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Earmarked Credit and Misallocation: Evidence from Brazil

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Earmarked Credit and Misallocation: Evidence from Brazil

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Resumo

Essa dissertação estuda os efeitos de políticas de direcionamento de crédito sobre alocação de recursos na economia brasileira. Esse é um tópico particularmente importante para o Brasil, dado que a proporção do crédito que é direcionada no Brasil é próxima a 40%. As regras de direcionamento provavelmente geram distorções no preço de empréstimos, afetando assim o retorno marginal de fatores entre firmas e entre setores, consequentemente gerando *misallocation* de recursos. Fazendo uso de um modelo de agentes heterogêneos em tempo contínuo, se é capaz de estudar efeitos distributivos de tais políticas e explorar vantagens computacionais na solução do modelo. Calibra-se o modelo usando dados da economia brasileira e estatísticas de microdados de crédito que conectam informações sobre crédito e tamanho de firmas. Adicionalmente, verifica-se como tais políticas de direcionamento de crédito interagem com restrições ao crédito.

Palavras-chaves: Crédito, Direcionamento, Misallocation, Restrições ao crédito.

Abstract

This paper looks at misallocation effects of earmarked credit in the Brazilian Economy. This is a very important topic in Brazil, where the proportion of credit earmarked for specific types of loans reach about 40% of total credit. The earmarking rules are likely to generate distortions in loan's prices, producing differences in marginal returns to inputs across firms and sectors, and therefore misallocation of resources. Using a heterogeneous agents in continuous time model, we are able to study distributional effects of such policies and explore some computational advantages to solve the model. Furthermore, we calibrate such model using Brazilian credit microdata statistics linking firm size and loans. Additionally, we will verify how these earmarked resources interact with credit constraints that are probably present in the Brazilian economy.

Key-words: Earmarked credit, Misallocation, borrowing constraints.

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1 Introduction

This work studies the general equilibrium effects of earmarked credit on the Brazilian economy. By earmarked credit we mean credit subject to legally pre-determined interest rates or legal restrictions regarding types of loans and borrowers. This includes mandatory lending to specific sectors, such as rural credit, or to a subset of households financing specific assets, such as low income families buying housing. Such constraints are likely to generate distortions, and thus misallocation of resources. They also generate impacts on the distribution of firm size, firm level productivity and inequality. Our analysis builds on a dynamic model of entrepreneurship, similar to the models in Buera and Shin (2011), where credit markets are subject to constraints that replicate the Brazilian credit earmarking structure. Literature on misallocation usually considers credit constraints, labor market frictions, or informational failure as main sources of misallocation. This paper considers earmarking credit requirements and credit subsidies as an additional source of misallocation. In our analysis, the presence of earmarked credit interacts with the presence of credit constraints. This is relevant since it is sometimes argued that earmarking rules might be used to help overcoming frictions in the credit markets. Our model is calibrated using data from the literature and from the Brazilian economy, and then solved for the steady state using the innovative approach for dynamic models with heterogeneous agents proposed by Achdou *et al.* (2015).

Earmarked credit is particularly relevant for the Brazilian Economy. In 2013, approximately 43% of Brazilian credit resources were earmarked, with housing loans, rural loans and the national development bank (BNDES) loans, accounting for more than 90% of the earmarked resources available. Additionally, approximately 85% of the earmarked resources are subject to a regulated cap for the interest rates[1]. Thus, it is reasonable to believe that the presence of directed credit have first order effects on Brazilian credit markets. The most obvious effects are the drop in borrowing costs for favored borrowers and the shrink of available resources to lend to the remaining borrowers. Furthermore, the

[1] Data available in Brazilian Central Bank Time Series Management System. For more information about evolution and composition of earmarked credit in Brazil, see Lundberg (2011) (in portuguese). For a general view of Brazilian credit market, see Pinho de Mello and Garcia (2012).

presence of cross-subsidies for earmarked credit probably increases borrowing costs for the remaining of the borrowers in this economy.

Previous work by Souza Sobrinho (2010) and Antunes *et al.* (2012) are closely connected to our main idea. Souza Sobrinho (2010) connects the effects of housing and rural directed lending and reserve requirements to the abnormal Brazilian bank spreads and estimates the welfare loss due to those policies. Antunes *et al.* (2012) focuses on the quantitative effects of the National Development Bank interest rate credit subsides on output, wages, inequality, and government finance. We add to this literature by resembling more closely the Brazilian earmarking rules and looking at effects on the distribution of a large set of variables, such as firm size, productivity, and inequality for heterogeneous agents. The paper also relates with Caballero *et al.* (2008) studies on the consequences of Japanese banking sector behavior of continuous borrowing to insolvent firms, which sustains unproductive firms and thus distorts the market.

Our paper is closely related to the literature on capital taxes with financial frictions on a heterogeneous agents setting, as Chen *et al.* (2015) and Itskhoky and Moll (2014). Nonetheless, the goal of this work is not to find the optimal policy, but to evaluate how Brazilian credit markets are affected by such policy as it is done and work some counterfactual exercises in order to get information that might be useful for future policy.

Our work does not account for possible externalities and its relationship to credit policies. Therefore, we consider our work complemental to Bonomo *et al.* (2014), in which the authors show that earmarked credit has been particularly important for sectors identified as intensive in social externalities. Nevetheles, the authors also show that those sectors were not the main beneficiaries of the strong expansion in earmarked credit observed after 2008.

We also refrain from accounting political economic issues on the subject. There is a growing literature on the subject, especially regarding government owned banks[2]. For instance, Carvalho (2014) and Leão (2011) study the political determinants of earmarked credit in the Brazilian case.

[2] La Porta *et al.*, Dinć (2005), Cornett *et al.* (2010) are some examples

Our paper has three main contributions to the literature. The first is to account for all the main types of earmarked credit (BNDES, rural credit and housing credit) in a general equilibrium model. The second is to connect the earmarking policies with firm size distribution, aggregate productivity, savings behavior and inequality. The third is take advantage of the new literature on heterogeneous agents models in continuous time, which has computational advantages [3].

We augmented an Aiyagari model in continuous time (as in Achdou *et al.* (2015)) with borrowing constraints and with occupational choice as in Lucas (1978) span of control model (similar to Buera and Shin (2011)) and study how equilibrium outcomes change with the introduction of an earmarked credit policies. For the sake of simplicity, we introduce earmarking requirements as a set of rules over the banking sector that states that fractions of the aggregate deposits must be allocated for two specific uses: i) productive earmarked loans, which are subsidized capital loans given only to some eligible favored firms; and ii) earmarked housing subsidies, which all individuals may have access. The main idea of this model is to create an economy composed by a continuum of entrepreneurs which must choose between opening a firm and collect profits or work for a wage, and this choice is modeled to depend on each individual wealth, business plan quality (which could be understood as a set of skills) and access to earmarked credit.

