Ann Finance (2010) 6:1–32
DOI 10.1007/s10436-009-0131-0

RESEARCH ARTICLE

Macroeconomics of bank interest spreads: evidence from Brazil

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Received: 29 March 2009 / Accepted: 28 July 2009 / Published online: 4 September 2009

Abstract Bank interest spreads in Brazil are up to ten times larger than international benchmarks. This paper shows that such high spreads can be largely accounted for by a policy that requires banks to invest about half of their deposits in mandatory reserves and selected loans. Using a general equilibrium model, augmented with a banking sector and tailored to the Brazilian economy, the paper also shows that the policy has significant positive and normative implications. It accounts for about half of the spread in the model and a third of the actual spread, and generates welfare costs of almost 2% of current consumption.

Keywords Interest rates · Bank interest spreads · Credit · Reserves · Government regulation · Financial markets

JEL Classification E43 · E51 · G21 · O16

This paper is part of my Ph.D. Dissertation Thesis at UCLA and would not be possible without the financial support of the Brazilian Ministry of Education—CAPES. I am very grateful to Lee Ohanian, Christian Hellwig, Gary Hansen and Antonio Bernardo for their valuable guidance. I thank Andrew Atkeson, Hanno Lustig, Márcio Nakane, Mauro Rodrigues, as well as the participants of the Economics seminars at UCLA, IMT Lucca Institute and University of São Paulo, for their helpful comments and suggestions. I also thank the Editor-in-Chief and an anonymous referee for their valuable insights and thoughtful advices. The views expressed in this paper are my own and do not reflect those of Banco Central do Brasil.

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1 Introduction

Brazilian bank interest spreads, measured by the difference between lending and deposit rates, are among the highest in the world. As Table 1 shows, Brazilian spreads averaged over 30% points in the last decade, up to ten times larger than typical spreads in developed countries and three times larger than the Latin American average. The table also reveals that the credit-to-GDP ratio in Brazil is very low even for Latin American standards. This paper argues that a policy that forces banks to invest a large portion of their deposits in mandatory reserves and selected loans is among the most important causes of those high spreads. The paper also suggests that the policy severely reduces the supply of credit, distorts the overall allocation of resources and generates large welfare costs.[1]

This paper has two goals. First, it quantifies the effects of credit and reserve requirements on bank spreads, resource allocation and welfare. Second, it identifies the channels through which the requirements distort the optimal decisions of agents, with special attention to lending decisions. In order to achieve these goals, I embed a stylized banking sector into a standard general equilibrium model. In the model, banks face the same type of requirements that actual banks do. The requirements resemble non lump-sum taxes distorting the optimal allocation of funds as well as loan pricing. The model is then calibrated to match the main facts about the Brazilian economy. The calibrated model does a very good job in matching the high spreads in Brazil. It explains nearly three-quarters of the actual spread and attributes about half of the explained spread to the policy. Additionally, the model predicts that eliminating the two requirements boosts financial intermediation and improves leverage ratios of both firms and banks in the long-run. Finally, the baseline version of the model also suggests that the welfare cost of the policy is economically relevant. The policy imposes a long-run loss of 3% in both output and consumption. Taking into account the transition dynamics, the model predicts a welfare cost of almost 2% in terms of annual consumption, a large figure by any measure.

At first glance, the Brazilian policy does not seem to be special nor unique. Governments worldwide very often intervene in the banking sector to achieve many development and monetary policy goals. However, several features make the Brazilian policy unique and interesting to study. First, the policy scale is unprecedented. Table 2 shows that Brazilian banks face an *effective* mandatary reserve rate of 29% of their deposits and an *effective* credit requirement of about 16% of their deposits. Together, mandatory reserves and loans absorb almost half of all bank deposits.

[1] For completeness, Table 1 also shows the spread over the interbank rate and the spread over the treasury bill rate, both of which are equally high in Brazil. In this paper I only consider *ex-ante* spreads, which are based on market interest rates. An alternative measure, but less precise for my purposes, is the *ex-post* spread or net interest margin, computed from bank accounting data. I focus on the current decade because Brazil experienced strong financial stability and low inflation rates during this period. The available evidence reveals that average spreads have been very high since at least 1994, when the central bank started to release more precise and comprehensive spread data. Notice in the table that equity and private debt may be substitutes for bank credit in Brazil. However, these two markets are not a viable source of external financing, especially for small and medium enterprises. The model in Sect. 3 takes into account the substitution between bank debt and other sources of external financing at the firm level.

Table 1 Bank interest spreads and financial depth worldwide, average 2000–2006

Variable	Brazil	Latin America (19)	Other developing (46)	Developed (24)	Sample (90)
Bank spreads (percentage points)					
Over deposit rate	31.3	9.6	6.8	3.6	6.8
Over interbank rate	30.3	9.1	5.1	2.6	5.5
Over treasury bill rate	30.3	7.6	5.4	2.6	5.4
Financial depth (percent of GDP)					
Private credit	17.2	32.6	42.8	108.8	58.1
Private debt market capitalization	10.1	7.6	17.0	44.7	30.6
Stock market capitalization	41.1	25.6	47.2	90.4	55.7

Figures in parenthesis are the number of countries in each group.
Bank spread: difference between the average lending rate and the corresponding interest rate
Private credit: loans by commercial banks to the private sector. Brazilian figures refer to freely allocated loans
Private debt market capitalization: private domestic debt securities issued by corporations and financial institutions
Stock market capitalization: value of listed shares
Original sources: Global Financial Data, IMF's IFS, Beck et al. (2000) and central banks

Table 2 Allocation of bank deposits in Brazil, weighted averages for 2005–2006

Destination	Nominal rate	Effective rate
A. Mandatory reserves	30.5	29.2
Non-interest-bearing	8.0	7.7
Interest-bearing	22.5	21.5
B. Selected loans	21.5	15.5
Rural loans	9.5	9.0
Housing loans	12.0	6.5
Mandatory allocation (A+B)	52.0	44.7
Free allocation	48.0	55.3

Figures are percent of total deposits (demand, savings and time deposits)
Nominal and effective rates differ because of exemptions and other regulatory details
Original source: Central Bank of Brazil

Second, mandatory reserves and selected loans distort the optimal leverage ratios of banks and hence their credit supply and spreads in different ways. Reserve requirements act as a tax on bank margins whose burden is ultimately shared by depositors and borrowers. The tax burden will depend on the interest rate elasticities of loan demand and deposit supply, and on the degree of competition in the banking sector. If the banking sector is fairly competitive and if deposit supply is relatively more elastic than loan demand—which appears to be the case of Brazil—then borrowers

will pay most of the *reserve tax* burden.[2] In the baseline simulations, borrowers fully pay the reserve tax because I assume perfect competition and perfectly elastic deposit markets. The size of the reserve tax depends on the interest rate paid by mandatory reserves. Because three-quarters of mandatory reserves in Brazil earn some interest rate (see Table 2), the baseline simulations suggest that the reserve tax is relatively small, accounting for about a tenth of the spreads in the baseline model. However, removing this distortion reduces the spread by more than one tenth because of its interaction with the credit requirement (more on this below).

In turn, selected loans distort bank spreads much more than mandatory reserves because there exist interest rate ceilings preventing banks to charge a fair price for those loans. Since the ceilings are usually lower than deposit rates, banks make up for the difference by charging higher spreads to non-selected borrowers. Therefore, while mandatory reserves impose a tax on all borrowers, selected loans forces bank to tax non-selected borrowers in order to fund the selected ones. In principle, this cross-subsidization sounds very familiar from the textbook but in reality it is far more interesting than the textbook stories because selected borrowers—*farmers* and *homeowners*—re riskier and costlier to monitor than the average borrower. Banks make losses not only because of the legal ceilings, which is the effect pointed out in textbook and which I call the *interest rate effect*, but also because selected loans are more costly to provide (*cost effect*) and default more frequently (*loan loss effect*). The baseline simulations suggest that these three effects combined account for more than a third of the spread level in the model.

The third key aspect about the Brazilian policy is that even though reserve and loan requirements are seemingly unrelated instruments used for different purposes, they are closely connected in at least three dimensions, thus requiring a joint analysis as I do in this paper.[3] We can interpret the two requirements as different tax rates on the same tax base (deposits), both distort banks' free margins, and they interact with each other in a perverse way. I show in Sect. 3 that the requirements reinforce each other through bank leverage ratios, thus distorting free spreads even further. The joint analysis also recommends taylor-made policy actions. For instance, the bulk of the welfare gains predicted by the model comes from eliminating reserve requirements, whereas most of the reduction in spreads comes from eliminating credit requirements. Intuitively, mandatory reserves impose larger welfare costs than selected loans because the first take resources away from the private sector whereas the second is just a transfer of resources between different private agents. Hence, a regulator concerned with both social welfare and the role of market prices as allocation devices should reduce the two requirements simultaneously. However, a regulator who only dislikes high spreads should prioritize the bank cross-subsidization.

Tough insightful, we must be cautious about the paper's message pointing to less government intervention in the credit markets. The paper does not suggest that all

[2] In Sect. 2, I present evidence regarding bank competition in Brazil and, in Sect. 5, I present sensitivity analysis relaxing the perfect competition assumption.

[3] The reserve requirement is a monetary policy tool and a source of seigniorage to the government. The credit requirement is a development tool used to correct alleged credit market failures. The model takes into account these two different roles.

bank regulation is undesirable. It just makes a strong case that the Brazilian regulation cannot be justified on sound economic grounds. Of course, some degree of wise regulation is still needed even when credit markets function relatively well. The ongoing financial crisis in the United States, triggered by lax regulation according to many observers, is a handy example.

This paper has five remaining sections. Section 2 discusses in detail the Brazilian policy and compares with similar policies in other countries. Section 3 presents the model and discusses its qualitative implications. Section 4 calibrates the model to the Brazilian data. Section 5 presents the quantitative results and policy implications. Section 6 concludes.

