Entrepreneurial Human Capital and Firm Informality*

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Abstract

This paper studies how entrepreneurial human capital affects firm informality in developing economies. We develop a life-cycle general equilibrium model with endogenous education and occupational choice under limited tax enforcement and credit frictions. Entrepreneurial ability is enhanced by college education. Calibrated to Brazil, the model shows that expanding college attainment reduces informality by reallocating talent toward larger, more productive formal firms. This raises GDP and aggregate productivity, with the magnitude of effects depending on the degree of credit frictions. We validate the mechanism using microdata, leveraging Brazil's 1996 education reform. The findings underscore the role of education in promoting formalization.

Keywords: Informality, Entrepreneurship, Human Capital, Financial Frictions, Misallocation, Tax Evasion.

JEL Classification: E26, E44, H26, I25, J24, L26, O17.

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1 Introduction

Firm informality is a pervasive feature of low- and middle-income economies (La Porta and Shleifer, 2014). In Brazil, for example, available estimates indicate that approximately two-thirds of firms operate without registration with tax authorities, absorbing nearly 35% of urban employment and generating output equivalent to between 30% and 40% of official GDP (Ulyssea, 2018; Medina and Schneider, 2018). A large body of literature has proposed various explanations for the persistent dominance of informal firms in developing countries, including weak regulatory enforcement, high entry costs, financial frictions, and the abundance of unskilled labor (Amaral and Quintin, 2006; Antunes and Cavalcanti, 2007; Haanwinckel and Soares, 2021; Erosa *et al.*, 2023).

One potential factor that has received comparatively less attention is the role of entrepreneurial human capital. Compared to formal firms, informal enterprises tend to be smaller, more stagnant, and are typically managed by individuals with lower levels of education (de Paula and Scheinkman, 2007; La Porta and Shleifer, 2008; Ulyssea, 2018). These empirical regularities−combined with new microdata evidence highlighting the importance of entrepreneurs' education for firm dynamics (Queiró, 2021)−raise the question of whether insufficient entrepreneurial human capital contributes to firm informality in developing countries, where large informal sectors and low educational attainment often coexist (La Porta and Shleifer, 2014). If so, what are the implications of this firm-level linkage for aggregate output and productivity?

To answer these questions, this paper develops a quantitative life-cycle general equilibrium model of occupational choice with endogenous college enrollment decisions, limited tax enforcement, and imperfect credit markets.[1] In this framework, educational choice plays a central role in shaping occupational outcomes, as acquiring a college degree affects individuals' skills through two distinct channels. First, consistent with traditional models of human capital accumulation (Heathcote *et al.*, 2017), college-educated individuals allocate their time endowment to the skilled labor market. Second, as a relatively novel feature in the literature (Berniell, 2021; Queiró, 2021; Morazzoni, 2021), we model entrepreneurial human capital by assuming that college education enhances managerial ability. We show that this firm-level mechanism has quantitatively important implications for GDP, TFP, and the extent of firm informality−with the magnitude of these effects shaped by the severity of financial frictions.

Our model is similar in spirit to Buera (2009), Buera and Shin (2013), and Franjo *et al.* (2022), featuring financially constrained, heterogeneous individuals who decide in each period whether to work as paid employees or operate an entrepreneurial activity, either formally or informally. Formal entrepreneurs comply with business regulations and pay taxes in exchange for access to external credit. Informal entrepreneurs, by contrast, are non-compliant individuals who evade taxes and rely exclusively on internal funds, while facing a probability of detection by fiscal authorities that rises with firm size. We enrich this framework by incorporating capital-skill complementarity in production (Krusell *et al.*, 2000) and endogenous

[1] Evidence from the World Bank Enterprise Surveys, as reported in La Porta and Shleifer (2014), shows that access to finance is perceived as the most significant obstacle to doing business by both formal and informal entrepreneurs in low- and middle-income countries.

educational choice, the latter modeled as a pre-working decision in which each individual determines whether to invest in a costly college degree or maintain a lower level of schooling.

We calibrate the model to match key features of the Brazilian economy, including the size of the informal sector, college completion rates, earnings-skill premia for both workers and entrepreneurs, and the firm size distribution for both formal and informal enterprises. The structure of the calibrated model is sufficiently rich to generate substantial heterogeneity in occupational choices conditional on education, and to rationalize a prominent feature of the data: informal entrepreneurship is predominantly concentrated among less-educated individuals.