Our model intuition is as follows: whether there are no credit frictions, the first welfare theorem holds and the equilibrium allocation is Pareto optimal. Whereas, if there are credit frictions, resources will not flow perfectly between less productive individuals to the more productive ones. Consequently, even among the highest productive individuals, there will be some that will choose to become entrepreneurs and will operate below their optimal firm size, and there will be some that, with sufficiently low wealth levels, will prefer to become workers.

In such economy, if constrained individuals have access to low cost credit, this will

[3] Such advantages include the use of sparse matrices which arise due to the fact that the system of equations that characterize this economy is entirely based on infinitesimal changes, that the borrowing constraint never binds in the interior of the state space, which guarantees that the wealth distributions has no spikes in the interior of the state space, and that first order conditions aways hold with equality and can be solved easily.

help them to foster their wealth accumulation, and thus overcome such limitation. Therefore, a policy that grants lower interest rates to high-productivity constrained individuals might improve the allocation of resources.

However, we also consider two side effects that such policy might generate which would hurt the economy: i) if the policy generates cross subsidy, it might be the case that some individuals that would choose to be entrepreneurs in the absence of such policy would leave the market not only due to congestion, but also due to the higher costs of capital; and ii) if the policy fails to target the high productivity entrepreneurs which are financially constrained or if it is not easily adjusted over time, then the reallocation of resources might not improve the aggregate productivity (as in Buera, Moll and Shin (2013) and Antunes *et al.* (2012)).

Our numerical exercises indicate that earmarked rules have a relatively small negative effect on the total factor productivity (about 2.3%). Not surprisingly, requirements regarding credit for production have a higher effect on total factor productivity than those regarding housing credit. Earmarking rules have a negative effect on both income and wealth inequality (the gini index increases by 0.02 and 0.04, respectively). They are also found to produce a sharp decrease of about 20% on capital demand and to increase bank spreads by about 3.9%. They also have a negative effect on the average size of firms (despite increasing the average size of firms benefiting from earmarked credit).

2 Earmarked Credit Policies in Brazil

The earmarking rules in Brazil are mainly characterized by three components: the sources of resources, the obligatory use and the maximum interest rate that a bank might charge. For example, a rule may say that X% of each bank total deposits in savings accounts might be used to be invested in sanitation at maximum interest rate of Y% per year. In such case, if the bank fails to address such requirements and only loans a smaller amount Z% of its total savings to this given use charging under the cap Y%, then the remaining amount (X-Z)% should be deposited by the bank in a Brazilian Central Bank account, which would earn a relatively low interest rate. Moreover, such failure would also make the bank face financial penalties. Nevertheless, evidence suggests that banks do observe the regulations: between January 2010 and December 2015, the average amount of resources that failed to be allocated as earmarked credit was about 0.03% of the total earmarked credit[1].

Between 2010 and 2015, approximately 42% of Brazilian credit resources were earmarked. Moreover, this period was marked by a fast expansion of earmarked credit, which went from 34% of total credit in 2010 to 49% in 2015. In fact, if we look at Table 1, we can see that, since 2008, the growth rate of such kind of credit was bigger than the free allocated credit growth rate.

Another important fact about earmarked credit in Brazil is that the majority of credit interest rates charged were regulated, having a cap. Specifically, between 2010 and 2015, regulated interest rates were used on 86% of the total earmarked credit. Opposing the evolution of earmarked credit, this ratio appears to be constant throughout the years of our sample[2].

Almost all earmarked credit comes through three main institutions: the national development bank (BNDES), the Rural Credit National System (SNCR) and the Housing National System (SNH). These institutions, combined, are responsible for lending 94% of the total credit that was earmarked between January 2010 and December 2015. Moreover,

[1] Source: Brazilian Central Bank Time Series Management System
[2] Data available in Brazilian Central Bank Time Series Management System.

Table 1 – Earmarked Credit Descriptive Statistics (2007-2015)

Table 1 - Earmarked Credit Desciptive Statistics (2007-2015)

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Credit growth rate (%)									
Total	-	22,77	14,43	13,09	12,15	11,33	9,05	5,65	0,47
Free allocated	-	27,02	10,54	7,73	10,09	9,09	3,46	-0,59	-3,89
Earmarked Credit	-	14,68	22,62	23,29	15,57	14,86	17,44	13,9	5,52
Earmarked credit									
Earmarked credit as a fraction of total credit	34%	32%	34%	38%	39%	40%	43%	46%	49%
Earmarked credit with regulated rates	82%	83%	85%	87%	87%	87%	86%	85%	85%
Earmarked credit decomposition									
BNDES	49%	50%	52%	54%	53%	50%	47%	45%	44%
Real estate/ Housing	15%	16%	19%	22%	26%	30%	32%	34%	36%
Rural	24%	23%	20%	17%	15%	15%	15%	16%	15%
Microcredit	0,4%	0,4%	0,3%	0,4%	0,3%	0,4%	0,4%	0,4%	0,4%
Others	12%	10%	8%	7%	5%	5%	6%	6%	6%
	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Brazilian Central Bank Time Series Management System (Public Module)

together they represented, on average, 40% of the total credit outstanding for such period. The relative weight of each of those earmarked credit channels might be seen in Table 1.

The resources used for such loans are received by a multitude of sources[3] and most of those resources have in common the fact that they have relatively low financial costs. Nonetheless, this low financial cost usually is also the result of governmental regulation, as it will be described below.

The national development bank uses mostly resources from i) national fund based on worker's compulsory savings collected as payroll taxes; and ii) direct transfers from the government[4]. This institution is, alone, responsible for more than 20% of the total credit outstanding. The financial cost of those resources is almost entirely based on the inflation target plus a risk premium, although between 2011 and 2015, there was no year which this measurement was above the inflation, thus the real cost was negative during most of this period, imposing a burden on workers and on the National Treasury.

[3] Nevertheless, usually only one or two sources are responsible for the majority of the resources received by each of these institutions.

[4] Respectively, an average of $27,4\%$ and 53% of its resources between 2010 and 2015

The bank usually charges very low interest rates (although they might be different depending on the resources used and borrower characteristics) and uses its resources mostly to finance business projects over R$20 million[5] and very small business seeking to buy capital goods. Despite the fact that a fraction of such resources is directly lend by the national development bank to firms, much of those resources are indirectly lend by commercial banks. In such cases, the commercial bank is responsible to screen the borrowers and holds the credit risk. On the other hand, once the loan is approved, the national development bank transfer the funds to the commercial bank, therefore the commercial bank do not need to use its resources on those operations.