2 Policy description and literature review

Until mid-1990s, the supply of credit by private banks was very small in Brazil. Government banks allocated two-thirds of all credit, of which a large fraction went to the government itself. Moreover, both private and government banks were focused on earning inflation rents from holders of non-interest bearing deposits. The part of inflation tax appropriated by banks averaged more than 3% of GDP in 1990–93 (Nakane and Weintraub 2005). However, the end of high inflation in 1994 ignited deep changes in the Brazilian banking sector. Private banks were forced to make up for the lost seigniorage by concentrating on lending activities, and the government helped to reorganize large private banks, facilitated foreign entry, recapitalized its federal banks and either privatized or liquidated most state banks.[4]

By the end of the 1990s, Brazil had fewer but more competitive and financially sound banks relative to the high-inflation period. It was then expected that bank interest spreads would quickly converge to international levels. Although credit growth resumed, bank spreads remained extremely high, even compared with Latin American benchmarks, as Table 1 shows. This paper argues that the policy of credit and reserve requirements is an important culprit behind the high bank spreads and the low credit-to-GDP ratio in Brazil.

The practice of imposing high reserve requirements on banks and using them for channeling funds to preferential borrowers in Brazil goes back to the 1950s and 1960s at least. Other developing countries also used similar policies at some point in time but most phased them out in the 1990s, as part of a broad financial liberalization process. What is striking about the Brazilian case is the persistence and the magnitudes of the requirements. To illustrate, during 2005–2006 commercial banks had to invest 53 and 25% of their demand deposits on mandatory reserves and on rural loans, respectively. They were also required to allocate 30 and 65% of their savings deposits on reserves and housing loans, respectively. In the same period, banks also had to invest 23% of their time deposits in required reserves. The second column of Table 2 summarizes all these numbers. The column shows the nominal rates for credit and reserves, weighted

[4] Beck et al. (2005) describe in detail the reorganization of state banks in Brazil. Goldfajn et al. (2003) estimate that the bailout of both private and government banks amounted to 9% of GDP, of which a significant fraction covered bad loans by federal banks to the farming and housing sectors.

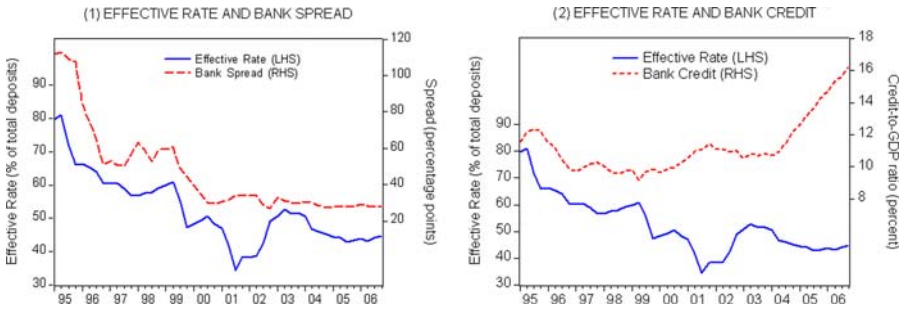

Fig. 1 Effective requirement rate and credit market indicators. Effective rate: effective reserve and credit requirements, as percentage of total deposits. Credit: freely allocated loans by deposit money banks, excluding foreign currency, lease and credit card loans. Original sources: Central Bank of Brazil, BNDES and IBGE.

by the volume of deposits. The third column of the table shows the effective rates. The effective rate is defined as the ratio of actual mandatory reserves and selected loans to total deposits, after taking account exemptions and other regulatory details. We can see in the third column that for each Brazilian Real deposited in the bank, about 45 cents must be invested according to government direction.

Figure 1 uncovers striking features about the effective rate, the average bank spread and the freely allocated credit. First, we observe a declining trend in the effective rate, specially in the second half of the 1990s (when reliable data became available), in part because nominal rates also fell in the same period. Second, we can see a clear positive correlation between the effective rate and the average spread. Of course, the decline in the effective rate between 1995 and 2006 is an important reason, but not the only one explaining the fall in bank spreads during that period. A more stable macroeconomic environment also played some role. Finally, the fall in the effective rate has been accompanied by strong growth of freely allocated credit. The model I develop in the next section predicts that the elimination of credit and reserve requirements—a fall in the effective rate—reduces spreads and raises the supply of credit, as suggested by the data.

On top of quantitative controls, there are legal ceilings on the interest rate charged to selected loans. Together, these ceilings and the quantitative controls do no good for the credit market. We can check in Table 3 that the selected loan policy artificially segments the credit market into two: a risky subsidized market where banks are unable to charge a fair spread, and a free market whose spread is distorted by the policy. Selected loans also account for a large fraction of bank credit and default twice as much as free loans.[5] Higher default rates are very costly to the bank not only because they imply direct losses but also because they require additional monitoring effort. Harrison et al. (2004) estimate that US banks spend between 50 cents and 1.5 dollar for each dollar of bank debt monitored. Monitoring costs and recovery rates are much higher in Brazil

[5] As the third column of Table 3 shows, the relevant loan sample considered in this paper excludes those loans that are not intensive in deposits such as loans by development agencies, foreign currency loans, leases and credit card loans. These represent about a fifth of all loans by commercial banks in Brazil. Section 5 presents sensitivity analysis regarding the sample selection.

Table 3 Bank interest spreads and credit in Brazil, averages for 2001–2006

Segment	Share of total loans	Share of baseline sample	Default rate	Interest spreads
Freely allocated loans	87.0	79.0	4.7	31.3
Selected loans	13.0	21.0	8.3	−6.7
Rural loans	7.7	12.0	6.0	−9.0
Housing loans	5.3	9.0	12.1	−3.5

Shares are percent of each category
The baseline sample excludes loans not intensive in deposits
Default rate: percent of 90 days or more past due loans
Spreads: difference between lending rate and deposit rate, in percentage points
Original source: Central Bank of Brazil

because its bankruptcy system is less efficient and its accounting standards are lower than in developed countries. Data from the World Bank's Doing Business reveal that the Brazilian courts take 4 years to solve a bankruptcy case (1.5 years in the US), at the cost of 12% of the firm's assets (7% in the US) and imply a recovery rate of only 17.1 cents (for each dollar at stake) to creditors (76.7 cents in the US).[6] Matters were worse before the reform in 2005 of the 50-year old Brazilian bankruptcy law. Araujo and Funchal (2005) provide a detailed description of this reform and its expected positive effects on the cost of credit and overall economic efficiency.

The empirical literature on bank spreads suggests that bank margins are mostly related to bank operating costs, the fraction on non-performing loans, the degree of banking competition and macroeconomic volatility. These variables are the usual suspects behind high bank spreads in industrial countries (Ho and Saunders 1981; McShane and Sharpe 1985; Angbazo 1997; Saunders and Schumacher 2000) and in Latin America (Barajas et al. 1999; Brock and Rojas-Suarez 2000a,b; Gelos 2006). However, such studies have yet to offer reasonable estimates of the direct and indirect effects of forced bank investments. Roughly speaking, the empirical literature finds small effects of reserve requirements on bank spreads, on one hand, and usually ignores the effects of credit requirements, on the other hand. Nevertheless, several country studies corroborate the distortive effects of similar policies elsewhere. For instance, Bergoeing et al. (2002) cite that in the 1980s the allocation of credit in Chile was determined by the market, whereas in Mexico it was mainly determined by the government, which used banks to channel funds to preferred borrowers at low interest rates. They argue that the different credit policies are amongst the main reasons why Chile's economy performed better than Mexico's in the 1980s. Similarly, Barajas et al. (1999) mention that subsidized loans, granted at real interest rates close to zero, represented up to 16% of the total bank credit in Colombia by the 1980s. The authors document that bank spreads fell after Colombia phased out its credit program in the late 1980s.

[6] See dataset and the Doing Business 2009 Report at http://www.doingbusiness.org/.

Outside Latin America, Cho and Vittas (1995) mention that by early 1990s Indian commercial banks had to invest a large fraction of their funds in reserve requirements, government securities and preferential credit at controlled interest rates to agriculture, low-income households and small-scale industrial firms. The policy led to substantial cross-subsidization of directed loans by the medium and large industrial firms and to high interest rates to industrial finance. Except maybe for East Asia, the international experience suggests that the credit market intervention has failed in many countries, since its widespread during the 1960s through the 1980s. Most credit programs were phased out in the late 1980s or early 1990s, as I mentioned before.[7] Many countries also took bold steps to relax their reserve requirements. For instance, Australia, Canada, New Zealand and the United Kingdom have abolished reserve requirements on demand deposits (Sellon and Weiner 1996, 1997). Likewise, Lora (1997) reports that sixteen Latin American countries reduced reserves rates by 20% points or more in the early 1990s, Brazil being a notable exception.

More recent studies have also tried to uncover the links between forced investments and bank spreads in Brazil. In the case of mandatory reserves, Cardoso (2003) and Takeda et al. (2005) find that the requirements have a negative impact on loan supply and real output. However, these and other empirical studies usually do not capture large effects of either credit or reserve requirements on the spread. For instance, Nakane et al. (2002) argue that even after controlling for all relevant bank-level and macroeconomic variables, their regressions are unable to account for the bulk of the high spreads in Brazil. They suggest that "regulatory restrictions in the form of compulsory credit at subsidized interest rates"(Nakane et al., 2002, p. 26) may be the missing explanation. In a 2005 follow-up investigation, Nakane and Costa estimate that the two requirements account for 17% of the actual spread or about half of the amount I find in this paper.[8] Aside from methodological differences, Nakane and Costa's estimates are lower than mine for two reasons. One, they only measure the interest rate effect of the credit program, which this paper also finds to be relatively small, and two, they ignore the cost effect, the loan loss effect and the amplification mechanism I mentioned before.