The characterization of the steady-state equilibrium allows us to disentangle two main channels driving this heterogeneity in occupational choice. First, we identify the interaction between entrepreneurial human capital and firm dynamics as the primary channel through which the incentive to operate informally is shaped by the manager's educational attainment. The key mechanism works as follows. Although agents in the model have access to the same production technology, college-educated entrepreneurs feature enhanced managerial ability. Their firms are therefore more productive than those run by entrepreneurs with the same innate ability but without tertiary education. Consistent with the empirical evidence provided by Queiró (2021), these firms enter the market at a larger size and grow at a faster rate over the life cycle. Since the probability of detection increases with firm size, the expected returns from tax evasion are lower for college-educated entrepreneurs, increasing their incentive to operate formally.

This effect is further amplified by a second channel: the wage-skill premium, which affects firm informality indirectly through the extensive margin of occupational choice. Due to the higher skilled wage, and unlike their less-educated counterparts, (i) college-educated individuals with low managerial ability have no incentive to engage in entrepreneurship—even informally—over the life cycle; and (ii) most highly talented college-educated individuals find it more profitable to work as skilled employees before transitioning directly to formal entrepreneurship, rather than starting with a small informal firm. As a result, informality becomes concentrated among less-educated entrepreneurs who operate small, financially constrained firms and face relatively low expected penalties for non-compliance.

To assess the aggregate consequences of these two channels in the general equilibrium, we conduct a counterfactual experiment in which the cost of acquiring a college degree is reduced to a level that yields an equilibrium college attainment rate equal to that observed in the U.S. economy. The results of our analysis show that raising the population's college attainment to the level of a more economically developed benchmark would lead to sizable long-run gains for the Brazilian economy: a 42.6% increase in official GDP, a 15% rise in measured TFP, and a 43.2% boost in fiscal revenues. Most importantly, we find that the size of the Brazilian informal sector declines by approximately 31 percentage points in the counterfactual scenario.

The mechanism driving these aggregate effects is primarily triggered by a shift in the skill composition of the labor force, resulting from the higher supply of skilled workers in the counterfactual scenario. The associated decline in the skill-wage premium incentivizes paid employment among non-college-educated individuals—thus reducing informal production and tax evasion—and entrepreneurship among college-educated individuals, who exhibit enhanced managerial skills and, therefore, face a stronger incentive to formalize. Additional

counterfactual experiments aimed at disentangling the partial impact of this latter effect reveal that: (i) accounting for entrepreneurial human capital significantly amplifies the aggregate gains from higher college completion rates; and (ii) limited entrepreneurial human capital−relative to a more economically developed benchmark−explains approximately 40% of the actual size of the Brazilian informal economy.

Notably, despite the quantitatively significant decline, we find that informality persists even under high human capital, with around 11.7% of firms remaining informal. This persistence is primarily driven by the interaction between financial frictions and a declining wage-skill premium, which together incentivize highly talented, college-educated entrepreneurs to operate informally as a more effective means of overcoming borrowing constraints than entering paid employment. A robustness exercise confirms that, due to this mechanism, informality persists even in an economy where virtually all entrepreneurs are college-educated. Thus, the model predicts that improvements in educational attainment alone are insufficient to fully eliminate informality in economies with imperfect financial markets.

We further explore this prediction through additional counterfactuals that vary both credit frictions and educational attainment. Our results confirm that firm informality can be fully eradicated only when access to both college education and credit improves simultaneously. In this circumstance, the aggregate gains from higher educational attainment are amplified by the relaxation of financial constraints, as financially constrained but talented entrepreneurs are able to enter directly into the formal sector. The policy implication is clear: in order to reduce informality and foster long-run growth, developing countries must tackle both financial and educational barriers jointly.

Finally, to empirically test the main predictions of the model, we draw on Brazil's 1996 Higher Education Reform, which reduced barriers to entry for for-profit higher education institutions (Cox, 2024). We begin by documenting a negative correlation between the share of college-educated individuals and the prevalence of informal entrepreneurship across Brazilian municipalities, both in levels and in growth rates. Next, following the empirical strategy of Duflo (2001), we exploit variation in exposure to the reform across cohorts and commuting zones, using excess college entry as a proxy for treatment intensity in a difference-in-differences framework. We find that individuals in areas with greater excess college entry were significantly less likely to engage in informal entrepreneurship. Altogether, these results support the model's prediction that expanding access to higher education is a powerful lever for shifting occupational choices away from informality.

