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ABSTRACT

What are the aggregate effects of informality in a financially constrained economy? We develop and calibrate an entrepreneurship model to data on matched employer-employee from both formal and informal sectors in Brazil. The model distinguishes between informality on the business side and the hiring of informal workers by formal businesses. Policies that reduce business informality increase aggregate output by 10.8%, TFP by 6.6%, and tax revenue by 33.2%. On the contrary, output and TFP decrease when policies reduce the intensive margin of informality, underscoring that the informal economy can play a positive role in an economy with financial frictions.

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1. Introduction

The prevalence of the informal sector in developing economies has widespread macroeconomic implications. It negatively affects the ability of the government to collect tax revenue, making the financing of social security and the provision of public goods difficult. It discourages the growth of businesses because small firms can avoid taxation more effectively by operating on a low scale, negatively affecting capital accumulation and resource allocation.

Developing economies also feature underdeveloped financial markets and high rates of entrepreneurship, which negatively affect the allocation of productive resources. Financial frictions constrain the scale of operation of entrepreneurs who lack internal funds to operate on an optimal scale, depressing aggregate labor demand and wages, and thereby distorting occupational choices by encouraging the operation of businesses on a small scale. On the one hand, informality and

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financial frictions reinforce each other in creating a competitive advantage for low-productivity entrepreneurs. On the other hand, informality allows financially constrained entrepreneurs to operate at lower costs, speeding up capital accumulation and relaxing their borrowing constraints. But the benefits of informality may come at a cost if entrepreneurs in the informal economy are subject to tighter borrowing constraints and face higher costs in the use of capital. In sum, whether the interaction between informality and financial frictions improves or worsens resource allocation is a quantitative question.

This paper assesses the effects of informality and financial frictions on misallocation and public finance. To this end, we develop a general equilibrium growth model of occupational choice and capital accumulation in which entrepreneurs face credit constraints and decide whether to operate in the informal or formal economy. Entrepreneurs can borrow in the financial markets subject to collateral constraints that vary between the formal and informal sectors of the economy. Informal entrepreneurs avoid payroll and sales taxes. Since the costs of production in the informal economy increase with the scale of operation (capturing distortions in the use of production inputs to avoid detection by the government), informal entrepreneurs only operate on a small scale. Entrepreneurs in the formal economy can partially avoid payroll taxes by hiring (some) workers informally. The cost reduction attained by hiring informal workers decreases with business size, a property that acts as a size-dependent policy. In sum, the theory developed models how two margins of informality affect resource allocation: (i) the extensive margin given by the extent of informal businesses; (ii) the intensive margin represented by the informal paid workers at formal firms. These two margins of informality are prominent features of developing economies. We show that the two forms of informality matter for occupational choices and the impacts of financial frictions.

Our framework extends [Ulyssea \(2018\)](#) by modeling capital and occupational choice decisions. The first extension is motivated by micro evidence on differences in capital and debt holdings between formal and informal businesses. The second extension is motivated by cross-country evidence of the high entrepreneurship rate in developing countries. A prominent feature of countries with underdeveloped financial markets is the high entrepreneurship rate caused by the prevalence of own-account entrepreneurs who operate their businesses without hiring workers (see [Allub and Erosa, 2019](#)). Our theory addresses these observations. In our model, consistent with results in the financial development literature, changes in occupational choice are crucial for how capital and aggregate total factor productivity respond to changes in financial frictions and formalization policies.

The theory is motivated by some key facts about informality and occupational choices in Brazil. Using data from household and small business surveys we document that informality is pervasive and varies across occupations: 47% of the labor force is informal, with about half of this rate explained by entrepreneurs. Most entrepreneurs (80%) are self-employed rather than employers (20%). The incidence of informality is higher among the self-employed than among employers and workers (92%, 53%, and 35%). Formal businesses employ about two-thirds of informal paid workers (intensive margin). As documented by [Ulyssea \(2018\)](#), the intensive margin of informality decreases with business size. We emphasize, however, that businesses with more than six workers account for about 50% of informal-paid workers. Informal entrepreneurs and workers tend to be less educated than their formal counterparts. Conditional on the size of the establishment and industry, informal entrepreneurs hold 66% less capital and 54% less debt than formal entrepreneurs.

We quantify the impacts of formalization policies in our calibrated model. We find that policies that act on the extensive margin of informality have quite different effects from policies that attack the intensive margin. Specifically, increasing monitoring of the extensive margin of informality increases output 10.8%, capital 13.9%, TFP 6.6%, and tax revenue 33.2%. On the contrary, increasing monitoring of the intensive margin leads to worse macroeconomic outcomes (output decreases by 3.6%, capital by 5.7%, TFP by 1.9%, and tax revenue by 6%). Informal businesses boost the misallocation of resources caused by malfunctioning credit markets because financial frictions and informal businesses complement each other, creating a competitive advantage for entrepreneurs with low productivity. However, the intensive margin of informality allows formal entrepreneurs to accumulate capital and relax credit constraints by hiring some workers off the books. Indeed, reducing the costs of the intensive margin expands labor demand, increases equilibrium wages, and diminishes self-employment and business informality.

We find that eliminating the payroll tax in our baseline economy reduces worker and business informality. This policy primarily benefits large employers, who hire most of their workers formally, reallocating labor and increasing labor demand and equilibrium wages. The mass of own-account workers decreases by two-thirds (from 0.25 to 0.088) and business informality from 0.248 to 0.077. In the absence of financial frictions, the increase in output would be less than half the amount in the baseline economy (4.7% versus 10.8%), underscoring that payroll taxation is more detrimental to economic activity in an economy with credit frictions. The explanation is that credit-constrained entrepreneurs tend to rely more intensively on the use of labor than unconstrained entrepreneurs, making payroll taxation more costly under credit frictions.

The elimination of financial frictions increases capital, output, and TFP by 40.3%, 27.4%, and 15.1% in the baseline economy. These effects are substantially smaller in an economy with low informality along both margins (30.1%, 21.1%, 11.9%). We highlight that the two margins of informality have different consequences for the impact of financial frictions. Financial frictions constrain the scale of business operations, thereby increasing the likelihood that high-productivity entrepreneurs choose to operate in the informal economy and misallocation. The intensive margin of informality reduces labor costs (payroll taxes) in the formal sector. Since credit-constrained entrepreneurs tend to rely more heavily on labor, they benefit more strongly from decreases in labor costs. Hence, the intensive margin of informality speeds up capital accumulation by entrepreneurs facing tight borrowing constraints, relaxing credit constraints, and improving resource allocation. In sum, the intensive margin diminishes the negative consequences of financial frictions on macroeconomic outcomes.

We evaluate the sensitivity of our results to modeling an occupational choice decision. We find that changes in the costs of the extensive and intensive margins of informality have similar effects as in the baseline model economy. However, we find substantially smaller gains when eliminating payroll taxes and shutting down financial frictions. A key mechanism is that changes in wages discourage self-employment and informality in our baseline model, an effect that is not present in an economy with fixed occupations. We end the paper discussing evidence from the bankruptcy reform in 2005 in Brazil to show that the mechanisms implied by our model economy are in line with observed changes in the occupational structure and informality in Brazil.

Literature Our paper is related to the literature that studies aggregate consequences of informality.¹ In recent work, [Ulyseas \(2018\)](#) develops a model of heterogeneous firms to evaluate the result of different formalization policies on output, TFP, and welfare. [Meghir et al. \(2015\)](#) analyzes the firm productivity distribution through the lens of a wage-posting model. [de Paula and Scheinkman \(2010\)](#) study how the incentives produced by value-added taxes increase informality across the supply chain. [Prado \(2011\)](#) uses cross-country data to calibrate a static industry model with tax, imperfect enforcement, and entry costs. Moreover, our paper is related to the misallocation literature and, in particular, to a large literature assessing the effects of financial frictions ([Allub and Erosa, 2019](#); [Buera et al., 2011](#); [Erosa, 2001](#); [Midrigan and Xu, 2014](#); [Moll, 2014](#)).² We are not the first to study the relationship between financial development and informality. [Ordóñez \(2014\)](#) and [Franjo et al. \(2022\)](#) study models where informal firms use little capital to avoid detection by tax authorities. [D'Erasmus and Moscoso Boedo \(2012\)](#) explicitly model firms' bankruptcy procedures in equilibrium with the credit market. [Antunes and Cavalcanti \(2007\)](#) use a static occupational choice model where formal firms have (imperfectly) access to finance. These papers abstract from the intensive margin of informality and its importance for self-financing in the presence of financial frictions. We also use firm-level data on capital and debt to discipline our theory.

The paper is structured as follows. [Section 2](#) reports facts on informality and occupational choice in Brazil. [Section 3](#) presents the theoretical framework. [Section 4](#) describes the calibration strategy and compares the baseline model to the data. [Section 5](#) describes the results from the main quantitative experiments. [Section 6](#) evaluates the role of the occupation choice.

2. Empirical evidence

Data This section discusses the main stylized facts regarding entrepreneurship, informality, and financial frictions. To carry out our empirical analysis, we use several Brazilian data sets. The main data is ECINF (*Pesquisa de Economia Informal Urbana*), a cross-sectional survey of non-agricultural businesses. The survey is nationally representative for small urban businesses (up to 5 employees) and it was conducted by the Brazilian Bureau of Statistics (IBGE) in 1997 and 2003. The objective of the survey was to measure the size of the informal activity in the Brazilian economy. As a consequence, IBGE had taken a couple of steps to ensure its quality, such as using a sampling procedure that adequately includes informal businesses and guaranteeing confidentiality of responses.³ The data cover detailed information on the business characteristics (revenue, capital, credit), and workers' characteristics - including the owner and non-paid labor. Because of its structure, it provides a unique opportunity to understand the relationship between productivity, credit, and hiring decisions of informal production units.

