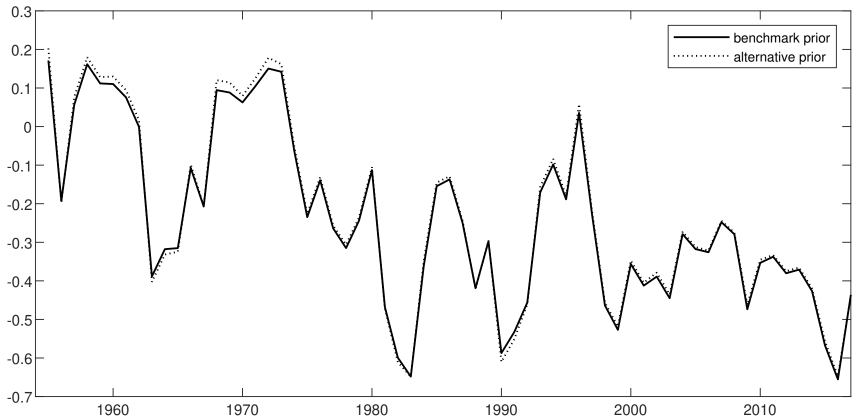
where and V is the variance-covariance matrix presented in Equation 3.6, and $B^T = \{\beta\}_{t=1}^T$ (the same holds for A^T and Σ^T)

For approximating the posterior distribution I draw 500,000 samples with the Gibbs sampler algorithm and a burn-in percentage of 20.

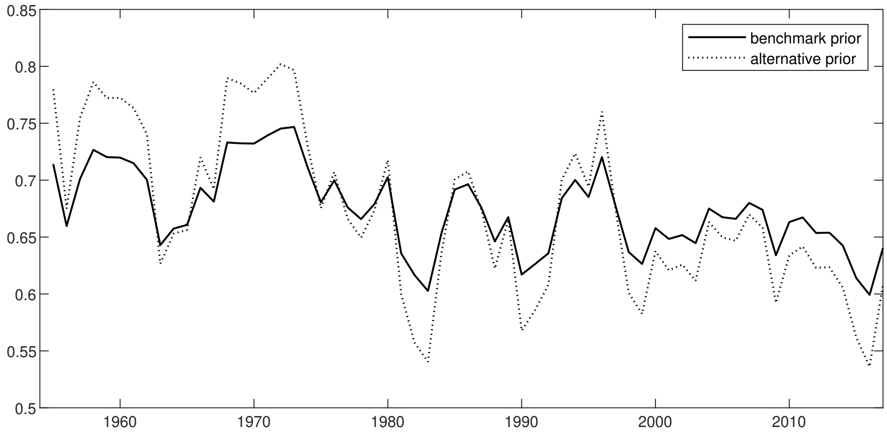
Appendix F

SENSITIVITY ANALYSIS

The sensitivity analysis uses different values for the prior hyperparameters for a robustness check. I selected new values for the two hyperparameters related to the variance-covariance matrix: $k_S = 0.01$, and $k_W = 0.001$. Thus, I consider the estimates for tighter values of S and W. This exercise aims to provide support for the robustness of the results reported in Figure 3.5, Figure 3.7 and Figure 3.6.



