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Access to Credit and the Size of the Formal Sector

ABSTRACT This paper studies the link between credit conditions and formalization in Brazil. Over the last decade, Brazil has experienced a large increase in the level of credit and the rate of formalization. these changes are linked to a reduction in the cost of credit and policy reforms oriented toward improving the efficiency of the financial sector. The paper develops a model with endogenous formal and informal sectors to evaluate how much of the change in corporate credit and the size of the formal sector can be attributed to a reduction in financial intermediation costs. The model predicts that the reduction in intermediation costs generates an increase in the credit-to-output ratio and the fraction of formal workers, in line with the data. By affecting the allocation of capital and the entry and exit rates, the change in credit conditions has important implications for the firm size distribution and aggregate productivity.

JEL classifications: D24, E26, L11, O16, O17

Keywords: Financial structure, Informal sector, Aggregate productivity

This paper analyzes the link between credit conditions, the level of formalization, and the firm size distribution. Formalization in Brazil has risen by 21.69 percent since 2001 (from 45.5 to 55.37 percent).[1] During the same period, favorable international liquidity and a decline in policy-controlled interest rates led to an improvement in credit conditions for Brazilian firms, as evident in the sharp increase in credit to firms over GDP (from 15 percent in 2003 to more than 22 percent in 2008) and a reduction on average interest rates charged on corporate loans.

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1. The definition of the formal sector is based on the share of workers who contribute to social security, as in Catao, Pagés, and Rosales (2009).

The Brazilian experience is of particular interest because Brazil is among only a handful of major emerging economies that saw bank lending double (as a share of GDP) in the last decade. The increase in credit and formalization was fostered by a period of sound macroeconomic policies, combined with structural reforms in the financial sector aimed at reducing the cost of corporate credit and improved access to credit by financial institutions.[2] For example, during the administrations of President Luíz Inácio Lula da Silva (2003–10), inflation rates remained low; the government ran a primary surplus of 0.75 percent of GDP, on average; the net public debt declined steadily; there was strong demand for Brazil's exports; and the terms of trade recorded large gains. The aim of this paper is to develop a parsimonious model to study how the increased efficiency of financial institutions and the reduction in their funding costs as a result of structural reforms and the good macroeconomic conditions and credit environment affected aggregate credit and the rate of formalization.

More specifically, the paper assesses the extent to which the change in the level of corporate credit to GDP and formalization can be attributed to improvements in the efficiency of financial intermediaries and a reduction in their cost of funding. To explore this issue, I develop a general equilibrium model of firm dynamics with endogenous entry and exit that incorporates capital financing and bankruptcy decisions. The model allows for the existence of a formal and an informal sector. Entering and operating in the formal sector is costly, but it allows firms to access credit markets with better commitment and greater efficiency. Financial intermediaries have access to international markets at a risk-free rate, but incur a proportional cost when issuing debt. The degree of debt enforcement affects the interest rate that nonfinancial firms face because there is equilibrium default.

The quantitative experiment proceeds as follows. I first calibrate a steady state of the model using firm-level data and other relevant aggregate statistics from Brazil in the early 2000s.[3] I also use country-specific institutions based on those reported by the World Bank in its *Doing Business* database. This calibration facilitates the identification of technological parameters for nonfinancial firms and financial intermediaries and determines the benchmark

2. The paper documents the structural reforms and the changes in credit conditions in the following section.

3. The data sources for Brazil include a firm-level survey (Annual Social Information Report, RAIS), a survey of informal firms (the Urban Informal Economy Survey, ECINF), a household survey, and detailed information on credit terms to the corporate sector, as well as aggregates from different sources. The data and data sources are presented in the following section and in the appendix.

size of the informal sector, the credit level, and corporate spreads in the economy. Once the model is calibrated, I study the effect of a 37 percent reduction in the cost of funds for financial intermediaries (from 7.5 to 4.7 percent) and a 44 percent reduction in the cost of issuing loans (from 5.58 to 3.31 percent). These changes are calibrated using Brazilian data from 2003 to 2010 to match the observed reduction in the money market interest rate and overhead costs for financial firms.

The reduction in intermediation costs produces an endogenous response in the level of credit, the firm size distribution, and the degree of formalization, which is at the center of our paper. More specifically, the exercise shows that a reduction in credit costs generates an increase in credit to GDP of approximately 87 percent. The increase in the formal labor force is 45 percent. Therefore, as in the data, the model generates sizable increases in the level of credit and the size of the formal sector. In the model, an increase in the level of formalization and a better allocation of resources generates an increase in measured aggregate total factor productivity (TFP) of approximately 15 percent and weighted firm-level productivity of about 16 percent.

The intuition for these results is as follows. Changes in intermediation costs have a first-order effect on corporate bond prices. This translates into lower default probabilities, which increase bond prices even further (the loan spread endogenously decreases by 21.96 percent in the model). This affects the firm size distribution through the following channels. First, it induces incumbent firms to change the composition of debt and capital. When interest rates are low, firms' precautionary motive for capital accumulation is reduced, and the incentives to borrow are stronger. Since firms do not face the need to accumulate capital to survive adverse shocks, this increases the efficiency in the economy (that is, firms move closer to their optimal level of capital). Second, it affects the endogenous entry and exit productivity thresholds. Since the value of the firm is higher, it lowers the entry threshold into formalization, increasing the fraction of output produced by formal firms. This affects productivity in different directions. On the one hand, a lower entry threshold has a negative impact on the average level of productivity of the entrant firm. On the other, a larger fraction of output is produced by more productive formal firms. Finally, higher entry also results in stronger competition and higher wages (due to higher aggregate demand for labor), which translates into more exit (with a positive effect on productivity) and a reduction in the average size of the firm. the positive effects on productivity dominate, and aggregate TFP increases.

To understand the overall results further, I also analyze separately the effects of changes in the cost of funds for financial intermediaries versus the

reduction in the cost of issuing loans. The results show that most of the effect on the credit level is due to the increase in the financial sector's efficiency (as opposed to changes in funding costs). Moreover, I uncover an important interaction effect between the level of efficiency and the cost of funds for intermediaries that allows the model to generate the overall change in the size of the formal sector. This has important policy implications. A reform targeted to increase only the financial sector's efficiency without reducing the borrowing costs for intermediaries can have a potentially large impact on the level of credit to GDP, but a minor effect on the level of formalization. Additionally, in an extension of the model suited to evaluating the direct effects of the bankruptcy reform on recovery rates and bankruptcy costs, I show that this reform in isolation generates a relatively small change in the level of credit and formalization. Again, focusing on policies that increase the efficiency of the financial sector and reduce intermediation costs is the key to increasing the credit level, promoting formalization, and improving the allocation of resources.

The approach used to study firm dynamics follows the work of Hopenhayn, Hopenhayn and Rogerson, and Cooley and Quadrini, who study the effects of financial constraints in a similar setup.[4] The modeling assumptions regarding the informal sector follow Rauch and Loayza, who consider informal activity to be an optimal response to the economic environment.[5] The treatment of informality and credit frictions follows D'Erasmo and Moscoso Boedo.[6] There is also related literature on the distributional consequences of frictions in this context.[7] This paper also introduces imperfect capital markets.[8] It builds on the existing literature by analyzing the extent to which the observed changes in credit conditions in Brazil can generate the pattern that aggregate credit and the size of the informal sector display. In contrast with most of the cited papers and in line with D'Erasmo and Moscoso Boedo, the pricing of corporate debt induces a well-defined distribution of borrowing

4. Hopenhayn (1992); Hopenhayn and Rogerson (1993); Cooley and Quadrini (2001).

5. Rauch (1991); Loayza (1996).

6. D'Erasmo and Moscoso Boedo (2012); D'Erasmo, Moscoso Boedo, and Senkal (2014).

7. For example, Restuccia and Rogerson (2008); Hsieh and Klenow (2009); Guner, Ventura, and Xu (2008); Arellano, Bai, and Zhang (2012); Buera, Kaboski, and Shin (2011).

8. Antunes and Cavalcanti (2007) and Quintin (2008) study endogenous informal sectors that result from imperfect contract enforcement. Castro, Clementi, and MacDonald (2009) and Erosa and Hidalgo Cabrillana (2008) study the effects of financial contracts in environments with asymmetric information.

costs.[9] By focusing on Brazil, the model can be tested on several important dimensions, such as the resulting distribution of firms in the microenterprise sector or firms with fewer than five workers, as well as the firm distribution in the informal sector. Moreover, it also makes it possible to establish a direct link between parameters in the model and the observed reform. In contrast, most previous papers in the literature focus on effects of changes in specific parameters (without a specific reform in mind) or exploit cross-country variation.[10] Finally, the literature includes a number of papers studying firm dynamics across countries, in both the formal and informal sectors.[11]

The paper is organized as follows. The next section presents the relevant facts on the evolution of formality and credit in Brazil in the last decade. The paper then describes the theoretical model and its equilibrium. A subsequent section is devoted to the calibration of the model to the Brazilian data, followed by a discussion of the main experiment. The final section concludes.

Credit, Formalization and Institutions in Brazil

This section describes the main facts driving the quantitative exercise. A description of the institutional framework and the changes in credit conditions is followed by an analysis of the firm size distribution and the size of the informal sector. Finally, I describe a set of measured institutions that are also important for understanding the link between credit imperfections, informality, and productivity.

Institutional Reforms and Credit Conditions

The role of institutions such as bankruptcy law in shaping economic outcomes has been studied extensively in the empirical literature.[12] The evidence points

9. D'Erasmo and Moscoso Boedo (2012).

10. See for example Gomis-Porqueras, Peralta-Alva and Waller (2014) and Bergoeing, Loayza, and Piguillem (2015). Restuccia and Rogerson (2013) and Hopenhayn (2014) provide excellent recent reviews of this literature.

11. The only papers that report data on firm characteristics in the informal sector are Tybout (2000) and La Porta and Shleifer (2008). Papers focusing on firms operating in the formal sector include Foster, Haltiwanger, and Krizan (2001); Bartelsman, Haltiwanger, and Scarpetta (2009); and Alfaro, Charlton, and Kanczuk (2009).

12. See, for example, Djankov and others (2008); Levine (1999).

toward the importance of creditor rights. Developing economies are characterized by lower legal protection of creditor rights, as well as inefficient credit markets. Brazil was no exception until the early 2000s. However, several structural reforms (such as the bankruptcy reform and the decline in policy-controlled interest rates), together with favorable international liquidity conditions, propelled an increase in corporate credit, especially bank lending, in the last decade. The reforms implemented during this period contributed to the improvement in intermediation efficiency and a large reduction in the cost of credit for nonfinancial and financial corporations in Brazil. Although many emerging economies experienced rapid credit growth, Brazil is among only a handful of major emerging economies that saw bank lending double (as a share of GDP) from 2000 to 2010.

One of the major changes in the institutional environment during the last decade was the reform of the Brazilian bankruptcy law to provide a significant increase in protection to creditors.[13] The old bankruptcy code in Brazil was enacted in 1945 and remained largely unchanged until 2005. Before the reform, creditors had a very low level of protection in Brazil. This characteristic raised the interest rate spread and inhibited the supply of credit. The new bankruptcy law encourages reorganization of claims in a bankrupt entity. In the event of liquidation, the new law rearranges the absolute priority rules in favor of secured creditors. Before the reform, bankruptcies in Brazil took ten years, on average, to be resolved, which is roughly three times longer than the time taken in the United States (three years) and in the Latin American and Caribbean region (just over three and a half years). This long bankruptcy resolution period reduced the time value of assets and led to greater attrition through depreciation in the value of fixed assets. In summary, the new law provided major protection to creditors and improved the efficiency of the bankruptcy process.[14]

Another important set of financial reforms arose in response to a number of bank failures in the late 1990s. Two major programs were implemented:

13. The appendix provides a comprehensive description of the bankruptcy reform. See also Araujo, Ferreira, and Funchal (2012) for an exhaustive description of the new bankruptcy law in Brazil.

14. Several major changes that affected the relationship between firms and creditors were introduced as part of the new bankruptcy law. For example, secured and unsecured credits are now given priority over tax credits; the distressed firm might be sold (preferably as a whole) before the list of creditors is constituted, which speeds up the process and increases firm value; and any new credit extended during the reorganization process is given first priority in the event of liquidation.

one for private banks (the Program of Incentives for the Restructuring and Strengthening of the National Financial System, or PROER) and one for public banks (the Program of Incentives for the Reduction of the State Role in the Banking Activity, or PROES).[15] Under the PROER program, the government gave financial support for the acquisition of failing but salvageable banks and for an orderly unwinding of insolvent ones, created a deposit guarantee fund, and increased the Central Bank's power of supervision and bank resolution. The PROES program mainly focused on closing or privatizing public banks that were not profitable. These programs were fundamental for the increase in efficiency observed in the financial sector in Brazil in the years that followed.

The financial reforms of the last decade also improved the legislation regulating the realization of collateral for nonperforming loans and the liberalization of entry by foreign banks. This increased competition in the financial sector (although the system remains dominated by relatively few large private and public banks) and drove down credit costs for market participants.

This set of financial reforms was accompanied by low inflation rates and strong demand for Brazil's exports due to the large gains in the terms of trade in the period. These factors also contributed to a better credit environment in general.

The reduction in intermediation costs translated into a lower cost of credit for nonfinancial corporations. Information on credit costs is available in the financial structure data compiled by Thortsen Beck and Asli Demirgüç-Kunt.[16] The interest rate margin (that is, the difference between the average lending rate and the average deposit rate) fell steadily throughout the 2000–10 period.[17] As shown in figure 1, the net interest margin peaked at 6.43 percent in 2002 and then fell sharply to 1.66 percent in 2010—a reduction of 75 percent. The drop was particularly steep after 2005, the year the new bankruptcy law was implemented.

Another observable measure of the changes in the structure of the financial sector and the funding costs of financial intermediaries is the sharp decrease in the real money market interest rate in the period (see figure 2).[18] I collected

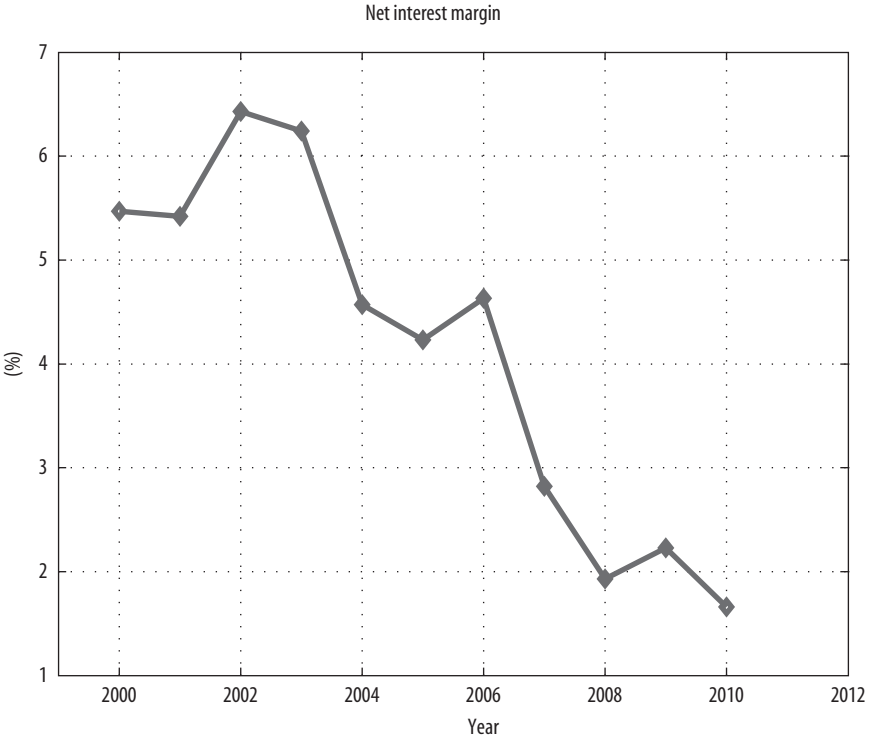
15. See Ter-Minassian (2012).