Although ECINF offers a good representation of the characteristics of the informal businesses, where the average size is 1.15 and 97% of them have two workers or less, the size cap of five workers is too small to provide a good representation of the size distribution of the formal sector. Therefore, we supplement the ECINF with two additional datasets. The formal firm size distribution comes from RAIS, an administrative matched-employer employee dataset covering the universe of formal firms. Unfortunately, RAIS does not provide information on informal firms or informal workers. Hence, we supplement it with the nationally representative household survey: PNAD (*Pesquisa Nacional por Amostra de Domicílios*). PNAD provides valuable individual-level information such as the total share of informal workers, the fraction of entrepreneurs in the economy, and the share of informal workers among large businesses.⁴ Unfortunately, the latest year available for the main dataset used in the paper, ECINF, is 2003. Therefore, to keep the data comparable, we restrict our analysis to 2003 and maintain the same sample selection whenever possible.⁵ The sample is restricted to privately owned firms, including own-account workers, in urban areas. Our definition of informality is the usual: a firm is formal when it possesses a tax identification number, and a worker is formal when the labor contract is registered in her worker's booklet - a document that records all formal employment relationships and ensures that workers are entitled to receive all social security benefits. For all purposes of the paper, we classify a self-employed individual (henceforth SE) as an entrepreneur, and high-skilled as individuals with at least a high-school degree.

¹ For a survey on the current state of the literature, see [Ulyseas \(2020\)](#).

² See [Guner et al. \(2008\)](#); [Restuccia and Rogerson \(2008\)](#) and [García-Santana and Pijoan-Mas \(2014\)](#). For a recent survey, see [Restuccia and Rogerson \(2017\)](#).

³ In Online Appendix B.2., we provide a detailed discussion on the steps used by IBGE to guarantee that ECINF correctly measures informality, and contrast the survey with other available data.

⁴ For a more detailed description of the data, see Online Appendix B.1.

⁵ As discussed in detail in Online Appendix B.3, the share of informal workers in Brazil decreased between 2002 and 2015, while the share of informal business did not change substantially. Despite an increase in the minimum wage, there are no meaningful changes in labor regulation during the period ([Haanwinckel and Soares, 2021](#)).

Table 1

Share of informal firms and informal workers by firm size (2003).

Panel A: Employers and self-employed entrepreneurs			
	All entrepreneurs	Self-employed	Employer
Fraction of the Labor Force (all)	32.2	26.7	5.6
Fraction of the Labor Force (high-skill)	26.1	18.3	7.8
Fraction of the Labor Force (low-skill)	36.8	33.0	3.8
Fraction of Informal among Small Bus. (all)	87.3	91.8	53.3
Fraction of Informal among Small Bus. (high-skill)	75.3	84.0	39.5
Fraction of Informal among Small Bus. (low-skill)	92.5	94.8	67.3
Panel B: Informality in small businesses			
Size (Owners+Employees)	Share informal businesses	Share inf. workers in formal bus.	Cumul. mass of inf. bus.
1	0.93	–	0.90
2	0.66	0.48	0.97
3	0.45	0.46	0.99
4	0.34	0.37	0.99
5	0.30	0.26	1.00
All (≤ 5)	0.87	0.32	

Notes: Size includes paid employees plus business owners. Share of informal workers in formal firms includes paid employees only. Cumul. Mass of Inf. Bus. denotes the cumulative distribution of informal firms. High-skilled is an individual with high school or more. Fraction of Informal among Small Business denotes the informality rate in firms with fewer than six workers and is calculated using ECINF. Fraction of the Labor Force includes all employed individuals older than 16 years and is calculated using PNAD. Source: PNAD and ECINF 2003.

Informal workers, informal businesses, and self-employment

Developing countries exhibit high rates of entrepreneurship, financial frictions, and high rates of informality both among workers and entrepreneurs. Brazil is no exception. Using the PNAD data we find that the entrepreneurship rate (fraction of entrepreneurs in the labor force) in Brazil in 2003 was 32%. Moreover, most entrepreneurs tend to be own-account workers (self-employed entrepreneurs) who work and manage their own businesses without hiring outside labor. Self-employed entrepreneurs (SE) represented about 26.7% of the Brazilian labor force, whereas employers represented 5.6% of the labor force (see Panel A in Table 1). Allub and Erosa (2019) have documented similar facts for a high number of developing countries. Below we argue that informality in Brazil is pervasive among SE but also affects employers and paid workers.

The Brazilian economy features high informality rates, both among workers and entrepreneurs. Out of all paid workers, around 35% are informal. Out of all entrepreneurs, about 66% operate in the informal economy. The informality among SE individuals is substantially larger than among employers. Using ECINF, we estimate that the fraction of informality is 92% for SE, while for employers with 5 workers or less, it is 53% (see Table 1). The sum of informal paid workers and informal entrepreneurs implies that 47% of the labor force is informal. Informal paid workers represent 24% of the labor force. Thus, about half of the labor force informality is explained by informal entrepreneurs. The high amount of informal entrepreneurs results from the high entrepreneurship rate (32% of the labor force) and the high informality rate among them (66%).

The literature has long emphasized that the incidence of informality decreases with the education of individuals (see Ulyssea, 2020). This observation holds for workers and entrepreneurs. In Brazil, about 43% of workers with fewer than 12 years of schooling are informal. This statistic is 26% among workers who have completed high school. Using ECINF data, we document that informality is also higher among low-skilled entrepreneurs than high-skilled entrepreneurs (92% versus 75%). Two reasons explain these facts: (i) low-skilled entrepreneurs run smaller businesses since almost all of them are self-employed; (ii) conditional on being self-employed, low-skilled entrepreneurs are more likely to operate informally (94% compared to 84%).

Many empirical facts about informal businesses have been documented in microdata from other countries as well. La Porta and Shleifer (2014) suggests that informal firms employ few workers, have low value-added per employee, and pay low wages relative to their formal counterparts. Ulyssea (2018) finds similar evidence for Brazil but adds that formal and informal firms coexist in narrowly defined industries. Table 1 (Panel B) confirms that, in Brazil, the share of informal firms decreases with firm size. The fraction of informal businesses among businesses with one worker is around 90%, while that fraction is 30% among businesses with 5 workers. Moreover, the size distribution of informal firms is highly concentrated, with 97% of all informal firms employing two workers or less (including the owner).

The intensive margin of informality The fact that informal businesses hire few paid workers suggests that formal firms must hire a large fraction of informal workers. Thus, the intensive margin of informality should be important in accounting for worker informality. Knowing the exact extent of the intensive margin is challenging. Table 1 indicates that 32% of the workers in small formal Brazilian firms are informal. Furthermore, the gradient of the intensive margin of informality decreases with business size. While formal businesses with at least two workers hire almost 50% of workers informally, formal businesses with five workers hire only half of that (see column 2 in panel B of Table 1). As argued by Ulyssea (2018), given that ECINF only covers small firms, the share of informal employment at formal businesses in the economy is likely much larger than 32%. Table 2 presents the employment share by worker-firm formality status using the 2012 household

Table 2

Employment share by worker and firm informality status and firm size (2012).

Worker-firm status	≤ 5	≥ 6 and ≤ 10	≥ 11 and ≤ 50	≥ 51	All firms
Formal Worker in Formal Firm (a)	42.48	69.99	82.95	91.36	78.02
Informal Worker in Formal Firm (b)	25.76	20.35	13.79	7.54	13.80
Informal Worker in Informal Firm (c)	31.75	9.66	3.27	1.11	8.18
Total Employment Share (d)	17.84	13.85	19.72	48.59	100.00
Intensive Margin (b/(a + b))	37.75	22.53	14.25	7.62	15.03

Notes: Employment share by worker and firm formality status and firm size. Urban paid employees in private firms only. Size is defined by the number of paid employees. Source: PNAD-Continua 2012.

Table 3

Partial correlations of debt, capital and investment with formality status.

Variables	(1) log(Debt)	(2) log(Capital)	(3) log(Investment)
Informal	−0.538*** (0.0760)	−0.658*** (0.0500)	−0.505*** (0.0902)
log(VA p/ worker)	0.455*** (0.0276)	0.789*** (0.0164)	0.673*** (0.0359)
Observations	7856	32,797	7696
R-squared	0.414	0.615	0.584
Size FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
State FE	Yes	Yes	Yes

Notes: Size is defined as number of paid workers plus business owners. Industry dummies are at 4-digit level. Only firms with positive values of debt, capital and investment are included. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: ECINF 2003.

survey PNAD. First, out of the 22% of informal workers in 2012, almost 14% were employed by formal firms (see column 5 in Table 2). It follows that formal firms account for 62.7% of the total informal employment.⁶ Second, similarly to ECINF, the employment share of informal workers decreases in larger firms. Yet, even in firms with more than 50 employees, 7.5% of the total employment is informal.