Related literature Our paper contributes to the literature on economic development, financial frictions, and informality by incorporating endogenous human capital accumulation into a general equilibrium model with occupational choice. We build on a well-established tradition of research that emphasizes the importance of financial frictions for development, including Erosa (2001), Buera (2009), Buera *et al.* (2011), Buera and Shin (2013), and Allub and Erosa (2019). These studies show that limited access to credit leads to misallocation of capital, thereby reducing income per capita and aggregate productivity. Extending this line of work, a parallel strand of the literature introduces informality into models with financial frictions to better capture the realities of developing economies. Papers such as Amaral and Quintin (2006), Antunes and Cavalcanti (2007), Quintin (2008), D'Erasmo and Boedo (2012), D'Erasmo (2013), Franjo *et al.* (2022), and Erosa *et al.* (2023) incorporate informal

production as a response to limited financial access and enforcement capacity. Our paper builds directly on this line of work by incorporating endogenous human capital into the analysis. This extension is important because it highlights that the capacity of entrepreneurs to benefit from formalization depends not only on institutional and financial constraints but also on their ability to manage firms efficiently, a margin that is endogenously determined and shaped by education decisions.

While prior research has studied the interaction between human capital and informality, the focus has largely been on workers' education within search and matching frameworks, as in Haanwinckel and Soares (2021), Bobba *et al.* (2021), and Bobba *et al.* (2022). We complement and extend this literature by shifting the focus to entrepreneurial human capital and showing how this margin plays a first-order role in shaping informality and development outcomes. The paper most closely related to ours is Berniell (2021), who analyzes theoretically the decision of entrepreneurs to acquire education in the presence of financial constraints. While our model is quantitative in nature, we also explore the implications of entrepreneurial human capital for informality and aggregate outcomes. In particular, our model quantifies how the limited accumulation of entrepreneurial human capital constrains firm growth and the formalization process. This contribution is essential because it shows that low levels of managerial ability, driven by constrained educational investment among potential entrepreneurs, are a central obstacle to formalization, offering a new explanation for persistent informality beyond labor market frictions and enforcement limitations.

Finally, our paper also complements recent work such as Allub *et al.* (2023), which explores capital-skill complementarity and workers' education in developing economies with financial frictions. We show that the interaction between financial access and entrepreneurial human capital is equally critical: formalization and productivity gains depend not only on access to capital and skilled labor, but also on who becomes an entrepreneur and the quality of their managerial capacity. This distinction is important because it highlights a different channel through which education and financial development interact: not only by increasing the productivity of workers, but also by enabling more talented and better-educated individuals to start and expand formal firms, thus amplifying aggregate gains from human capital accumulation and credit market reforms. In this way, our paper contributes a novel mechanism to the broader literature on informality, development, and human capital accumulation.

Outline The rest of the paper is organized as follows. Section 2 presents key stylized facts, while Section 3 describes the theoretical framework. Section 4 outlines the calibration strategy and evaluates the model's fit for both targeted and non-targeted moments. Section 5 derives the main firm-level mechanisms and assesses aggregate implications through a series of counterfactual experiments. Section 6 provides empirical evidence supporting the model's main predictions, and Section 7 concludes. Additional details on the data, calibration, and further model results are provided in the Online Technical Appendix.

2 Background

In this section, we present key facts about the relationship between informality and education. While we primarily focus on the Brazilian economy, which serves as the benchmark

for our analysis, we also investigate this relationship from a cross-country perspective. We begin by introducing precise definitions for the main variables of interest, then present a combination of micro and macro data, and finally provide statistics on informality and education that characterize the main stylized facts. These facts provide empirical support for our modeling assumptions in Section 3 and inform our quantitative exercises in Sections 4 and 5.

2.1 Definitions and data description

Throughout the paper, we define the *informal economy* as all production activities of a country involving legal goods and services that are deliberately concealed from fiscal authorities to evade taxes. In line with Medina and Schneider (2018), this definition does not include illegal economic transactions−such as drug trafficking−or home production, thereby establishing a one-to-one relationship between informality and tax evasion. Consistently, we classify *informal firms* as enterprises that are not registered with tax authorities and *informal workers* as employees who do not hold a regular labor contract. Finally, we define *skilled workers* and *college-educated entrepreneurs* as employees and managers, respectively, who have completed tertiary education. We apply these definitions both to the data and in the model.