16. See the new data version (2012) of the data originally provided in Beck and Demirgüç-Kunt (2009).

17. See appendix A for data sources and definitions.

18. The money market corresponds basically to short-term funds available to banks in everyday operations.

FIGURE 1. The Cost of Credit

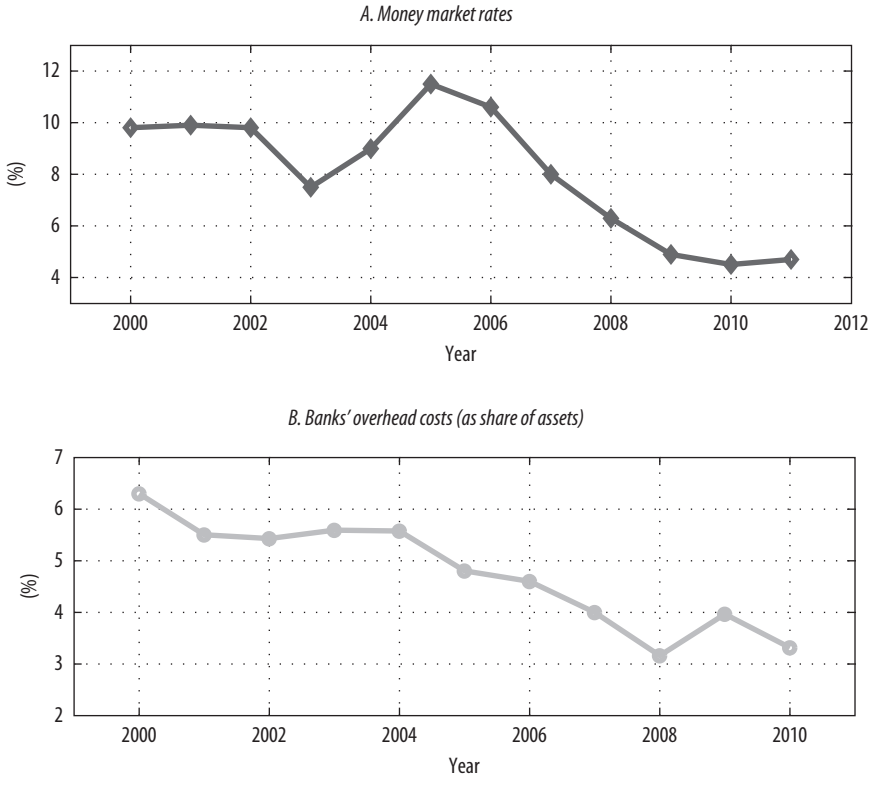


Source: Beck and Demirgüç-Kunt (2009, updated in 2012).
a. Net interest margin is the difference between the average lending rate and the average deposit rate.

data on the nominal money market interest rate and transformed it into real rates using the consumer price index. Both series are from the International Financial Statistics (IFS) database maintained by the International Monetary Fund (IMF).

Panel A of figure 2 shows that the cost of funds for the Brazilian financial sector was reduced by almost half in less than ten years (from approximately 10 percent in 2000 to less than 5 percent in 2010). Another important factor affecting the cost of credit for nonfinancial corporations is the efficiency level in the financial sector. Panel B of the figure provides additional evidence on the reduction in the cost of accessing credit, based on data on bank overhead costs

FIGURE 2. Intermediation Costs



Source: International Monetary Fund, International Financial Statistics (IFS); Beck and Demirgüç-Kunt (2009, updated in 2012).

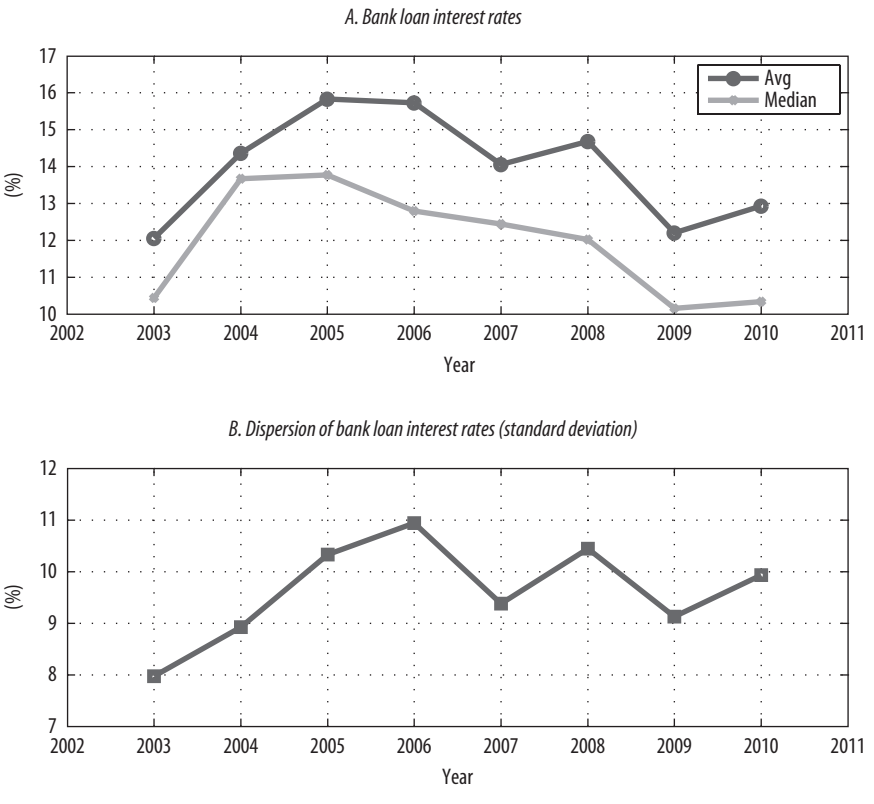
as a share of total assets.[19] The figure shows that overhead costs decreased by 47 percent after 2000.

The Central Bank of Brazil maintains data on bank lending to individual firms (the Credit Information System, or SCR). These data contain very valuable information on loan interest rates and lending amounts at the firm level, reported directly by financial institutions.[20] Figure 3 presents the

19. The data are from Beck and Demirgüç-Kunt (2009).

20. These data is not publicly available. I thank Luis Catao, who provided the data, for allowing me to present this set of summary statistics.

FIGURE 3. Corporate Loan Interest Rates

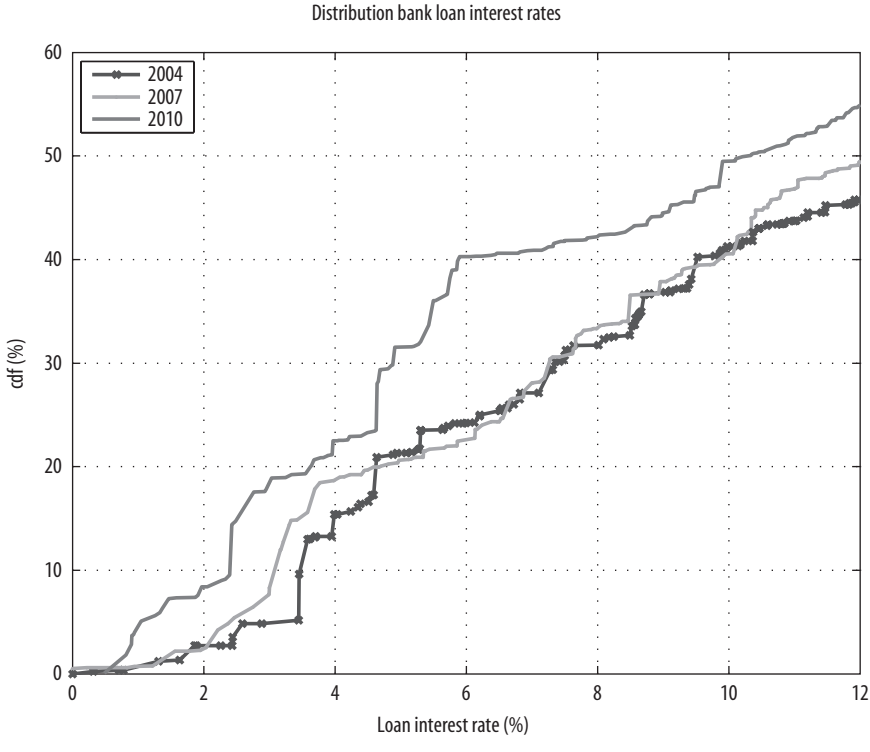


Source: Central Bank of Brazil, Credit Information System (SCR).

average, the median, and the standard deviation of real loan interest rates.[21] The data do not show as clear a pattern as in figure 1, but the average and the median corporate interest rates decrease after peaking in 2004–05. Consistent with the aggregate data, the reduction in interest rates is approximately 18 percent for the average and 25 percent for the median. The standard deviation is a useful summary statistic of the dispersion of the observed distribution of interest rates and allows inference on the degree to which

21. All measures presented correspond to loan-weighted measures. To avoid distortions caused by a few outliers, we restrict the sample to ±2 standard deviations of the original weighted mean.

FIGURE 4. Distribution of Corporate Loan Interest Rates

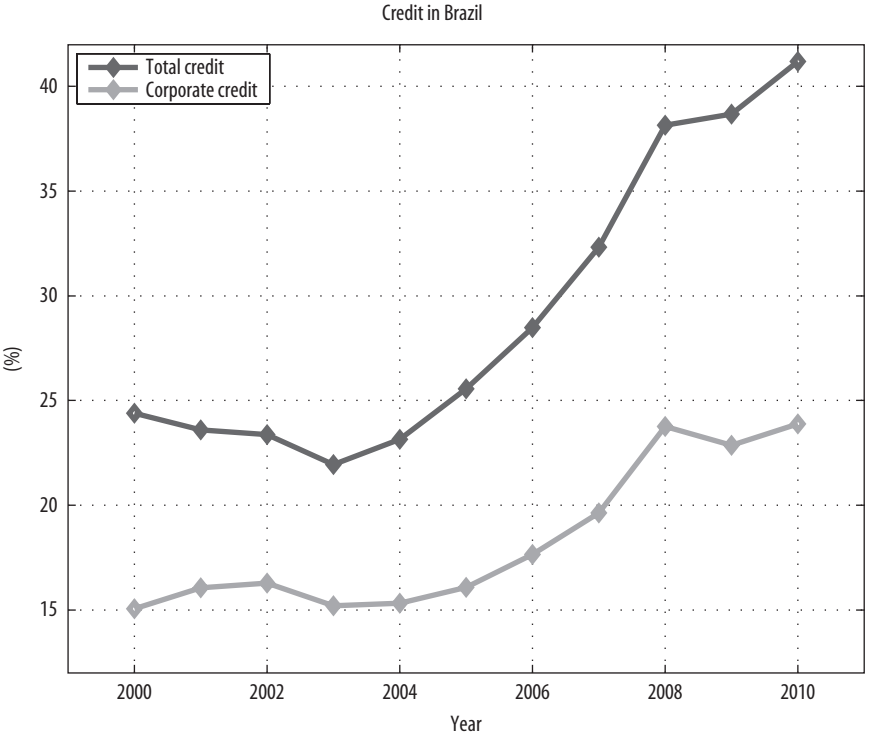


Source: Central Bank of Brazil, Credit Information System (SCR).

financial intermediaries are expanding credit to those at the low and the high ends of the distribution. There seems to be an increase in dispersion during this period. To shed more light on the change in interest rates, figure 4 graphs the entire distribution for selected years. The weight of low interest rates in the distribution increased between 2004 and 2010. For example, the fraction of the total amount loaned with interest rates at or below 6 percent increased from 20 percent in 2004 to 40 percent in 2010.[22]

22. The data show interest rates on all outstanding loans. While the median lifespan of corporate loans is relatively low (under three years), the effect of lower interest rates for new credit appears with a lag in the distribution.

FIGURE 5. The Evolution of Credit



Source: Catao, Pagés, and Rosales (2009).

Together with the reduction in intermediation costs and interest rates, there was a large expansion in credit in Brazil in the period. Funchal finds evidence that the use of bank debt increased significantly in the Brazilian market after the bankruptcy reform.[23] Figure 5 presents data consistent with this empirical finding. The figure shows the evolution of total domestic bank credit and domestic bank credit to the corporate sector to GDP, two traditional measures of financial deepening. Total credit to the private sector (that is, including credit to both firms and households) relative to GDP rose dramatically in the period under analysis. Credit to the corporate sector experienced a similar expansion, rising from 15 percent in 2000 to 24 percent in 2010 (an increase of 58.7 percent).

23. Funchal (2008).

TABLE 1. Effects of the Bankruptcy Reform

	Dependent variable	
Explanatory variable	*Total debt*	*Cost of debt*
Bankruptcy reform	0.1780	−0.1678
Standard error	0.0640	0.0040
Other controls	Yes	Yes
No. observations	3,143	2,487
R^2	0.09	0.03

Source: Araujo, Ferreira, and Funchal (2012).

Before moving to the data on informality and then to the model, I would like to provide more information on the link between financial reforms, credit conditions, and credit at the firm level. Araujo, Ferreira, and Funchal use a difference-in-differences approach to analyze the consequences of the bankruptcy reform.[24] Specifically, they compare Brazilian firms (the treatment group) to non-Brazilian firms from Argentina, Chile, and Mexico (the control group) with respect to the behavior of debt-related variables.[25] Their database, which is from Economatica, includes 698 publicly traded nonfinancial firms from 1999 to 2009, of which 338 firms are Brazilian (the treatment group) and the rest make up the control group. Table 1 presents their main results. As the table shows, the bankruptcy reform generated an increase of 17.8 percent in total debt and a reduction of approximately 16.78 percent in the cost of debt.