The resources directed to the Rural Credit National System are mostly from the resources deposited in banks checking accounts, which has 34% of its balance earmarked to rural credit. Additionally, 68% of the total amount deposited in savings accounts in most federal public banks is earmarked to rural credit. The checking accounts funds have no financial costs but the opportunity cost of lending on market interest rates, while the savings accounts funds have the regular savings interest rate as its financial cost. These resources are mostly used to foster investment in agricultural business, but part of these resources must be lent to small scale agricultural production units. Since there is a myriad of programs to foster rural credit, there is not a unique cap on interest rates, but the average interest rate charged for rural loans from earmarked resources is well below the free market interest rate, as indicated by Figure 1.

The Housing National System resources are from i) 65% of the total amount deposited savings accounts in each bank[6] and ii) a share of payroll taxes. While the savings deposits have the financial costs equal savings returns, payroll taxes have financial cost set as at least 3% per year less then the savings returns.

The earmarked housing loans differ from the other types of directed credit because they are mostly used to foster low income people housing consumption, thus affecting indirectly firms in such market. Despite such focus on low income and limited housing

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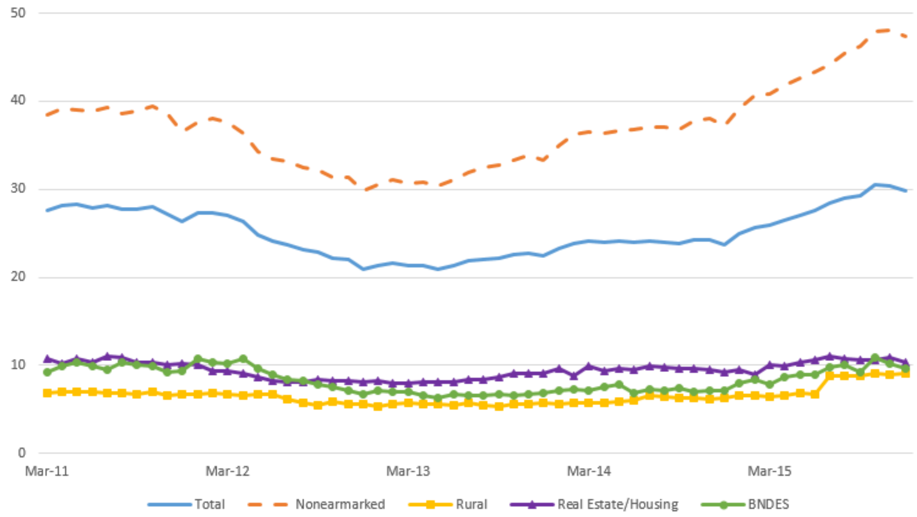
[5] About US$6 million.
[6] Except federal public owned banks.

Figure 1 – Average nominal interest rates (%)



value, the earmarked housing credit accounts for more than 85% of total housing credit. Roughly described, the policy is designed in a way that anyone that is buying a house under a regionally fixed cap value and has an income under a fixed cap may apply for a subsidized credit. Additionally, although not every loan has a regulated cap on interest rate, most of them have it and, again, the average interest rate charged is below the free market rate, as we can see in Figure 1.

3 The Model

We augment an Aiyagari-type model in continuous time (as in Achdou *et al.* 2015) with borrowing constraints as Evans and Jovanovic (1989) and with occupational choice as in Lucas (1978) and study how equilibrium outcomes change with the introduction of earmarked credit policies. In order to do so, we translate the myriad of requirements that exist in real world in two simpler requirements that we believe capture all main features of such policies which will be explained in detail below.

Also, as previously mentioned, there are two main differences between freely allocated and earmarked credit. The first difference is that productive earmarked loans have a fixed interest rate which is smaller than the deposits returns, $R_s < r$, while the regular loans have an interest rate given by the market. The second difference concerns the origin of its resources. Earmarked credit resources are a fraction ω of S, the total deposits in the economy. The parameter ω is given by the data and includes not only the requirements that banks face, but also the amount of workers compulsory savings used. On the other hand, the freely allocated credit resources are the residual deposits that are not earmarked, $(1-\omega)S$.

The earmarked credit is used in two different ways: while a share of the earmarked resources is used as directed loans to entrepreneurs (productive earmarked loans), the remaining resources will be used to cover subsidies costs in the housing market (earmarked housing subsidies). The fraction of earmarked credit used as earmarked housing subsidies is given by ω_h and it generates an *ad valorem* subsidy over housing consumption.

Since the goal of our paper is to look on productive effects of earmarked credit policies and the channel that concern us about earmarked housing credit is not housing consumption, but savings decisions, for the sake of simplicity, we will allow all agents in this economy to receive earmarked housing subsidies.

The details of the model are as follows: there is a continuum of infinitely lived individuals, who are heterogeneous in their wealth a, the quality of their entrepreneurial talent z, and about being (or not) receivers of productive earmarked credit. While wealth is determined by forward looking behaviour, both talent and being (or not being) receiver of productive earmarked credit are stochastic process. In particular, receiving productive earmarked credit is a two-stage Poisson process $s \in \{0, 1\}$ in which each individual is assigned a value and, if $s = 1$, the individual is a recipient. The process jumps from 0 to 1 with intensity ϕ_0 and from 1 to 0 with intensity ϕ_1 and (ϕ_0, ϕ_1) are chosen as to have always a constant share of individuals in each state. Additionally, since the price of the productive earmarked credit is fixed, the share of people under $s = 1$, which is given implicitly by ϕ_0 and ϕ_1, is such as the demand of capital of these individuals is equal to the total amount of earmarked resources allocated to be used as productive earmarked credit.

The talent process is a stationary Ornstein-Uhlenbeck diffusion process on a bounded interval $[\underline{z}, \overline{z}]$ evolving according to:

$$dz_t = \mu(z_t)dt + \sigma(z_t)dW_t \tag{3.1}$$

in which W_t is a standard Brownian motion with drift μ and diffusion σ. Thus, the state of the economy is given by the joint distribution of a, z, and s, $\Gamma(a, z, s)$.

Since all the values linked to governmental activity are considered exogenous, the government in our economy is not truly an agent, but a set of rules and some exogenous variables values such as: R_s, the interest rate of directed loans; ω, the earmarked share S; and ω_h, the share of S that is earmarked specifically to be used as earmarked housing subsidies.