We use two main datasets specific to the Brazilian economy: the ECINF (*Pesquisa de Economia Informal Urbana*) and the PNAD (*Pesquisa Nacional por Amostra de Domicílios*) surveys. The former is a repeated cross-sectional survey of small businesses conducted by the Brazilian Bureau of Statistics (IBGE) in 1997 and 2003. The main advantage of ECINF is that it is a matched employer-employee database, providing detailed information on both firm and worker informality. Specifically, firms are asked whether they hold the tax identification number required for Brazilian businesses (i.e., registration in the *Cadastro Nacional de Pessoa Jurídica*) and whether each of their employees holds a formal labor contract.[2] Thus, the ECINF data set allows the identification of informal production units in the sample, providing valuable information on the characteristics of their managers and workers.

However, since the main objective of the ECINF survey was to measure the role and operational characteristics of informal activity in Brazil, IBGE applied sampling procedures designed to ensure national representativeness for small firms (up to five employees) and informal businesses. To complement this, we use the PNAD, a nationally representative household survey that provides detailed information on labor market outcomes (e.g. earnings, employment), sociodemographic characteristics (e.g. age, level of education), and informality status. For comparability, we restricted our sample to 2003, as it is the last available year of ECINF. One drawback of PNAD 2003 is that it does not distinguish between formal and informal entrepreneurs, a limitation that was addressed starting in 2012 with the introduction of PNAD *Contínua* (PNAD-C). Consequently, in this section we rely on PNAD 2003 to primarily characterize labor informality, while using the 2012 release when additional insights are needed. Further details on the ECINF and PNAD datasets can be found in the Section C of the Online Technical Appendix.

[2]In Brazil, firms are required to record a worker's employment history in an employment booklet known as a *carteira de trabalho*. A salaried position is considered formal if it is registered in this booklet.

We also conduct a cross-country analysis by merging two databases: the Global Entrepreneurship Monitor (GEM) dataset and the Medina and Schneider (2018) estimates on the size of the informal economy around the world. The GEM's objective is to measure the level and nature of entrepreneurial activity worldwide by collecting nationally representative samples of entrepreneurs across countries. We restrict our sample to the years 2009–2015 to leverage a harmonized variable on education levels and to focus on non-agricultural, non-nascent entrepreneurs.[3] Additionally, we include only countries with at least three years of available observations, resulting in a sample of 54 countries. This database is then merged with the Medina and Schneider (2018) dataset, which provides yearly estimates of the size of the informal sector in 158 countries over the 1991–2015 period. The methodology used to estimate these figures is based on a modified version of the standard Multiple Causes, Multiple Indicators approach.

2.2 Stylized Facts

Fact 1: The informal sector is more intensive in less-educated workers and entrepreneurs. There is substantial evidence in the literature that informal firms, on average, are run by less-educated entrepreneurs and tend to hire more unskilled workers compared to formal firms (La Porta and Shleifer, 2014). These features are also apparent in Brazilian data. As shown in Panel B.1 of Table 1, informal firms in the ECINF dataset have a lower share of college-educated entrepreneurs relative to formal firms of comparable size. This trend is further corroborated by Panel B.2, which shows that informality is more prevalent among non-college-educated entrepreneurs. Specifically, among small businesses, 80% of entrepreneurs with low educational attainment were running informal firms in Brazil in 2003. This figure is about 24 percentage points higher than the corresponding statistic for college-educated entrepreneurs. Similarly, Panel C.2 shows that the informality rate is in general higher among non-college educated workers, confirming that the informal sector is more intensive in unskilled labor as shown in Panel C.1. This evidence, coupled with the fact that (i) informal firms tend to be smaller in size compared to formal firms (de Paula and Scheinkman, 2007; La Porta and Shleifer, 2008; Leal Ordoñez, 2014; Ulyssea, 2018), and (ii) formal and informal firms coexist within narrowly defined industries (Ulyssea, 2018), is consistent−among other possible explanations−with a theoretical model in which formal and informal enterprises have access to an identical production technology featuring capital-skill complementarity. Further support for this explanation comes from FON (2022), who provides evidence that capital-skill complementarity is an empirically relevant feature of production technologies in Brazil.