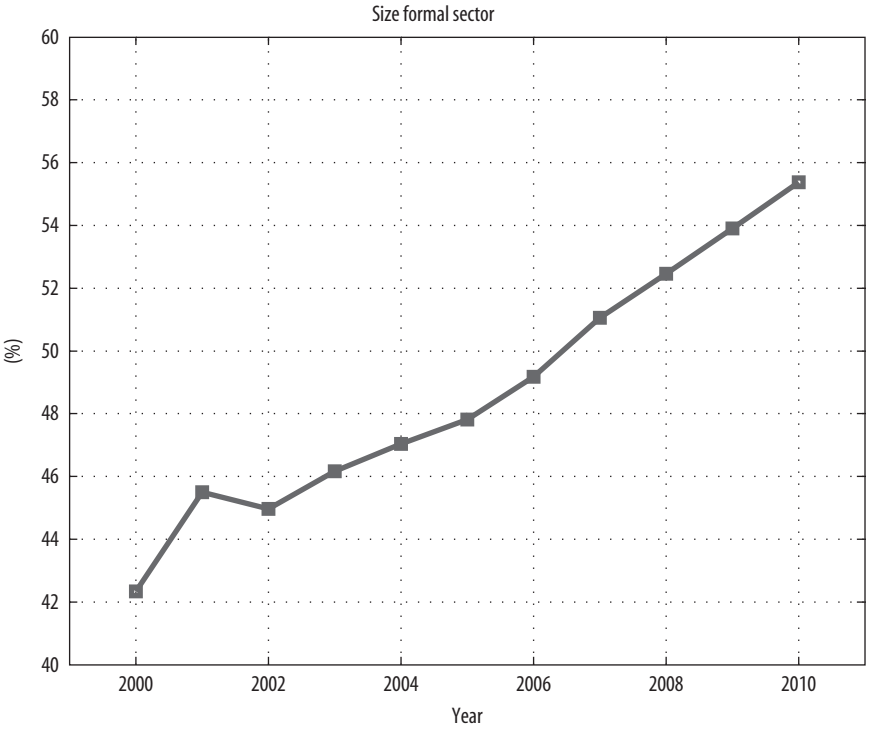
Formalization and Firm Size Distribution

How does the change in credit conditions affect the firm size distribution in Brazil? Credit markets allow for a better allocation of resources. When credit markets improve, capital and labor move closer to the efficient level. An important margin affecting resource misallocation is the level of formalization in the economy. One of the main benefits of formalization is better access to credit, since operating in the formal sector increases access to courts and other contract-enforcement mechanisms. Financial institutions are generally not willing to extend loans to firms that lack the proper documentation. Changes in funding costs affect not only the structure of existing firms, by allowing

24. Araujo, Ferreira, and Funchal (2012).

25. They allow for different firm trends within treatment and control groups to account for the fact that the standard difference-in-differences approach may not consistently estimate the average treatment effect due to the assumption of common trends.

FIGURE 6. Level of Formalization



Source: Brazilian Institute of Geography and Statistics (IBGE).

them to expand or to survive large adverse shocks, but also the number and size of firms that decide to start operating in the formal sector. This has important implications since it affects the dynamics of the firm size distribution.

The level of formalization in Brazil underwent a dramatic change in the period. Figure 6 graphs the share of formal workers in the economy (measured as the share of workers that contribute to social security), based on data from the Brazilian Institute of Geography and Statistics (IBGE). As the figure shows, the fraction of formal workers has increased by more than 21 percent—from 45 percent in 2001 to 55 percent in 2010.

Catao, Pagés, and Rosales also present evidence on the credit channel.[26] They apply a difference-in-differences approach to Brazilian household survey

26. Catao, Pagés, and Rosales (2009).

TABLE 2. Firm Size Distribution in the Microenterprise Sector
Percent

No. workers	*Share of firms*	*Cumulative distribution function (CDF)*
0	86.60	86.60
1	7.40	94.00
2–3	4.60	98.60
4–5	1.40	100.00

Source: IBGE, 2003 ECINF Survey.
a. The microenterprise sector is defined as firms with five employees or fewer and includes both formal and informal firms.

data to show that formalization rates increase with financial deepening, especially in sectors where firms are typically more dependent on external finance.[27]

The relation between credit and formalization has important effects for the firm size distribution because informal firms tend to be much smaller and less productive than formal firms. Two data sources can shed light on the firm size distribution. First, the Brazilian Institute of Geography and Statistics (IBGE) conducted an Informal Urban Economy Survey (ECINF), based on a representative cross-section of small firms (with at most five employees) at the national level, in 2003.[28] Second, the Brazilian Ministry of Labor compiles an Annual Social Information Report (RAIS), based on information reported by all formally registered firms each year on each worker employed by the firm, as required by law.[29]

The ECINF provides the basis for taking a close look at the microenterprise sector in Brazil. Table 2 presents the distribution of firms with five workers or fewer, including both formal and informal firms. The table reveals that a considerable mass is allocated to the small bins of the distribution. More than 80 percent of the firms employ no workers, and almost 95 percent employ one worker or fewer.

27. The measure of external finance is the standard Rajan-Zingales (1998) index.

28. The ECINF, which was conducted in 1997 and 2003, samples households located in urban areas and seeks to identify the self-employed and employers with up to five employees in at least one work situation. The survey provides extensive detail on the main firm and the entrepreneurial characteristics of the microenterprises, such as sector revenues, profits, employment size, capital stock, and time in business. Examples of works drawing on this data set include Fajnzylber, Maloney, and Montes-Rojas (2011) and Ulyssea (2010). For more information, see www.ibge.gov.br/home/estatistica/economia/ecinf/2003/default.shtm.

29. For both the ECINF and RAIS, the respective organizations provide access to aggregate information compiled in a large set of tables based on the original sources. See the data appendix for a full description of variables used and links to the corresponding tables.

TABLE 3. Formal and Informal Firm Size Distribution
Percent

Sector and no. workers	*Share of firms*	*Cumulative distribution function (CDF)*
Formal sector		
0–4	69.58	69.58
4–9	15.22	84.80
9–19	8.06	92.86
19–49	4.43	97.29
49–99	1.36	98.64
99–249	0.82	99.46
249–499	0.30	99.76
>499	0.24	100.00
Informal sector		
0	80.12	80.12
1	12.23	92.35
2–3	5.88	98.23
4–5	1.77	100.00

Source: Brazilian Ministry of Labor, Annual Social Information Report (RAIS); IBGE, 2003 ECINF Survey.

Taken together, the ECINF and RAIS can be used to identify differences in the firm size distribution of formal and informal firms. Table 3 presents the formal size distribution from RAIS (that is, the distribution of registered firms) and the informal size distribution from ECINF (that is, the distribution of unregistered firms). As is evident from the table, most informal firms employ fewer than three workers (98.23 percent), the first bin in the distribution of formal firms. The IBGE identified 10,525,954 small enterprises in Brazil in 2003, and 98 percent of them were defined as informal (not registered). A large fraction of formal firms are also concentrated in the small-size bins, but there is considerable dispersion in terms of workers per plant or firm.

Measured Formal Institutions

Besides access to credit, institutions that affect the cost of operating a formal firm are also important determinants of the size of the formal sector and the level of aggregate credit in the economy. These include corporate taxes, the entry costs of the formal sector, and labor market costs such as payroll taxes and firing costs. Information on these institutions is available in the World Bank's Doing Business data set, which measures the costs, in terms of time and resources, of many aspects of running a business, including starting a business, getting construction permits, employing workers, obtaining

credit, protecting investors, paying taxes, trading across borders, enforcing contracts, and closing a business. Of particular interest are the cost of entering the formal sector, the profit tax rate, the payroll tax rate, the efficiency of the bankruptcy law, and firing costs. These institutions are measured as follows:[30]

—Entry cost: The cost of entering the formal sector corresponds to the reported costs of registering a business and of dealing with licenses to operate a physical locale. It involves the cost of starting a business as a fraction of income per capita. The estimated entry cost for Brazil is 0.739 of per capita gross national product (GNI).

—Taxes: The tax rate paid on firms' profits corresponds to the variable "Paying taxes—Profit tax (percent)," and the payroll tax to "Paying taxes—Labor tax and contributions (percent)."[31] The estimated values for Brazil are 22.4 percent and 51.65 percent, respectively.[32]

—Bankruptcy costs: The efficiency of the system in the event of default is measured by the fraction of the asset value of the firm that is lost during bankruptcy. The cost of the system (ϕ), reported as a percentage of the estate's value, includes court fees and the cost of insolvency practitioners, such as legal and accounting fees. The estimated value for Brazil is 9 percent.[33]

—Firing costs: Firing costs are obtained using information on the variable "Firing cost (weeks of wages)." The estimated value of firing one worker equals 88 percent of the worker's annual wage.

30. The values reported in 2003 are used unless unavailable, in which case the most recent year is used. Since these variables measure long-term institutional arrangements, not having the information for a particular year does not bias the estimates significantly. See Djankov and others (2002).

31. Because both tax rates are expressed as a function of profits, they need to be adjusted and the labor tax rate expressed as a function of payroll. To do that, the standardized balance sheet and income statements were used to construct the exercise as explained in table 1 of Djankov and others (2010).

32. Labor and corporate tax rates differ from those presented in Carvalho and Valli (2011), who use the statutory level of taxes. As they explain on their page 26, "Tax laws in Brazil allow for a great variety of exemptions and usually differentiate tax rates according to taxable bases. As such, they are not concise references for calibration" (p. 26). Additionally, the labor tax used in this study incorporates social contributions made by firms.

33. This parameter corresponds to the costs associated with court and lawyer fees. Since the main focus of the paper is on how changes in the financial sector affected formalization, the value of ϕ is kept fixed for the main quantitative exercise. However, the paper also presents the results of an experiment analyzing changes in ϕ as measured by Doing Business in addition to changes in the cost of credit and the efficiency of the financial sector.

Environment

The paper uses a standard firm dynamics model based on Hopenhayn, with credit markets as in Cooley and Quadrini.[34] The environment extends the environment of D'Erasmo and Moscoso Boedo to incorporate firing costs.[35] Time is discrete, and the period is set to one year. There are three types of entities in the economy: firms, lenders, and consumers. Firms operate in one of the two sectors (formal or informal) and produce the consumption and capital goods used in the economy. They are the capital owners and pay dividends to the consumers. The model is used to analyze the stationary equilibrium in a small open economy where lenders have unlimited access to international markets and make loans to the nonfinancial firms. Consumers supply labor to the firms and receive their profit net of entry costs.

Consumers

There is an infinitely lived representative consumer who maximizes expected discounted utility:

$$\mathsf{E}\left[\sum_{t=0}^{\infty}\beta^{t}U\left(C_{t}\right)\right],$$

where $\mathsf{E}[\cdot]$ is the expectation operator, C_t is consumption (restricted to be nonnegative), and $\beta \in (0, 1)$ is the discount factor. The household is endowed with one unit of labor, which supplies firms at the market wage rate, w. The consumer is responsible for the creation cost of new firms, c_e, and consequently owns existing firms in the economy and receives income from the dividends they pay. Finally, the household receives a lump-sum transfer for the total amount of taxes collected.

Firms and Technology

The unit of production is a single-establishment firm, also understood as a unique investment project. Each project is described by a production function, $f(z, k, n)$, that combines productivity, z; capital, k; and labor, n. The production function is assumed to have decreasing returns to scale. In particular,

34. Hopenhayn (1992); Cooley and Quadrini (2001).
35. D'Erasmo and Moscoso Boedo (2012).

the production function is defined as $f(z, n, k) = z(k^{\alpha}n^{1-\alpha})^{\gamma}$ with $\alpha \in (0, 1)$ and $\gamma \in (0, 1)$.

There are two processes for z: high (h) and low (l). The high productivity process is given by

$$\ln(z_{t+1}) = (1-\rho)\ln(\mu_h) + \rho \ln(z_t) + \varepsilon_{t+1},$$

with $\varepsilon_{t+1} : N[0,(1-\rho^2)\sigma^2]$, where σ^2 is the variance of $\ln(z)$, μ_h is the mean, and ρ the autocorrelation parameter of the process. The conditional cumulative distribution of z_{t+1} is denoted by $\eta(z_{t+1}, z_t)$. The use of the high productivity process is restricted to the formal sector. To simplify the exposition of the model, the following two assumptions are made. First, the low productivity process is assumed to be a constant given by μ_l and restricted to the informal sector. Second, once operating as either formal or informal, firms are not allowed to switch between sectors. These assumptions imply that formal firms will use the high productivity process and that informal firms will use the low productivity process. Other potential possibilities would be to allow firms to switch between sectors and to allow formal firms to use the low productivity process.[36] The two processes will be calibrated to match the size distribution of formal firms and the size of the informal sector. The fraction of firms operating under each process is an endogenous outcome of the model and a function of the country-specific frictions.[37]

The assumption of different productivity processes is consistent with the evidence provided by La Porta and Shleifer, who document firm-level productivity differences between informal firms and small formal firms ranging from 100 to 300 percent.[38] They also find that these differences are permanent and not the result of informal sector firms operating at a lower scale in

36. The version of the model that allows for all of these possibilities was computed and calibrated. At the calibrated parameters, the dichotomy between sectors and productivity processes arose endogenously. A model that allowed informal firms with the low productivity process to switch to the formal sector reproduces the same equilibrium as the benchmark economy. Provided the technology choice is irreversible, the main reason for an informal firm to switch to the formal sector is to access better credit terms to attain the optimal capital level faster than is possible in the informal sector. At the estimated costs of switching (see values for entry costs and taxes in the calibration section), informal firms choose to stay in the informal sector and accumulate capital more gradually rather than pay these costs. Substantially lower costs of entry and taxes than those estimated would generate switching in equilibrium.

37. Since the high productivity process is distributed normally, there is a positive probability of obtaining values of z_t from this process below μ_l.

38. La Porta and Shleifer (2008).

order to avoid detection.[39] This is also consistent with evidence presented by Fajnzylber, Maloney, and Montes-Rojas, who analyze microenterprises in Brazil.[40] They find that 85 percent of the firms that did not have a license made no attempt to regularize at the time of start-up. In contrast, 75 percent of the licensed entrepreneurs did at least try to regularize their firm when they began operating.

Firms maximize expected discounted dividends:

$$\mathsf{E}\left[\sum_{t=0}^{\infty} R^t d_t\right],$$

at the rate R.[41] Firms are created by the consumer paying a cost, c_e. Once launched, firms face a technology-adoption decision. They draw their initial productivity, z_0, in the h process from the distribution $\nu(z_0)$. Draws from this distribution are assumed to be independent and identically distributed (i.i.d.) across firms. Firms then compare z_0 to μ_l and choose between staying out of the market or operating one of the projects as a formal or informal firm, that is, the project choice is irreversible.[42] Unimplemented projects go back into the pool.

There is a random fixed cost of production, c_f, measured in units of output, which is i.i.d. across firms and over time, with distribution $\xi(c_f)$. A firm that does not pay this fixed cost is not allowed to produce. Firms own their capital and can borrow from financial intermediaries in the form of noncontingent debt, $b \geq 0$. They finance investment with either debt or internal funds.

If the firm operates in the formal sector, it is subject to a proportional tax on profits, τ, and a payroll tax, τ_w. Creating a formal sector firm requires an entry cost, κw. When a formal firm exits, it has to go through a bankruptcy procedure if it defaults on its debt. The bankruptcy procedure has an associated cost

39. For example, differences in sales per worker are much higher (two to three times) than the average entry cost, implying that it is not just the barrier to entry that is the main factor affecting scale, productivity, or the decision to operate informally. La Porta and Shleifer (2008) also note that in a sample of developing economies, approximately 91 percent of registered firms at the time of the survey started as registered firms and did not come from the informal sector. Moreover, Bruhn (2008), Bertrand and Kamarz (2002), and McKenzie and Sakho (2010) present empirical evidence that shows that improvements in entry costs do not lead to the formalization of previously informal firms, but rather only generate the creation of new businesses.