Individuals' preferences are described by the following expected utility function over sequence of consumption:

$$U(c) = \mathbb{E}_0 \int_{t=0}^{\infty} e^{-\rho} u(c(t), h(t))dt \tag{3.2}$$

where ρ is rate of time preference and $u(c(t), h(t))$ is a strict concave function in which $c(t)$ is the consumption of goods and $h(t)$ is the housing consumption[1].

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[1] Some straightforward functional forms to $u(c(t), h(t))$ are a CRRA utility function with a CES agregator (as in Buera *et al.* (2011)), a CRRA utility with a Cobb-Douglas function aggregating the consumption goods, or a sum of two CRRA's utilities function: $u(c, h) = \frac{c^{1-\sigma}-1}{1-\sigma} + \psi \frac{h^{1-\sigma}-1}{1-\sigma}$). Our

At each point in time, individuals choose their occupation: whether to work for a wage or to become an entrepreneur and collect profits from a business. Their occupational choice is based on their comparative advantage as an entrepreneur (z and s) and their access to capital, which is limited by their wealth through a collateral constraint. There is no market for managers or entrepreneurial talent.

Individuals who choose to be workers receive a wage proportional to their talent $w(z)$. On the other hand, individuals who choose to be entrepreneurs start a firm that produces the consumption goods c. The production function of an entrepreneur with talent z, who uses capital (k) and labor (l), is:

$$zf(k,l) = z(k^{\alpha}l^{1-\alpha})^{\theta}$$

where α and θ are the elasticities of output with respect to capital and labor. The span of control feature of the model translates into entrepreneurs set of skills becoming gradually limited over larger projects, which means that $\theta < 1$. Entrepreneurs also pay for the depreciation of the capital. Therefore, the profit function is:

$$\pi(k,l;R,R_s,w,p_c,s) = p_c z(k^{\alpha}l^{1-\alpha})^{\theta} - wl - [(1-s)R + sR_s + \delta]k \tag{3.3}$$

where R is the free rental rate of capital, p_c is normalized to one and δ is the depreciation. The unconstrained optimum k and l choices is:

$$(k^u(z,s), l^u(z,s)) = \underset{k,l}{\operatorname{argmax}}\{z(k^{\alpha}l^{1-\alpha})^{\theta} - wl - [(1-s)R + sR_s]k\} \tag{3.4}$$

Nonetheless, every entrepreneur faces a borrowing constraint as in Evans and Jovanovic (1989):

$$k \leq \lambda a \qquad \lambda > 1 \tag{3.5}$$

which may be a constraint to achieve $(k^u(z,s), l^u(z,s))$.

Entrepreneurs have access to competitive financial intermediaries. These intermediaries receive deposits - for which the financial cost is r - and rent capital k to entrepreneurs. They also have the technology to transform each unity of consumption goods in one unit

quantitavive exercises use the third option.

of housing goods at no cost. Earmarking rules states that a fraction ω of the total capital must be earmarked. This fraction can be decomposed in two other fractions, ω_k, which is the fraction of S that is supposed to be lent at rate R_s to the subset of the population with $s = 1$; and ω_h, which is the fraction of S that is directed to cover the housing subsidy policy cost. The remaining capital can be freely allocated at the market rate R. In order to be able to replicate the large spread observed in Brazilian economy, which we believe plays a role in the misallocation results, we introduce also a reserve requirement ω_r that banks must obey[2].

Also, it is assumed that entrepreneurs may not renegade on the contracts and that banks follow the earmarked policies. Thus, the zero profit condition of intermediaries also implies:

$$r = (1 - \omega_r - \omega)R + \omega(\omega_k)R_s \tag{3.6}$$

and

$$p_h = 1 - \frac{r\omega_h S}{\int h d\Gamma(a, z, s)} \tag{3.7}$$

While the first equation represents that banks revenues must equal its cost, the second equation stands that the housing price must be such that the total expenditure on housing must equal the total cost that a bank faces minus the subsidy on housing.

We can summarize the individual problem as:

$$\max_{(c_t, h_t)} \mathbb{E}_0 \int_{t=0}^{\infty} e^{-\rho} u(c_t, h_t) dt \tag{3.8}$$

subject to

$$M(a, z, s) = \max\{w, \pi(a, z, s)\}$$

$$dz_t = \mu(z_t)dt + \sigma(z_t)dW_t$$

$$da_t = M(a, z, s) + r_t a_t - c_t - p_h h$$

2 For the sake of simplicity, we normalize the reserves interest rate as zero.

$$k \leq \lambda a$$

The individual problem constraints are, respectively, the occupational choice income, the talent stochastic evolution, the wealth evolution and the borrowing constraint. While most of those equations are quite similar to their discrete time counterparts, the talent stochastic evolution equation is quite unique to the continuous time setting.

We modeled the talent evolution such as $d(ln(z))$ follows a Ornstein–Uhlenbeck process, which is the AR(1) equivalent for continuous time[3]. This choice implies that $d(ln(z))$ has a Gaussian Distribution on the steady state[4] and, thus, dz has a log-normal distribution on the steady state. Additionally, from $d(ln(z))$ equation we apply Ito's Lemma to get a solution to dz.

The model accounts for the interaction of an infinity of heterogeneous agents and each action of an individual, to whom prices are taken as given, may affect the distribution of individuals and so other agents actions. Our choice of modelling the problem in continuous time set up allow us to express the individual problem stationary solution with just a system of coupled equations: a Hamilton-Jacobi-Bellman to account for the atomistic individual optimal choices and a Fokker-Planck (also know as Kolmogorov Forward Equation) to describe the changes in the state of the economy. Those equations, together with some standard equilibrium conditions, can be seen as necessary and sufficient conditions to the equilibrium. These coupled equations were called by Larsy and Lions (2007) a Mean Field Game, which is a relatively new mathematical tool in economics that was much developed by Achdou *et al.* (2015).

Specifically, our model deals with a Mean Field Game in the stationary form. We characterize the equilibrium as a system of partial differential equations, in which the individual problem and the joint distribution $\Gamma(a, z, s)$ that satisfy both the following stationary Hamilton-Jacobi-Bellman equation:

[3] $d(ln(z))$ evolution was set as $d(ln(z)) = \kappa(\mu_{log} - ln(z))dt + \sigma dW_t$
[4] To be precise, $d(ln(z))$ has a stationary distribution $N(\mu_{log}, \frac{\sigma}{2\kappa})$.

$$\rho v_s(a,z,t) = \max_{c,h} u(c,h) + \partial_a v_s(a,z,t)[M(a,z,s) + ra - c - p_h h]$$

$$+\partial_z v_s(a,z,t)\mu(z) + \frac{1}{2}\partial_{zz} v_s(a,z,t)\sigma^2(z) + \phi_s[v_{-s}(a,z,t) - v_s(a,z,t)] \tag{3.9}$$

and the following stationary Fokker-Planck equation:

$$0 = -\partial_a[(M_s(a,z,t) + ra - c_s(a,z) - p_h h_s(a,z))g_s(a,z,t)] - \partial_z[\mu(z)g_s(a,z,t)]$$

$$+\frac{1}{2}\partial_{zz}[\sigma^2(z)g_s(a,z,t)] - \phi_s g_s(a,z,t) + \phi_{-s} g_{-s}(a,z,t) \tag{3.10}$$

on $(0,\infty)\times(\underline{z},\overline{z})$.