Fact 2: Educational attainment of entrepreneurs is positively correlated with firm size. Extending the previous analysis, we now assess how the educational attainment of entrepreneurs correlates with firm size. Due to the size cap of the ECINF survey, we address this question using the PNAD dataset, which includes medium and large firms. We begin by reporting college attainment rates among entrepreneurs by firm size. We compute these statistics for

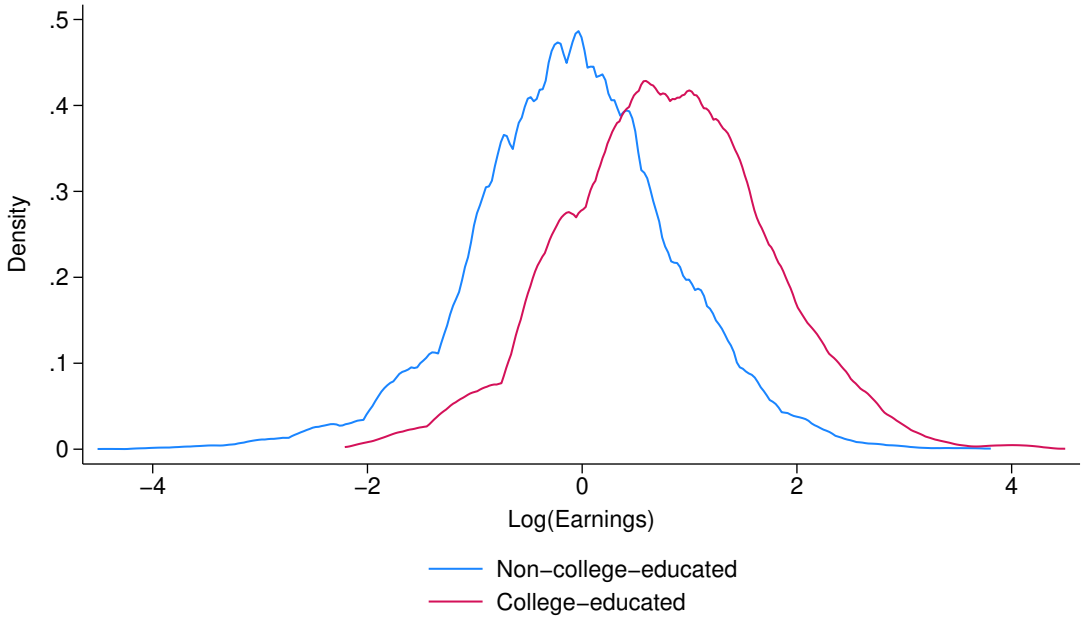
[3]GEM defines entrepreneurship as "Any attempt at new business or new venture creation, such as self-employment, a new business organization, or the expansion of an existing business, by an individual, a team of individuals, or an established business."

Table 1: Informality and education

Moments	Source	Value
Panel A: Educational attainment of working aged population		
(A.1) *College rate*:		
All individuals	PNAD 2003	8.36
Among entrepreneurs	PNAD 2003	10.16
Among workers	PNAD 2003	7.64
Panel B: Small businesses		
(B.1) *Share of college-educated entrepreneurs*:		
In formal firms	ECINF 2003	17.45
In informal firms	ECINF 2003	6.28
(B.2) *Informality rate*:		
Among college-educated entrepreneurs	ECINF 2003	57.13
Among non-college-educated entrepreneurs	ECINF 2003	80.78
Panel C: All firms		
(C.1) *Share of skilled workers*:		
In formal firms	PNAD-C 2012	13.16
In informal firms	PNAD-C 2012	2.88
(C.2) *Informality rate*:		
Among all workers	PNAD 2003	26.91
Among skilled workers	PNAD 2003	17.14
Among unskilled workers	PNAD 2003	27.72
(C.3) *Share of college-educated entrepreneurs by firm size*:		
1-5 workers	PNAD 2003	18.86
6-10 workers	PNAD 2003	28.46
$>$ 10 workers	PNAD 2003	36.77

firms in general (i.e., without distinguishing for informality status), using the number of paid workers as a measure for firm size. As illustrated by Panel C.3 of Table 1, we observe a clear upward trend in the share of college-educated entrepreneurs as firm size grows. While only 19% of entrepreneurs running small firms in Brazil were college educated in 2003, this figure rises to 28% for medium-sized firms and nearly doubles for large firms. Additional evidence of this firm heterogeneity is presented in Figure 1, which shows that the distribution of earnings for college-educated entrepreneurs−as a proxy for firm size−is right-shifted relative to that for non-college individuals. In other words, our findings indicate that, on average, firms run by college-educated entrepreneurs tend to be larger. This evidence is consistent with the results provided by Queiró (2021), who, through analysis of Portuguese administrative data, also documents a positive relationship between educational attainment of entrepreneurs and firm size−both in life-cycle behavior and in cross-sectional firm heterogeneity. Additionally, Queiró investigates the mechanisms underlying this empirical pattern, providing evidence that technology adoption and innovation may be the primary drivers linking firm size, and productivity, with entrepreneurial human capital accumulation through schooling. Similar

Figure 1: **Firm size distributions**



Notes: Data are taken from PNAD 2003. To compute the reported distributions, we first regress log-earnings, normalized by the average across working aged population, on industry dummies to control for inter-industry variability. We then use the residuals from this regression to compute the weighted kernel density of log-earnings by college attainment.

conclusions are drawn in Ciccone and Papaioannou (2009).