(a) First lag of subsidized credit in the growth equation

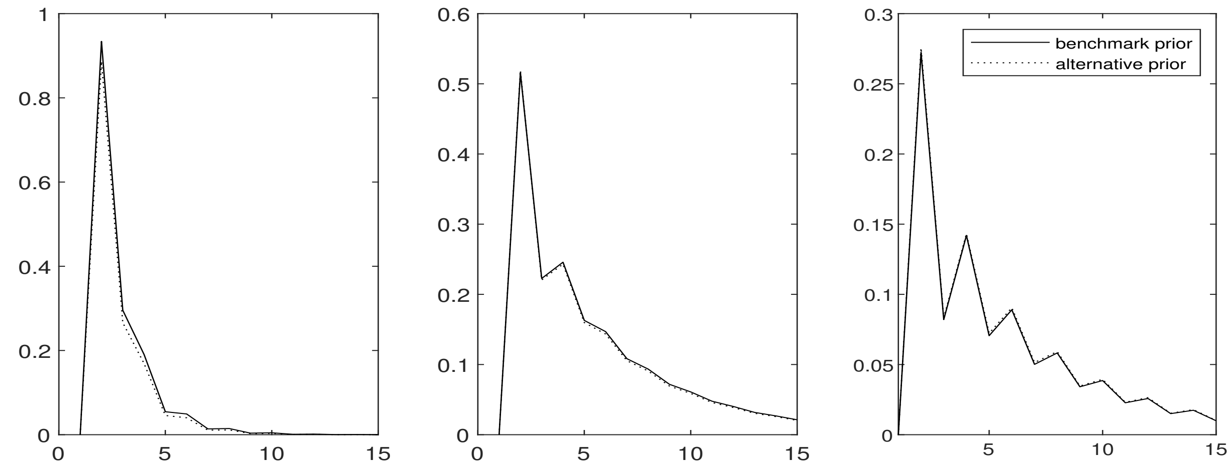


(b) First lag of subsidized credit in the productivity equation

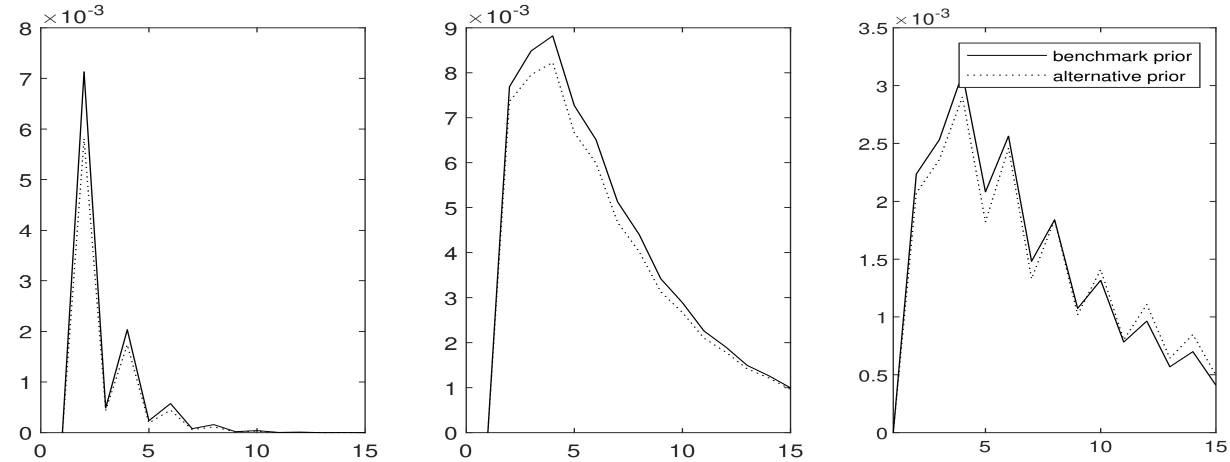
Note: The prior hyperparameters in the variance-covariance matrix of each model are: (i) benchmark prior: $k_Q = 0.1, k_S = 0.1$ and $k_W = 0.01$; (ii) alternative prior: $k_Q = 0.1, k_S = 0.01$ and $k_W = 0.001$.

Figure F.1: Posterior Median for Selected Coefficients (sensitivity analysis)
Source: Own Elaboration (2021).

Figure F.1 shows the impact of the prior specification on the posterior median estimates for selected coefficients. The dotted line represents the estimates for the benchmark prior hyperparameters, and the solid line the estimates for the alternative prior specification. We see in the upper panel that the estimate for the coefficient of the subsidized credit in the growth equation is virtually the same for both specifications. In the bottom panel, the coefficient of the subsidized credit in the productivity equation follows the same dynamic in both specifications, however, the coefficient displays greater amplitude.



(a) Impulse Response of Growth (1959, 1977, 2012)



(b) Impulse Response of TFP (1959, 1977, 2012)

Figure F.2: Impulse Responses to Subsidized Credit Shocks (sensitivity analysis)
Source: Own Elaboration (2021).

To compare the impulse response of a subsidized credit shock to growth and productivity on the models with the benchmark and the alternative prior, I plot individually the impulse response function for 1959, 1977, and 2014 (see Figure F.2). Considering a 15-period horizon, both specifications deliver very similar results. We can spot differences in the initial behavior of the TFP in 1959 that is positive in the benchmark specification and negative in the alternative specification, but before the fifth period both specifications have the same behavior, and in the downfall's magnitude in the TFP in 2014.

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