The function η is the optimal drift of wealth, i.e, $\eta(a,z,s) = M(a,z,s) + ra - c(a,z,s) - p_h h(a,z,s)$, in which $c(a,z,s) = (u')^{-1}(\partial_a v((a,z,s)))$ and $h(a,z,s) = \frac{\Psi}{p_h}(u')^{-1}(\partial_a v((a,z,s)))$. Furthermore, $\int \eta(a,z,s)d\Gamma(a,z,s) = 0$ must hold.

The function v also has to satisfy a state constrained boundary condition $u'(w(z)) = \partial_a v(a,z,s)$ for all z, which ensures that the drift of wealth is non-negative at the borrowing constraint and therefore the constraint is not violated. Moreover, since we deal with a bounded diffusion process, $\partial_z v(a,\underline{z},s) = 0$ and $\partial_z v(a,\overline{z},s) = 0$ must hold for all values of a.

Additionally, the individuals density integrate to 1 and never be negative: $\int d\Gamma(a,z,s) = 1$ and for every (a,z,s), $\Gamma(a,z,s) \geq 0$.

The equilibrium is also composed of individual decision rules on occupational choice ($o(a,z,s) \in \{e,w\}$), labor and capital demands (respectivly, $l(a,z,s)$ and $k(a,z,s)$), the price vector (w,r,R,p_h), the financial sector zero profit conditions, and the pair (ϕ_0,ϕ_1) such that:

The labor market clears:

$$\int_{o(a,z,s)=l} d\Gamma(a,z,s) = \int_{o(a,z,s)=e} l d\Gamma(a,z,s)$$

The goods market clear:

$$\int_{o(a,z|s=0)=e} zf(k,l)d\Gamma(a,z,s) = \int (c(a,z,s) + h(a,z,s))d\Gamma(a,z,s)$$

The productive earmarked loans market clear:

$$\omega_k S = \int_{o(a,z|s=1)=e} kd\Gamma(a,z,s)$$

The free allocated credit market clear:

$$(1-\omega)S = \int_{o(a,z|s=0)=e} kd\Gamma(a,z,s)$$

Our solution to the model is numeric and the algorithm used is based on the methodology given by Achdou *et al.* (2015) Numerical Appendix. Due to the facts that the algorithm is has many steps and that our solution only differs from the authors by the introduction of markets and financial frictions, we consider that interested readers should read chapters 1,2,5 and 6 from Achdou *et al.* (2015) Numerical Appendix. Our strategy is to guess a price vector and an initial value for the value function and then proceed to solve the Hamilton-Jacobi-Bellman using finite differences and the implicit method. After that, we are able to solve the Fokker-Planck equation, thus getting the distribution of individuals, and then calculate aggregate variables and check if such price vector generates an equilibrium. Since this model is designed in a general equilibrium set up, Walras Law guarantees that, if we clear all but one market, this market will also clear. Therefore our algorithm clears all markets but the consumption goods market.

4 Calibration

We use data from different sources. Interest rates and credit outstanding data are from Brazilian Central Bank Time Series Management System Public Module. Our database accounts for values between March 2007 to December 2014. This data helps us to pin down policy parameters ω, ω_k, ω_h, ω_r and R_s for Brazilian economy[1]. It is important to state that R_s is set as the difference between the earmarked credit average interest rate minus the reserve requirements interest rate, which in the model we set as zero.

Also from Brazilian Central Bank, but not publicly available, are the statistics from Brazilian Credit Information System (SCR) data, a repository of every loan contract above a chosen threshold[2]. This particular statistics allow us to map firm size distribution and earmarked access to credit in our model to Brazilian data[3]. Thus, $\mu(z)$ and $\sigma(z)$ are determined so that the stationary equilibrium results match the frequency of firms that receive earmarked credit.

We choose ψ in order to match the data on housing consumption from Consumption Expenditure Survey (in portuguese, Pesquisa de Orçamento Familiar - POF) from 2008-2009, which is the most recent reliable information that we were able to find on the subject. The data points out that $29,2\%$ of total consumption spending was on housing, which imply $\psi = 0.86$.

Given the credit markets connection with borrowing constraints, thus with wealth distribution, it is important to incorporate wealth heterogeneity in the study. There are two problems that arrive from introducing wealth heterogeneity: the first one is the quality of the available information about wealth distribution in Brazil. The fact that Brazil's wealth distribution is quite concentrated on the top levels is well accepted, but we lack data to measure the magnitude of such concentration. There are some indirect measures, such as as in Davies *et al.* (2011), in which 20 countries wealth Gini indexes first are calculated, and then other countries indexes were estimated based on their calculations.

1 $\omega = 43\%$, $\omega_k = 21.5\%$, $\omega_h = 21.5\%$, $\omega_r = 25.6\%$ and $R_s = -2.24\%$
2 Nowadays, this threshold is approximately US$ 280.
3 SCR statistics are from December 2013.

They found that, for Brazil, the wealth Gini index was about 0.784, the second highest in their sample. Nonetheless, Medeiros *et al.* (2015) use microdata statistics recently released by the Brazilian federal revenue service agency (Brazilian equivalent to IRS) and, despite the fact that they are not able to calculate an income Gini index with this newly available data, they find indication that income distribution in Brazil is much more concentrated than it was previously though[4], which would make Davies *et al.* a lower bound for Brazilian wealth Gini index

The second problem related to introducing wealth heterogeneity is that our capability to match the model with income and wealth distributions data in rather limited. We chose $\theta = 0.75$ in order to get the higher income Gini index that still implies a wealth Gini index different from 1, thus still allows countefactual exercises. Therefore, we are not able to match the Brazilian income Gini index calculated by the World Bank 0.52[5]. This number is close to Midrigan and Xu (2013), Basu and Fernald (1997) and Atkeson and Kehoe (2007).