Fact 3: College and formal earning premia are substantial. As shown in Panel A of Table 2, in 2003 there were substantial earnings gains from completing tertiary education in Brazil. On average, a college-educated entrepreneur and a skilled worker earned approximately 3.9 and 3.5 times more, respectively, than their non-college-educated counterparts. Similarly, we find significant earnings premia for individuals operating in the formal sector, with entrepreneurs and workers earning, on average, 2.44 and 1.70 times more than informal employers and employees, respectively. All of the reported statistics are in line with the evidence provided by de Paula and Scheinkman (2011), who, using ECINF 2003 data in a *Mincerian* regression, found positive and statistically significant returns from both formalization and education for Brazilian entrepreneurs. Our results further highlight that, on average, skill and formal premia for entrepreneurs are larger relative to those for workers. These findings are consistent with the evidence reported by Berniell (2021), who documents that education returns for entrepreneurs tend to be higher compared to workers in countries with large informal sectors.

Fact 4: Across countries, the size of informal sector is negatively correlated with the share of college-educated entrepreneurs. Another interesting feature of the Brazilian economy, apparent in our data, is its combination of low educational attainment among entrepreneurs and high informality rates. In 2003, only 10.16% of all entrepreneurs were college-educated (Panel A of Table 1),[4] and around 66% of all firms operated in the informal sector (Ulyssea,

[4]This number reflects the low college attainment rate in the Brazilian population, where only 8.36% of

Table 2: Earnings gaps

Moments	Source	Value
(A) *College earning premium*:		
Entrepreneurs	PNAD 2003	3.93
Workers	PNAD 2003	3.55
(B) *Formal-informal earning gap*:		
Entrepreneurs	ECINF 2003	2.44
Workers	PNAD 2003	1.70

Note: College and formal earning premia are computed as ratio of average earnings.

2018), with nearly 27% of all salaried employees not holding a regular labor contract (Panel C.2 of Table 1).[5] Using the GEM and Medina and Schneider (2018) databases, we find that this characteristic holds true across countries, with the share of college-educated entrepreneurs being negatively correlated with the size of the informal economy. This finding is well apparent in Figure 2, which shows that, on average, countries characterized by a large share of output produced informally are also characterized by low college rates among entrepreneurs.

3 Model

We consider an overlapping generations model of entrepreneurship with endogenous educational choices, taxation and financial market frictions.[6] Each generation consists of individuals who are heterogeneous in terms of innate talent, costs of education, and wealth profiles, the latter being endogenously determined by forward-looking saving decisions.

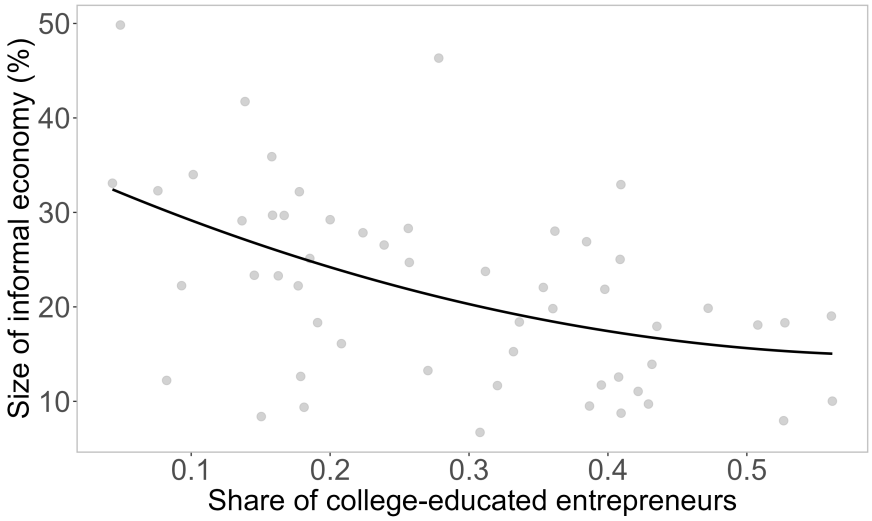
The life cycle of each individual is characterized by three distinct stages: education, work and retirement. The first stage, labeled age 0, is a pre-working period of life in which the individual chooses the education level $h = \{s, u\}$, where s denotes college education and u non-college education. In the subsequent work stage, an individual decides in each period whether to become a worker or to run an entrepreneurial activity, on the basis of her financial wealth, her occupational skills, and her education attainment. Workers supply their time-endowment inelastically and receive a gross wage conditional to their educational status, while entrepreneurs operate a technology that combines their managerial abilities