This paper contributes to the existing literature on several dimensions. I carefully identify the exact channels through which the policy distorts the spread, and conduct controlled experiments with the model, isolating the policy effects from other potential changes in the economy. Econometric studies usually have a hard time disentangling the effects of forced investments from the impact of other policy changes. I believe this paper is one of the first attempts to provide a welfare analysis of the high spreads in Brazil relying on a general equilibrium model. Antunes et al. (2009), in a very insightful paper but using a different approach, also measure the welfare implications of high

[7] Even in East Asia, where credit programs seemed to have accelerated economic growth in the 1960s and 1970s (Cho and Vittas 1995, 1996; Calomiris and Himmelber 1993), there were significant costs involved, as the South Korean experience illustrates. Kwack (1984) argues that the Korean credit policy led to serious misallocation of resources within and across sectors during the 1970s. The selected sectors ended up having excess capacity, high production cost and low product quality, whereas the unsupported sectors faced a shortage of capital and were forced to borrow at very high rates from the curb market. The program also helped to fuel inflation by depressing the supply of non-selected sectors such as consumer goods.

[8] Available only in Portuguese at www.bcb.gov.br/pec/spread/port/rel_econ_ban_cred.pdf, pp. 29–43.

intermediation costs and thus high spreads. They also find large welfare gains from improving intermediation efficiency. The authors rely on a one-sector growth model but add heterogeneous agents (individuals faces uninsurable idiosyncratic shocks to their labor productivity), endogenous borrowing limit, and costly financial intermediation. Another difference is that they use net interest margins as a measure for bank spreads (see discussion on footnote 1). A third important distinction is that Antunes et al. take intermediation cost as given, which implies a constant interest spread. In this paper, intermediation costs and bank interest spreads are endogenous because they depend upon equilibrium variables (labor cost and deposit rate) and on time-varying policy distortions. However, their model yields richer results than mine in other dimensions. For instance, their departure from the representative agent framework, which I use in this paper, allows them to show that welfare gains are not evenly distributed across agents. In fact, they find that individuals at the bottom decile of the wealth distribution are significantly more benefited than individuals at the top decile. Given the large wealth inequality in Brazil, this result, taken at face value, suggests that most of the welfare gains from the policy change would accrue to poor families, which happen to be the most credit-constrained.

This paper claims that forced investments are an important determinant of the spread, but it also acknowledges that other factors may be at work as well. For instance, bank market power is often blamed for the high spreads, despite the evidence suggesting that Brazilian banks are just as competitive as their international counterparts. Micco et al. (2004) point that Brazilian banks are not more profitable than their Latin neighbors and that bank concentration and foreign penetration in Brazil are identical to Latin American benchmarks. Econometric studies also reveal that bank competition increased after the end of high inflation in 1994 (Nakane 2001; Belaisch 2003). Even though I take this evidence at face value in the baseline model, I do provide sensitivity analysis showing that bank market power does not overturn—and even reinforces—the main predictions of the model. There are additional factors that neither I nor the available empirical studies have measured. For instance, the policy may increase the welfare cost of inflation, and exacerbate adverse selection and moral hazard problems in the free credit market. My conjecture is that all these factors have second-order effects on spreads and welfare, especially in the case of inflation, whose level has been anchored to the central bank's target of 4.5% in recent years.

I also do not address the reasons why the credit and reserve policies have not been phased out yet. I think the underlying political economy is similar to that of international trade policy. As we know, resistance to trade liberalization comes from relatively small, well-organized groups that benefit the most by the autarky, while losses are usually relatively small and spread across many individuals who do not even perceive themselves as an interest group.

3 Model

Time, equivalent to a calendar year, is discrete and indexed by $t = 0, 1, 2, \ldots, \infty$. The economy is closed, there is no uncertainty or growth, there are no restrictions to factor mobility, and all markets are competitive in the baseline version of the model. I abstract

from uncertainty because I mainly focus on the long-run implications of the policy. I also ignore monetary issues because I study the policy effects in an environment with low and stable inflation rates. There is a representative household with standard preferences defined over consumption and leisure. The household owns the capital stock and the shares of firms and banks. To simplify the model, I lump corporate and household credit into a single corporate credit market and treat households as net savers. Additionally, I assume two different economic sectors, which produce intermediate goods. As I make clear later, only Sector 1 will receive selected loans in equilibrium. Another important distinction between this model and the standard growth model is that here I conceive two different assets—physical capital and "financial capital" (bank deposits)—both of which are used as inputs in the production of intermediate goods. Physical capital is produced by final good firms as in the standard model, whereas financial capital is produced by the banking sector, which has a technology that transforms physical capital into deposits and vice-versa. Having two different assets in the economy is not essential but is necessary to make the return to physical capital distinct from the deposit yield, as observed in the data. It also captures the comparative advantage of banks over other firms in transforming household savings into loanable funds.

3.1 Households

Given the initial capital stock, the representative family chooses sequences of consumption C_t, labor H_t and physical capital K_{t+1}, to maximize the discounted flow of utility $\sum_{t=0}^{\infty} \beta^t u(C_t, 1 - H_t)$, where $\beta \in (0, 1)$ is the time discount factor and $u(C_t, 1 - H_t) = \log(C_t) + \phi \log(1 - H_t)$, with $\phi > 0$, is the instantaneous utility function. Households face the flow budget constraint:

$$C_t + K_{t+1} \leq (1 + r_t - \delta)K_t + w_t H_t + \Pi_t + T_t \tag{1}$$

where r_t is the competitive rental rate of capital, w_t is the competitive wage rate, Π_t is aggregate profits and T_t is net transfers from the government. Aggregate profits is the sum of bank profits, when banks have monopoly power, and profits from Sector 1 accruing from the subsidized loans (more on this below). Aggregate labor includes the time spent working in the real sector and the time effort required to monitor bank loans, that is, $H_t = H_{1t} + H_{2t} + H_t^L$. Similarly, the aggregate capital stock is the sum of capital rented to firms and the capital required to transform physical capital into deposits, $K_t = K_{1t} + K_{2t} + K_t^D$.[9] The following first-order conditions describe the household's optimal choices of capital and labor:

$$\frac{C_{t+1}}{C_t} = \beta(1 + r_{t+1} - \delta) \tag{2}$$

$$\frac{\phi C_t}{1 - H_t} = w_t \tag{3}$$

[9] I use subscripts to denote real sector variables and superscripts to denote banking sector variables.

3.2 Firms

Each sector produces an intermediate good that is used as input by a competitive final good producer according to the following CES technology:

$$Y_t = \left[\theta \left(\frac{Y_{1t}}{\theta} \right)^{\frac{\sigma-1}{\sigma}} + (1-\theta) \left(\frac{Y_{2t}}{1-\theta} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{4}$$

where θ is the weight of Sector 1 in total output and $\sigma \geq 0$ is the elasticity of substitution between the two intermediate goods. These are perfect complements if $\sigma = 0$, perfect substitutes if $\sigma = \infty$, and are aggregated according to the familiar Cobb-Douglas function if $\sigma = 1$. In the benchmark version of the model, I assume that the above production function is Leontief because I view the good produced by Sector 1 (agriculture and housing in the data) as complement rather than substitute for the good produced in Sector 2 (manufacturing and services). I provide sensitivity analysis to assess the implications of such an assumption. The final good can be consumed or invested and is set as the numéraire in the model.

The final good producer chooses the optimal amounts of intermediate inputs to maximize profits, taking the relative prices P_{1t} and P_{2t} as given, and then breaks even in equilibrium. The following first-order conditions describe the inverse demand functions for the two intermediate goods:

$$P_{1t} = \left(\theta \frac{Y_t}{Y_{1t}} \right)^{\frac{1}{\sigma}} \tag{5}$$

$$P_{2t} = \left((1-\theta) \frac{Y_t}{Y_{2t}} \right)^{\frac{1}{\sigma}} \tag{6}$$

Intermediate goods are produced through Cobb-Douglas technologies:

$$Y_{it} = \bar{K}_{it}^{\alpha_{it}} H_{it}^{1-\alpha_i} \tag{7}$$

where $i = 1, 2$, H_i is the labor input and $\alpha_i \in (0, 1)$ is the capital income share. In order to have a meaningful demand for bank loans, I assume that the capital $\bar{K}_i$ at the firm level is a composite of internal capital K_i and bank loans L_i as follows:

$$\bar{K_{it}} = \left[\theta_i \left(\frac{L_{it}}{\theta_i} \right)^{\frac{\rho-1}{\rho}} + (1-\theta_i) \left(\frac{K_{it}}{1-\theta_i} \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

where θ_i is the weight of bank debt in total firm financing and $\rho \geq 0$ is the elasticity of substitution between bank debt and internal capital. Here, internal capital is a proxy for all other financing sources of actual firms (e.g. trade credit, retained profits, etc). Bank debt is the sum of freely allocated loans L_{it}^F and selected loans L_{it}^S, $L_{it} = L_{it}^F + L_{it}^S$.

I will focus on equilibria where *all* selected loans are granted to Sector 1 so that $L_{1t} = L_{1t}^F + L_{1t}^S$ and $L_{2t} = L_{2t}^F$.

We can interpret $\bar{K}_{it}$ as the reduced form of the optimal capital structure in a fully micro-founded model. The parameters θ_i and ρ are a rough description of the choice between external and internal financing, and the leverage ratios. Typically, they would depend on time and on firm characteristics such as size and age. For simplicity, I assume that θ_i only depends on firm's sector and that ρ is the same across firms and across sectors. Notice that if $\rho = 0$, internal and external funds are perfect complements, and if $\rho = \infty$, they become perfect substitutes, as suggested by the Modigliani-Miller theorem. In the intermediate case of $\rho = 1$, bank debt and firm internal capital are combined through a Cobb-Douglas aggregator. Because the paper's results depend upon the degree of complementarity between bank debt and firm capital, I provide sensitivity analysis regarding the choice of ρ.