40. Fajnzylber, Maloney, and Montes-Rojas (2011).

41. At the stationary equilibrium, the firm's discount factor is constant.

42. This is consistent with the evidence presented in Atkeson and Kehoe (2007), who argue that manufacturing plants need to be completely redesigned to make good use of the new technologies.

equal to a fraction ϕ of the firm's capital. It is assumed that a formal firm that exits in period t has to pay firing costs equal to $\tau_f w n_t$, where τ_f is the fraction of real wages that the firm has to pay per worker fired.[43] In a given period, firm exit happens before production takes place, so an assumption is made to accommodate the payment of firing costs at this stage. The labor choice is made in two stages. In the first stage, in addition to choosing its capital investment, the firm hires a set of workers termed advance workers.[44] The number of workers the firm hires at this stage depends on the firm's choice of capital and the expected value of productivity (conditional on current productivity). It corresponds to the best estimate of the number of workers the firm will utilize in production in the following period. The second stage occurs after the realization of the fixed cost. After observing the realized fixed cost, the firm will decide whether to exit or to continue. If the firm exits, it will pay the firing costs on those workers hired in advance, that is, the advance workers. Since productivity is highly persistent, the value of advance workers will not differ much from the workers the firm hires when production takes place. If the firm continues, productivity is realized, and the firm is allowed to adjust its number of workers to the optimal level at no extra cost if advance workers are already in place. In the quantitative exercise, taxes and the costs of formality are set directly from the corresponding measures in the Doing Business database, as described in the previous section.

Credit Markets

Asset markets are incomplete. In each period, firms borrow using only one-period noncontingent debt, denoted by b. The credit industry is composed of a continuum of lenders that make loans to firms in the formal and informal

43. An earlier version of the paper did not consider firing costs. Qualitatively, the results of the main experiments are not affected by its introduction. These costs play an important role in the Brazilian labor market, and their inclusion helps bring the quantitative predictions of the model closer to the data. The model abstracts from formal firms paying firing costs period by period. In a model where firing costs are paid every period, the state space of an incumbent firm is the set $\{z_{-1}, k, b, n_{-1}, c_f\}$, where z_{-1} denotes previous productivity, k is current capital, b is the firm's debt level, n_{-1} is the number of workers hired last period, and c_f is the observed fixed cost. The model incorporates three continuous variables plus the exogenous process for productivity and the fixed cost. Solving this model is computationally challenging and beyond the scope of this project. Since the focus of this paper is on credit frictions, I abstract from extending the model in this dimension.

44. The assumption of hiring workers one period in advance is a standard assumption in the literature on labor adjustment costs at the firm level. See, for example, Hopenhayn and Rogerson (1993).

sectors. These lenders are risk-neutral and competitive. They have unlimited access to international markets at the risk-free rate, r_t. They compete by offering loan contracts to each firm. Because there is perfect competition and full information, prices depend on firms' characteristics, given by their choice of sector (formal or informal), future level of capital, level of borrowing, and current productivity under each technology. In particular, firms in the formal sector borrow at price $q^f(k_{t+1}, b_{t+1}, z_t)$; firms in the informal sector borrow at price $q^i(k_{t+1}, b_{t+1})$. Lenders incur a proportional intermediation cost, ζ. Without loss of generality, firms can be assumed to take loans only from one lender.[45]

Consistent with bankruptcy law across countries, I follow the limited liability doctrine, which limits the owner's liability to the firm's capital. In each period, firms can default on their debt. A default triggers a bankruptcy procedure that liquidates the firm. The formal bankruptcy procedure has an associated cost equal to a fraction, ϕ, of the firm's capital. The value of the bankruptcy cost, ϕ, is obtained from the Doing Business database. When making a loan to a formal sector firm, lenders take into account that there is limited liability and that they can recover only up to the value of capital in the event the firm defaults. Because the capital of the informal firm is not legally registered, the recovery rate of a loan to an informal sector firm that defaults is assumed to be zero. This assumption follows Pratap and Quintin, who suggest that there is segmentation in the financial markets across formal and informal sectors.[46]

Timing

The timing of a formal incumbent firm is as follows:

1. Period t starts. The relevant state space is $\{z_{t-1}, k_t, b_t\}$, where z_{t-1} denotes productivity in $t - 1$, k_t is current capital, and b_t is the firm's debt level. The firm also knows the number of advance workers that were hired previously.[47]
2. The fixed cost c_f is realized.

45. The relevant state space that determines the default probability is $\{k_{t+1}, b_{t+1}, z_t\}$ in the case of the formal firm and $\{k_{t+1}, b_{t+1}\}$ in the case of the informal firm. Consistent with bankruptcy procedures and the problem of the firm presented in this paper, firms have the option to default on all of their loans or none of them. Then, the price charged on any debt subcontract b'_s, with $\Sigma_s b'_s = b'$, must be the price that applies to the single contract of size b'. Consequently, as long as lenders condition their loan price on the total end-of-period debt position of a firm, there is a market arrangement in which the firm is indifferent between writing a single contract with one lender or a collection of subcontracts with the same total value with many lenders.

46. Pratap and Quintin (2008).

47. Advance workers are a function of $\{z_{t-1}, k_t\}$, so they do not need to be included as part of the state space.

3. The firm decides whether to continue or exit.

(a) If it decides to exit, the firm pays the firing cost on its advance workers, and it chooses whether to exit by default or by repaying its debt.

(b) If it decides to stay, the level of productivity, z_t, is realized.

(c) The firm hires workers, n_t, for production in period t. It also repays the existing debt b_t, decides the level of capital k_{t+1} and debt b_{t+1} at price $q^f(k_{t+1}, b_{t+1}, z_t)$, and chooses advance workers for the following period.

(d) Profit and payroll taxes are paid.

(e) Dividends (if any) are distributed.

The timing of an informal incumbent firm is similar to that of a formal incumbent with the difference that informal firms do not pay taxes or firing costs and they face (endogenously) different borrowing costs. It is given by the following series:

1. Period t starts. The relevant state space is $\{\mu_l, k_t, b_t\}$, where μ_l denotes productivity in $t-1$, k_t is current capital, and b_t is the firm's debt level.

2. The fixed cost c_f is realized.

3. The firm decides whether to continue or exit.

(a) If it decides to exit, the firm defaults on its debt and keeps the installed capital.

(b) The firm hires workers n_t, repays the existing debt b_t, and decides the new level of capital k_{t+1} and debt b_{t+1} at price $q^i(k_{t+1}, b_{t+1}, z_t)$.

(c) Dividends (if any) are distributed.

The timing of a potential entrant firm is as follows:

1. The owner of the firm (the consumer) decides whether to pay the entry cost, c_e.

2. If the entry cost is paid, the firm draws the initial productivity, z_0, of the h process from the distribution $\nu(z_0)$.

3. Firms then compare z_0 to μ_l and choose between staying out of the market or operating one of the projects as a formal or informal firm.

4. Depending on this decision, they start as a formal or informal incumbent with no capital and no debt.

Equilibrium

In the stationary equilibrium, the wage rate, the risk-free rate, and the schedule of loan prices are constant. Every equilibrium function depends on the set of loan prices, the risk-free rate, and the wage rate. For ease of exposition, this dependence is not explicitly presented.

Consumer's Problem

In the stationary equilibrium, all prices and aggregates in the economy are constant. Hence, household maximization implies that the consumer supplies its unit of labor inelastically, $\beta = R$, and that aggregate consumption is

$$C = w + \Pi + T - E + X, \tag{1}$$

where Π is total dividends from incumbent firms, T is the lump-sum transfer from the income and payroll taxes, E is the aggregate creation cost, and X is the exit value of firms.

Formal Sector Incumbent

The incumbent firm in the formal sector operating a project with technology h starts the period with capital k, debt b, and previous productivity z_{-1}. The firm then draws the fixed cost that is required for continuing the operation, c_f, and decides to either operate the project, exit after repayment of debts, or default and liquidate the firm.

Operating revenue, R^f, for an incumbent formal firm is defined as follows:

$$\mathsf{R}^f\left(z, k, c_f\right) = \max_{n \geq 0} (1 - \tau)\left[z\left(k^{\alpha} n^{1-\alpha}\right)^{\gamma} - c_f - w(1 + \tau_w) n \right].$$

The first-order condition of this problem (in an interior solution) is

$$z k^{\gamma\alpha} \gamma (1 - \alpha) n^{(1-\alpha)\gamma - 1} = w(1 + \tau_w).$$

The solution to this problem provides the optimal labor decision, denoted by $n(z, k)$. Knowing z and the choice of k', the advance workers or the best estimate of the number of workers the firm will utilize in production in the following period is equal to $E_{z'|z}[n(z', k')]$.

The value function of a firm when deciding whether to stay or exit is denoted as $W^f(z_{-1}, k, b, c_f)$. If the firm decides to remain in business, it pays c_f and observes the current period's productivity, z. The value function of a firm operating in the formal sector is denoted as $V^f(z, k, b, c_f)$. The incumbent solves the following problem:

$$W^f\left(z_{-1}, k, b, c_f\right) = \max\left\{ \int V^f\left(z, k, b, c_f\right) d\eta\left(z | z_{-1}\right), V^x\left(z_{-1}, k, b, c_f\right) \right\}, \tag{2}$$

where the continuation value is

$$V^f\left(z,k,b,c_f\right)=\max_{n,k',b'} d^f+\beta\int W^f\left(z,k',b',c_f'\right)d\xi\left(c_f\right),$$

such that

$$\begin{aligned} d^f=&\left(1-\tau\right)\left[z\left(k^\alpha n^{1-\alpha}\right)^\gamma-c_f-w\left(1+\tau_w\right)n\right]\\ &-k'+\left(1-\delta\right)k+q^f\left(k',b',z\right)b'-b\geq 0. \end{aligned}$$

The exit value is given by

$$V^x\left(z_{-1},k,b,c_f\right)=\max\left\langle\begin{array}{l} k-b-\tau_f wE_{z|z_{-1}}\left[n\left(z,k\right)\right],\\ \max\left\{0,\left(1-\varphi\right)k-b-\tau_f wE_{z|z_{-1}}\left[n\left(z,k\right)\right]\right\}\end{array}\right\rangle,$$

where the zero lower bound comes from the limited liability constraint; the second term corresponds to exit without default, where the firm repays the debt and pays the firing costs to advance workers; and the third term refers to the exit-by-default option that incorporates bankruptcy costs.

The solution to equation 2 provides the exit decision rule, $\chi^f(z_{-1}, k, b, c_f)$, which takes the value of zero if the firm continues to operate, one if the firm decides to default, and two if the firm decides to exit after repayment. The optimal capital and debt decision rules for a firm in the formal sector are given by $k'^f(z, k, b, c_f)$ and $b'^f(z, k, b, c_f)$, respectively.

The exit and default decision rule of the formal firm can be used to define the default probability of a formal firm, $p^f(k', b', z)$, as follows:

$$p^f\left(k',b',z\right)=\int I_{\left\{\chi^f\left(z,k',b',c_f\right)=1\right\}}\,d\xi\left(c_f\right),$$

where $I_{\{\cdot\}}$ is the indicator function that takes a value of one when the condition in between brackets is true. At a given level of productivity and choices of capital and debt by the formal firm, the default probability integrates over different values of the fixed cost c_f to capture those states in which the firm finds it optimal to exit by default.

Informal Sector Incumbent

An incumbent firm in the informal sector, after observing the fixed operating cost c_f, can choose to stay active or to exit the market after a default.

More specifically, the informal incumbent firm solves the following Bellman equation:

$$W^i\left(k, b, c_f\right) = \max\left\{V^i\left(k, b, c_f\right), k\right\}, \tag{3}$$

where the value of remaining in the informal sector is given by

$$V^i\left(k, b, c_f\right) = \max_{n,k',b'} d^i + \beta \int W^i\left(k', b', c'\right) d\xi\left(c_f\right),$$

such that

$$d^i = \mu_l\left(k^\alpha n^{1-\alpha}\right)^\gamma - c_f - wn - k' + \left(1-\delta\right)k + q^i(k', b')b' - b \geq 0.$$

The solution to equation 3 provides the exit decision rule $\chi^i(k, b, c_f)$, which takes the value of zero if the firm continues to operate in the informal sector and one if the firm decides to default. The optimal capital and debt decision rules are given by $k'^i(k, b, c_f)$ and $b'^i(k, b, c_f)$, respectively.

Similar to the definition of the default probability for a formal firm, the default probability of an informal firm can be defined using the exit decision rules. Specifically, the default probability of an informal firm $p^i(k', b')$ is

$$p^i\left(k', b'\right) = \int I_{\left\{\chi^i\left(k', b', c_f\right)=1\right\}} d\xi\left(c_f\right).$$

Entrants

The value of a potential entrant (net of entry cost), W_e, is given by

$$W_e = \int \max\left\{W^i\left(0,0,0\right), \int \tilde{V}^f\left(z,0,0,0\right)\eta\left(z|z_0\right)\right\} d\nu\left(z_0\right) - c_e, \tag{4}$$

where $\tilde{V}^f(z, 0, 0, 0)$ is the value of starting as a formal firm, given by

$$\tilde{V}^f\left(z,0,0,0\right) = \max_{k',b'} \tilde{d}^f + \beta \int W^f\left(z, k', b', c_f'\right) d\xi\left(c_f\right),$$

such that

$$\tilde{d}^f = -w\left(1+\tau_w\right)\kappa - k' + q^f\left(k', b', z\right)b' \geq 0.$$

An entrant has no capital and no debt, and its cost of production c_f equals zero. The entrant chooses between projects and sectors. The sector and project adoption decisions are made after paying c_e and observing the productivity level z_0, which affects the conditional distribution from which the first productivity parameter will be drawn. Differences in the volatility of the processes, together with differences in initial productivity, generate variation in the decisions made by entrants and by potential lenders. That introduces differences in behavior as a function of volatility and contract enforceability. In equilibrium, under free entry, $W_e = 0$ will hold. The solution to equation 4 provides the entry decision rule, $\Xi^e(z_0)$, which takes a value of zero if the firm decides to enter informally and one if the firm decides to enter formally. This will determine the entry productivity threshold to the formal sector, z_0^*. More specifically, let z_0^* be the value of initial productivity in the high productivity process, such that

$$W^i(0,0,0) = \int \tilde{V}^f(z,0,0,0)\eta\left(z\middle|z_0^*\right).$$

Then, since it is possible to show that the value of being in the formal sector is increasing in the level of productivity, the entry decision rule will be $\Xi^e(z_0) = 1$ for $z_0 \geq z_0^*$ and equal to zero otherwise. The solution to this problem also provides capital and debt decision rules, $\tilde{k}'(z, 0, 0, 0)$ and $\tilde{b}'(z, 0, 0, 0)$, for a firm that starts operating in the formal sector.