Informality, capital and debt

In this subsection, we discuss the relationship between informality, capital, and debt. One may expect registered businesses to have access to better credit conditions as banks may require some form of managerial supervision such as well-developed business plans or accounting books.⁷ Using the World Bank Enterprise Surveys, La Porta and Shleifer (2014) show that access to financing is the most important obstacle to doing business for both formal and informal firms. Nevertheless, while 43.8% of informal businesses report financing as the most important issue, just 18.5% of formal businesses argue the same. ECINF directly asked the entrepreneurs seeking credit about the source of the loan. While 73.6% of the formal firms used public or private banks instead of other loan sources such as friends and family, the same share for informal firms is only 53% (see Appendix Table A.1).

In our ECINF sample, on average, formal firms have higher profits, revenues, and costs than informal firms. Also, they employ more capital and more debt. Aggregate debt to output (considering only small firms) is 43% in the formal sector, while just 31% in the informal sector. The aforementioned differences are explained, to a large extent, by the fact that formal firms are larger and possibly operate in different sectors than informal firms. Hence, to account for possible differences across sectors, Table 3 exhibits the partial correlations of debt, capital, and investment with the formality status conditional on size, industry, and value-added per worker.

After differences in the number of workers, sector of activity, and value-added are taken into account, an informal business still holds 53.8% less debt, 65.8% less capital, and invests 50.5% less than a formal business. Although this can be seen as evidence that the informal sector faces stronger frictions in the financial market than the formal sector, we cannot argue that there is a direct causal relationship since the demand for credit and capital could vary across entrepreneurs selecting into the formal and informal economy.

⁶ The formality status of the employer is asked only in the updated PNAD, which started rolling in 2012. Because the share of informal workers decreased by around 11 p.p. from 2003 to 2012 (see Online Appendix B.3), the number of informal workers at formal firms is presumably higher in 2003. In Online Appendix B.4, we argue that it should be around 66%.

⁷ In general, a registered entrepreneur has better loan conditions, such as a friendlier repayment structure, higher credit limits, and different default options.

3. Model

We study an economy with two margins of informality and financial frictions. The framework extends [Ulyssea \(2018\)](#) to model capital accumulation and occupational choice decisions. The financial frictions literature has emphasized the importance of these two features for misallocation in developing countries.

Population and preferences We consider the steady state of a growth model populated by a unit measure of infinitely-lived individuals. Individuals are heterogeneous in assets a , education e (high and low), and entrepreneurial ideas s . With probability π_s , individuals keep the same business idea as in the previous period or, with probability $1 - \pi_s$, they draw a new idea from a fixed Pareto distribution (which depends on the education e). Individuals maximize the expected discounted utility from consumption:

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \log(c_t) \right], \quad \text{where } \beta \in (0, 1). \quad (1)$$

Production technology Entrepreneurs own a production technology, which can be operated in the formal (f) or informal sector (i). The output of an entrepreneur with productivity s , capital k , and labor input l is $q(s, k, l) = s(k^\alpha l^{1-\alpha})^\theta$, $\alpha, \theta \in (0, 1)$, where (α, θ) are the capital share and span-of-control parameters. We assume the same production function for formal and informal entrepreneurs.

Following [Buera and Shin \(2013\)](#); [Moll \(2014\)](#), and [Midrigan and Xu \(2014\)](#), the capital used by an entrepreneur with a units of assets, in sector $j \in \{f, i\}$, is limited by the collateral constraint: $k \leq \lambda_j a$, $\lambda_j \geq 1$. Intuitively, λ_j controls the degree of credit frictions faced by the entrepreneur, where the limiting case $\lambda_j = \infty$ corresponds to a perfect capital market, and $\lambda_j = 1$ represents the case where all capital has to be self-financed. The degree of credit friction may differ across entrepreneurs in the formal and informal sectors ($\lambda_f \neq \lambda_i$).

Labor demand and self-employment A key feature of the Brazilian data is that unskilled workers are much more likely to be informal than skilled workers. This observation motivates modeling heterogeneity in skills. We assume that the labor input l is a CES aggregation of two types of workers: $l = (\eta l_1^\rho + (1 - \eta) l_2^\rho)^{\frac{1}{\rho}}$, where l_1 denotes high-skill workers and l_2 low-skill workers, η determines the share of skilled workers, and ρ the elasticity of substitution of the two labor inputs.

Regarding entrepreneurship, the Brazilian data reveal that most formal and informal entrepreneurs are own-account workers who do not hire outside labor. To mimic this fact, we assume that entrepreneurs (whether formal or informal) choose between being employers or self-employed (SE). Employers hire all labor from outside the household unit. SE entrepreneurs produce with their labor input (set to \bar{l} units of the CES labor aggregate). Later, we pin down the value of the parameter \bar{l} to match the entrepreneurship rate in Brazil.

Informal entrepreneurs Informal entrepreneurs do not pay payroll and sales taxes, but, in avoiding taxation, they disrupt their production decisions and incur resource costs $\tau_i(k, l_1, l_2)$. The function $\tau_i(\cdot)$ is assumed to be increasing and convex in its arguments. Earnings of an informal employer with assets a and entrepreneurial idea s are given by:

$$y(a, i, s, e) = \max_{k, l_1, l_2} \{q(s, k, l) - (r + \delta)k - w_1 l_1 - w_2 l_2 - \varepsilon_i - \tau_i(k, l_1, l_2)\}, \quad (2)$$

where $k \leq \lambda_i a$,

$$l = \begin{cases} (\eta l_1^\rho + (1 - \eta) l_2^\rho)^{\frac{1}{\rho}} & \text{if } (l_1, l_2) > 0, \\ \bar{l} & \text{if } (l_1, l_2) = (0, 0), \end{cases}$$

where ε_i is a fixed cost of operation. Notice that if the entrepreneur chooses to be self-employed, $l = \bar{l}$ and the wage bill is zero. If the entrepreneur hires labor, the wage bill is $w_1 l_1 + w_2 l_2$. The resource cost of operating informally $\tau_i(k, l_1, l_2)$ is discussed in detail in the calibration section.

Formal entrepreneurs Formal entrepreneurs pay payroll (τ_{ss}) and sales taxes (τ_y). As in [Ulyssea \(2018\)](#), formal entrepreneurs may hire informal workers to avoid part of their payroll taxes (i.e., the intensive margin of informality). However, in avoiding payroll taxes, they incur a resource cost given by the function $\tau_f(\cdot)$. Earnings of formal entrepreneurs satisfy:

$$y(a, f, s, e) = \max_{k, l_{1,f}, l_{1,i}, l_{2,f}, l_{2,i}} \{ (1 - \tau_y) q(s, k, l) - (r + \delta)k - (w_1 l_1 + w_2 l_2) \\ - \tau_{ss}(w_1 l_{1,f} + w_2 l_{2,f}) - \varepsilon_f - \tau_f(l_{1,i}, l_{1,f}, l_{2,i}, l_{2,f}) \} \quad (3)$$

where $k \leq \lambda_f a$,

$$l_e = l_{e,i} + l_{e,f} \quad \text{for } e = 1, 2,$$

$$l = \begin{cases} (\eta l_1^\rho + (1 - \eta) l_2^\rho)^{\frac{1}{\rho}} & \text{if } (l_1, l_2) > 0, \\ \bar{l} & \text{if } (l_1, l_2) = (0, 0), \end{cases}$$

where l_e denotes total labor input of skill-type e , $l_{e,i}$ and $l_{e,f}$ are the number of workers of skill e that are hired informally and formally, k is the capital input, τ_{ss} is the payroll tax used to finance social security, τ_y the sales tax, and ε_f is a fixed cost of operation. Following [Ulyssea \(2018\)](#), we assume formal and informal workers are perfect substitutes in production. Since formal and informal employees perform the same tasks, conditional on skills, there are no wage differences between

formal and informal workers.⁸ Formal entrepreneurs choose the mix between formal and informal labor that minimizes total labor costs.

The individual's problem Individuals make consumption, savings, and occupational choice decisions to maximize their expected discounted utility. The occupation of an individual at t is denoted by $o_t \in O = \{\omega, f, i\}$, where $o_t = \omega$ corresponds to paid workers, $o_t = f$ to formal entrepreneurs, and $o_t = i$ to informal entrepreneurs. An individual in occupation o_t , with assets a_t , business idea s_t , and education e faces the budget constraint:

$$c_t + a_{t+1} + \chi(o_t, o_{t+1}) = y(a_t, o_t, s_t, e) + (1+r)a_t \quad (4)$$

where $\chi(o_t, o_{t+1})$ gives the cost of switching from occupation o_t to occupation o_{t+1} . The function $y(\cdot)$ expresses earnings as a function of the individual's state. Individuals receive $y(a, o, s, e) = w_e$ when they decide to be paid workers, and entrepreneurial profits given by Eqs. (2) and (3) in case they are informal or formal entrepreneurs. Denoting cash-on-hand by $z(o_{t+1}; a_t, o_t, s_t, e) = y(a_t, o_t, s_t, e) + (1+r)a_t - \chi(o_t, o_{t+1})$, the budget constraint becomes $c_t + a_{t+1} = z(o_{t+1}; a_t, o_t, s_t, e)$. We are now ready to write the problem of a dynasty in recursive form. Given the state (a, o, s, e) , the set of feasible choices is: $\Omega(\cdot, \cdot, a, o, s, e) = \{(a', o') : a' \in [0, z(o'; a, o, s, e)], o' \in \{\omega, f, i\}\}$. Denote the o' -contingent value functions as

$$V^{o'}(a, o, s, e) = \max_{a' \in \Omega(\cdot, o', a, o, s, e)} u(z(o'; a, o, s, e) - a') + \beta \mathbb{E}[V(a', o', s', e) | s]. \quad (5)$$

Finally, the Bellman equation summarizing the individual's problem is given by the upper envelope:⁹ $V(a, o, s, e) = \max_{o' \in O} V^{o'}(a, o, s, e)$.