working-aged individuals were college-educated in 2003. It is also interesting to note that the college rate among entrepreneurs was 1.32 times larger compared to that of workers (see Panel A of Table 1). This feature is consistent with the findings of Berniell (2021), who documents that in countries with relatively large informal sectors, a larger fraction of skilled individuals choose to become entrepreneurs.

[5]According to the Medina and Schneider (2018), these numbers translate into a total output produced by informal firms equivalent to a 39% of the official Brazilian GDP in 2003.

[6]The overlapping generations structure of the model is motivated by compelling empirical evidence highlighting the importance of the life cycle stage of firms and entrepreneurs in influencing informality rates among enterprises in developing countries (Perry *et al.*, 2007; de Paula and Scheinkman, 2010, 2011; Williams *et al.*, 2016; Diaz *et al.*, 2018).

Figure 2: **Entrepreneurial college rates and size of the informal economy**



Notes: The grey dots represent average values for cross-country data over the 2009–2015 period. Fitted values from a quadratic regression are reported with a continuous black line.

with skilled labor, unskilled labor, and capital to produce output. Individuals enter the labor market at age 1, retire at the mandatory age J_R and then die when they reach the age $J \in (J_R, \infty)$.

As in Buera and Shin (2013), imperfections in financial markets manifest as collateral requirements on capital rentals. Tax enforcement is also imperfect, as government can detect informal economic activities−those carried out by unregistered firms−only upon inspection. Entrepreneurs can thus avoid taxation by operating informally. However, non-compliance with tax payments incurs costs. Firstly, access to credit requires registration with tax authorities, meaning that informal entrepreneurs must operate in a financial autarky regime. Secondly, the government conducts random audits on a number of individuals each period, so informal entrepreneurs face a probability of being detected and forced to pay the taxes due, augmented by a penalty surcharge.

3.1 Time convention, preferences and endowments

Time is discrete, and at the beginning of every period, a new generation of individuals is born. Agents discount the future exponentially using a common discount factor $\beta \in (0, 1)$, and have instantaneous preferences over consumption that are represented by a CRRA utility function of the form

$$u(c_j) = \frac{c_j^{1-\sigma}}{1-\sigma}$$

where c_j denotes consumption at age $j = \{1, 2, ..., J\}$, and $\sigma > 0$ is the coefficient of relative risk aversion.

A newly born individual is endowed with (i) zero assets; (ii) an innate talent $e_u \in \Theta$, drawn from an invariant distribution with CDF $\Phi(e_u)$, which determines the managerial productivity of non-college-educated entrepreneurs, and (iii) one unit of time that can be

supplied in the market for unskilled labor in each period of the working stage. As described in a separate section below, labor and managerial skills remain unchanged throughout the life cycle unless the agent acquires a college degree during the educational stage, which affects innate abilities in two ways. First, college-educated individuals can allocate their time endowments to the skilled labor market. Second, higher education enhances managerial productivity (i.e., $e_s > e_u$) with an impact that is individual-specific. To distinguish between the productivity of college- and non-college-educated entrepreneurs, in what follows we refer to e_h as the managerial ability of an individual with education level $h = \{s, u\}$.

3.2 Firms

Following Quadrini (2000), we assume that there are two distinct sectors producing the same homogeneous consumption good. The first sector, labeled the entrepreneurial sector, is characterized by small-scale enterprises owned by individuals engaged in entrepreneurship. The second one, referred to as the corporate sector, comprises large-scale, impersonal firms. In addition to differences in size, firms run by entrepreneurs and corporations are assumed to differ along two other key dimensions: the possibility of non-compliance with business regulations and the severity of financial constraints.