Lenders

Lenders make loans to formal and informal firms while taking prices as given. Profit for a loan b' to a firm in the formal sector with future capital k' and productivity z is

$$\pi^f(k',b',z) = -q^f(k',b',z)b' + \frac{1-p^f(k',b',z)}{1+r}b'$$
$$+ \frac{p^f(k',b',z)}{1+r}\min\left\{b',(1-\varphi)k' - \tau_f wE_{z|z_{-1}}\left[n(z,k)\right]\right\} - \zeta b',$$

where $p^f(k', b', z)$ denotes the default probability of this borrower as defined before. Profit for a loan b' to a firm in the informal sector with future capital k' is

$$\pi^i(k',b') = -q^i(k',b')b' + \frac{\left[1-p^i(k',b')\right]}{1+r}b' - \zeta b',$$

where $p^i(k', b')$ denotes the default probability of the informal borrower defined before. In equilibrium, the schedule of prices will adjust so that $\pi^f(k', b', z) = 0$ and $\pi^i(k', b') = 0$ for all (j, k', b', z). That is, the equilibrium price schedule is given by

$$q^f\left(k', b', z\right) = \frac{1 - p^f\left(k', b', z\right)}{1 + r} + \frac{p^f\left(k', b', z\right)}{1 + r} \frac{\min\left\{b', (1 - \varphi)k' - \tau_f w E_{z|z_{-1}}\left[n\left(z, k\right)\right]\right\}}{b'} - \zeta \tag{5}$$

and

$$q^i\left(k', b'\right) = \frac{\left[1 - p^i\left(k', b'\right)\right]}{1 + r} - \zeta. \tag{6}$$

Definition of Equilibrium

A stationary competitive equilibrium is a set of value functions $\{W^f, W^i, V^f, V^i, \tilde{V}^f\}$, decision rules (capital, debt, default, exit, and sector), a wage rate w, a schedule of lending prices $q^f(k', b', z)$ and $q^i(k', b')$, aggregate distributions $\vartheta(k, b, z; M)$ and $\hat{\vartheta}(k, b, M)$ of firms in the formal and informal sectors, and a mass of entrants M, such that

1. Given prices, firms' value functions and their decision rules are consistent with the problems defined in equations 2, 3, and 4;
2. The free entry condition is satisfied (that is, $W_e = 0$);
3. Lenders make zero profit for every loan type;
4. The distributions of firms ϑ and $\hat{\vartheta}$ are stationary;
5. Aggregate consumption satisfies equation 1; and
6. The labor market clears—that is, $1 = \int n^f(z, k) d\vartheta(k, b, z; M) + \int n^i(k) d\hat{\vartheta}(k, b; M)$.

Calibration

To calibrate the initial steady state of the model, I start with the parametrization of the stochastic processes in the model and then explain the calibration procedure. The process for productivity will be discretized to obtain the grid for z and the transition probabilities $\eta(z'|z)$ following the Tauchen's

method.[48] From the transition matrix $\eta(z'|z)$, the unconditional probability $\eta^*(z)$ is derived. The distribution of initial shocks is set to $\nu(z_0) = \eta^*(z)$. Operating fixed costs are assumed to take values of $\{0, \hat{c}_f, \infty\}$, and the probability density function (PDF) is denoted by $\xi(0)$, $\xi(c_f)$, $\xi(\infty)$.

The model is calibrated in two steps. A first set of parameters can be calibrated without solving the model. In the second step, and taking all other parameters as given, a set of parameters is chosen to match relevant moments from the Brazilian economy in 2003.[49] The first set contains the following parameters $\{\beta, \alpha, \gamma, \delta, r, \zeta, \rho, \tau, \kappa, \varphi, \tau_w, \tau_f\}$. The second set includes the next six parameters, $\{\mu_h, \sigma_h, \mu_l, \hat{c}_f, \xi(0), \xi(c_f)\}$.

The assumed discount factor is $\beta = 1/(1 + r)$. The parameter r is set to 8.2 percent, which is the value observed for the real money market rate in Brazil in 2003. The intermediation cost, ζ, is set to 5.58 percent to match the overhead cost over assets in 2003. The capital share, α, is set to one-third, a standard value, and the parameter that controls the degree of decreasing returns, γ, is set to 0.85, a value based on previous estimates of the degree of decreasing returns to scale at the firm level. In particular, $\gamma = 0.85$, as in Restuccia and Rogerson.[50] The depreciation rate, δ, is set to 7 percent, also a standard value.

The tax structure and the cost of formalization parameters $\{\tau, \tau_w, \tau_f, \varphi, \kappa\}$ are computed directly from the values reported in the Doing Business database for the Brazilian economy following the procedure explained in D'Erasmo and Moscoso Boedo.[51] They are set as follows: the tax rate is $\tau = 0.224$ and $\tau_w = 0.517$; firing costs, $\tau_f = 0.8846$; bankruptcy costs, $\varphi = 0.09$; and entry costs, $\kappa = 0.739$.

The autocorrelation of the high productivity process, ρ, is set to 0.78, as estimated by Ulyssea using the RAIS data set.[52] This is the same data set used here to compute the moments of the firm-size distribution. The parameter is in the range of commonly estimated values in the literature. Six parameters are left for the second step of the calibration process: the mean of the

48. Tauchen (1986). The number of grid points for z is set to twenty-one.

49. This is the last year period before the reduction in credit costs started and the first year for which firm-level data are available.

50. Restuccia and Rogerson (2008).

51. D'Erasmo and Moscoso Boedo (2012). I use data from the earliest year available (in most cases 2007). As one would expect from parameters that reflect national institutions, there is almost no variation over time, so this does not generate an inconsistency with a calibration based on year 2003.

52. Ulyssea (2010). The paper estimates several values that range between 0.72 and 0.90; I choose a value in the middle of this range.

productivity process of the high and low projects, μ_h and μ_l, respectively; the volatility of the high productivity process σ_h; the operating costs $\hat{c}_f$; and the associated probabilities $\{\xi(0), \xi(\hat{c}_f)\}$. To obtain values for these parameters, the following moments of the Brazilian economy are targeted: (i) the size of the formal labor force (46.16 percent), measured as workers covered by a pension scheme as reported by Brazilian National Institute of Geography and Statistics (see figure 6 in the data section); (ii) the average size of formal establishments in Brazil (10.8 workers), based on RAIS data (see table 3); (iii) the average level of corporate credit to GDP, computed using values reported by Catao, Pagés, and Rosales (equal to 15.19 percent; see figure 5); (iv) the average exit rate of formal firms (equal to 12.9 percent), computed by Ulyssea based on RAIS data; (v) the average exit rate for large formal firms (that is, formal firms with more than twenty workers) (equal to 5 percent), following Bartelsman, Haltiwanger, and Scarpetta; and (vi) the average age of informal firms (8.84 years), based on ECINF data reported by Ulyssea.[53]

Identification of the model parameters is key to performing a sensible quantitative exercise. The identification strategy is as follows. Since all the moments generated by the model are a function of all deep parameters, it is not possible to associate individual parameters with individual statistics. However, the numerical results suggest that particular moments are more informative for identifying particular parameters or sets of parameters. First, the size of the informal sector is informative about μ_l since, all else equal, this parameter determines the entry threshold to the formal sector and the size of the informal firm. Second, the average size of the formal firm is informative about μ_h since this parameter determines the average productivity for an incumbent formal firm. Third, the average corporate credit to GDP is informative of σ_h. If productivity is constant and no other shocks are present, firms have incentive to borrow only until they reach their optimal size. As the volatility of productivity changes, firms' demand for credit is also affected. The demand for credit is a function of the price schedule firms face, and the dispersion of interest rates (a function of the dispersion of default probabilities) is tightly linked with the dispersion of firm productivity. Fourth, the average exit rate is informative of $\hat{c}_f$ since a nontrivial fraction of firms exits when receiving this shock, and that fraction is affected by changes in $\hat{c}_f$. Fifth, the average age of informal firms is informative of $\xi(0)$ since, in most cases, informal firms survive when $c_f = 0$, and the age of the firm is directly related to the

53. Catao, Pagés, and Rosales (2009); Ulyssea (2010); Bartelsman, Haltiwanger, and Scarpetta (2009). A full description of the moments and the sources is provided in the appendix.

probability of exit. In particular, the average age of an informal firm is equal to $[1 / \Pr(survivalinformal)] = [1 / \Pr(exitinformal)] \approx [1 / (1 - \xi(0))]$. Finally, the average exit rate of large firms is informative of $\xi(\hat{c}_f)$ since large firms exit only with probability $[1 - \xi(\hat{c}_f) - \xi(0)]$.

The only parameter left to calibrate is the entry cost, c_e. Once this parameter is set, the model equilibrium can be computed (that is, the equilibrium wage, w, the equilibrium mass of entrants, M, and the equilibrium schedule of prices, $q^f(k', b', z)$ and $q^i(k', b')$, that clear the labor market and satisfy the free-entry condition of firms and the zero-profit condition of financial intermediaries). However, since it is very hard to obtain information to identify the cost of entry, the calibration strategy follows the seminal work of Hopenhayn and Rogerson.[54] In particular, the wage rate is normalized to one and used to find the value of c_e that, in equilibrium, satisfies the free-entry condition with equality. This also implies deriving endogenously the equilibrium mass of entrants, M, and the menu of prices, $q^f(k', b', z)$ and $q^i(k', b')$, that clear the labor market and satisfy the zero-profit condition for financial intermediaries.

Table 4 presents the model parameters.[55] Table 5 shows that the model approximates the targeted moments relatively well.

After the calibration exercise is complete, I test the model in different dimensions. In particular, I assess how the distribution of operating establishments generated by the model compares with that of Brazil, starting with the distribution of firms in the microenterprise sector, that is, firms with up to five employees. The ECINF data include the universe of firms in this sector. Table 6 shows that the model approximates the microenterprise sector distribution considerably well. As in the data, most firms employ no workers or only one worker (80.59 percent in the model versus 86.6 percent in the data). About 90 percent of firms in the microenterprise sector in the model are informal (versus 87 percent in the data). Since informal firms are very small with zero or one worker (both in the model and in the data), this results in the distribution observed in table 6.

The distribution across the formal and informal sectors can be explored using both the RAIS and ECINF data. Table 7 presents the distribution of firms conditional on whether they operate in the formal or informal sector.[56]

54. Hopenhayn and Rogerson (1993).

55. The wage rate and the equilibrium mass of entrants are presented in table 8. The equilibrium menu of prices is presented in figure 7.

56. The sample with the distribution of informal firms is restricted to firms with up to five workers. The fact that more than 90 percent of these firms have two workers or fewer implies that the results are most likely not distorted by this restriction.

TABLE 4. Model Parameters

Parameter	*Symbol*	*Value*	*Target*
Discount factor	β	0.93	$1/(1+r)$
Capital share	α	0.33	Capital share standard
Returns to scale	γ	0.85	Returns to scale
Depreciation	δ	0.07	Capital depreciation
Risk-free rate	r	0.08	Real interest rate
Autocorrelation	ρ	0.78	Autocorrelation productivity
Profits tax	τ	0.22	Profit tax in Doing Business database
Labor tax	τ_w	0.52	Labor cost in Doing Business database
Firing cost	τ_f	0.88	Firing cost in Doing Business database
Bankruptcy cost	ϕ	0.09	Bankruptcy cost in Doing Business database
Formal entry cost	κ	0.74	Entry cost in Doing Business database
Intermediation cost	ζ	0.06	Overhead cost Brazil
Entry cost	c_e	1.03	Equilibrium condition
Average low productivity process	μ_l	1.349	Size formal sector (46.16 percent)
Average high productivity process	μ_h	2.961	Average size formal firm (11.69)
Dispersion h process	σ_h	0.048	Average corporate credit to GDP (15.19%)
Med. fixed cost (percent)	$\hat{c}_f$	0.358	Average exit rate formal sector (12.9%)
Prob. low fixed cost	$\xi(0)$	0.872	Average age informal firms (8.84 years)
Prob. med fixed cost	$\xi(\hat{c}_f)$	0.091	Exit rate large formal firms (5.0%)

TABLE 5. Targeted Moments

Moment	*Data*	*Model*
Size of formal sector (%)	46.16	46.15
Average size of formal firm	11.69	11.18
Average corporate credit to GDP (%)	15.20	16.80
Average exit rate from formal sector	12.90	11.58
Average age informal firms (in years)	8.84	7.69
Average exit rate of large formal firms (%)	5.00	4.70

TABLE 6. Firm Size Distribution in the Microenterprise Sector[a]
Percent

	Data		*Model*	
No. workers	*Share of firms*	*CDF*	*Share of firms*	*CDF*
0	86.60	86.60	80.59	80.59
1	7.40	94.00	18.39	98.98
2–3	4.60	98.60	0.22	99.21
4–5	1.40	100.00	0.80	100.00

Source: IBGE, 2003 ECINF Survey.
a. Microenterprises are firms with five employees or fewer.

TABLE 7. Firm Size Distribution, Formal and Informal Sectors
Percent

	Data		*Model*	
No. workers	*Share of firms*	*CDF*	*Share of firms*	*CDF*
Formal sector				
0–4	69.58	69.58	24.85	24.85
4–9	15.22	84.80	39.99	64.84
9–19	8.06	92.86	32.09	96.93
19–49	4.43	97.29	3.06	99.99
49–99	1.36	98.64	0.01	100.00
99–249	0.82	99.46	0.00	100.00
249–499	0.54	100.00	0.00	100.00
Informal sector				
0	80.12	80.12	81.34	81.34
1	12.23	92.35	18.66	100.00
2–3	5.88	98.23	0.00	100.00
4–5	1.77	100.00	0.00	100.00

Source: Brazilian Ministry of Labor, Annual Social Information Report (RAIS); IBGE, 2003 ECINF Survey.

The model does a good job generating the right distributions of operating establishments in the two sectors, with some caveats. In the formal sector, it generates the right number of establishments with fewer than nine employees, but misses at the very low end of the distribution (fewer than five employees) and at the very top (firms with more than ninety-nine workers).[57] Table 7 shows that the model is right on target for the distribution of informal establishments.

The model also captures the first and second moments of the distribution of corporate spreads. As discussed in the next section, the average corporate spread in the model is 12.48 percent, versus 14.37 percent in the data. The cross-sectional standard deviation of corporate spreads in the model is 5.08 percent, compared with 7.96 percent in the data.

57. A different entry process into the formal sector can correct this problem. One alternative is to assume that firms receive a signal of their initial productivity before entering, as opposed to an initial draw from the productivity distribution. If the correlation of the signal and the initial productivity is lower than that used for the productivity process, firms that originally invested a large amount of capital can find themselves with low productivity and hiring a small number of workers in the initial period. Another alternative is to assume that the demand for new firms depends on the time the firm has spent on the market. A final option is to incorporate a detection probability when firms are in the informal sector. If detected firms are forced to formalize, that would move a set of small firms to the formal sector, generating an increase in the 1–4 bin. The analysis of these alternatives is beyond the scope of this paper.

TABLE 8. Aggregate Results on Reducing the Cost of Credit

	Data			*Model*		
Variable[a]	*2003*	*2010*	Δ	*Benchmark*	*{↓r, ↓ζ}*	Δ
Corporate credit to output (%)	15.19	23.88	57.21	16.80	31.57	87.89
Formal labor force (%)	46.16	55.37	19.95	46.15	66.95	45.07
TFP	—	—	—	1.62	1.86	15.40
Output per worker	13,850	15,970	15.31	2.31	2.81	21.64
Capital per worker	36,370	37,850	4.07	2.95	3.46	17.32
Average spread (%)	14.37	12.93	–10.02	12.48	9.74	–21.96
Standard deviation, spread (%)	7.96	9.92	24.62	5.08	5.69	12.01
Average size of formal firms	11.69	12.95	10.76	11.18	10.18	–8.94
Mass entrants	—	—	—	0.12	0.10	–22.03
Wage rate, *w*	—	—	—	1.00	1.12	12.03
Entry/exit rate formal sector (%)	12.9	—	—	11.58	13.89	19.95

a. Output per worker and capital per worker in the data computed from Penn World Tables. In the case of these variables, only the change is comparable to the model counterpart due to the model normalization. Size of formal firms is measured using number of workers.