Equilibrium The model is closed by assuming that the tax revenue funds a public good G . The public good does not affect the marginal utility of private consumption and thereby has no consequences on household decisions. In equilibrium, the rental rates on capital, skilled and unskilled labor adjust to clear factor markets (see Online Appendix C).

4. Calibration of baseline economy

In this section, we motivate the functional forms chosen for the analysis in the paper, present the calibration strategy, and show the calibration results. We end with a discussion on the performance of the baseline economy along non-targeted dimensions.

4.1. Functional forms

Entrepreneurial ideas are drawn from a Pareto distribution, with tail parameter ξ . The location parameter $s_{0,e}$ is allowed to vary with the skill type of the entrepreneur. Note that if the distribution of ideas were the same across skill-types ($s_{0,1} = s_{0,2}$), in equilibrium with $w_1 > w_2$, unskilled entrepreneurs would have a comparative disadvantage at entrepreneurship when $s_1 = s_2$. The calibration determines the extent to which the distribution of ideas differs between skill groups.

The costs of the extensive margin of informality are given by:

$$\tau_i(k, l_1, l_2) = \tau_k k^2 + \sum_{e=1}^2 w_e \tau_{i,e} l_e^2, \quad \text{where} \quad \tau_k, \tau_{i,1}, \tau_{i,2} > 0. \quad (6)$$

The parameter τ_k will target the low capital intensity of informal firms. The costs of the intensive margin of informality are specified as follows:

$$\tau_f(l_{1,i}, l_{1,f}, l_{2,i}, l_{2,f}) = \sum_{e=1}^2 w_e \tau_{f,e} \frac{(l_{i,e})^2}{(l_{f,e})^\omega} \quad \text{where} \quad \tau_{f,1}, \tau_{f,2}, \omega > 0. \quad (7)$$

The parameter ω implies that the costs of hiring informal workers decrease with the number of formal workers in the business. It captures the idea that the more formal workers the firm has, the easier it is to hide informal workers from tax authorities.

4.2. Parameter values set exogenously

The calibration targets data for 2003 to take advantage of the ECINF survey, which is the latest year available. The model period is fixed to a year. The discount factor and the parameters of the production function are set to standard values in the literature: $\beta = 0.92$, $\alpha = 0.3$ and $\theta = 0.90$. The depreciation rate of capital is $\delta = 0.06$. The fraction of high-skill dynasties is fixed at 43 percent, consistent with the fraction of workers in the labor force with completed high school in Brazil in 2003. The persistence of entrepreneurial ideas is set to $\pi_s = 0.85$, a standard value in the literature.

⁸ Exploiting the fact that ECINF provides matched employer-employee data, Ulyssea (2018) runs a wage regression that controls for the firm's fixed effects. He finds that the within-firm formal-informal wage gap becomes negligible and insignificant.

⁹ Note that, as o' is a discrete variable and $\Omega(\cdot, \cdot, a, o, s, e)$ is non-convex, $V^{o'}(a, o, s, e)$ has kinks at the values of a for which the discrete choice o' switches, and is (in general) globally not concave (Fella, 2014).

Occupational switching costs Recall that the function $\chi(o, o')$ gives the resource cost of switching from occupation o to occupation o' . We assume that $\chi(\cdot, \cdot) = 0$ except for the following cases: i) a worker or an informal entrepreneur incurs a fixed entry-cost $\chi_{\text{entry}} > 0$ to start a formal business (meant to capture the resource cost of registering a business and comply with regulations); ii) Formal entrepreneurs cannot (directly) transit to informality ($\chi(f, i) = \infty$). The entry cost χ_{entry} is calibrated internally (see below).

Costs of informality The parameters $(\tau_k, \tau_{i,1}, \tau_{i,2})$ driving the costs of informal entrepreneurs will be calibrated internally. The parameter ω is set to 0.5 so that the cost of hiring informal workers by formal entrepreneurs is reduced by 40% when the number of formal workers doubles. The parameters $(\tau_{1,f}, \tau_{2,f})$ are pinned down to match aggregate data on informal workers by skill type.

Taxes The taxes are assigned their statutory values, specifically $\tau_y = 0.2925$ and $\tau_{ss} = 0.29$.

4.3. Parameter values set by solving the model economy

The remaining 16 parameters are chosen to minimize a loss function that consists of the square deviations between some selected model statistics and their data counterparts. In particular, we pin down the parameters of the CES aggregator of the two labor inputs (η and ρ), the labor input of the self-employed entrepreneur (\bar{l}), the location parameter of the distribution of entrepreneurial ideas for the two education groups ($s_{0,1}, s_{0,2}$), the tail parameter for the Pareto distribution of ideas (ξ), the fixed cost of operation of formal and informal businesses (ε_f and ε_i), the entry cost (χ_{entry}), the parameters governing the cost of hiring informal workers by formal and informal businesses ($\tau_{1,f}, \tau_{2,f}, \tau_{1,i}, \tau_{2,i}, \tau_k$), and the parameters on the collateral constraint faced by formal and informal entrepreneurs (λ_f and λ_i).

Solving for an equilibrium requires finding factor prices (rental rate of capital, wages of skilled and unskilled labor services) so that factor markets clear. Although the equilibrium outcomes will be jointly determined by all of the parameters, it is useful to discuss how each of the parameters connects with some moments of interest. The labor input (\bar{l}) supplied by self-employed entrepreneurs is used to match the fraction of entrepreneurs in the population. The share parameter η in the CES labor aggregate has a first-order effect on the skill premium of workers. The parameter determining the elasticity of substitution between labor inputs affects the relative demand for skilled workers and has a direct effect on the fraction of skilled paid workers in equilibrium. The parameters of the Pareto distribution of entrepreneurial productivity, together with the fixed operating costs ε_f and ε_i , determine the size distribution of formal and informal establishments. The difference between the location parameters ($s_{0,1}$ and $s_{0,2}$) of the Pareto distribution of ideas across skill groups matters for the entrepreneurial skill premium. The parameters λ_i and λ_f determine the credit to output ratio of informal and formal entrepreneurs. The entry cost χ_{entry} affects the share of formal businesses in the economy. The parameters $(\tau_{i,1}, \tau_{i,2}, \tau_{f,1}, \tau_{f,2})$ determine the mass of informal workers in informal and formal establishments by skill type. The parameter τ_k is used to match the K/Y ratio of informal businesses, as it determines the capital intensity of informal firms.

With these connections in mind, our calibration targets the following moments in the Brazilian data:

1. The share of informal paid workers among total paid workers: 35%.
2. The share of informal paid workers among high-skilled paid workers: 27%.
3. The share of informal paid workers among low-skilled paid workers: 42%.
4. The share of informal paid workers hired by formal businesses: 66%.
5. Entrepreneurship rate (fraction of entrepreneurs): 32%.
6. The skill premium among paid workers: 47%.
7. The skill premium among entrepreneurs: 55%.
8. The fraction of high-skilled workers: 47%.
9. The fraction of high-skilled entrepreneurs: 35%.
10. The fraction of formal businesses: 24%.
11. A credit to output ratio: 0.43 (formal entrepreneurs).
12. A credit to output ratio: 0.31 among informal entrepreneurs.
13. A capital to output ratio: 1.04 (informal entrepreneurs).
14. The size distribution of formal establishments (2 targets).
15. The size distribution of informal establishments (5 targets).

4.4. Calibration results

The model is over-identified as the calibration procedure involves more targets than parameters. Nonetheless, the model economy accounts reasonably well for the targeted moments. Table 4 presents the calibration results (parameter values, targets, and model and data moments). We now describe how the calibrated parameters fit the calibration targets.

The model successfully matches the high rate of entrepreneurship in Brazil: the mass of entrepreneurs represents 32% of the labor force, both in the model and in the data. To mimic the data along this dimension, the model requires $\bar{l} = 0.317$. The model economy closely matches the skill distribution by occupation in Brazil. In 2003, the share of high-skilled individuals in the labor force was 43%, with this share being lower among entrepreneurs than workers. The fraction of high-skilled individuals was 0.35 among entrepreneurs and 0.47 among workers. We directly set the fraction of high-skilled individuals

Table 4
Calibration results: baseline economy.