The remaining parameters are based on related literature: capital share of output is set as $\alpha = 0.4$ based on Kanczuk (2002) and Bugarin and Paes (2006). The credit constraint parameter is set as $\lambda = 2.33$ based on Madeira (2008). This value is also interesting since it is close to the situation in which individuals are able to use all their wealth as collateral. The coefficient of relative risk aversion is set as $\gamma = 2$ in accordance to Mehra and Prescott (1985). The rate of time preference is set to be $\rho = 0.07$. Depretiation rate δ is set as 6% per year, as in Antunes *et al.* (2012) and as in many others papers in growth theory.

We summarize the model parametrization in Table 2:

4 Furthermore, the authors acknowledge that their results might be considered a lower bound on wealth distribution in Brazil due to two main factors: i) Their data do not account for every marriage, so many individuals that are considered one household might be, in fact, only a household fraction; and ii) they methodology tends to underestimate wealth concentration on its higher distribution levels.

5 Which, according to Madeiros *et al.* (2015) should be considered a lower bound for the true value of the variable.

Table 2 – Fixed parameters and their sources

	Parameters	Values	Comments
ω	Total earmarked resources (%)	0,43	Based on Brazian Central Bank data
ω_h	Housing subsidy earmarked resources (%)	0,22	
ω_k	Productive earmerked credit resources (%)	0,22	
ω_r	Reserve requirements	0,26	
R_s	Productive earmerked credit interest rate	-2,24%	
κ	Talent's log rate of mean reversion	0,10	Targets wealth and income Gini indexes and total ratio of entrepreneurs that receive earmarked credit
μ	Talent's log mean	0,00	
σ	Talent's log volatility	0,30	
ϑ	Span of control	0,75	
α	Capital elasticity of output	0,40	Based on Kanczuk (2002) and Burarin and Paes (2006)
β	Labor elasticity of output	0,60	
δ	Depretiation rate	0,06	Yearly depretiation rate of 6%
λ	Borrowing constraint parameter	2,33	Based on Madeira (2008)
γ	Relative risk aversion	2,00	Based on Mehra and Prescott (1985)
ψ	housing utility weight	0,85	Implies that 29% of total consumption is on housing
ρ	Rate of time preference	0,07	Based on Achdou (2015) Numerical Methods appendix

5 Results

In order to get some intuition about the effects of changes on policy parameters (ω, ω_k, ω_h, R_s) and how do they interact with borrowing constraints, we perform counterfactual exercises on all policy parameters and on λ. Our main findings are that earmarked credit policies, in the way in which they are set up nowadays in Brazil, do not improve TFP nor have sizable positive distributional effects. Moreover, results seem to be monotonic to most variables, which implies that, the more capital is allocated to such policies, the bigger is the fall in aggregate productivity and the higher is the wealth and income concentration. Those results are summarized in Table (3).

- Productive earmarked credit (ω_k)

To observe how the economy behaves with changes in ω_k, we made the variable to range from zero, which means a complete shutdown of the productive earmarked credit policy, to one and a half times our benchmark value, which translates into an expansion of 50% of the resources earmarked for such policy. It should be noticed that the earmarked housing subsidy parameter ω_h in does not change during this exercise.

In what concerns aggregate productivity, we observe that the total shutdown of ω_k implies a TFP increase of approximately 1.47%. If we look separately at the aggregate productivity of non-subsidized firms, for a decrease in one quarter of the original value of ω_k, we will see that their aggregate productivity increased on average almost 10%.

Table 3 – Summary of counterfactual results

	TFP	Capital	Spread	Average firm size	Average favored firm size	Average non-favored firm size	Gini (income)	Gini (wealth)
Total Effect								
ω	2,30%	19,24%	3.88 p.p.	19,54%	-	-	-0,02	-0,04
ω_k	1,47%	9,17%	2.81 p.p.	8,16%	-	-	-0,02	-0,02
ω_h	0,82%	18,37%	2.04 p.p.	20,36%	-	-	0,00	-0,02
25% change average effect								
ω	0,71%	4,26%	0.85 p.p.	4,28%	-23,72%	10,94%	-0,003	-0,007
ω_k	0,39%	1,58%	0.54 p.p.	1,29%	-29,10%	8,02%	-0,003	-0,003
ω_h	0,24%	3,06%	0.37 p.p.	3,21%	3,14%	3,04%	0,000	-0,003

The most immediate changes in the economy due to decreases in ω_k are decrease in the spread and decrease in the mass of favored entrepreneurs. Indeed, for a decrease in one quarter of the original value of ω_k, on average, the model predicts a decline of 0.84% on the spread and a 2.77% reduction in the ratio of favored entrepreneurs to total entrepreneurs, while the total mass of entrepreneurs barely suffers any change.

As should be expected, the observed spread reduction causes an increase on the non-favored entrepreneurs average firm size. This increase in firm size, combined with the increase in the non-favored entrepreneurs density, is enough to overcome the drop in capital demand caused by favored entrepreneur density reduction and generate a positive net effect on capital and labor demands.

Since the labor demand was increased, higher wages are put in place. Additionally, the decrease in R causes the average firm size of non-favored entrepreneurs firms to expand. Both these movements are linked to a lower income and wealth Gini indexes. Evidence of this reasoning may be seen in Table (2).

On what concerns the constrained population, as ω_k declines, the constrained population increases. The model predicts that, for a decrease in one quarter of the original value of ω_k, on average, there is an increase of 0.86% on the constrained population, and this change is almost entirely driven by by workers that, for lower values of λ, would choose to become entrepreneurs.

- Earmarked housing subsidy (ω_h)

In order to observe how the economy behaves with changes in ω_h, we made the variable to range from zero, which means a complete shutdown of the earmarked housing subsidy policy, to one and a half times our benchmark value, which translates into an expansion of 50% of the resources earmarked for such policy. It should be noticed that the productive earmarked credit parameter ω_k does not change during this exercise.

Changes in earmarked housing subsidy generates smaller effects in both TFP and distributional variables when compared to similar effects after changes in productive earmarked credit. A complete shutdown of the housing subsidy policy would imply an increase of 0.8% in TFP and an increase of 0.02 in the Gini wealth index, with no sizable effects on the income Gini index.

Changes in the resources available to earmarked housing subsidies have two main effects: the first is that there are more resources available to subsidize housing consumption, thus p_h should decrease; and the second is that there are fewer resources to free allocated capital markets, therefore R should increase. Indeed, we do observe these movements in our findings: as the policy is further implemented, p_h tends to decline and, in our exercise, going from $\omega_h = 0$ to our benchmark value causes p_h to fall more than 75% of its original value. While this value is clearly not realistic, we do not consider this a serious concern, once understanding how the economy reacts to such changes is, in fact, our goal.