I assume that intermediate good producers are not fully committed to their debt obligations, but may default on both types of loans. I follow Wong (1997) and model loan risk by a random variable $1 - \pi^j$, which only depends on the loan type $j = F, S$. This random variable has support [0, 1], mean $1 - \bar{\pi}^j$, and can be interpreted as the proportion of non-performing loans or the default rate. Taking into account the evidence mentioned in Section 2 that recovery rates in Brazil are quite low due to the inefficient bankruptcy system, I assume that non-performing loans pay nothing to the bank.[10] The actual gross repayment of type-j loan is $\pi^j(1+r^j)L^j$, which is less than or equal to the contractual loan repayment $(1 + r^j)L^j$, depending on the realization of π^j. As in Wong (1997), I abstract from asymmetric information problems in the loan contract and assume that the distribution of π^j is independent of the loan size. Based on the evidence in Table 3, the average default rates satisfy $1 - \bar{\pi}^S > 1 - \bar{\pi}^F$.

The simplifying assumptions regarding the firm capital structure and default probabilities buys a great deal of tractability. However, I do acknowledge that they might subject some of the results to the Lucas critique because the reduced-form parameters might respond to policy changes. In order to properly address this issue I would have to depart from the representative firm approach and fully specify the problem of credit constrained entrepreneurs, as in Castro et al. (2004), Antunes et al. (2008), Buera (2009), and others. The resulting model would be richer but would require dealing with additional complications such as endogenous default and wealth distribution in a dynamic environment.

Even granting that the parameters ρ, θ_i and π^j might be endogenous, I conjecture that their responses to the change in policy tend to reinforce rather than weaken the main results of this paper. For instance, lifting credit and reserve restrictions might not only facilitate firms' access to freely allocated credit but also expand their financing opportunities which may improve their funding composition. Thus firms would be able to borrow relatively more from banks (higher θ_i) and substitute more easily

[10] The 2005 reform of the Brazilian corporate bankruptcy law represents an important attempt to improve the efficiency of the bankruptcy system. Among other things, the new law tries to speed up the time to solve a bankruptcy case, and reorders the priority of claims giving more rights to secured creditors. See Araujo and Funchal (2005) for a detailed discussion on the bankruptcy law reform in Brazil and comparison with other Latin American countries.

between internal and external capital (higher ρ). The exercises in Section 5 suggest that, given θ_i, the change in policy increases Sector 2's credit-to-output ratio without hurting that of Sector 1. However, we can conceive a situation in which the change in policy increases the leverage ratio of Sector 2 (higher θ_2) and reduces it in Sector 1 (lower θ_1). But even in this unlikely case, if the de-leveraging of Sector 1 is not too large, the aggregate leverage ratio would still increase. Similarly, the exercises also suggest that, given ρ, the welfare effects of the policy are stronger when ρ is large. Therefore, I conjecture that if the elasticity of substitution between bank debt and firm capital increases along with the policy change, the welfare effects would also be stronger than in the case of a constant ρ. Lastly, by reducing bank interest spreads, the change in policy may mitigate existing adverse selection and moral hazard problems that are usually associated with excessively high lending rates. At the same time, as I argue in Sect. 5, the change in policy may well lead to an improvement in the monitoring capabilities of the banking sector. These two effects work in the same direction to bring down average defaults rates. Hence, keeping default rates constant in the simulation exercises tends to undermine rather than overestimate the effects of the policy on banks spreads and welfare.

Intermediate good producers choose the optimal amounts of labor, internal capital and freely allocated loans to maximize their expected profits:

$$\max_{\{H_{it}, K_{it}, L_{it}^F\}} \left\{ P_{it} Y_{it} - w_t H_{it} - r_t K_{it} - \sum_{j=F,S} \left[\bar{\pi}^j (1 + r_t^j) - 1 \right] L_{it}^j \right\}, \quad i = 1, 2$$

In this maximization problem, firm capital K_{it} is simply rented from households as in the standard growth model, whereas bank loans are intermediated. In the beginning of each period, firms borrow from banks and promise to pay back principal and interest. However, after production takes place, firms repay only a fraction π^j of the loan obligations. The term inside the square brackets is the average net loan repayment, which collapses to $r_t^j L_{it}^j$ if the repayment rate $\bar{\pi}^j$ is one. Sector i's optimal demand for freely allocated loans is given by:

$$\bar{\pi}^F \left(1 + r_t^F\right) - 1 = P_{it} \alpha_i \left(\frac{Y_{it}}{\bar{K}_{it}}\right) \left(\frac{\theta_i \bar{K}_{it}}{L_{it}}\right)^{\frac{1}{\rho}}, \quad i = 1, 2 \tag{8}$$

In equilibrium, it is optimal for Sector 1 to accept all selected loans offered by banks and borrow any additional amount, if needed, in the free credit market. Thus, Sector 1's marginal loan cost is equal to Sector 2's, however it makes positive profits by the amount $\left[\bar{\pi}^F (1 + r_t^F) - \bar{\pi}^S (1 + r_t^S)\right] L_{1t}^S$.[11] The optimal demands for labor and physical capital are given by the following first-order conditions:

[11] I assume that Sector 2 firms cannot disguise themselves as Sector 1 firms. Otherwise, profits would dissipate. This assumption simplifies the analysis.

$$r_t = P_{it}\alpha_i \left(\frac{Y_{it}}{\bar{K}_{it}}\right)\left(\frac{(1-\theta_i)\bar{K}_{it}}{\bar{K}_{it}}\right)^{\frac{1}{\rho}}, \quad i = 1, 2 \tag{9}$$

$$w_t = P_{it}(1-\alpha_i)\left(\frac{Y_{it}}{H_{it}}\right), \quad i = 1, 2 \tag{10}$$

3.3 Banks

I do not motivate banking activity from first principles but the banking model I lay down next delivers a good compromise between simplicity, realism and economic content. Banks play two roles in the model. They transform physical capital into loanable funds (or deposits), and then channel these funds to intermediate firms. The first role is related to the production of claims on the liability side of banks' balance sheet, whereas the second role is related to the production of claims on the asset side. For convenience, I break up the bank decision problem into two. First, banks transform physical capital received from households into deposits through the following linear technology:

$$D_t = A^D K_t^D \tag{11}$$

where $A^D > 1$ is an efficiency factor. Perfect competition in the production of deposits implies the following relation between the deposit yield, r_t^D, and the return on physical capital r_t:

$$r_t^D = \frac{r_t}{A^D} \tag{12}$$

Therefore, whenever $A^D > 1$, the return to physical capital will exceed the real deposit rate. The second and more important role of banks is to lend their deposits to intermediate good producers. I abstract from bank capital and loan collateral and assume that monitoring is costly and labor-intensive, according to the following technology:

$$L_t^j = A^j H_t^j \tag{13}$$

where $j = F, S$ is the loan type, H_t^j is the labor input and A^j is an efficiency parameter that captures overall loan productivity and determines the unit cost of type-j loan. Having loans being produced like any other good was first proposed by Lindley and Sealey (1977) and has been applied in many general equilibrium models with financial intermediation ever since.[12] Let

$$\eta_t^j = \frac{w_t}{A_t^j}$$

[12] For recent applications, see Harrison et al. (2004) and Goodfriend and McCallum (2007). The latter assumes a more general Cobb-Douglas production function that uses collateral as an additional input.

denote the marginal (and average) nonfinancial cost of type-j loan. Clearly, the higher the loan efficiency the lower the type-j unit cost. The discussion in Sect. 1 implies $A^F \geq A^S$.

The loan market is perfectly competitive in the baseline model but I also analyze a loan market equilibrium under oligopolistic competition, as in Freixas and Rochet (1997, chap. 3). In the model, banks face policy constraints as actual Brazilian banks do. Four policy parameters describe such constraints: the reserve requirement $\tau_t^R \in [0, 1)$, the selected loan requirement $\tau_t^S \in [0, 1)$, the interest rate on reserve $r_t^R \leq r_t^D$ and the lending interest rate ceiling $r_t^S \leq r_t^D$. The first two parameters are the model versions of the effective reserve rate and the effective credit requirement, showed in Table 2. These requirements satisfy $\tau_t^R + \tau_t^S < 1$. The interest rates are the model versions of the average returns on reserves and selected loans, respectively.

Banks maximize profits by choosing the amount of loans they are willing to provide, as well as the corresponding amount of deposits needed to service these loans, taking the deposit rate as given and subject to the following constraints:

$$\begin{aligned} L_t^F + L_t^S + R_t &\leq D_t \\ L_t^S &\geq \tau_t^S D_t \\ R_t &\geq \tau_t^R D_t \\ D_t &\geq 0 \\ L_t^F &\geq 0 \end{aligned}$$

where R_t is total reserves. The first constraint is the balance sheet identity, the next two are the policy constraints, and the last two are non-negativity constraints. Notice that the non-negativity constraint on deposits implies that subsidized loans and bank reserves are also non-negative. I assume that the first three constraints bind in equilibrium and write bank expected profits as follows:

$$\max_{L_t^F} \left\{ \left[\bar{\pi}^F \left(1+r_t^F\right) - (1+\eta_t^F) \right] + \frac{\tau_t^S \left[\bar{\pi}^S \left(1+r_t^S\right) - (1+\eta_t^S) \right]}{1-\tau_t^R-\tau_t^S} - \frac{r_t^D - \tau_t^R r_t^R}{1-\tau_t^R-\tau_t^S} \right\} L_t^F$$

where the term in the first square brackets is the net loan revenue from the free credit market, the term in the second square brackets is the net loan revenue from the subsidized credit market and the last term is the financial cost of deposits net of reserve revenue.