Parameters	Values	Target	Model	Data
\bar{l}	0.317	Entrepreneurship rate	0.319	0.320
η	0.569	Skill premium workers	0.464	0.467
ρ	0.244	Fraction high-skilled workers	0.467	0.469
$s_{0,1}$	1.619	Skill premium entrepreneurs	0.657	0.550
$s_{0,2}$	1.363	Fraction high-skilled entrepreneurs	0.352	0.348
χ_{entry}	0.051	Share of formal firms	0.222	0.242
$\tau_{f,2}$	0.119	Share of informal workers in formal firms	0.630	0.660
$\tau_{i,1}$	0.202	Share informal among high-skilled workers	0.286	0.258
$\tau_{i,2}$	0.249	Share informal among low-skilled workers	0.365	0.431
τ_k	0.078	K/Y informal	1.09	1.04
$\tau_{f,1}$	0.229	Fraction of informal workers	0.328	0.350
λ_f	1.838	Credit/GDP formal entrep. (≤ 5)	0.421	0.431
λ_i	1.450	Credit/GDP informal entrep.	0.313	0.311
(ε_f, ξ)	(0.046, 7.62)	Formal size: ≤ 5	0.725	0.698
		Formal size: 6–10	0.133	0.141
		Formal size: 11–20	0.075	0.083
		Formal size: 21–50	0.047	0.050
ε_i	0.170	Informal size: ≤ 2	0.929	0.972
		Informal size: ≤ 5	1.0	0.998

in the population to 0.43 before solving the model. However, the skill distribution by occupation is a calibration result. We thus highlight that the calibration reproduces the fraction of high-skilled individuals among workers and entrepreneurs in Brazil. To this end, the calibration needs the Pareto distribution of ideas to have a higher location parameter for high-skilled individuals than that for low-skilled individuals ($s_{0,1} = 1.619 > s_{0,2} = 1.363$).

The calibration matches that the skill premium among paid workers is 0.46 by setting the labor share of skilled workers in the CES aggregate of labor inputs to $\eta = 0.57$. The model also implies that skilled entrepreneurs have higher average earnings than unskilled entrepreneurs (66% versus 55% in the data).

The model matches the low capital intensity of informal businesses (the K/Y ratio is 1.09), which follows from the assumption that the costs of the extensive margin of informality rise with the use of capital ($\tau_k = 0.0779$ in Eq. (6)). Furthermore, by setting $\lambda_f = 1.837 > \lambda_i = 1.450$, the model accounts for the fact that the credit-to-output ratio of formal businesses (of size less than six workers) is higher than that of informal businesses in Brazil. This finding is consistent with the idea that informal entrepreneurs face more stringent collateral constraints.

The model implies that informal businesses tend to be much smaller than formal businesses. While all informal entrepreneurs employ fewer than six workers, only 73% of formal businesses employ fewer than six workers (70% in the data). In the model, the fraction of firms with more than 20 workers is about 6%, relative to 5% in the data.

4.5. Model performance in non-targeted dimensions.

We now argue that the model is consistent with dimensions of informality and occupational choice not directly targeted (see Table 5).

Entrepreneurs comprise employers and self-employed. The model is consistent with the (non-targeted) fact that about 80% of entrepreneurs in Brazil are SE. In the model, the mass of SE and the mass of entrepreneurs are 0.247 and 0.32, relative to 0.267 and 0.32 in the data. The model replicates that the entrepreneurship rate in Brazil is higher among low-skilled than high-skill individuals (36% and 26% both in the model and data). Moreover, entrepreneurship decreases with education because of the lower incidence of self-employment among the highly skilled.

SE is also crucial for understanding the high informality rate among small businesses in Brazil. Indeed, data from ECINF and PNAD imply that informal entrepreneurs represent 86.8% of small businesses (with fewer than six workers) in Brazil and that the share of informality is much higher among SE than employers (91.8% versus 53.2%). The baseline economy is consistent with the evidence: The informality rate among small businesses is 86%, 87.7% among the SE, and 73% among employers. The fact that most self-employed are informal, means that “labor force” informality (i.e., the sum of worker and entrepreneur informality) is much larger than just “paid worker” informality (35% versus 47%). Our theory accounts well for the extent of both paid-worker and entrepreneurial informality, which will prove important for assessing the effects of formalization policies and financial frictions on resource allocation.

The extent of business informality varies with entrepreneurial skills both in the data and model. In Brazil, 84% of high-skilled entrepreneurs are informal own-account workers, and this statistic rises to 94.8% among low-skilled entrepreneurs. In the baseline economy, 77% of high-skilled entrepreneurs are informal own-account workers, with this statistic rising to 91% among low-skilled entrepreneurs (see Table 5). Hence, the model reproduces the fact that the incidence of informal SE in Brazil is higher among low-skilled entrepreneurs.

Table 6 presents statistics on the baseline economy on the employment share by firm size and worker formality status. We find that, across the size distribution, entrepreneurs hire a non-trivial fraction of workers informally. The share of infor-

Table 5

Model performance along selected macroeconomic moments.

Variable	Model	Data
<i>Small firms and occupational choice</i>		
Fraction of Informal Firms (size ≤ 5)	86.0	86.8
Fraction of Informal Workers in Formal Firms (size ≤ 5)	39.0	32.2
Fraction of Entrepreneurs (among HS)	26.1	26.1
Fraction of Entrepreneurs (among LS)	36.2	36.8
Fraction of Self-Employed (among HS)	13.3	18.3
Fraction of Self-Employed (among LS)	33.3	33.0
Fraction of Informal Self-Employed (among entrep.)	87.7	91.8
Fraction of Informal Self-Employed (among HS ent.)	76.7	84.0
Fraction of Informal Self-Employed (among LS ent.)	91.0	94.8
<i>Capital and debt heterogeneity</i>		
Std(K) Formal (≤ 5)	2.06	2.00
Std(K) Informal	0.39	0.39
Std(Debt) Formal (≤ 5)	1.22	0.72
Std(Debt) Informal	0.12	0.13
<i>Public finance and other moments</i>		
Social Security Rev./GDP	0.06	0.07
Sales Tax/GDP	0.24	0.17
(Sales Tax + Income Tax)/GDP	0.24	0.24
Labor Share	0.49	0.48

Notes: Labor share is the wage payments on national income (does not include self-employed income). Social Security Revenue includes payroll taxes plus SS contribution (Appendix Table A.3). Sales Tax includes federal, state and local government taxes. Sources: PNAD (2003), Penn World Table 8.0, and IMF Government Finance Statistics (2006).

Table 6

Employment share: in the baseline model.

<i>Baseline model</i>					
Worker-firm status	(≤ 5)	(≥ 6 and ≤ 10)	(≥ 11 and ≤ 50)	(≥ 51)	All firms
Formal Worker in Formal Firm (a)	24.6	67.2	77.4	87.3	67.2
Informal Worker in Formal Firm (b)	15.6	32.8	22.6	12.7	20.6
Informal Worker in Informal Firm (c)	59.8	0.0	0.0	0.0	12.1
Total Employment Share (d)	20.30	17.3	39.1	23.3	100.0
Intensive Margin (b/(a + b))	38.80	32.8	22.6	12.7	23.5
Share Inf. Paid Workers ((b + c) d)	15.10	5.7	8.8	3.0	32.7
<i>Data: PNAD 2003</i>					
Total Employment Share	(≤ 5)	(≥ 6 and ≤ 10)	≥ 11		All firms
	24.5	14.2	61.3		100.0

Source: The table presents data on employment shares by the worker and firm formality status in the baseline economy. The last row contains data from the 2003 PNAD on employment shares by business size in Brazil. Note that the PNAD 2003 only reports data for three size groups.

mal workers in total employment declines with the size of formal businesses: from 38.8% to 12.7% as business sizes increase from less than six workers to more than 50 workers. We also highlight that paid worker informality is not circumscribed to small businesses: Entrepreneurs with more than six workers hire more than half of informal paid workers.

The model accords well with data on worker and business informality (see Table 6). First, in 2003, small formal firms (fewer than 6 workers) in Brazil hire about 39% of their paid workers informally, as implied by our baseline model. Second, the share of employment accounted for by small firms in Brazil is about 24.5% (relative to 20.3% in the model). Third, the fraction of informal paid workers hired by firms with more than five workers is 50% (versus 54% in the baseline economy), underscoring that large businesses matter for paid worker informality.¹⁰ The implications of the model economy are also qualitatively consistent with the patterns documented for 2012 on PNAD data (see Table 2). For 2012, the PNAD data contains information on informality at businesses with more than five paid workers. We highlight that the share of employment accounted for by informal workers decreases steeply with business size, albeit the employment share by informal paid

¹⁰ Although ENCIF only reports data on small businesses, we can back out the fraction of informal workers at firms of size bigger than 5 using data on the aggregate amount of informal paid workers from household surveys.

workers at firms with more than 50 employees is sizeable (7.54% in 2012 while being 12.7% in our baseline model calibrated to 2003).¹¹

The calibration of the baseline model targeted aggregate data on the low capital intensity and the low credit reliance of informal firms relative to formal firms (see Table 5). The model economy matches the dispersion of the distributions of capital and debt across entrepreneurs in Brazil, and it reproduces that these distributions are more dispersed among formal than informal entrepreneurs. The standard deviation of capital (normalized by aggregate output per capita) among small formal businesses is about 2.0 in the model and data. This statistic takes a much lower value of 0.39 among informal firms in the model and data. The model captures the fact that formal entrepreneurs use substantially more capital than informal businesses: In the model, the median entrepreneur in the distribution of capital across formal entrepreneurs uses 2.7 times more capital than the corresponding informal entrepreneur (relative to 2.2 in the data). The baseline economy mimics the dispersion of debt among informal entrepreneurs in Brazil, with a standard deviation of 0.12, relative to 0.13 in the data. However, the calibrated model overstates the debt dispersion among small formal businesses.

Table 5 shows data on aggregate tax revenue in Brazil as a fraction of GDP, both for social security contributions (including other payroll taxes) and for sales tax. The aggregate revenue from payroll taxes relative to GDP is 6.2% in the model and 6.5% in the data. The aggregate revenue to GDP from sales and social security taxes represents 24% in the model economy and 17% in the data. Since the model economy abstracts from income taxes and informal entrepreneurs in Brazil are likely to evade income taxes (on top of sales taxes), it is reasonable to view the sales tax in our model economy as representing income and sales taxes. Under this view, the tax revenue implied in our baseline economy (24%) aligns well with the revenue from sales and income taxes in Brazil (24% of GDP).