Due to the lower housing prices, for each increase of one quarter of the benchmark value of ω_k, on average, the model predicts that individuals increase their consumption by 5%, what causes individuals to save less and wealth takes longer to accumulate. Consequently, some individuals are not able to accumulate wealth fast enough and remain constrained in the equilibrium, what causes the demand for capital and labor to be lower as ω_h increases. Moreover, if these individuals are entrepreneurs, their income would be negatively affected.

The consequence of such movement int capital markets is that, once capital demand drops, banks can now pay smaller deposits returns to depositors, what implies that the increase in R is partially suppressed and explains why changes in ω_h generates smaller effects on R than similar changes in ω_k would create. This relationship can be seen clearly in Figure (2).

Nonetheless, the increase of spread is enough to make some non-favored entrepreneurs to exit the market and become workers, what causes wages to decline and, due to lower labor costs, the average size of favored firms increases and the size of non-favored firms decreases in a slower pace than when a similar change in ω_k occurs.

The consequence of such movements in the economy is a higher concentration of wealth, which is indeed observed in our calculated wealth Gini index (see Table 3). Nevertheless, contrary to the results for ω_k, changes in ω_h do not have a sizable impact on income distribution. This might be explained due to the fact that total income decreases and all the groups (workers, favored entrepreneurs and non-favored entrepreneurs) feel equally the effect of such change.

- Total earmarked credits (ω)

Changing ω values and looking at the results give us an idea of what would be the consequences for changes in the policy as it is done nowadays. In our exercise, we look on how the economy would behave for values between $\omega = 0$, which means a complete shutdown on earmarked credit policy, and one and a half times our benchmark value, which translates into an expansion of 50% of the resources earmarked. It should be noticed that the ratio between productive earmarked credit and earmarked housing subsidy is kept constant in December 2013 values throughout the exercise.

Changing ω is a mixture of the two previous counterfactual exercises on ω_k and on ω_h, thus we do not observe anything new compared to the previous counterfactual exercises. Nonetheless, by only changing ω we can observe how the economy would respond to a discontinuation on nowadays practiced earmarked credit policies.

Our main results on a complete shutdown of the earmarked credit policies are that TFP would increase by 2.3%, the spread would decline 3.88%, causing the firm average size to increase by 19.5%, and the mass of entrepreneurs would suffer a slightly increase. The distributional effects would be a 0.04 reduction in the wealth Gini index and a 0.02 reduction in the income Gini index.

It is important to state that, when comparing effects of changes in ω with effects of changes in ω_k and ω_h, we should consider that we are looking at relative changes, and since $\omega = \omega_k + \omega_h$, the relative changes in ω are absolutely bigger then relative changes in its components, thus the effects tend to be stronger.

- Productive earmarked credit interest rate (R_s)

Figure 2 – Comparing policies (1)

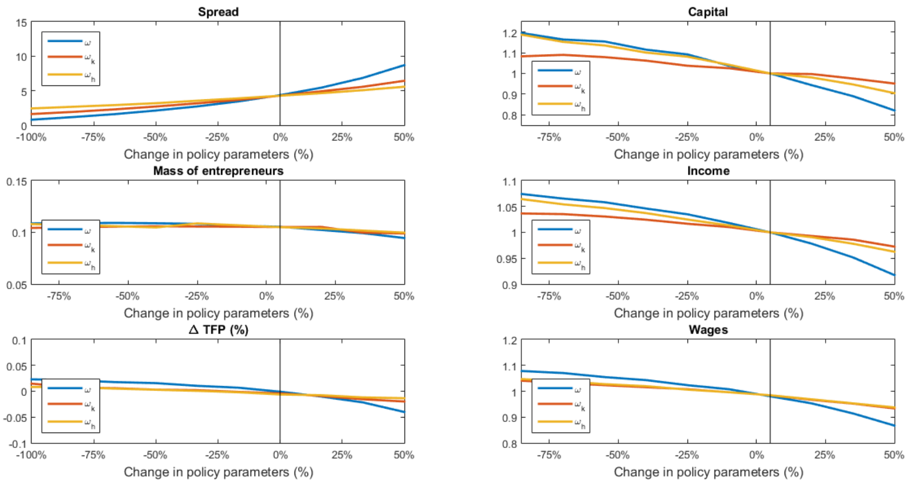


Figure 3 – Comparing policies (2)

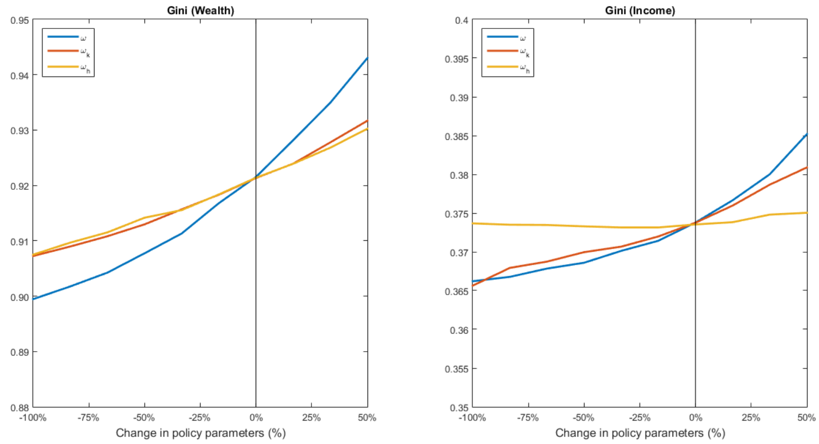
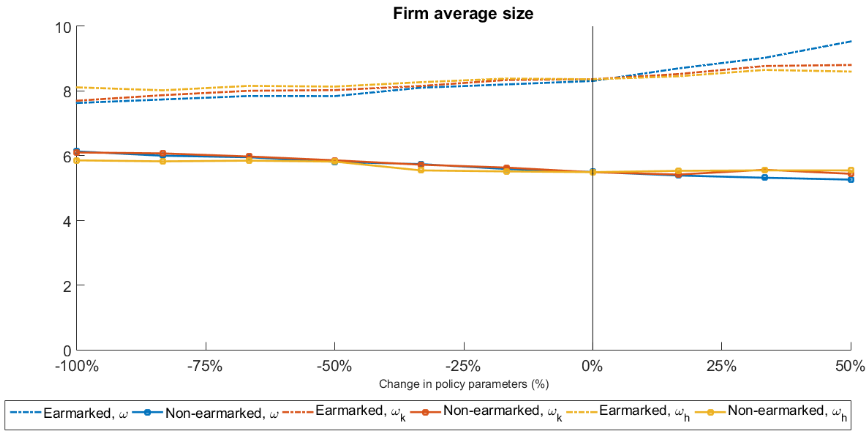


Figure 4 – Comparing policies (3)



To study the effects of changes in the productive earmarked credit subsidized interest rate, R_s, we look how the economy behaves when it assumes values between -4% and 0%. This means that the upper boundary of our parameter space (0%) implies a subsidy that, for the banking sector, is equal to the reserves interest rate. The presented results are summarized in Figure (5).