Let us first consider the competitive solution. Under perfect competition, the free lending rate is determined by the following break even condition[13]:

$$r_t^F = \bar{r}_t^F + s_t^R + s_t^S \tag{14}$$

[13] Actual loan contracts may incorporate non-pricing elements such as hidden fees, commissions, reciprocities and collateral, which I ignore in the baseline model. Rojas and Rojas (1997) argue that a large fraction of the actual interest rate charged to subsidized borrowers in Mexico incorporate such non-pricing elements. Section 5 provides sensitivity analysis regarding this issue.

where $\bar{r}_t^F$ is the free *undistorted* lending rate that would prevail in the absence of credit and reserve requirements:

$$\bar{r}_t^F = \frac{r_t^D + \eta_t^F + (1 - \bar{\pi}^F)}{\bar{\pi}^F} \tag{15}$$

s_t^R is the *reserve tax* rate:

$$s_t^R = \frac{\tau_t^R}{1 - \tau_t^R - \tau_t^S} \left(\frac{r_t^D - r_t^R}{\bar{\pi}^F} \right) \tag{16}$$

and s_t^S is the *cross-subsidy*, that part of the free lending rate due to the credit requirement:

$$s_t^S = \frac{\tau_t^S}{1 - \tau_t^R - \tau_t^S} \left(\frac{r_t^D - \bar{\pi}^S r_t^S}{\bar{\pi}^F} + \frac{1 - \pi^S}{\bar{\pi}^F} + \frac{\eta_t^S}{\bar{\pi}^F} \right) \tag{17}$$

Notice that the undistorted lending rate in (15) only depends on the bank opportunity cost of funds, the marginal nonfinancial cost and the average default rate. The reserve tax in (16) simply captures the bank loss due to the below-market reserve yield. In turn, the cross-subsidy in (17) is the sum of three positive terms, from left to right: the risk-adjusted interest rate differential or the *interest rate effect*, the *loan loss effect* and the *cost effect*. If $\tau_t^R = \tau_t^S = 0$, equations (16) and (17) vanish in equilibrium. These equations also show that the bigger the requirements the larger the multipliers $\frac{\tau_t^R}{1-\tau_t^R-\tau_t^S}$ and $\frac{\tau_t^S}{1-\tau_t^R-\tau_t^S}$. Therefore, credit and reserve requirements interact with each other in a perverse way, thus amplifying the distortion on the free lending rate and the interest spread. The latter is defined as $s_t^F \equiv r_t^F - r_t^D$ and is given by

$$s_t^F = \bar{s}_t^F + s_t^R + s_t^S \tag{18}$$

where $\bar{s}_t^F$ is the *undistorted* spread:

$$\bar{s}_t^F = \frac{(1 + r_t^D)(1 - \bar{\pi}^F) + \eta_t^F}{\bar{\pi}^F} \tag{19}$$

Notice that the undistorted spread only depends on the "fundamentals" of the free credit market and not on the policy parameters.

In the non-competitive solution, I consider a Cournot equilibrium between $N \geq 2$ identical banks, each facing an inverse aggregate demand for bank loans $r^F(L_t^F)$, where $L_t^F = L_{1t}^F + L_{2t}^F$ is aggregate loans and L_{it}^F, $i = 1, 2$, are the individual demands given by (8).[14] The aggregate loan amount must also equate the total credit

[14] The problem is not well defined for $N = 1$. Though easy to model, the number of banks is not the only or the more precise indicator of market concentration. However, the alternatives (e.g., switching costs, geographic distance etc) would complicate the analysis and yield similar qualitative results.

supplied by the banking sector, that is, $L_t^F = \sum_{n=1}^{N} L_{nt}^F$. The n^{th} bank chooses L_{nt}^F to maximize its own profits taking into account the loan demand $r^F(L_t^F)$. This is the only difference relative to the competitive case. There is a unique and symmetric equilibrium in which each bank chooses $L_{nt}^F = L_t^F/N$ (Freixas and Rochet, 1997, chap. 3), and in which the free lending rate is given by:

$$r_t^F = m(r_t^F)\left(\bar{r}_t^F + s_t^R + s_t^S\right) \tag{20}$$

where $m(r_t^F) = \left(1 + \frac{1}{N\varepsilon(r_t^F)}\right)^{-1} > 1$ is the gross markup and $\varepsilon(r_t^F) < 0$ is the loan demand elasticity, calculated from (8). Notice that the perfectly competitive solution emerges as a special case of (20) when $N = \infty$. The bank interest spread in the Cournot equilibrium is given by:

$$s^F(r_t^F) = m(r_t^F)\left(\bar{s}^F(r_t^F) + s_t^R + s_t^S\right) \tag{21}$$

where the undistorted spread $\bar{s}^F(r_t^F)$ depends on the same market fundamentals as before and on the gross markup:

$$\bar{s}^F(r_t^F) = \frac{(1 + r_t^D)(1 - \pi^F) + \eta_t^F}{\bar{\pi}^F} + r_t^D\left(1 - \frac{1}{m(r_t^F)}\right) \tag{22}$$

If N is very large, the gross markup converges to 1, the last term in (22) disappears and the undistorted spread collapses to the competitive solution (19).

3.4 Equilibrium

To close the model, I suppose the government pays interest rate on reserves and rebates all net proceeds to households in a lump-sum fashion: $-r_t^R \tau_t^R D_t = T_t$. I now define an equilibrium for the economy. For $\forall t = 0, 1, 2, \ldots, i = 1, 2$ and $j = F, S$, an equilibrium is a sequence of allocations $\{K_{t+1}, C_t, H_t\}$ for the household; a sequence of allocations $\{H_{it}, K_{it}, L_{it}^F\}$ for intermediate good producers; a sequence of allocations $\{Y_{it}\}$ for the final good producer; a sequence of allocations $\{H_t^j, K_t^D, L_t^F\}$ for the banking sector; market prices $\{w_t, r_t, r_t^D, r_t^F, P_{it}\}$ and a government policy $\{\tau_t^R, \tau_t^S, r_t^R, r_t^S\}$, such that given prices and policy the allocations satisfy equations (1)–(14) in the competitive banking case, and (1)–(13) plus (20) in the oligopolistic case.

4 Calibration

In the model calibration, I use aggregate credit statistics and bank-level information from the Brazilian central bank, as well as National Accounts data and Input-Output tables provided by the Brazilian Bureau of Statistics (IBGE). In order to avoid problems with high inflation I do not use data prior to 1995, and in the case of most

Table 4 Sectoral bank credit and output, percent averages for 2001–2006

Shares	Agriculture (A)	Housing (B)	Sector 1 (A+B)	Sector 2
Value added share	6.7	5.3	12.0	88.0
Sector loans/Aggregate credit	16.6	9.8	26.4	73.6
Selected loans/Sector loans	70.5	94.5	85.1	0
Credit/Output	40.0	30.0	35.6	14.0
Capital income share	62.6	46.2	55.1	41.4

Aggregate Credit excludes foreign currency, lease, credit card and 2nd-tier BNDES loans
Original sources: Central Bank of Brazil and IBGE

bank variables I consider a more restricted sample period, starting in 2000 or 2001, depending on the variable.

There are nineteen parameters to be calibrated, grouped into four categories: preferences, firm technology, banking and policy. Starting with preferences, I chose ϕ so that $H = 1/3$ in steady state, and set β to match the long-run capital-output ratio. Moving to technology parameters, I chose δ to match the observed capital-investment ratio, and set θ to match Sector 1's share of value added. In order to calibrate the sectoral parameters, I first identify Sector 1 and Sector 2 in the data. Sector 1 is an aggregation of housing construction and agriculture, whereas Sector 2 includes manufacturing and services. According to Table 4, Sector 1 accounts for only 12% of total value added but receives 26.4% of total credit, of which 85.1% refers to selected loans. As a consequence, the credit-to-GDP ratio in Sector 1 is more than double the ratio in Sector 2. The last row of Table 4 shows the capital income shares that I need to calibrate α_1 and α_2.[15] I chose θ_1 and θ_2 to match the implied leverage ratio of each sector, defined as the ratio of bank loans to sectoral capital. The two remaining technology parameters—ρ and σ—are unobservable. In the baseline calibration, I set $\sigma = 0$ because I view intermediate goods are complements, and chose ρ to match the aggregate credit-to-GDP ratio because this parameter governs the capital mix of the economy. Section 5 section presents sensitivity analysis regarding these two choices.

Turning to banking parameters, I set $1-\bar{\pi}^F$ and $1-\bar{\pi}^S$ to match the average default rates on freely allocated loans and on selected loans, respectively (see Table 3). I measure the default rates by the fraction of loans that are 90 or more days past due. I chose A^D to match the average real deposit yield in steady state, according to the non-arbitrage condition (12):

$$A^D = \frac{r}{r^D} = \frac{1/\beta + \delta - 1}{r^D}$$

Because the remaining banking parameters (A^F, A^S) cannot be identified with the available data, I set $A^S = (1/2)A^F$ in the baseline calibration and choose A^F so that

[15] Data on capital income are adjusted for the income of self-employed people. The weighted (by value added) average of the sectoral capital income shares is 0.42, which is close to international benchmarks (Golin 2002).

Table 5 Baseline parameters

Symbol	Description	Value
Preferences		
β	Time discount factor	0.912
ϕ	Leisure weight	1.414
Technology		
δ	Depreciation rate	0.070
θ	Sector 1 share of value added	0.120
α_1	Sector 1 capital income share	0.551
α_2	Sector 2 capital income share	0.414
θ_1	Sector 1 leverage ratio	0.210
θ_2	Sector 2 leverage ratio	0.083
ρ	Equity-debt elasticity of substitution	1.000
σ	Sectoral goods elasticity of substitution	0.000
Banking		
A^D	Deposit efficiency factor	1.721
A^F	Free loans efficiency factor	18.50
A^S	Selected loans efficiency factor	9.25
$1-\bar{\pi}^F$	Freely allocated loans default rate	0.047
$1-\bar{\pi}^S$	Selected loans default rate	0.083
Policy		
τ^R	Reserve requirement	0.292
τ^S	Credit requirement	0.155
r^R	Real interest rate on reserves	0.065
r^S	Real lending rate on selected loans	0.030

the unit loan cost in the model exactly matches the unit cost in the data, where the latter is calculated as the ratio of bank total cost to bank assets. Hence, the unit cost of selected loans is twice the unit cost of freely allocated loans, which I believe is a very conservative estimate.[16] I also provide sensitivity analysis to evaluate the implications of this choice.

Lastly, the policy parameters are taken directly from Tables 2 to 3. Credit and reserve requirements match the effective rates shown in Table 2; the lending rate on selected loans is chosen to match the average spread on selected loans shown in Table 3; and the interest rate on reserves is the average of the sample counterpart. Table 5 summarizes all parameter values.