Finally, a notorious characteristic of emerging economies is their low labor share of the national income relative to developed economies, which our model economy replicates well: Wage payments as a fraction of national income represent 49% in the model and 48% in the data.

5. Quantitative experiments

5.1. Formalization policies

We study the effects of five formalization policies in our baseline economy: (i) eliminating the cost of starting a business in the formal sector; (ii) increasing the costs of informal entrepreneurs (costs of extensive margin); (iii) increasing the costs of formal entrepreneurs hiring informal workers (costs of intensive margin); (iv) decreasing the costs of the intensive margin; (v) eliminating the payroll tax. The policies increasing (decreasing) the costs of informality are interpreted as the outcome of an increase (decrease) in the monitoring efforts by the government.¹²

We find that the experiments have quite different effects on informality, occupational choice, and macroeconomic aggregates (see Table 7). The elimination of entry costs reduces the mass of informal entrepreneurs by only 0.7 p.p., reflecting the fact that entry costs in the baseline economy are low (about 10% of the unskilled wage rate). This reform does not affect labor demand as the mass of employers in the economy does not change. It only leads to a small increase in the formalization of self-employed entrepreneurs (the informality rate among the SE decreases by 2 p.p.) who benefit from using capital more intensively. Aggregate output increases by 0.4%, capital by 0.7%, and tax revenue by 1.1%.¹³

Increasing the costs of the extensive margin of informality leads to higher output (10.8%), capital (13.9%), TFP (6.6%), and tax revenue (33.2%). On the contrary, increasing the costs of the intensive margin worsens macroeconomic outcomes (output decreases 3.6%, capital 5.7%, TFP 1.9%, and tax revenue 6%). In understanding these results, it is crucial to consider how changes in the costs of informality affect the decisions of entrepreneurs on whether to become employers or not and whether to operate formally or informally.

In experiment (ii), the increase in the costs of the extensive margin reduces the mass of informal businesses from 0.248 to 0.014. Most of this change is due to own-account workers switching from the informal sector to the formal sector. (The mass of formal own-account workers rises from 0.03 to 0.19). Nonetheless, informality among paid workers remains high (0.242 relative to 0.33 in the baseline economy) as formal employers hire workers off the books (intensive margin). Thus, consistent with Ulyssea's findings, eliminating informality requires attacking both margins of informality. In our framework, the increase in the formalization of businesses leads to higher capital (13.9%), a credit expansion (20%), and changes in the occupational structure. The mass of paid workers rises from 0.68 to 0.735. The decline in informal businesses causes a decrease in the number of SE entrepreneurs (0.04) and employers (0.015). The share of workers in micro firms decreases by 6.5 pp. The better allocation of productive resources combined with the increase in capital leads TFP and output to increase by 6.6% and 10.8%. The formalization of businesses boosts tax revenue more than output (33.2% versus 10.8%). In the next section, we show that the interaction between financial frictions and informality is key to this result.

¹¹ Note that, relative to 2003, in 2012 Brazil had substantially lower informality and a higher share of employment by large firms. As discussed later, these may have been (partly) caused by a relaxation of credit constraints.

¹² Experiments (ii) and (iii) increase the parameters determining the costs of the extensive margin and intensive margin of informality by a factor of 5. Experiment (iv) decreases the costs along the intensive margin by a factor of 5.

¹³ This result is in line with the empirical literature, which finds small effects of the reduction in the entry cost on overall informality (Bruhn and McKenzie, 2014).

Table 7

Macroeconomic effects of formalization policies.

	Baseline economy	No entry cost (i)	Extensive margin (ii)	Intensive margin (iii)	Alleviate int. margin (iv)	Payroll tax (v)
<i>Informality share</i>						
Paid Workers	0.328	0.326	0.242	0.222	0.628	0.010
Inf. by Formal	0.630	0.642	1.000	0.203	0.924	0.000
Self-Employed	0.877	0.857	0.068	0.881	0.881	0.861
Labor Force	0.472	0.463	0.192	0.431	0.644	0.083
<i>Informal irms</i>						
Mass	0.248	0.241	0.014	0.287	0.171	0.077
Output (Share)	0.196	0.189	0.007	0.246	0.119	0.047
Capital (Share)	0.166	0.159	0.003	0.211	0.098	0.042
Credit (Share)	0.123	0.119	0.002	0.157	0.072	0.030
<i>Prices</i>						
Wage High-Skilled	100	0.1%	-2.6%	-1.7%	5.4%	22.4%
Wage Low-Skilled	100	0.1%	-1.4%	-1.2%	3.7%	13.8%
Interest Rate	0.028	0.027	0.032	0.026	0.029	0.023
<i>Aggregate economy</i>						
Mass Entrep.	0.319	0.318	0.264	0.352	0.246	0.135
Mass Employers	0.072	0.072	0.056	0.074	0.068	0.047
Mass Self-Emp.	0.247	0.246	0.208	0.278	0.178	0.088
TFP	100	0.2%	6.6%	-1.9%	2.5%	7.4%
Output	100	0.4%	10.8%	-3.6%	5.4%	10.8%
Capital	100	0.7%	13.9%	-5.7%	9.9%	11.1%
Credit	100	1.3%	20.1%	-7.3%	13.2%	18.1%
Tax Revenue	100	1.1%	33.2%	-6.0%	5.0%	3.8%

Notes: The table reports the changes in selected model statistics in five experiments: (i) the entry cost into the formal sectors is set to zero; (ii) increased monitoring on the extensive margin (costs parameters ($\tau_{i,1}$, $\tau_{i,1}$, τ_k) of informal businesses are multiplied by 5); (iii) increased monitoring along the intensive margin (costs parameters $\tau_{f,1}$, $\tau_{f,2}$ of the intensive margin are multiplied by 5); (iv) reduced costs of intensive margin (the baseline values of parameters $\tau_{f,1}$, $\tau_{f,2}$ are divided by 5); (v) the payroll tax is set to zero.

Experiment (iv) shows that relaxing monitoring along the intensive margin can lead to favorable macroeconomic outcomes, despite the increase in worker informality. The decrease in labor costs by formal employers expands their labor demand, increasing equilibrium wages, diminishing self-employment (from 0.247 to 0.178), and reducing the mass of informal businesses (from 0.248 to 0.171). The share of output by informal entrepreneurs decreases to 0.119. The reduction in business informality leads to an increase in capital accumulation (9.9%) and a credit expansion (13.2%). As a result, TFP, output, and tax revenue rise by 2.5%, 5.4%, and 5.0%. We highlight that the improvement in macroeconomic aggregates occurs even though the share of informality in the workforce (workers and entrepreneurs) increases to 64% (from 47% in the baseline economy). A key takeaway is that in our environment with financial frictions and capital, the extent of business informality is quite detrimental to macroeconomic outcomes. When formal entrepreneurs can hire workers off the books (intensive margin), business informality diminishes, leading to improved macroeconomic outcomes.

Experiment (v) considers the elimination of payroll taxes. This experiment leads to a reduction of *both* business and worker informality. The elimination of payroll taxes benefits primarily large formal employers for whom social security taxation represents a high share of their labor costs. In the absence of payroll taxation, small employers no longer obtain a competitive advantage by hiring informal workers. As a result, labor becomes reallocated towards larger (more productive) businesses, and wages increase, leading to changes in the occupational structure. In equilibrium, the mass of workers increases by 18.5 p.p., and the number of own-account workers falls by two-thirds (from 0.25 to 0.088), reducing business informality from 0.248 to 0.077. The formalization of businesses is associated with an expansion of credit and the aggregate capital stock (18.1% and 11.1%). The rise in equilibrium wages causes the mass of employers to fall by a third (from 0.072 to 0.047). The share of employment in micro firms (fewer than six workers) decreases from 0.20 to 0.06. The changes in resource allocation imply a TFP gain of 3.8%. Somewhat surprisingly, overall tax revenue increases by 3.8%. The revenue increase from the taxation of sales more than offsets the revenue losses from payroll taxes, which follows from the changes in the formalization of businesses and the rise in output. Again, financial frictions play a crucial role in these results.

5.2. Financial frictions

We simulate the effects of relaxing the collateral constraint in the baseline economy by setting the parameters of the collateral constraint of formal and informal entrepreneurs to 100.¹⁴ Table 8 compares statistics on informality and macroeconomic variables in the baseline economy with those of the economy with low financial frictions (see columns (i) and (ii)).

¹⁴ Implicitly, the reductions in financial frictions are assumed to benefit both formal and informal entrepreneurs.

Table 8

Informality, financial frictions, and occupational choice.