Experiment: Reducing the Cost of Credit

The objective of this paper is to analyze the effects of the reduction in credit costs on firm size, the amount of credit in the economy, and the level of formality. The experiment can be interpreted as a counterfactual experiment that measures the effects of reducing r and ζ to their 2010 values and evaluates the steady-state effect. The experiment can be summarized as follows. First, the model is calibrated to the Brazil economy. In this case, I normalize $w = 1$ to then iterate on the set of loan prices, $q_j^f(k', b', z)$ and $q^i(k', b')$, until lenders make zero profit on each contract. I then find the mass of potential entrants, M, that clears the labor market and the value of entry cost, c_e, that satisfies the zero-entry condition. Next, the credit market condition parameters, r and ζ, are adjusted to the values observed in 2010 ($r = 4.70$ percent and $\zeta = 3.31$ percent) and iterate on the wage rate, w, and loan prices, $q^f(k', b', z)$ and $q^i(k', b')$, until lenders make zero profits and the zero-entry condition is satisfied (given c_e obtained in the benchmark economy). Finally, the mass of entrants, M, adjusts to clear the labor market. The results on the most relevant aggregates are presented first, followed by the effects on the firm size distribution.

Table 8 shows how the main aggregates are changed from the benchmark to the equilibrium with lower credit costs. As in the data, after a reduction in credit costs (that is, $\{\downarrow r, \downarrow \zeta\}$), the model generates a rise in corporate credit to GDP and the size of the formal sector. Both increases are larger than in the data. In particular, the increase in credit in the model is around 87.89 percent,

whereas in the data it is 57.21 percent. Moreover, the increase in the formal labor force is 45.07 percent in the model versus 19.95 percent in the data. One possible explanation for the overshoot is the fact that the model compares two steady states, whereas in the data firms might not expect the reduction in credit costs (and the implied size of credit to GDP and formal sector) to be permanent at the 2010 level.

Table 8 also shows that the reduction in credit costs has important aggregate productivity effects. To compute total factor productivity in the model and the data, I follow the cross-country studies such as Klenow and Rodríguez-Clare or Hall and Jones.[58] They compute the following equation:

$$\text{TFP} = \frac{Y}{K^{\alpha} H^{(1-\alpha)}},$$

where Y denotes aggregate output, K denotes aggregate capital, H denotes some aggregate for labor (usually adjusted for human capital), and α is the capital share. We do exactly the same in the model, where aggregate output is the sum across both formal and informal establishments, aggregate capital is the sum of capital across establishments in both sectors, and the aggregate labor measure equals one. Aggregate productivity (TFP) in the model increases more than 15 percent. The increase in productivity generates an increase in output per worker of about 21.64 percent and an increase in capital per worker of 17.32 percent.

Once credit costs are reduced, the value of creating a firm increases, generating an increase in the entry rate (19.95 percent). This results in an increase in the wage rate (12.03 percent), which is necessary to clear the labor market since at the original wage rate aggregate demand for labor exceeds aggregate supply. The increase in wages, together with the reduction in credit costs, induces firms to substitute away from workers into capital. This results in the observed reduction in the average size of the formal firm in the model, as opposed to the increase observed in the data. The experiment provides a counterfactual where the cost of credit is reduced using the benchmark economy as the starting point. In the data, other factors such as changes in trade costs and labor regulations (not studied in this paper) affected the size of the formal firm in Brazil. Moreover, there was a change in the way that RAIS data (our data for formal firms) were collected between 2003 and 2010. Specifically, through 2006, reference companies and other organizations were classified

58. Klenow and Rodríguez-Clare (1997); Hall and Jones (1999).

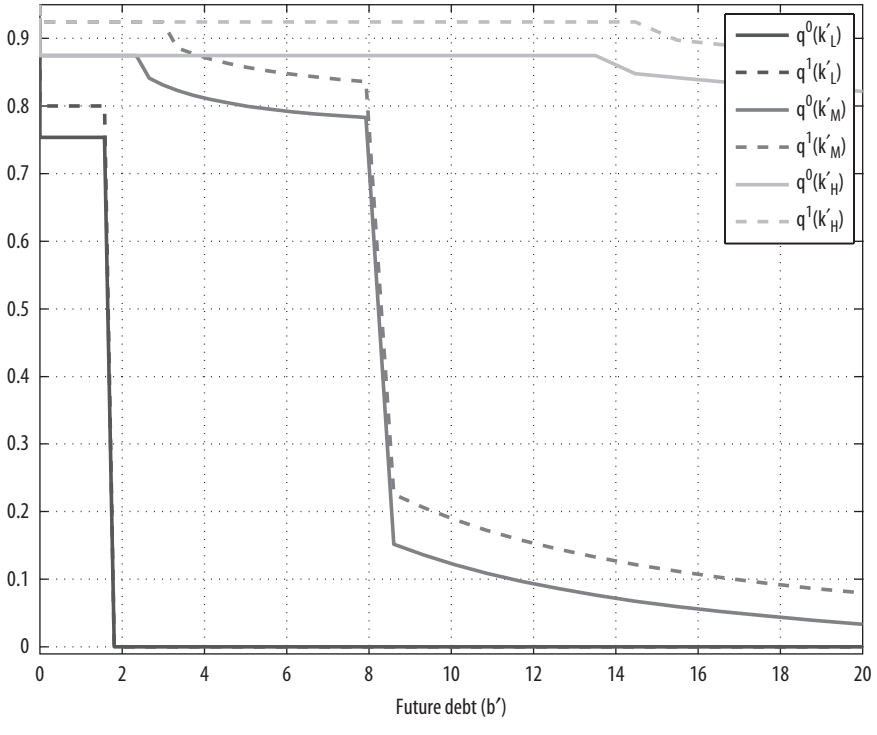
according to version 1.0 of the National Classification of Economic Activities (NCEA). This was updated to version 2.0 in 2007, to maintain international comparability and equip the country with a classification system that incorporated the changes in the production system. The methodology for identifying active units was also completely redesigned in 2007. Unlike previous years, the new selection criteria take into consideration not only completing the declaration of RAIS and the research base year, but also a range of other indicators of the unit's economic activity.

Firm-Level Effects

Changes in costs for financial intermediaries have a first-order effect on the prices that firms pay for borrowing. This translates into lower default probabilities, which reduce bond prices even further. This affects the firm size distribution mainly through three channels. First, it induces incumbent firms to hold a different composition of debt and capital. Second, it affects the entry and exit thresholds. Third, it changes the productivity composition of formal firms. By reducing the entry threshold (since the firm's value is higher), it reduces the average productivity of the entrant firm. However, higher entry also results in a higher level of competition and higher wages, which translates into more exit. This latter effect also affects the fraction of firms producing in the informal sector (those with lower productivity). These three channels together generate an extra effect on the labor demand and the level of efficiency in the economy. I start by describing the effect on prices and then present the effects on the distribution of debt, capital, and labor. This is followed by a discussion of how the entry threshold and the productivity composition of the economy are affected.

Figure 7 presents the schedule of prices in the benchmark case (denoted by q^0) and in the economy with lower r and ζ (denoted by q^1) as a function of b' for different levels of capital $k' \in \{k_L, k_M, k_H\}$ (that is, k' taking a low, medium, and high value from the equilibrium distribution). Bond prices are decreasing in debt levels and capital, since the default probability and the expected recovery for lenders is decreasing in debt and capital. The higher default probability is translated into higher interest rates. Importantly, this figure shows that bond prices are lower (that is, interest rates are higher) in the benchmark economy than in the case with lower r and ζ for every combination of capital and debt levels. This effect allows firms to borrow more (as shown below) in the case with lower r and ζ. As firms increase their borrowing level, bond prices increase. However, as noted in table 8,

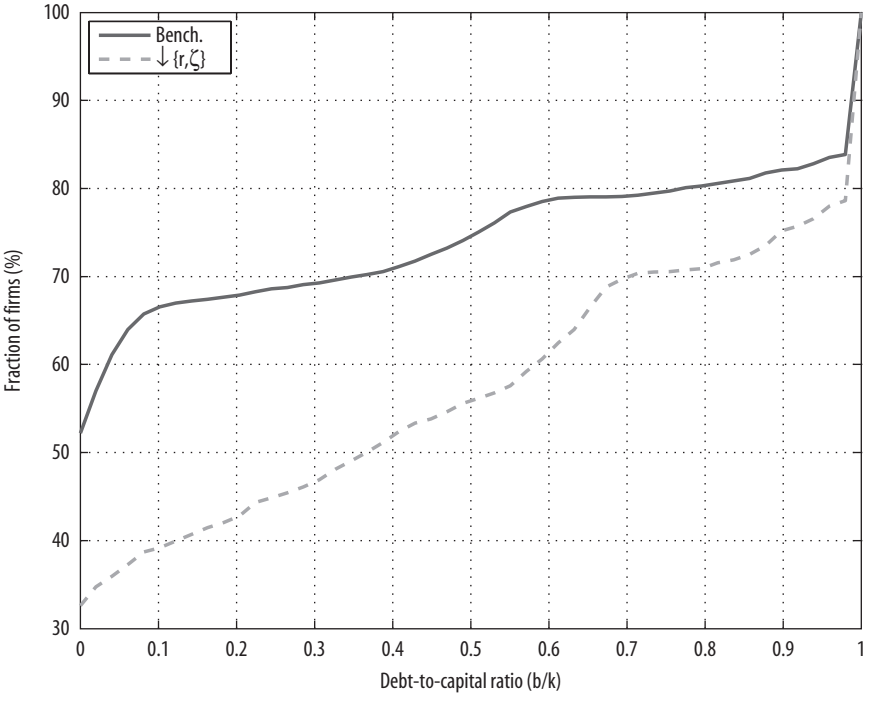
FIGURE 7. Bond Prices of Formal Firms: Benchmark versus ↓{*r*, ζ}



the average spread decreases by 21.96 percent, so the effect of higher bond prices dominates (all else equal).

As table 8 showed, when r and ζ are reduced, there is an increase in the ratio of aggregate credit to output of 87.89 percent. When bond prices are higher, the value of capital as a buffer stock against a negative productivity shock is reduced (that is, a lower precautionary motive). Firms can sustain lower levels of capital since it is cheaper to attain the optimal level of investment by borrowing in financial markets (this is also reflected in the smaller average size of the formal firm). Figure 8 shows the distribution of the debt-to-capital ratio in both economies. These ratios are considerably lower in the benchmark economy. The median firm in the benchmark case has a debt-to-output ratio around 0 percent, whereas the median firm in the economy with lower {r, ζ} sustains a debt-to-output ratio that is close to 35 percent.

FIGURE 8. Distribution of the Debt-to-Capital Ratio: Benchmark versus ↓{*r*, ζ}



Changes in the portfolio composition also have important effects on the size of the firm (in terms of workers). Figure 9 shows the distribution of capital and labor in both economies. The shift in the distribution of capital (displayed in panel A), together with the increase in wages (12 percent), translates into a reduction in labor demand for each firm (panel B). The median firm in the formal sector in the benchmark economy holds approximately twenty-seven units of capital and hires nine workers in the benchmark case. The median firm in the counterfactual economy holds approximately nineteen units of capital (a 29 percent reduction) and hires about six workers (a 30 percent reduction).

The microenterprise sector (firms with five workers or fewer) represents the largest share of firms in the economy. Table 9 displays the effect on the size distribution for this type of firm. Recall that the microenterprise sector includes formal and informal firms. The table shows that there is an increase in the share of firms in the smallest bin (those with no workers) and also an

FIGURE 9. Distribution of Capital and Labor: Benchmark versus ↓{*r*, ζ}

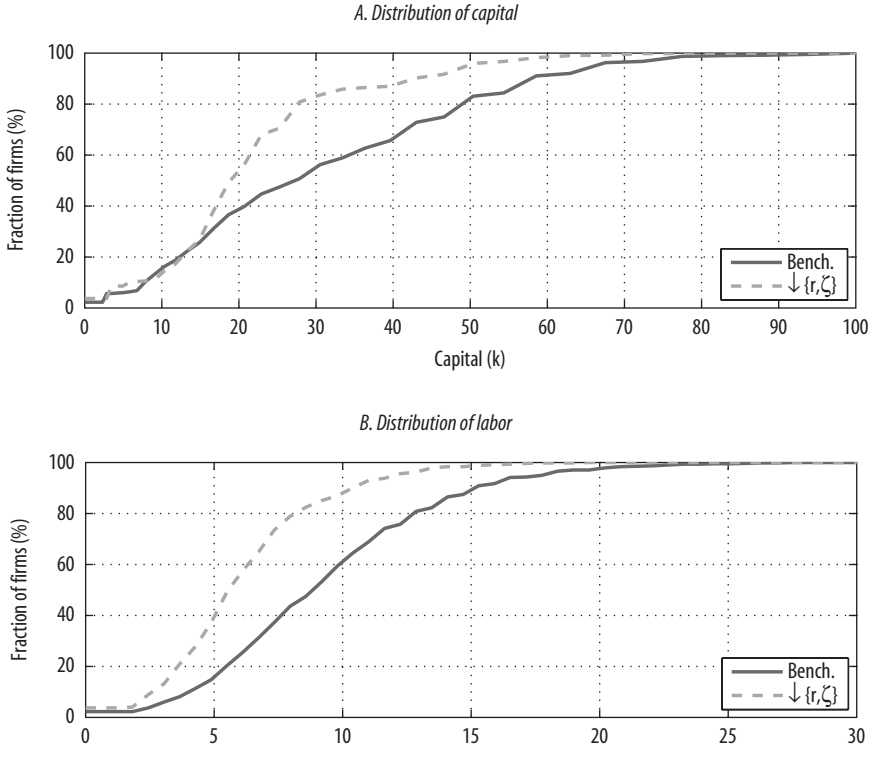


TABLE 9. Firm Size Distribution in the Microenterprise Sector: Benchmark versus ↓{*r*, ζ}
Percent

	Benchmark		*{↓r, ↓ζ}*	
No. workers	*Share of firms*	*CDF*	*Share of firms*	*CDF*
0	80.53	80.53	92.32	92.32
1	18.38	98.91	0.04	92.36
2–3	0.32	99.23	2.66	95.02
4–5	0.77	100.00	4.98	100.00

TABLE 10. Firm Size Distribution: Benchmark versus ↓{*r*, ζ}
Percent

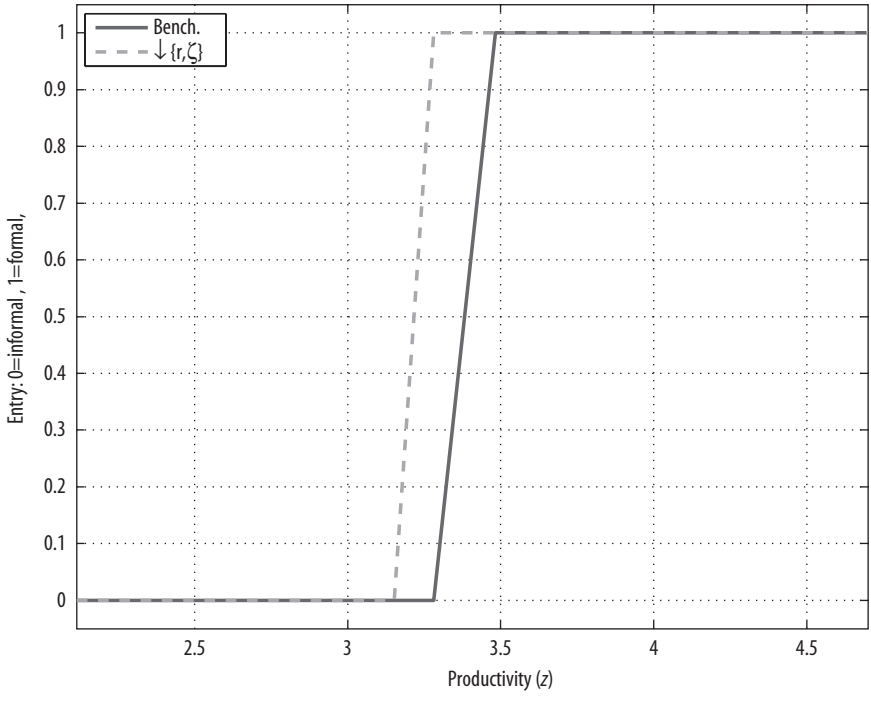
	Benchmark		*{↓r, ↓ζ}*	
No. workers	*Share of firms*	*CDF*	*Share of firms*	*CDF*
Formal sector				
0–4	24.85	24.85	35.67	35.67
4–9	39.99	64.84	58.61	94.28
9–19	32.09	96.93	5.53	99.81
19–49	3.06	99.99	0.19	100.00
49–99	0.01	100.00	0.00	100.00
Informal sector				
0	81.34	81.34	100.00	100.00
1	18.66	100.00	0.00	100.00
2–3	0.00	100.00	0.00	100.00
4–5	0.00	100.00	0.00	100.00

important increase in the fraction of firms with four and five workers. The general equilibrium effect that results in a larger wage induces both informal and formal firms to hire fewer workers. The increase in the smallest bin is mostly due to changes in the labor demand of informal firms. The change in the largest bin is due to changes in the labor demand of formal firms that were not included in the microenterprise sector before, but that reduced their workforce after the change in credit conditions.