[16] Rojas and Rojas (1997) find that the loan transaction cost of small firms in Mexico is six times larger than the loan cost of medium and large firms. Additionally, Saito and Villanueva (1981) find that the administrative costs of loans to small-scale industries in Philippines are ten times larger than the costs of handling loans to large-scale industries. Finally, Nakane and Costa (2005) find that providers of housing and rural credit in Brazil have larger loan cost than typical commercial banks. Unfortunately, these studies do not provide enough information for identifying the two efficiency factors.

Table 6 Model versus data

Financial ratios	Data	Baseline model	Bank spread	Data	Baseline model
Sector 1 share of total credit	26.4	26.9	Free spread (1+2+3)	31.3	22.3
Sector 1 selected-to-total loans	85.1	84.8	1. Undistorted spread		11.8
Sector 1 credit-to-output ratio	35.6	37.6	2. Reserve tax		2.0
Sector 2 credit-to-output ratio	13.9	13.8	3. Cross-subsidy (a+b+c)		8.5
Aggregate credit-to-GDP ratio	17.2	16.6	a. Interest rate effect		2.2
Selected-to-total loans ratio	21.0	22.9	b. Loan loss effect		2.5
Bank average cost	7.5	7.5	c. Cost effect		3.8

Spreads in percentage points, financial ratios in percent

5 Results

This section examines the quantitative implications of the credit and reserve requirements. To begin with, I check the baseline calibration with the data, paying attention to the spread components. Next, I study the short- and long-run implications of the policy for resource allocation and welfare. At the end, I check the robustness of the results.

5.1 Model meets data

Table 6 compares the steady state values of the baseline model with long-run moments in the data. I focus on the main leverage ratios and on the spread components. The calibrated model is able to reproduce all the financial ratios of interest, including credit-to-output ratios and sectoral leverage ratios. Moreover, this parsimonious is able to explain almost three-quarters (about 22 percentage points) of the actual spread level. Compared to the available accounting decomposition of the spread (Nakane and Costa 2005), bank profits and bank taxes are the only two quantitatively relevant components left out of the baseline calibration. These two items explain about a third of the spread level in those accounting exercises. Thus, the model does a good job at matching the actual spread.

A closer look at the spread components reveals that the policy distortions—captured by the reserve tax and the cross-subsidy—accounts for almost half of the spread level in the model and a third of the actual spread level. Moreover, the policy distorts the free spread mainly through the cross-subsidy, whose major component is the cost effect. Notice that the reserve tax alone only explains one-tenth of the spread level in the model, in line with the available estimate (see footnote 8). The undistorted spread accounts for the other half of the spread in the model, or almost 12% points, which is closer to the Latin American average (see Table 1).

Table 7 Long-run policy effects

Variable	Baseline	No reserve requirement	No credit requirement	No reserve, No credit requirements
Free spread (1+2+3)	22.3	17.4	13.5	12.0
1. Undistorted spread	11.8	11.9	12.0	12.0
2. Reserve tax	2.0	0	1.4	0
3. Cross-subsidy	8.5	5.6	0	0
Sector 1 share of total credit	26.9	26.7	26.3	26.3
Sector 1 selected-to-total loans	84.8	60.0	0	0
Sector 1 credit-to-GDP ratio	37.6	44.5	53.2	57.2
Sector 2 credit-to-GDP ratio	13.8	16.7	20.3	22.0
Aggregate credit-to-GDP ratio	16.6	20.1	24.3	26.1
Selected-to-total loans ratio	22.9	16.0	0	0
Bank average cost	7.5	7.2	6.3	6.3
Long-run changes relative to baseline				
Labor	–	0.2	0.7	0.6
Investment	–	0.3	5.8	4.0
Output	–	1.2	3.1	3.3
Consumption	–	1.4	2.6	3.2

Spreads and changes in percentage points, financial ratios in percent

5.2 Long-run implications

I now turn to the long-run effects from eliminating all credit and reserve requirements in Brazil. I treat any policy change in this and in the remaining sections as unanticipated events. For now, I abstract from alternative policies (e.g. lifting the interest rate ceiling) that could also bring the average spread down. Table 7 compares the steady state statistics of the baseline economy with equivalent statistics in the economy without reserve requirements ($\tau^R = 0$), the economy without credit requirements ($\tau^S = 0$), and the economy without both requirements ($\tau^R = \tau^S = 0$). *Ceteris paribus*, eliminating reserve requirements reduces the spread level by about 5% points, an amount that is twice as large as the reserve tax itself in the baseline model due to the amplification effect. The model predicts that both sectoral and aggregate credit-to-GDP ratios go up, while the proportion of selected loans in total credit goes down. Lastly, the policy change yields substantial welfare gains as measured by the permanent increase in consumption and output.

The fourth column of Table 7 shows that the elimination of the credit requirement has an even larger impact on the bank spread, bank performance and allocation of resources in the long-run. Bank spreads decrease by almost a half to about 13.5% points. Again, the fall in the spread is larger than the cross-subsidy in the baseline model because this no longer interacts with the reserve tax. Eliminating the credit program boosts financial intermediation significantly—credit-to-output ratios in Sector 2 and in the aggregate increase by almost 50%. Interestingly, Sector 1's access to credit

is not hurt, its share of total credit remains unchanged and its credit-to-output ratio also increases by a large amount. Turning to banking performance, the average loan cost goes down because banks save on monitoring costs and because the volume of credit increases by more than the unit labor cost.[17] The lower cost of credit boosts capital accumulation and hence leads to a large permanent increase in both investment, output and consumption.

The last column of Table 7 suggests that eliminating both requirements delivers the largest welfare and efficiency gains. The spread falls by almost a half and credit indicators increase by more than 50%, becoming closer to the Latin American average (see Table 1). Moreover, consumption increases permanently by more than 3%. Though large, this welfare measure does not take into account the potential losses during the transition to the new steady state, as I do in the next section.

5.3 Transition dynamics and welfare

Suppose that at $t = 0$ the baseline economy is at its distorted steady state and that at $t = 1$ the requirements are eliminated-both τ^R and τ^S are set to zero. After these policy changes, the economy converges overtime to a new steady state. Figures 2 and 3 show the percentage changes (relative to the initial steady state) of the main variables during the transition to the new steady state. These figures reveal many interesting details about the timing and the magnitudes of the effects.

First of all, because the economy is closed, the transition is relatively slow for most variables, except for bank credit. Second, the liberalization of the credit market improves the allocation of resources across sectors and overtime, and the reduction in bank spread boosts the demand for bank credit in the two sectors. The first panel of Fig. 2 shows that bank credit increases immediately by more than a half in both sectors. We may think that firms are simply shifting resources towards bank debt and away from internal financing, but the second panel reveals that firm capital also increases permanently in Sector 2, whereas it remains virtually unchanged in Sector 1. In other words, the two sectors experiment significant changes in both the level and the composition of their capital structure. Consequently, aggregate credit and capital also increase substantially, as we can check in the first two panels of Fig. 3. Turning to the reaction of labor, the third panel of Fig. 2 shows that labor experiences a permanent drop of 4% in Sector 1, but it displays a slight increase in Sector 2. The third panel of Fig. 3 shows the net effect on aggregate labor, which increases by almost 1% in the long-run, in part because the banking sector absorbs the labor dismissed by the real sector. The model also predicts that the credit boom raises sectoral output by more than 3% (fourth panel of Fig. 2). Sectoral and aggregate output go up by exactly the same

[17] In the model, average cost goes down simply because banks are no longer forced to provide costly selected loans. In practice, however, the mechanism is less straightforward. It is reasonable to think that loans intensive in monitoring (e.g., rural and housing loans) are managed more efficiently by specialized institutions like farming banks and mortgage houses. In Brazil, the policy forces all commercial banks to provide such loans regardless their monitoring capabilities. Hence, we should expect overall banking efficiency to increase not only because the credit program is eliminated but also because rural and farming loans would be provided by specialized and hence more efficient banks.

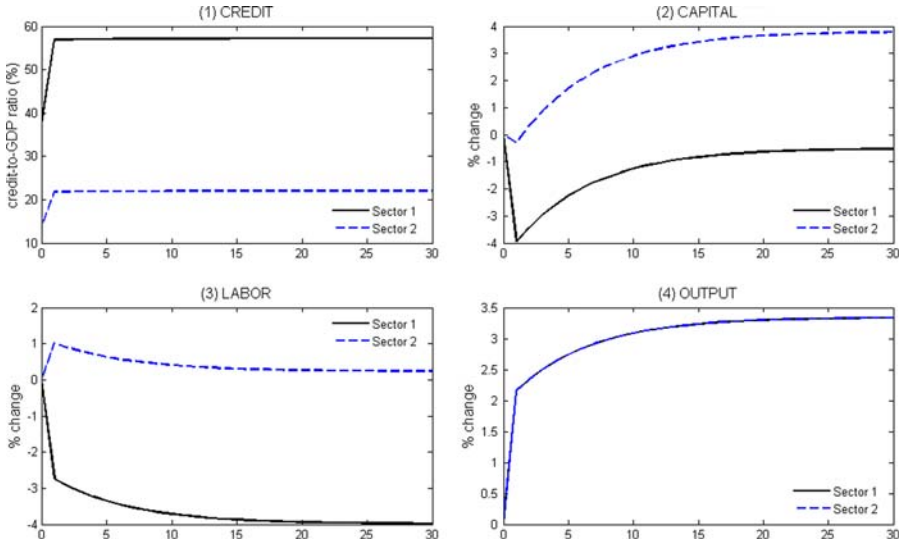

Fig. 2 Transition paths of sectoral allocations. Sectoral responses to the elimination of all requirements: $\tau^R = \tau^S = 0$