	Baseline economy (i)	Low financial frictions (ii)	No occupational choices (iii)	Low financial frictions (iv)
<i>Informality share</i>				
Paid Workers	0.328	0.227	0.315	0.260
Inf. by Formal	0.630	0.970	0.619	0.957
Self-Employed	0.877	0.946	0.862	0.966
Labor Force	0.472	0.314	0.455	0.426
<i>Informal firms</i>				
Mass	0.248	0.128	0.242	0.249
Output (Share)	0.196	0.065	0.148	0.093
Capital (Share)	0.166	0.060	0.122	0.092
Credit (Share)	0.123	0.055	0.071	0.030
<i>Prices</i>				
Wage High-Skilled	100	12.8%	100	7.6%
Wage Low-Skilled	100	10.9%	100	8.1%
Interest Rate	0.028	0.074	0.046	0.081
<i>Aggregate economy</i>				
Mass Entrep.	0.319	0.178	0.322	0.322
Mass Employer	0.072	0.045	0.079	0.67
Mass Self-Emp.	0.247	0.133	0.243	0.255
TFP	100	15.1%	100	6.3%
Output	100	27.4%	100	10.8%
Capital	100	40.3%	100	14.9%
Credit	100	190.0%	100	72.3%
Tax Revenue	100	49.6%	100	17.7%

Notes: The table reports model statistics in different scenarios: (i) baseline economy, (ii) baseline economy when financial frictions are relaxed ($\lambda_f = \lambda_i = 100$), (iii) re-calibrated model economy with fixed occupations (see Section 6), (iv) low financial frictions ($\lambda_f = \lambda_i = 100$) in economy with fixed occupations.

Informality We find that the extent of informality is substantially smaller in the economy with low financial frictions than in the baseline economy: The mass of informal businesses and the share of informality among paid workers are 0.128 and 0.227 in the former economy, relative to 0.248 and 0.328 in the baseline economy. The aggregate informality rate in the labor force (among workers and entrepreneurs) diminishes by a third (from 0.47 to 0.31). When financial frictions are relaxed, the share of capital in the informal economy decreases from 0.166 to 0.06 and the share of informal output decreases from 0.196 to 0.065. We thus conclude that financial frictions play an important role in accounting for informality in Brazil. Nonetheless, the economy with low financial frictions still features substantial informality along both margins: 70% of entrepreneurs are informal and formal firms hire about 19% of the aggregate labor force informally. At the aggregate level, the economy with low financial frictions features substantially higher capital, output, and TFP (40.3%, 27.4%, and 15.1%). Tax revenue is about 50% higher. A takeaway is that eliminating the informal economy in Brazil requires policies that confront informality along the extensive and intensive margins. Improving financial institutions is not enough.

Formalization policies To isolate how financial frictions affect the impact of formalization policies, we compare the effects of three policy experiments in the baseline economy with those of an economy with low financial frictions ($\lambda_f = \lambda_i = 100$). Table 9 reports the effects of increasing the costs of the extensive margin, alleviating the costs of the intensive margin, and eliminating the payroll tax (experiments ii, iv, and v in the previous section) for the two economies considered. Overall, we find that the changes in output, capital, TFP, and tax revenue are substantially lower in the economy with low credit frictions than in the baseline economy (compare columns (i) and (ii)).

We find that increasing the cost of the extensive margin leads to an increase in capital, output, and TFP of 4.8%, 4.3%, and 2.8%. These changes are less than half the changes in the baseline economy (13.9%, 10.8%, 6.6%). Furthermore, the increase in tax revenue is about a third of the one in the baseline economy (10.3% versus 33.2%). Since the mass of informal firms in the economy with low financial frictions is about half the one in the baseline economy (0.128 versus 0.248), it should come as no surprise that the gains of increasing the cost of business informality are lower.

The elimination of payroll taxes increases output by 4.7% and decreases tax revenue by 13.6%. In the baseline economy, output increases twice as much (10.8%), which leads to an increase in total tax revenue (3.8%). It follows that financial frictions make payroll taxation much more costly for the macroeconomic performance of the economy.

To understand this result, we highlight that financial frictions cause payroll taxation to have subtle and heterogeneous effects on the demand for capital across entrepreneurs. To build some intuition, consider the static problem faced by an entrepreneur with productivity s and assets a :¹⁵

$$\max_{l, k \leq \lambda a} (1 - \tau_y) s k^{\alpha \theta} l^{(1-\alpha)\theta} - w(1 + \tau_{ss})l - (r + \delta)k.$$

¹⁵ For simplicity, we ignore the possibility of hiring informal workers and abstract from skill heterogeneity in the labor input.

Table 9

Formalization policies under low financial frictions and no occupational choice, and financial frictions.

	Baseline economy (i)	Low financial frictions (ii)	No occupational choices (iii)
<i>Panel 1: Elimination of payroll tax</i>			
Agg. Output (change)	10.8%	4.7%	5.5%
Agg. Capital (change)	11.1%	2.7%	7.7%
TFP (change)	7.4%	3.9%	3.2%
Total Tax Rev. (change)	3.8%	-13.6%	-12.4%
Y_i/Y (change)	-0.148	-0.050	-0.051
Fraction Paid Workers (change)	0.185	0.100	0.000
Fraction Self-Emp. (change)	-0.160	-0.090	0.036
Fraction Informal Entrep. (change)	-0.171	-0.100	-0.003
<i>Panel 2: Increase the cost of extensive margin</i>			
Agg. Output (change)	10.8%	4.3%	12.0%
Agg. Capital (change)	13.9%	4.8%	25.4%
TFP (change)	6.6%	2.8%	4.6%
Total Tax Rev. (change)	33.2%	10.3%	27.6%
Y_i/Y (change)	-0.189	-0.060	-0.150
Fraction Paid Workers (change)	0.055	0.050	0.000
Fraction Self-Emp. (change)	-0.039	-0.060	0.009
Fraction Informal Entrep. (change)	-0.234	-0.130	-0.240
<i>Panel 3: Alleviate the intensive margin</i>			
Agg. Output (change)	5.4%	1.0%	5.3%
Agg. Capital (change)	9.9%	3.2%	12.1%
TFP (change)	2.5%	0.1%	1.7%
Total Tax Rev. (change)	5.0%	-6.2%	1.2%
Y_i/Y (change)	-0.077	-0.030	-0.050
Fraction Paid Workers (change)	0.073	0.040	0.000
Fraction Self-Emp. (change)	-0.069	-0.040	0.018
Fraction Informal Entrep. (change)	-0.078	-0.050	-0.020

Notes: The table presents the effects of eliminating the payroll tax, increasing the monitoring costs along the extensive margin, and alleviating the costs of the intensive margin in three economies: (i) baseline economy, (ii) baseline economy with no financial frictions, (iii) re-calibrated economy with fixed occupations (see Section 6).

Denoting by μ the Lagrange multiplier on the collateral constraint, the FOC yields:

$$\frac{k}{l} = \frac{\alpha}{(1-\alpha)} \frac{w(1+\tau_{ss})}{[r+\mu(s,a)]}, \quad \text{where} \quad \mu(s,a) = \max\left\{C_\mu \left[\frac{(1-\tau_y)s}{\lambda a}\right]^{\frac{1}{1-\theta(1-\alpha)}} \left[\frac{1}{w(1+\tau_{ss})}\right]^{\frac{(1-\alpha)\theta}{1-\theta(1-\alpha)}} - r, 0\right\},$$

and C_μ is a constant that depends on the parameters (α, θ) .

When the borrowing constraint binds ($\mu(a,s) > 0$), the capital to labor ratio varies across entrepreneurs. Intuitively, as the labor input is not directly affected by the collateral constraint, entrepreneurs facing tight borrowing constraints (high μ due to a low a/s ratio) rely relatively more on labor than on capital in their production than unconstrained entrepreneurs. Since payroll taxation hurts relatively more constrained entrepreneurs, eliminating the payroll tax has higher effects in an economy with tight borrowing constraints.

The same logic explains why reducing the costs of the intensive margin (experiment (iv) in Table 7) leads to substantial increases in output and tax revenue in the baseline economy (by 5.4% and 5.0%), whereas in the economy with low financial frictions, output barely increases by 1% and tax revenue *decreases* by 6.2%. Entrepreneurs facing tight borrowing constraints use labor more intensively and rely more heavily on informal labor than unconstrained businesses. Thus, relaxing the monitoring along the intensive margin allows these firms to operate at a larger scale, accumulate more capital, and improve overall resource allocation. Capital and TFP rise by 9.9% and 2.5% relative to the baseline economy.¹⁶

Informality and the effects of financial frictions

We now show that informality amplifies the effects of financial frictions on macroeconomic outcomes. We assess how the gains of improving financial markets interact with the extent of business and worker informality.

Table 10 presents the effects of increasing λ_f and λ_i to 100 in four different economies. The first column considers the effects of relaxing financial frictions in the baseline economy. The second column considers the effects of relaxing credit constraints when the cost of informality along the extensive and intensive margins in the baseline economy are multiplied by 5. The third (fourth) column considers an economy in which the cost along the extensive (intensive) margin of informality is 5 times the one of the baseline economy.

Reducing financial frictions improves macroeconomic outcomes substantially more in the baseline economy than in the economy with *low informality along both margins*. Capital, output, and TFP increase by 40.3%, 27.4%, and 15.1% in the baseline

¹⁶ In this regard, the finding is consistent with the view of *Itskhoki and Moll (2019)*, who advocate for an initial phase of low labor taxation as a financially constrained economy moves to its steady-state from an initial situation with low capital.

Table 10
Eliminating financial frictions in alternative economies.