To clarify these results, table 10 presents the distribution of formal and informal firms individually. As the table shows, labor demand is affected in both the formal and informal sectors. In the formal sector, the fraction of firms in the 0–4 worker bin and the 4–9 worker bin increases by approximately 50 percent. The other size bins record reductions, with the largest impact in the 9–19 and 19–49 bins. The increase in wages and the reduction in bond prices also affects the informal size distribution: only very small firms remain active in this sector.

FIRM-LEVEL PRODUCTIVITY. Changes in credit costs affect the firm size distribution via changes in both the entrant's and the incumbent's productivity level. Figure 10 presents the entry threshold to the formal sector (that is, the value of z_0^* in each case, as defined in the solution to the entrant's problem). Two factors affect the entry threshold in opposite directions: an increase in the wage rate reduces firm profitability, increasing the threshold; the reduction in loan prices increases the value of the firm, decreasing the threshold. As evident from figure 10, the latter factor dominates and results in a reduction

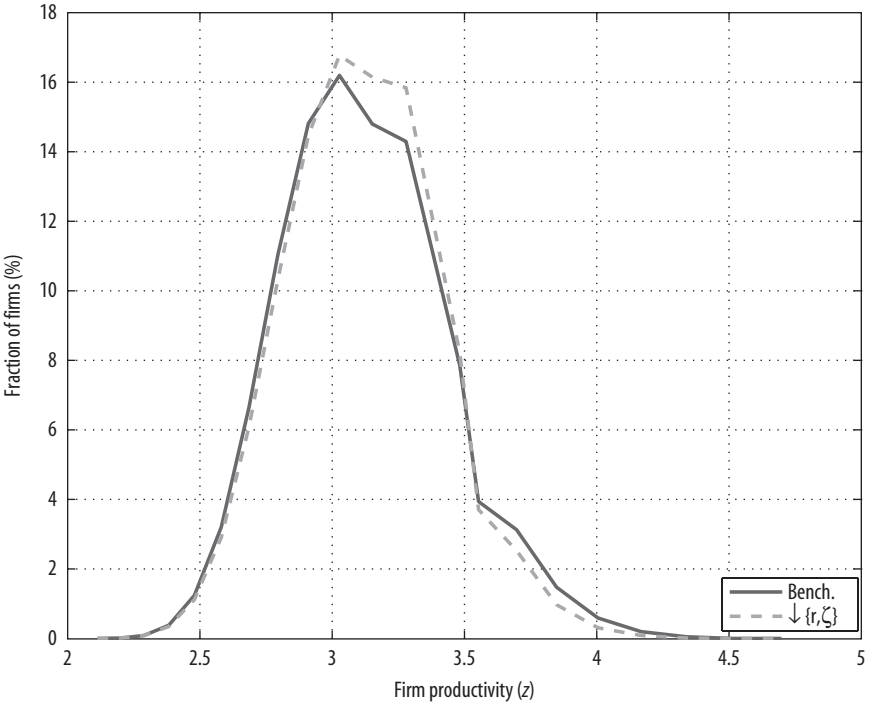
FIGURE 10. Entry Threshold: Benchmark versus ↓{*r*, ζ}



in the entry threshold to the formal sector of 5.82 percent. This smaller entry threshold results in higher entry rates. The higher level of entry also results in higher exit rates, increasing the productivity level of incumbent firms (the so-called cleansing effect). The effect of the lower productivity of entrants is dominated by the cleansing effect, which causes a shift to the right of the distribution of firm productivity. Figure 11 shows precisely the distribution of firm level productivity in the formal sector in both economies.

To understand the total effect on aggregate productivity (TFP) of reducing credit costs, it is necessary to identify how production is allocated across firms of different productivity levels and to incorporate the informal sector in the analysis. Figure 12 presents the distribution of aggregate production for the entire economy as a function of firm-level productivity. The figure shows that production is allocated more efficiently when credit costs are lower. The production distribution shifts to the right when comparing the benchmark case versus the economy with lower {*r*, ζ}. An important factor generating this

FIGURE 11. Productivity Distribution in the Formal Sector: Benchmark versus ↓{r, ζ}



result is the fraction of firms operating in the informal sector. The fraction of formal firms increases in the counterfactual economy by almost 37 percent. The reduction in productivity in the formal sector due to the lower entry threshold is more than compensated for by this effect, increasing aggregate TFP.

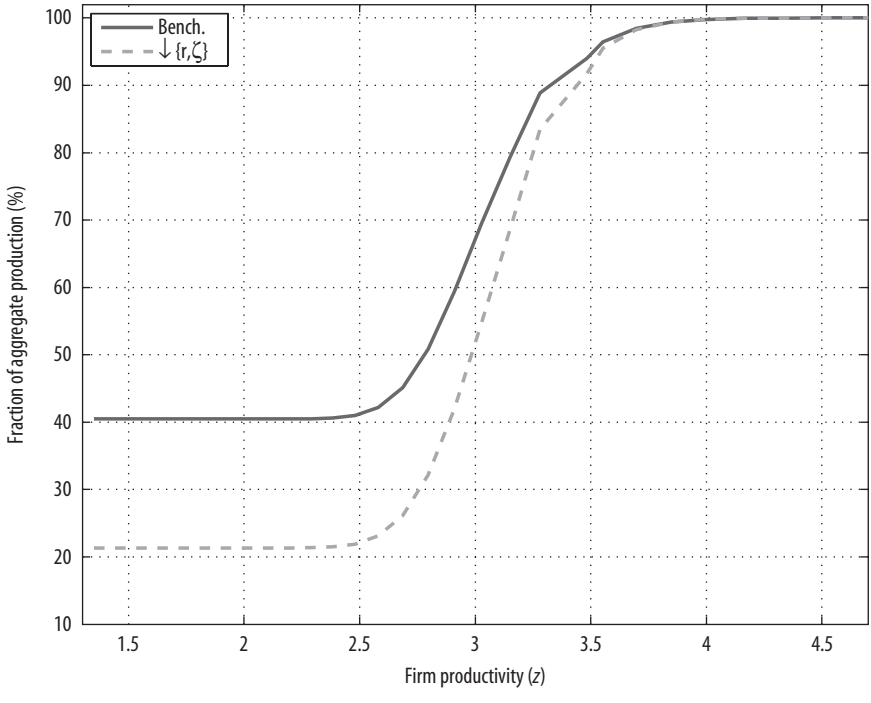
The effect can be explored further using a decomposition of weighted-average plant-level productivity originally proposed by Olley and Pakes:[59]

$$\hat{z} = \int z_s \omega_s \, ds = \Omega \mu_l + (1 - \Omega)\left[\overline{z} + cov\left(z_s, \omega_s^f\right)\right],$$

where $\hat{z}$ is the average of plant-level productivity weighted by output share, Ω is the informal share of output, ω_s represents the output shares of each establishment, ω_s^f denotes the output shares of each establishment in the formal

59. Olley and Pakes (1996). This decomposition is also used by Bartelsman, Haltiwanger, and Scarpetta (2009).

FIGURE 12. Distribution of Production (Both Sectors): Benchmark versus $\downarrow\{r, \zeta\}$



sector, and $\overline{z}$ is the unweighted mean productivity in the formal sector. Therefore, the output-weighted productivity can be decomposed into three terms: the effect of informal activity, given by Ω, and the two components of formal weighted productivity, which can be decomposed into the unweighted average of firm-level productivity plus a covariance between output share and productivity. The covariance captures allocative efficiency within the formal sector because it reflects the extent to which firms with above-average productivity have a greater market share. Table 11 displays the values of this decomposition for both economies.

TABLE 11. Firm Productivity Decomposition

Group	$\hat{z}$	W	$\overline{z}$	$cov(z_s, w_s^f)$
Benchmark	2.407	0.373	3.0908	0.035
$\downarrow\{r, \zeta\}$	2.771	0.213	3.0904	0.067

TABLE 12. Decomposing the Effects of r and ζ[a]

Variable	*Financial efficiency* {↓ζ}	*Intermediation costs* {↓r}	*Both* {↓r, ↓ζ}
r	0.08	0.047	0.047
ζ	0.031	0.06	0.031
Corporate credit to output	1.98	1.31	1.88
Formal labor force	0.90	0.91	1.45
Output per worker	1.03	1.02	1.22
TFP	1.02	1.01	1.15
Average spread (%)	1.13	0.67	0.78
Average size of formal firms	1.12	1.15	0.91
Wage rate, w	1.04	1.03	1.12
Entry/exit rate in formal sector	1.02	1.00	1.2

a. Except for parameter values, all statistics are reported relative to the benchmark case. The values of the parameters in the benchmark model are $r = 0.08$ and $\zeta = 0.06$.

The value of output-weighted productivity correlates with the value of aggregate TFP. As the cost of credit decreases, the value of $\hat{z}$ increases (15 percent). This effect is generated by an important shift of firms into the formal sector (the share of informal output decreases by 42 percent) and by a better allocation of resources in the formal sector (evident in the increase in the $\text{cov}(z_s, \omega^f_s)$ term of 91 percent).

Decomposing the Effect of r and z

The paper's main quantitative experiment consisted in analyzing the effects of a joint reduction in r and ζ. If one takes Brazil as a small open economy, one can think of changes in r to be outside the set of factors the government can control and changes in ζ as being a function of government policies. It is therefore important to understand the source of the aggregate effects. This can be achieved through a counterfactual experiment in which one parameter is changed at a time and then compared to the final joint result. Table 12 presents the results of these experiments. All values are reported as a fraction of the values in the benchmark economy. As the table shows, most of the effect on the credit level is coming from a reduction in ζ (the proportional cost of generating a loan). Reductions in the risk-free interest rate, r, generate an increase in credit that is only one-third of the overall effect.[60]

60. Recall that the percent change in ζ and r is approximately similar (44 percent and 37 percent, respectively), where z falls from 5.58 percent to 3.31 percent and r from 7.5 percent to 4.7 percent.

The intuition can be found in equations 5 and 6. A change in ζ has a first-order effect on prices q^f and q^i, while changes in r affect prices q^f and q^i weighted by the corresponding default probability. This is reflected in the observed average spread. The model generates a higher spread consistent with higher borrowing when only ζ changes, as opposed to a lower spread when r is lower.

There is an interaction effect between ζ and r that allows the model to generate the overall change in the size of the formal sector. When ζ and r change individually, the formal sector contracts. Both a lower ζ and a lower r are needed to make the model move in the direction observed in the data, because informal firms also have access to credit (at prices q^i), and changes in ζ and r also affect their menu of prices. When only one of the parameters changes, all firms have access to better credit terms and demand more workers (which is reflected in higher wages). The increase in the wage rate reduces the incentives to enter the formal sector, thereby increasing the entry threshold, and this result in a smaller formal sector. This is also evident in the larger size of the formal firm when ζ and r change individually. When both ζ and r change together, the effect of better credit terms dominates the increase in the wage rate, and the formal sector increases. The change in the entry rate when both ζ and r change is larger than the sum of the individual changes.

Bankruptcy Costs and Recovery Rates

This section further analyzes changes in the structural parameters of the model to capture other potential effects of the bankruptcy reform and also introduces an extension of the model that allows for changes in the recovery rate when a formal firm defaults.

Bankruptcy Costs

One relevant aspect of the bankruptcy reform implemented in Brazil during this period is how it affected bankruptcy costs. In this section, I analyze changes in bankruptcy costs, ϕ, as measured by Doing Business. The new law provided a significant increase in creditor protection, but it resulted in an increase in bankruptcy costs. In particular, the value of ϕ in the benchmark calibration (set to 2003 values) is 9 percent of the asset value of the firm, according to Doing Business. The value of ϕ in 2012 is 12 percent, also

TABLE 13. Cost of Credit, Financial Sector Efficiency and Bankruptcy Costs[a]

Variable	*Financial reform* $\{\downarrow r, \downarrow \zeta\}$	*Bankruptcy costs* $\{\uparrow \phi\}$	*Both* $\{\downarrow r, \downarrow \zeta, \uparrow \phi\}$
r	0.047	0.08	0.047
ζ	0.031	0.06	0.031
ϕ	0.09	0.12	0.12
Corporate credit to output	1.88	0.79	1.82
Formal labor force	1.45	0.24	1.47
Output per worker	1.22	0.83	1.30
TFP	1.15	0.86	1.22
Average spread (%)	0.78	1.45	1.10
Average size of formal firms	0.91	1.03	0.83
Wage rate, w	1.12	0.99	1.14
Entry/exit rate in formal sector	1.20	0.94	1.04

a. Except for parameter values, all statistics are reported relative to the benchmark case. The values of the parameters in the benchmark model are $r = 0.08$, $\zeta = 0.06$, and $\phi = 0.09$.

according to Doing Business. Table 13 presents the results for the full set of changes in this period (that is, a reduction in the costs of borrowing, $\downarrow r$, an increase in financial sector efficiency, $\downarrow \zeta$, and changes in bankruptcy costs, $\uparrow \phi$), as well as a decomposition of these changes.

The increase in bankruptcy costs alone has the expected results. Lenders expect to recover a smaller fraction of the firm's capital; since they only receive $(1 - \phi)k$ in the case of default. this has a direct impact on the interest rate schedule firms face and results in much higher spreads than in the benchmark (45 percent higher). This increase in borrowing costs induces firms to hold more capital and reduces allocative efficiency as measured by TFP (a 14 percent reduction relative to the benchmark). Importantly, this increase in bankruptcy costs generates a large reduction in the level of formalization, which is only 24 percent of the benchmark, and a reduction in labor demand (reflected in lower wages), since higher borrowing costs reduces the benefits of formalization.