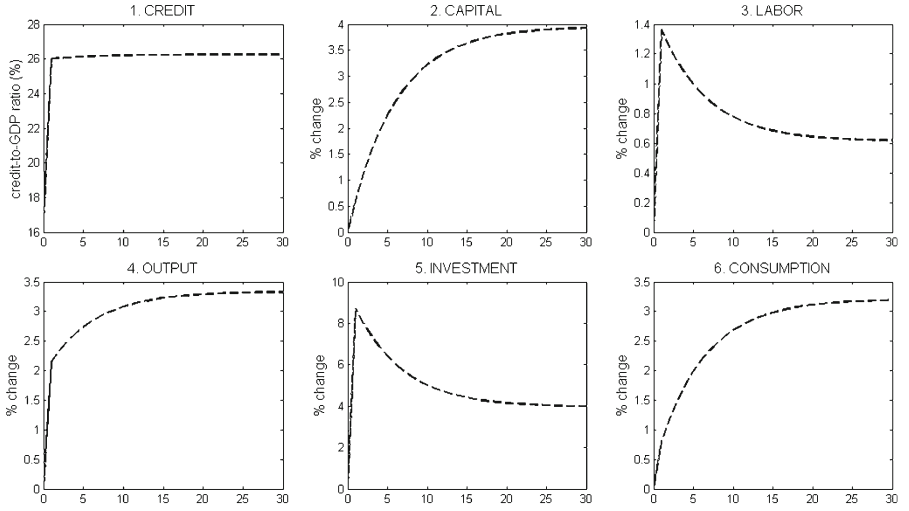

Fig. 3 Transition paths of aggregate allocations. Aggregate responses to the elimination of all requirements: $\tau^R = \tau^S = 0$.

amount because of the Leontief technology. The last two panels of Fig. 3 display the behavior of the two components of aggregate expenditure. On impact, the economy experiences an investment boom, which dies out as time goes by, and consumption increases steadily until the transition is complete.

I obtain similar figures (not shown) in the case of a partial market liberalization, that is, when only reserves requirements or only credit requirements are eliminated.

Consumption, however, does not grow monotonically in the latter case. In fact, consumption initially drops by about 1% because of the strong reaction of investment, which increases by more than 12% in the first period. This last experiment suggests that there might be short-run consumption losses from phasing out the credit program, though the long-run gain is unambiguously positive. I calculate the welfare gain from each policy change taking into account the transition dynamics. Specifically, I compute the percentage increase in steady state consumption necessary to make households indifferent between having and not having the policy around. I find that eliminating reserve requirements yields a welfare gain of 1.2% of current consumption, whereas eliminating credit requirements implies a gain of only 0.4%. Eliminating both requirements yields a welfare gain of 1.63% of current consumption, which is equivalent to 13 billion dollars a year at 2006 prices. The combined welfare gain is larger than ballpark estimates found in the literature. For instance, it is twice the gain from eliminating all taxes on capital income in the US (Lucas 1990), twice the gain from reducing long-run inflation to zero (Lucas 2000), and 63% higher that the gain by a typical non-OECD country from switching from autarky to complete financial integration (Gourinchas and Jeanne 2006). Note that the slow transition to the new steady state tends to reduce the welfare gains. Had I considered a small open economy, I would probably find larger gains because convergence to the new steady state would be faster.[18]

As I mentioned in Sect. 2, Antunes et al. (2009) also find significant welfare effects from improving the efficiency of financial intermediation in countries like Brazil. They estimate that reducing Brazilian intermediation costs to the US level implies a welfare gain of 2.8% in terms of consumption equivalent to baseline. They also find that welfare gains are substantially larger for individuals at the bottom of the wealth distribution. Thus despite our different modeling approaches, we both find that the welfare effects from removing distortions in financial intermediation are large and in the same order of magnitude.

One could argue that my model overestimates the welfare gains because required reserves are set to zero. The complete elimination of reserve requirements might be undesirable because they could function as a liquidity insurance device and thus prevent bank crises. An extreme way to prevent bank runs is to require banks to hold a reserve ratio of 100%, but such policy may lead to suboptimal equilibria. On the other hand, a zero-reserve banking system may be optimal only if bank runs never occur (Freixas and Rochet (1997), chap. 7). In actual fractional reserve banking systems, panic and runs eventually occur, causing real economic damage and reducing social welfare. However, the classical analysis of bank runs by Diamond and Dybvig (1983) suggests that there might be alternative policies, such as deposit insurance or a lender of last resort, for preventing runs and ensuring banking stability. The key issue then is whether reserve requirements are superior devices for preventing liquidity crises. As far as I know, the theoretical literature offers little guidance about this issue. On the other hand, the empirical evidence discussed in Sect. 2 suggests that mandatory reserves are no longer a relevant mechanism for ensuring financial stability.

[18] The closed economy assumption is a reasonable approximation for the Brazilian economy.

A thorough analysis of the full costs and benefits of mandatory reserves would require deeper changes in the model, including the optimal reserve mix (remunerated versus non-remunerated), which is out of the scope of this paper. Despite these limitations, we can still assess the welfare effects of a partial reduction in reserve rates, but we must remember that the potential insurance benefits of reserves are ignored, which may lead to an overestimation of the true welfare gains. With this in mind, I find that reducing requirements on both remunerated and non-remunerated reserves to one-digit levels still yields quite large welfare gains. For instance, there is a 0.63% gain (instead of the 1.2% gain from full elimination) when the reduction in the effective reserve rate is from 29.2 to 8%, and 1% gain if the reduction is to 3%. Thus the gain from reducing mandatory reserve ratios to 8% (3%) and at the same time phasing out the credit program is about 1% (1.42%) of equivalent consumption, again a sizeable amount.

5.4 Sensitivity analysis

This section checks the robustness of the baseline results. I present sensitivity analysis regarding the choices of the elasticities σ and ρ, and the choices of the efficiency factors A^F and A^S. I also consider non-binding interest rate controls, an oligopolistic banking sector and an alternative loan sample.

Table 8 presents the welfare gain from eliminating *all* requirements for different choices of the pair (σ, ρ). I compare the baseline case with the other two cases shown in the table. The welfare gain varies more across columns, for a given σ, than across rows, for a given ρ, meaning that the complementary between firm capital and bank capital is more important for welfare than the complementarity between sectoral outputs. However, as bank debt and firm capital become closer substitutes (higher ρ) the welfare gain increases, which seems counter-intuitive. To better understand this result we must consider that the policy change produces an inter-temporal effect and an intra-temporal effect on the allocation of capital. The first refers to the change overtime in the aggregate stock of capital, whereas the latter has to do with the reallocation of the existing capital between bank debt and firm internal capital. The magnitude of the welfare gain will depend on which effect dominates. When ρ is relatively high, firms substitute away from bank loans into internal financing more easily. Thus the policy change induces a strong reallocation towards bank debt, not necessarily followed by accumulation of aggregate capital. In this case, the financial liberalization benefits consumption more than investment and implies that the welfare gain accrues earlier than in the baseline case. Therefore, when the intra-temporal effect dominates, welfare increases by more than in the baseline exercise. On the other hand, when ρ is small, the increase in bank debt must be followed by a proportional increase in firm capital because both inputs are complements. Thus, investment must react more strongly than consumption, eliminating some of the short-run gains. Hence, when the inter-temporal effect dominates, the welfare gain becomes smaller than in the baseline case. The bottom line is, any bias that may exist in the baseline model will tend to underestimate rather than overestimate the welfare gain because the baseline calibration probably understates the actual elasticity between firm capital and bank debt.

Table 8 Production complementarity and welfare

		Low* $\rho = 0$	Baseline $\rho = 1$	High* $\rho = 5$
Baseline	$\sigma = 0$	1.25	1.63	4.71
Unitary	$\sigma = 1$	1.26	1.63	4.69
High	$\sigma = 5$	1.28	1.60	4.73

* $\theta, \theta_1, \theta_2$ and A^F are re-calibrated to match the baseline case
Welfare gain is equal to equivalent consumption variation (in percent)

Table 9 Lending efficiency, welfare gain and bank spread

Variable	Low efficiency* $A^S = 0.25A^F$	Baseline $A^S = 0.5A^F$	High efficiency* $A^S = A^F$
Welfare gain from policy change	2.20	1.63	1.18
Free spread after policy change	10.3	12.0	13.5
Free spread before policy change (1+2+3)	22.3	22.3	22.3
1. Undistorted spread	10.1	11.8	13.3
2. Reserve tax	2.0	2.0	2.0
3. Cross-subsidy (a+b+c)	10.2	8.5	7.0
a. Interest rate effect	2.2	2.2	2.2
b. loan loss effect	2.5	2.5	2.5
c. Cost effect	5.5	3.8	2.3

* θ_1, θ_2 and A^F are re-calibrated to match the baseline case
Spread in percentage points and welfare gain in percentage variation of equivalent consumption

The following robustness check evaluates the choice of efficiency parameters in the loan production function. I recalculate the welfare gain and the spread components for different values of the pair (A^F, A^S) such that the average banking cost remains the same in each experiment. Table 9 shows how these different choices affect welfare and bank spread. In the second column, I assume that the efficiency of selected loans is lower than in the baseline case, while in the last column it is the same as in the baseline model. In the first case, the marginal cost of providing subsidized loans is four times the marginal cost of providing free loans, whereas it is the same in the second case. Even in this second and unlikely scenario, the welfare cost still exceeds 1% of current consumption, and the impact on the free spread is still significant. Therefore, even if bank efficiency is better than we think, the policy effects remain large.