	High informality costs			
	Baseline economy (i)	Both margins (ii)	Extensive margin (iii)	Intensive margin (iv)
<i>Change in macroeconomic aggregates (%)</i>				
Agg. Output	27.4%	21.1%	19.9%	31.0%
Agg. Capital	40.3%	30.1%	29.1%	45.4%
TFP	15.1%	11.9%	11.1%	17.1%
Tax Revenue	49.6%	26.1%	23.8%	61.3%

Notes: The table displays the effects of eliminating financial frictions ($\lambda_f = \lambda_i = 100$) in alternative model economies: (i) baseline economy, (ii) economy with low informality along both margins of informality (costs of informality multiplied by 5), (iii) economy with low informal business (cost of extensive margin of informality multiplied by 5), (iv) economy with no informal paid workers (costs of intensive margin of informality multiplied by 5).

economy and by 30.1%, 21.1%, 11.9% in the economy with high costs of informality in both margins (compare columns (i) and (ii) in Table 10). Moreover, tax revenue increases much more in the baseline economy (49.6% versus 26.1%). At the heart of these findings is the fact that relaxing credit constraints in the baseline economy leads to a large reduction in informality along the extensive and intensive margins, thereby amplifying the gains in capital accumulation and improving resource allocation.

We find that the extent of business and worker informality affects the impact of financial frictions in different ways. The smallest output and TFP gains of reducing financial frictions are attained in the economy with high costs of the extensive margin of informality (third column in Table 10). These gains are now 19.9% and 11.1%, relative to 27.4% and 15.1% in the baseline economy. These findings underscore the fact that financial frictions play an important role in accounting for the high mass of informal entrepreneurs in the baseline economy. Since informal businesses enhance the misallocation of productive resources, the gains from removing financial frictions become smaller when the extensive margin (i.e., business informality) is not as important as in the baseline economy.

The highest output and TFP gains of eliminating financial frictions are attained in the economy with the high cost of the intensive margin (fourth column in Table 10). The output and TFP gains are now higher than in the baseline economy (31.0% and 17.1% versus 27.4% and 15.1%). The reason is that high costs of informality along the intensive margin hurt productive entrepreneurs with tight financial constraints, increasing the extent of business informality. As a result, the gains of reducing financial frictions become larger.

In sum, financial frictions and business informality negatively affect the allocation of productive resources by encouraging the operation of small businesses. On the contrary, by allowing formal employers to hire some workers off the books, the intensive margin discourages business informality, benefiting productive entrepreneurs who are more likely to operate formally and face tight borrowing constraints. The misallocation caused by financial frictions diminishes.

6. The role of occupational choice

We evaluate the sensitivity of our results to modeling an occupational choice decision through two experiments. First, we consider a version of our model economy with an exogenously fixed mass of workers and entrepreneurs. As in de Paula and Scheinkman (2010), entrepreneurs decide whether to operate formally or informally. Finally, we show evidence of changes in the occupational structure in Brazil during 2003–2012. Since Brazil reformed the bankruptcy legislation in 2005, we use our baseline model to assess the changes in the occupational structure in Brazil.

Fixed occupational structure The new model economy is calibrated to the targets used in the baseline economy (see Online Appendix D for calibration results). Here, we highlight that the economy with no occupational choice fits the calibration targets reasonably well, although somewhat worse than our baseline economy. A crucial difference between the two model economies is that all the assets are held by entrepreneurs in the economy with fixed occupations. Since workers will never be entrepreneurs, they face a deterministic savings problem. As the equilibrium interest rate is below the rate of time preference, workers dissave and will hold zero assets in the steady state.¹⁷ In the baseline model, as individuals transit between entrepreneurship and being a worker, the wealth distribution across entrepreneurs becomes more dispersed.¹⁸

In the model economy with a fixed mass of entrepreneurs, the credit to output ratio by formal and informal entrepreneurs (0.33 and 0.26) is low relative to the data (0.43 and 0.31), which follows from the fact that there is no lending from workers to entrepreneurs.

Formalization policies We find that changes in the costs of the extensive and intensive margins of informality have similar effects as in the baseline model economy (see Table 9). However, relative to the baseline economy, the elimination of payroll

¹⁷ Moll (2014) arrives to similar conclusions when considering a model where entrepreneurs face financial frictions but no occupational choice.

¹⁸ In every period a fraction of entrepreneurs become workers and start dissaving. As some workers switch back into entrepreneurship after a positive productivity shock, the distribution of wealth across entrepreneurs becomes more dispersed.

taxation has much lower effects on capital (7.7% versus 11.1%), output (5.5% versus 10.8%), TFP (3.2% versus 7.4%), and tax revenue (−12.4% versus 3.8%). Moreover, it decreases the informal share of output by 5.1 pp. relative to a decrease of 14.4 pp. in the baseline economy. Whereas the elimination of the payroll tax causes wages to increase in both economies, the consequences of the changes in wages differ substantially across economies. In the baseline economy, the fraction of workers increases from 0.68 to 0.87, and the mass of SE entrepreneurs (and informal entrepreneurs) decreases by 0.17. By contrast, in an economy with no occupational choice, the number of workers is fixed by assumption. The increase in wages diminishes the fraction of employers who find it more costly to hire labor, leading to an *increase* in the mass of SE by 0.036. Moreover, the number of informal entrepreneurs remains roughly constant, which explains the large decrease in tax revenue.

Financial frictions Relaxing financial frictions in the economy with fixed occupational choices has a much lower impact on macroeconomic variables than in the baseline economy (see columns (iii) and (iv) of Table 8). Output, capital, and TFP increase by 10.8%, 14.9%, and 6.3%. In the baseline economy, these changes are 27.4%, 40.3%, and 15.1%. Since credit plays a more prominent role in the baseline economy (channeling funds from workers to entrepreneurs), the relaxation of credit constraints leads to a higher reallocation of productive resources in this economy.

Changes in the occupational structure enhance the reallocation of resources in the baseline economy. Recall that the fraction of SE entrepreneurs decreases from 0.247 to 0.133 in the baseline economy, implying the reallocation of productive resources towards employers. In contrast, in the economy with fixed occupations, the mass of SE entrepreneurs *rises* from 0.243 to 0.255 so that the employers' share of labor decreases. Finally, we highlight that the relaxation of financial frictions does not reduce business informality in the economy with no occupational choices as the incidence of SE does not decrease. Hence, the increase in tax revenue is substantially lower than the one in the baseline economy (17.7% versus 49.6%).

The 2005 bankruptcy reform In 2005, the Brazilian Congress passed a bankruptcy law that changed the liquidation procedure in favor of creditors.¹⁹ By 2012, Brazilian credit to GDP rose by about 30 p.p., a performance unmatched by other Latin American countries such as Chile, Argentina, and Colombia. During the 2003–2012 period, the Brazilian economy experienced changes in its occupational structure and the extent of informality. The share of workers in the labor force increased by 4.1 p.p. (from 67.8% to 71.9%). The shares of SE and employers decreased by 3.4 and 0.7 p.p., respectively. Finally, the fraction of informal paid workers decreased by about 11 p.p. (from 35% to 24%).

We use our theory to assess the effects of the financial reform in Brazil. To this end, we set the parameters of the collateral constraints to match the increase in the credit to GDP ratio of 30 p.p. in the data (we assume that λ_f and λ_i increase proportionally). We find that the changes in the occupational structure predicted by our baseline model economy are in line with the ones observed in the data: Whereas the share of workers increases by 5.5 p.p., the masses of SE entrepreneurs and employers decrease by 4.3 and 1.2 p.p. The fraction of informal paid workers falls by 5.5 p.p. Thus, our results suggest that the bankruptcy reform accounts for about half of the change in the fraction of informal paid workers in Brazil (11 p.p.) during the period 2003–2012. We also find that the employment share of micro firms (less than six employees) diminishes by 7.3 p.p. in the model, which aligns well with the observed change in the Brazilian data (6.7 p.p.).

7. Conclusion

We develop a quantitative theory of entrepreneurship and financial frictions to study how informality in Brazil affects occupational choice, capital accumulation, resource allocation, and government tax revenue. We find that the interactions of financial frictions with informality are crucial for understanding the occupational structure, the prevalence of small businesses, and misallocation. Policies that encourage informal businesses amplify the distortions caused by credit constraints. Policies that reduce the intensive margin of informality have pervasive effects on output and tax revenue. By allowing formal employers to hire workers off the books, the intensive margin of informality allows small but productive businesses to outgrow borrowing constraints. Without this option, most entrepreneurs would operate on a small scale in the informal sector, increasing business informality and amplifying the negative impact of financial frictions on macroeconomic variables.

Our framework features many elements analyzed in the macro-development literature: financial frictions, informality, and entry/regulation costs. These institutional features affect the macroeconomic consequences of financing government outlays. Indeed, the output cost of payroll taxation in our baseline economy is about twice as much as in an economy with no financial frictions. A thorough evaluation of tax reforms is left for future research.

Data availability

The data from PNAD and ECINF surveys are publicly available. The administrative Social Security data from Brazil is confidential.

¹⁹ Under the previous law, the liquidation procedure was slow, ineffective, and highly punitive to creditors for the following reasons: (i) tax, labor, and other liabilities, were transferred to the buyer, which depressed the market value of the company's assets; (ii) secured creditors' claims came after labor and tax claims in case of a liquidation. The new law, inspired by Chapter 11 of the U.S. Bankruptcy Code, removed successor liability and favored secured creditors at the expense of labor and tax claims. In the year following the reform, the bankruptcy recovery rate increased to 12% from 0.2% in 2005 (the Latin American average was 26%).

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.jmoneco.2022.12.004](https://doi.org/10.1016/j.jmoneco.2022.12.004).

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