The most direct effects of decreasing the subsidy in R_s is a decrease in R and, thus, a decrease in the spread between capital costs for favored and non-favored entrepreneurs, and a increase in capital costs for favored entrepreneurs.

Indeed, we observe that the favored entrepreneurs average firm size reduces almost a quarter of its original size. Due to the fact that regulation requires that a fraction ω_k of banks deposits must be allocated to favored entrepreneurs, and since their businesses are smaller now, in order to satisfy the earmarked requirements, banks increase the mass of individuals that are favored. This movement results in some workers to chose to became entrepreneurs, what causes wages to grow. Moreover, since the costs for favored entrepreneurs increased, less talented favored entrepreneurs leave the market, thus slightly increasing productivity, income and capital demand.

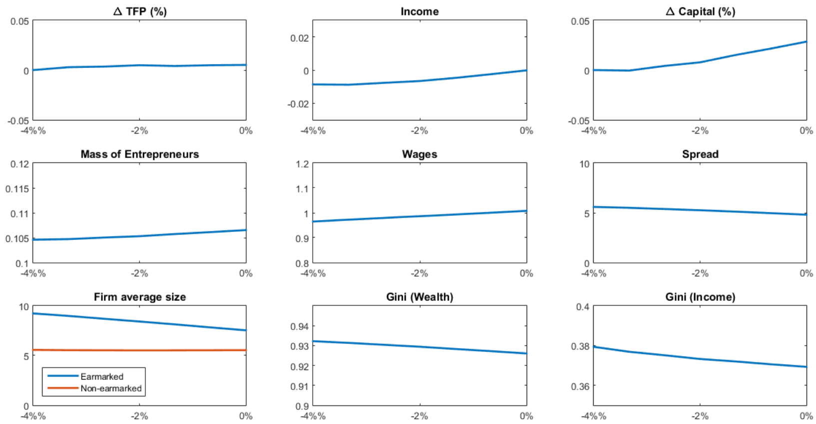
On the other hand, we do not observe a sizable change in non-favored entrepreneurs firm size, likely due to the fact that wages grew, almost completely compensating for the decrease in capital costs.

Lower subsidies to favored entrepreneurs also had distributional effects. Higher wages caused entrepreneurs share of total wealth to drop and made easier to individuals to accumulate enough wealth to become entrepreneurs. The quantitative effect of such changes can be illustrated by both income and wealth Gini indexes going down 0.01 each.

- Credit constraints (λ):

In order to study the aggregate and distributional effects of changes in λ, we looked how the economy differ when we set the λ values between 1 and 4. The lower bound on the range is quite meaningful: when λ is equal to 1, credit markets are shut down, meaning that

Figure 5 – Summary of results (R_s)



individuals can only borrow capital up to their own wealth. Our main findings regarding changes in λ are summarized in Figure (6).

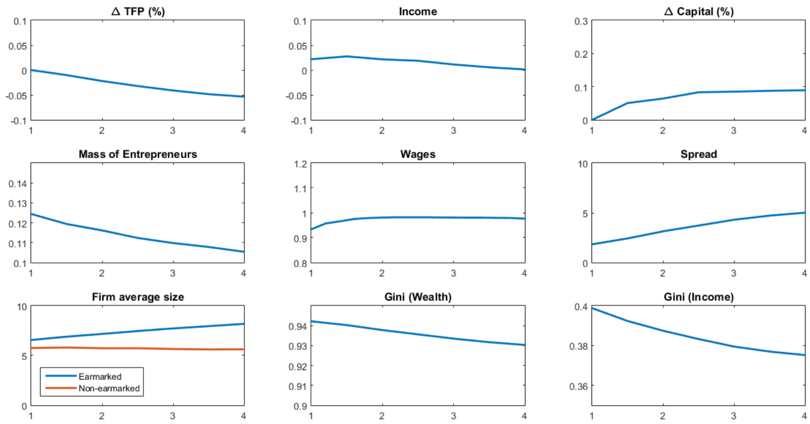
The most immediate effect of increases in λ is that the amount of constrained individuals drops. This causes some high talented workers to become entrepreneurs and previously constrained entrepreneurs to expand their businesses. Nonetheless, looking at Figure 6 we can see that favored entrepreneurs firm size seems to be the only one reacting to such change in λ. We will discuss this lack of non-favored entrepreneurs firm size growth later.

The increase in favored entrepreneur firm size makes the banking sector to decrease the mass of favored individuals, which translates into a smaller density of favored entrepreneurs. The effect of such changes over capital and labor demand is positive, causing wages to growth.

Additionally, as λ increases, one should expect that the amount of constrained individuals decreases in a diminishing manner. Indeed, such behaviour in wage (which is a reflect of labor demand) and capital demand can be observed in Figure (6).

To explain why non-favored entrepreneurs average firm size does not have a sizable effect on λ changes, we have to consider that they face a much higher cost of capital, thus their optimal firm size is smaller than favored entrepreneurs optimal firm size and, consequently, their constrained population is relatively smaller. But only considering this

Figure 6 – Summary of results (λ)



argument would imply that we should observe a small effect on non-favored entrepreneurs average firm size, since a fraction of them is, indeed, willing to expand their business when λ increases. Nonetheless, adding up the fact that wages increased due to favored-entrepreneurs choices (with stronger effects on lower levels of λ, which is the region that we most likely would see effects on non-favored average firm size due to movements on λ), it is reasonable to assume that both effects cancel out, thus keeping the non-favored entrepreneurs average firm size almost constant.

6 Concluding Remarks

In this paper, we solved a dynamic entrepreneurship model calibrated for the Brazilian economy to estimate the effects of earmarking rules on economic variables. Our results indicate that earmarked rules decrease the total factor productivity in about 2.3%. Earmarking rules have also negative effects on both income and wealth inequality (the gini index decreases by 0.02 and 0.04, respectively). They are also found to produce a sharp decrease of about 20% in capital demand and to increase bank spreads in about 3.9 %. They also have a negative effect on the average size of firms (despite increasing the average size of firms benefiting from earmarked credit).

Since we do not compute optimal policies, we cannot rule out that other credit policy designs (for instance with different distributions per size of firm or wealth of borrower) could improve the aggregate productivity or inequality. We also did not take into account the possibility of productive externality. One possible extension would be to measure how strong such externalities should be in order to justify the adoption of earmarking policies.

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