So far I have assumed that banks are unable to charge a selected lending rate above the legal ceiling, but I argued in Sect. 3.3 that banks may actually charge a higher lending rate by adding non-pricing elements to the ceiling. Such practices are difficult to prevent and even more difficult to identify in the data. To keep matters simple, I now assume that banks are able to charge a lending rate r^S that covers the loan loss and the loan cost in the selected market. Table 10 shows the bank spread in each market and the welfare gain from eliminating the policy. We can check in the third column that

Table 10 Interest rate controls, welfare and bank spread

Variable	Binding control* (baseline)	Non-binding control* ($\tau^S = 0$)
Welfare gain from policy change	1.63	1.13
Spread on selected loans	−6.7	22.8
Spread on freely allocated loans (1+2+3)	22.3	13.7
1. Undistorted spread	11.8	11.7
2. Reserve tax	2.0	0
3. Cross-subsidy	8.5	0

* θ_1, θ_2 and A^F are re-calibrated to match the baseline case
Spread in percentage points and welfare gain in percentage variation of equivalent consumption

when the interest rate ceiling is non-binding the subsidized spread becomes almost twice as large as the free spread, which is now only affected by its fundamental level and by the reserve tax. Moreover, removing all requirements still yields a welfare gain that exceeds 1% of current consumption. Therefore, the contribution of binding interest rate controls to the welfare gain is about 0.5% of current consumption, the difference between the baseline 1.63% gain and the 1.13% gain when controls are no longer binding.

The next sensitivity analysis looks at the interaction between the policy and banking market structure. Standard measures of bank competition suggest that loan and deposit markets are quite concentrated in Brazil. Although Brazilian concentration ratios are within the Latin American range, by mid-2008 the 4 (40) largest banks controlled about 60 (95)% of both markets. The Herfindahl index also points that banking concentration in Brazil is moderate but not negligible (in the 900–1,100 range).[19] I now recalculate the policy effects under oligopolistic competition. Equations (20)–(21) suggest that market power raises the gross markup above 1 and thus increases the free lending rate and spread above their perfect competition counterparts. Figure 4 plots the spread and the welfare gain for different number of banks, N. The first panel shows that for small N the distorted spread under imperfect competition (solid line) is almost double the distorted spread under perfect competition (dash-dotted line). The model exactly matches the actual spread when $N = 4$, though this number would imply excessive market concentration relative to the data. We can see in panel 1 that removing all requirements lowers the spread by about 10% points, regardless the degree of competition. However, market power does make a difference in terms of welfare because higher market concentration implies larger monopoly rents and thus larger welfare gains, compared to perfect competition (panel 2). Different from standard econometric exercises, this experiment clearly uncovers the individual contributions of the policy distortions and the monopoly power to the spread level. For instance, for $N = 4$, the three main determinants of the spread level are the policy

[19] For concentration ratios in Latin America, see Micco et al. (2004) and Beck et al. (2000). As a rule of thumb, a Herfindahl index smaller than 1,000 indicates low concentration, 1,000-1,800 indicates moderate concentration, and 1,800 or larger denotes high concentration.

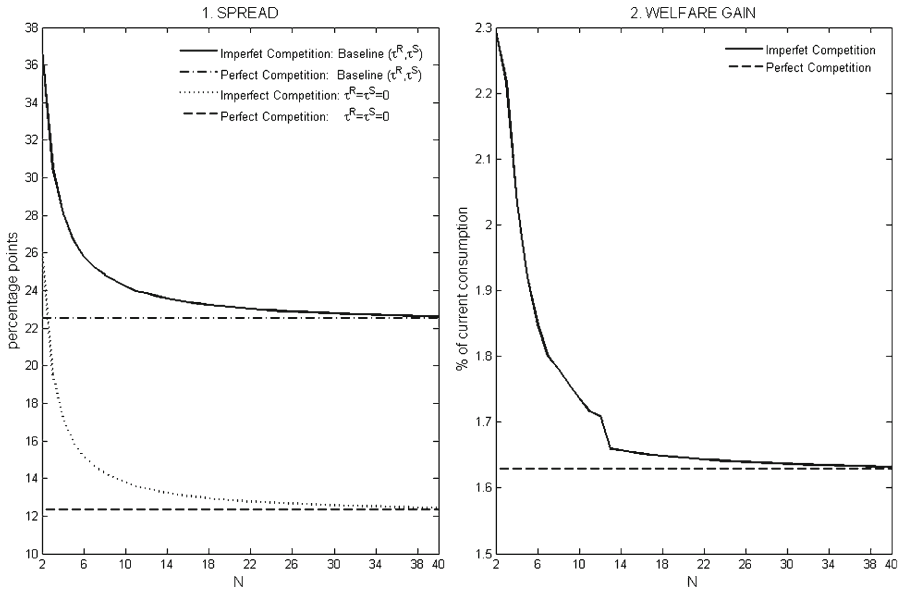

Fig. 4 Effects of market structure on bank spread and welfare. For each N, θ_1, θ_2 and A^F are re-calibrated to match the baseline case

distortions (34%), bank market power (25%) and operating costs/loan losses (41%). These last two shares are comparable to the estimates based on information from bank accounting data compiled by the Brazilian central bank.

The last sensitivity analysis evaluates my choice of the relevant loan sample. So far, I only considered loans intensive in deposits, which are more likely to be distorted by the policy. The loans I left out represent a fifth of all loans and include credit card loans, foreign currency loans, lease loans and, especially, second-tier loans by the Brazilian Development Bank (BNDES)—a government bank which is the main source of long-term credit in Brazil. The first three loan categories are less likely to be affected by the policy but not the latter. About half of BNDES loans reaches its target (mainly manufacturing firms) through first-tier commercial banks. By using the commercial branching network, BNDES is able to reach customers more easily in the vast Brazilian territory. Some argue that BNDES is playing a positive role in Brazil's economic development (IDB, 2005), but its presence may distort market interest spreads and lending volumes in at least two different ways. First, its virtual monopoly of long-term financing may be crowding out private credit and capital markets (Kumar, 2005). Second, although first-tier banks are free to charge their own spreads, there is indirect pressure by BNDES to keep spreads small (IDB, 2005, p. 201). In order to compensate the relatively small rate of return on BNDES loans, it is a common practice by first-tier banks to bundle those loans with their own, more expensive, credit lines. Thus the presence of BNDES appears to induce private banks to recoup their average return by charging higher interest rates on their own products in the bundle. The main difference between BNDES loans and the selected loans of the baseline sample is that the first generate cross-subsidy of bank products and the second produce cross-subsidy of bank customers.

Table 11 Policy effects using extended loan sample

Variable	Extended baseline	No reserve requirement	No credit requirement	No reserve, No credit requirements
Free spread (1+2+3)	27.6	20.7	12.7	11.5
1. Undistorted spread	11.1	11.3	11.5	11.5
2. Reserve tax	2.0	0	1.2	0
3. Cross-subsidy	14.5	9.4	0	0
Welfare gain	–	1.6	1.2	2.7

Extended sample is the baseline sample plus BNDES second-tier loans
$\theta_1, \theta_2, \alpha_1, \alpha_2, A^F, \tau^R, \tau^S$ and r^S are re-calibrated in the extended baseline model
Spread in percentage points and welfare gain in percentage variation of equivalent consumption

This difference is not important in the model because selected borrowers receive all subsidized loans, meaning that the cross-subsidization of bank borrowers still persists in the augmented sample. Thus, adding BNDES loans into the model only requires the re-calibration of a subset of parameters, whose new values are: $\theta = 0.33$, $\theta_1 = 0.15$, $\theta_2 = 0.14, \alpha_1 = 0.46, \alpha_2 = 0.39, A^F = 19.5, \tau^R = 0.19, \tau^S = 0.28$ and $r^S = 0.045$. Table 11 shows the bank spread and the welfare gain from eliminating all requirements in the re-calibrated economy. The extended model predicts a bank spread of 27.6% points, almost 90 of the actual spread. The policy distortions now explain more than half of the spread level in the model. In turn, the welfare gain from eliminating all distortions is almost twice the baseline gain. These results are a warning against the commonly held belief that BNDES' role in fostering economic development in Brazil does not come without a cost.

6 Conclusion

This paper showed that the policy of credit and reserve requirements in Brazil distorts bank spreads, undermines financial intermediation and generates large welfare losses. The paper has two important contributions. First, it carefully identifies and measures the channels through which the policy affects bank spreads and resource allocation. Second, under very reasonable assumptions, it predicts that eliminating the policy yields a permanent increase in consumption of over 3% in the long-run. If we take into account the short-run losses, the welfare gain is almost 2% of current consumption in the conservative calibration. The baseline results are fairly robust to the choice of the data sample and to a wide range of parameter values.

This paper leaves open several directions for further exploration. First, it abstracts from information asymmetries and monetary issues, which may further reinforce the policy distortions on spread and welfare found in this paper. Second, it abstracts from consumer credit market and assumes that all bank loans are in fact business loans. Loans to households already account for half of all freely allocated loans in Brazil and are growing rapidly. Third, the model focuses on resource allocation and abstracts from the potential effects on productivity. As Levine (2005) and many others suggest,

policies that distort financial intermediation harm not only the allocation of savings but also the efficiency with which resources are allocated. Fourth, the analysis of the underlying political economy may shed additional light into the problem.

Lastly, some parameters deserve better microfoundation. There is a large literature on credit constrained entrepreneurs (see Quadrini (2009) for an excellent survey). In order to understand the macroeconomic aspects of entrepreneurship, papers such as Castro et al. (2004), Antunes et al. (2008), Buera (2009), and others, tend to make two key simplifications. First, they abstract from a firm's capital structure and agents are constrained by their wealth. Profit maximization is static but repeated (as is occupational choice), and dynamics occur through the distribution of wealth. Second, default does not occur in equilibrium and entrepreneurs are limited by the evolution of their wealth. Alternatively, recent work on firm dynamics by Herranz et al. (2009) examines how entrepreneurs use endogenously determined firm size, capital structure and default to manage risk intertemporally. For tractability, their paper assumes an elastic supply of funds (i.e., it does not consider the lender's problem) in a partial equilibrium model. My model includes banking system and considers general equilibrium effects, but uses a reduced form for the optimal capital structure. I match the leverage ratios to sector data, and estimate the unobservable elasticities to substitution between bank debt and internal capital and between the two intermediate goods. All reduced-form models are subject to the Lucas critique, and it would clearly be desirable to have a tractable dynamic general equilibrium model with a banking system, endogenous credit constraints, firm size, capital structure and default, which is amenable to policy analysis. As conjectured in Sect. 3, the results obtained from such a setup may reinforce rather than weaken the baseline results. However, such a model remains for future research.

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