Table 13 shows that the results of the main experiment are similar to those presented in table 12. After incorporating the changes in bankruptcy costs, the improvement in financial efficiency and the reduction in borrowing costs for intermediaries generate a sizable increase in credit to output, the formal labor force, and TFP. That is, the positive effects derived from changes in the cost of borrowing and financial efficiency are more than enough to overcome the negative effects on credit, formalization, output, and TFP from the increase in bankruptcy costs.

Bankruptcy Reform and Recovery Rates

As described earlier, the bankruptcy reform enacted in 2005 encouraged the reorganization of claims, rearranged the absolute priority rule in favor of secured creditors, reduced the length of bankruptcy resolution, and provided major protection to creditors. These changes have potentially affected recovery rates after bankruptcy. The benchmark model generates endogenous changes in recovery rates since firm-level heterogeneity (in terms of debt-to-capital ratios) among firms that default results in different final payments to lenders.[61] However, this endogenous mechanism does not capture all potential factors affecting recovery rates (such as delays and capital specificity). I therefore extend the benchmark model to incorporate an upper level on recovery rates as measured by Doing Business.[62] In particular, lenders can recover up to a fraction λ of the original claim, b. The firm's problem remains unchanged, except that the value of exit now becomes

$$V^x\left(z_{-1}, k, b, c_f\right) = \max\left\langle \begin{array}{l} k - b - \tau_f w E_{z|z_{-1}}\left[n\left(z, k\right)\right], \\ \max\left\{0, \left(1-\varphi\right)k - \lambda b - \tau_f w E_{z|z_{-1}}\left[n\left(z, k\right)\right]\right\} \end{array} \right\rangle.$$

Note the introduction of λ in the second term of the equation. As in the benchmark, limited liability and firm heterogeneity will generate dispersion in recovery rates, but the presence of λ puts a maximum on that level of recovery. In the benchmark model, $\lambda = 1$. The change in the potential recovery rates also affects the bond pricing equation. In particular, the profit for a loan, b', to a firm in the formal sector with future capital k' and productivity z is

$$\pi^f\left(k', b', z\right) = -q^f\left(k', b', z\right)b' + \frac{1 - p^f\left(k', b', z\right)}{1+r}b' + \frac{p^f\left(k', b', z\right)}{1+r}\min\left\{\lambda b', \left(1-\varphi\right)k' - \tau_f w E_{z|z_{-1}}\left[n\left(z, k\right)\right]\right\} - \zeta b',$$

61. See $V^x(z_{-1}, k, b, c_f)$ in equation 2.

62. The extension is in line with D'Erasmo and Moscoso Boedo (2012). The recovery rate refers to what external lenders obtain once the firm decides to default on its debt (Λ). In Doing Business, the recovery rate is measured as the cents on the dollar recovered from that point on, and it includes different channels to resolve the contract breach, such as foreclosure, liquidation, and reorganization, as reported by Djankov and others (2008).

TABLE 14. Bankruptcy Reform and Recovery Rates[a]

Variable	*Benchmark*	*Recovery rate* $\{\uparrow\lambda\}$	*Bankruptcy reform* $\{\uparrow\lambda, \uparrow\phi\}$	*Both* $\{\downarrow r, \downarrow\zeta, \uparrow\lambda, \uparrow\phi\}$
r	0.08	0.08	0.08	0.047
ζ	0.06	0.06	0.06	0.031
ϕ	0.09	0.09	0.12	0.12
λ	0.002	0.171	0.171	0.171
Corporate credit to output	16.31	1.05	0.99	2.69
Formal labor force	52.55	1.03	1.02	1.36
Output per worker	2.21	1.01	1.01	1.29
TFP	1.56	1.01	1.00	1.23
Average spread (%)	24.12	0.99	1.00	0.82
Average size of formal firms	11.46	1.03	1.03	0.50
Wage rate, w	1.00	0.95	0.98	1.09
Entry/exit rate in formal sector	10.37	0.98	0.98	1.16

a. Values reported in the benchmark column are in levels. Except for parameter values, all statistics reported in the remaining columns are relative to the benchmark case.

where $p^f(k', b', z)$ denotes the default probability of this borrower as defined earlier. This change in recovery rates and the resulting change in bond prices will generate a set of general equilibrium effects that induce changes in the firm's borrowing decisions and in the likelihood of default.

According to Doing Business, the value of λ for Brazil before the bankruptcy reform was 0.2 percent, versus 17.1 percent in 2012 (that is, after the bankruptcy reform).[63] A new benchmark is computed using the specification presented in this section, with all parameters as set in the calibration section and $\lambda = 0.002$. A full experiment (that is, changes in r, ζ, ϕ, and λ) is then considered, in which the model is solved again to find the new set of equilibrium decision rules, value functions, and prices. Table 14 presents the moments of this new benchmark and the comparison with the full experiment, together with a decomposition of the contribution of changes in recovery rates and changes in ϕ (both parameters are directly affected by the bankruptcy reform).

The third column in Table 14 shows that an increase in recovery rates, λ, results in higher credit to output, formal labor force, output per worker, and TFP. The increase in the recovery rate after a default allows firms to borrow at better credit terms, inducing firms to formalize and to borrow in order to finance investment. Relaxing credit constraints induces an increase in output

63. For comparison, the value for the United States was 76 percent in the year 2012.

per worker and TFP. The value of λ as measured by Doing Business is still relatively small compared to developed economies, which is why the observed changes are relatively small compared with the full experiment.

In terms of the joint effects of the bankruptcy reform on recovery rates and bankruptcy costs (where only λ and ϕ change), the negative effects of the increase in bankruptcy costs are muted due to the positive effects of higher recovery rates. Most variables remain very close to the values reported in the benchmark.

The final column of table 14 shows that the results of the full experiment are qualitatively and quantitatively similar to those presented in table 12. The observed changes in the borrowing costs of intermediaries and financial sector efficiency generate the bulk of the changes in corporate credit, the formal labor force, output per worker, and TFP. The full set of changes results in substantially smaller corporate spreads and a reduction in the average size of the formal firm (since now they need less capital in order to borrow at low interest rates) and increases in the wage rate (due to the higher labor demand from formal firms) and exit rates.

Conclusion

This paper develops a firm dynamics model with endogenous formal and informal sectors to quantitatively evaluate how much of the change in corporate credit and the size of the formal sector can be attributed to an increase in the efficiency of the financial sector (measured as a reduction in the cost of funds for financial intermediaries and an increase in their efficiency to extend loans).

The quantitative exercise shows that, as a response to the changes in the financial sector, the model generates an increase in credit to GDP of 87.89 percent, paired with an increase in the size of the formal labor force of 45.07 percent. This is consistent with the data for the same period in Brazil. The increase in the level of formalization and the better allocation of resources induce an increase in measured aggregate TFP of 15.40 percent and in weighted firm-level productivity of 16 percent. To understand the overall results even further, I analyze the changes in the financial sector one by one. Interestingly, most of the effect on the credit level is coming from the increase in the level of efficiency in extending loans (as opposed to changes in funding costs). Moreover, the experiments show that effects in terms of the size of the formal sector are not additive, since there is an important interaction effect

between the efficiency level and the funding cost for intermediaries that allows the model to generate the overall change.

This model shows that changes in the cost of credit are important to generate an increase in the size of the formal sector, the amount of credit, and aggregate productivity. One possible avenue for future research is the study of the optimal size and timing of the structural reforms affecting financial intermediaries. Moreover, important institutions that affect the cost of formality (such as the cost of entry and the tax level) interact with credit costs since they affect the incentives to enter and to exit by repayment or default. The extent to which changes in credit conditions are effective depends on whether these institutions are also reformed. The analysis of joint reforms is another interesting line for future research.

Appendix A: Data

This section provides a description of the variables and sources used in the paper.

—Net interest margin: The counting value of a bank's net interest revenue as a share of its interest-bearing (total earning) assets. Source: Beck and Demirgüç-Kunt (2009). Note: see the World Bank website for the full data set.

—Real money market interest rate: Interest rates, money market rate. Source: International Financial Statistics (IFS). Note: The nominal rate is converted to the real rate using the consumer price index, which is also from IFS.

—Bank overhead costs: The value of a bank's overhead costs as a share of its total assets. Source: Beck and Demirgüç-Kunt (2009). Note: see the World Bank website for the full data set.

—Corporate loan interest rates (median, average, distribution): Loan interest rate. Data span all nationwide bank lending to individual firms above a minimum threshold of R$5,000. These data contain information on interest rates and lending amounts at the firm level. Source: Central Bank of Brazil (BACEN). Note: The nominal rate is converted to the real rate using the consumer price index.

—Total domestic bank credit to GDP: Total domestic bank credit. Source: Catao, Pagés, and Rosales (2009), using data from the Institute of Applied Economic Research (IPEA) (ipeadata.gov.br).

—Domestic bank credit to the corporate sector to GDP: Domestic bank credit to the corporate sector. Source: Catao, Pagés, and Rosales (2009), using data from the Institute of Applied Economic Research (IPEA) (ipeadata.gov.br).

—Formal size distribution: The size distribution of firms in the formal sector. Source: The Annual Social Information Report (RAIS). Notes: The RAIS is compiled by the Brazilian Ministry of Labor, which requires by law that all formally registered firms report information each year on each worker employed by the firm. I use aggregate tables reported on the website of the Brazilian Institute of Geography and Statistics (IBGE) and summary statistics reported in cited papers. Tables of interest (1996–2010) can be found in the Central Register of Enterprises (*Cadastro Central de Empresas,* CEMPRE), available online at www.sidra.ibge.gov.br/bda/pesquisas/cempre/default.asp. The CEMPRE comprises companies and other organizations and their formally constituted local subsidiaries, registered in the National Register of Legal Entities. The CEMPRE is updated annually based on administrative records and the annual IBGE economic surveys in the areas of industry, trade, construction, and services.

—Informal size distribution: The size distribution of firms in the informal sector. Source: The 2003 Informal Urban Economy Survey (ECINF). Notes: The ECINF is a representative cross-section of small firms, collected at the national level by the Brazilian Institute of Geography and Statistics (IBGE). ECINF samples households located in urban areas and seeks to identify the self-employed and employers with up to five employees in at least one work situation. The ECINF offers extensive detail on the main firm and the entrepreneurial characteristics of the microenterprises, such as sectoral revenues, profits, employment size, capital stock, and time in business. The IBGE does not allow access to the microdata, but it provides a large set of descriptive tables, which are available online at www.ibge.gov.br/home/estatistica/economia/ecinf/2003/default.shtm.

Measured Institutions

—Entry Costs: The cost of entering the formal sector corresponds to the reported costs of registering a business and of dealing with licenses to operate a physical locale. Source: World Bank, Doing Business database. Note: Entry costs involve the cost of starting a business measured in time and the cost of starting a business as a share of per capita income.[64] The estimate of the entry cost for Brazil is 0.739 of GNI per capita.

64. Following D'Erasmo and Moscoso Boedo (2012), the time cost is translated to monetary units by assuming that one worker has to be employed full time in order for the firm to go through the entry process.

—Taxes: Profit and payroll taxes paid by firms. Source: World Bank, Doing Business database. Notes: The profit tax rate is the item "Paying taxes—profit tax (percent);" the payroll tax is "Paying taxes—labor tax and contributions (percent)." Because both tax rates are expressed as a function of profits, they need to be adjusted and the labor tax rate expressed as a function of payroll. To do so, the standardized balance sheet and income statements were used to construct the exercise, as explained in table 1 of Djankov and others (2010). The estimated values for Brazil are 22.4 percent and 51.65 percent, respectively.

—Firing costs: The total cost to the firm of firing workers. Source: World Bank, Doing Business database. Notes: Firing costs are obtained from the item "Firing cost (weeks of wages)." A year corresponds to 52 weeks, so the estimated value of firing one worker equals 88 percent of his or her annual wage.

—Bankruptcy costs: The fraction of the firm's asset value that is lost during bankruptcy. Source: World Bank, Doing Business database. Notes: Bankruptcy costs are a measure of system efficiency in the event of default. The cost (ϕ), reported as a percentage of the estate's value, includes court fees and the cost of insolvency practitioners, such as legal and accounting fees. The estimated value for Brazil is 9 percent.

The complete Doing Business data set is available online at www.doingbusiness.org/custom-query.

Appendix B: Bankruptcy Reform in Brazil

In 2005, Brazil introduced a bankruptcy reform. The previous law dated from 1945.[65] The old law was particularly unfavorable toward secured creditors. Two characteristics of the old liquidation procedure were the key determinants of the structure of this process: successor liability and first priority given to labor and tax claims. The process through which the assets were made available to creditors was slow (the average time to close a business in Brazil was more than twice the average for Latin America) and highly ineffective, since it only postponed debt payment and did not lead to actual restructuring. This liability transfer depressed the market value of an insolvent company's assets, while the priority given to labor and tax claims had the pernicious

65. See Araujo, Ferreira, and Funchal (2012) for an exhaustive description of the new bankruptcy law in Brazil. This appendix follows their presentation closely.

effect of eliminating any protection to other creditors. Proceeds after liquidation were expected to be almost zero for most creditors. Doing Business reports that just before the bankruptcy reform, lenders expected to recover only twenty cents on the dollar. The procedure also incentivized an informal use of the system to promote consensual renegotiations, notwithstanding an insufficient legislative framework capable of fostering workouts.

The new law, enacted in 2005, was inspired mostly by the U.S. law, which allows for liquidation (Chapter 7) and reorganization (Chapter 11) and thus enhances the protection given to creditors considerably. The new law provided in- and out-of-court options to reorganize with a reasonable balance between liquidation and reorganization. It also significantly improved the flexibility of the insolvency legal system by allowing the conversion of reorganization proceedings into liquidation, by establishing a period in which debtors can apply for rehabilitation in response to liquidation proceedings filed against them, and by introducing a new out-of-court reorganization system for prepackaged restructuring plans. In addition, the new law imposed a new constraint on debtors' bankruptcy requests: the value of the ending liabilities must exceed 40 times the minimum monthly wage. Ponticelly summarizes the changes introduced by the new law as follows:[66]

—Secured creditors have priority over tax claims, and there is a cap of 150 minimum wages for each claim on previously unlimited labor claims.

—Successor liability is eliminated when selling business units or the full business as a going concern. Tax, labor, and social security claims remain liabilities of the debtor and are no longer passed on to the purchasers in liquidation.

—Automatic stay: the debtor is protected by the court from legal action from other creditors for a period of 180 days (time to present a restructuring plan); otherwise bankruptcy is started.

—Introduction of creditors' committees: the three classes of creditor (labor, secured, and unsecured) can discuss and approve or refuse the restructuring plan. If one class does not approve, the judge has the power to impose the plan anyway.

—Debtor in possession financing: creditors providing new liquidity post-bankruptcy enjoy absolute priority.

—The bankruptcy plan requires the consent of 60 percent of creditors in each class (value of their debt).

66. Ponticelly (2013).

The bankruptcy reform had several visible direct effects. It increased recovery rates (as measured by Doing Business) from 0.2 percent to 17.1 percent of the asset value of the firm in only a few years. Creditors now face new incentives to actively participate in the bankruptcy procedure. The use of the reorganization procedure increased. The number of liquidation requests is now about the same as the number of reorganization requests. Also, the average time to close a business in Brazil has fallen from ten to four years, which tends to reduce the depreciation of assets.

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