3.2.1 Entrepreneurial sector

We follow Allub *et al.* (2023) by assuming that an entrepreneurs combines her managerial ability, e_h, with capital, k, skilled labor, ls, and unskilled labor, lu, to produce output via the following CES technology

$$f(e_h, lu, ls, k) = e_h^{\eta} \left[\mu lu^{\theta} + (1-\mu)(\iota k^{\rho} + (1-\iota) ls^{\rho})^{\frac{\theta}{\rho}} \right]^{\frac{1-\eta}{\theta}} \tag{1}$$

where μ, ι, $\eta \in (0, 1)$ are distribution parameters, while θ, $\rho \leq 1$ control for the elasticities of substitution between unskilled labor, capital, and skilled labor. This production function is a variant of the technology proposed by Krusell *et al.* (2000) and exhibits decreasing returns to scale, thereby capturing the notion of *span of managerial control* popularized by Lucas (1978). Additionally, provided that $\theta > \rho$, it also embodies capital-skill complementarity.[7]

Unskilled and skilled workers are hired from perfectly competitive labour markets at the wage rates w_u and w_s, respectively, while capital is financed by entrepreneurs using their own assets, a, and, in addition, external resources borrowed from financial intermediaries. We assume that to access credit, entrepreneurs need to register with tax authorities, which makes their production activities observable by the government. Entrepreneurs who comply with these regulations are labeled formal. In contrast, informal entrepreneurs are non-compliant individuals who consequently choose to operate their businesses without resorting to external financing. These entrepreneurs, however, may successfully evade taxation by hiding their production activities, which can only be detected by the government after a monitoring process.

[7] More specifically, under the parameterization $\theta > \rho$, the production function features higher elasticity of substitution between capital and unskilled labor (i.e., $1/(1-\theta)$) than between capital and skilled labor (i.e., $1/(1-\rho)$).

An implicit assumption of the production function specified in Equation (1) is that, apart from the entrepreneur' managerial ability, there is no difference in the technology adopted by formal and informal firms, with both types demanding capital, skilled labor, and unskilled labor. In other words, firms are ex-ante identical, and any difference in productivity, size and skills intensity between formal and informal firms endogenously arises in equilibrium from the self-selection of talent into entrepreneurship.[8] To distinguish between formal and informal factor demands, in what follows we use the subscript f for variables associated with formal entrepreneurs and i for variables associated with informal entrepreneurs.

3.2.2 Corporate sector

Following Franjo *et al.* (2022), we assume that in the corporate sector operate a large number of perfectly competitive firms. These enterprises are heterogeneous in productivity and use the same production technology as firms in the entrepreneurial sector. In addition, we assume that firms in the corporate sector (i) pay a operational fixed cost; (ii) cannot engage in informal activities, and (iii) are not subject to collateral constraints on capital rentals.[9,10] In the Online Technical Appendix A, we show that under these assumptions the aggregate net output of the sector, Y_c, is given by

$$Y_c = A\left[\mu L u_c^{\theta} + (1-\mu)(\iota K_c^{\rho} + (1-\iota) L s_c^{\rho})^{\frac{\theta}{\rho}}\right]^{\frac{1-\eta}{\theta}} - \phi_f \tag{2}$$

where $A > 0$ is a parameter controlling for the sector-specific productivity; K_c, Lu_c and Ls_c respectively stand for aggregate capital, aggregate unskilled labor and aggregate skilled labor in the corporate sector, while $\phi_f > 0$ is the operational fixed cost aggregated across firms.

3.3 Financial intermediaries

We assume that there is a continuum of perfectly competitive financial intermediaries, each receiving deposits from households at a risk-free interest rate, r, and renting capital to firms at a rental rate, r_k. In equilibrium, the zero-profit condition implies

$$r_k - \delta = r \tag{3}$$

[8] In addition to the stylized facts documented in Section 2, this implicit assumption is also supported by evidence that challenges the dualistic view of formal and informal firms. See for example Meghir *et al.* (2015), Allen *et al.* (2018), Ulyssea (2018) or Haanwinckel and Soares (2021).

[9] In our model, financial frictions and firm informality depress capital demand, potentially preventing the clearing of capital market. By incorporating large corporations that are not subject to borrowing constraints, we introduce in the model an additional source of capital absorption that resolves this issue and ensures the existence of general equilibrium for any model parameterization. For a more detailed discussion on this topic, interested readers are referred to Franjo *et al.* (2022).

[10] The assumption on the operational fixed cost has been introduced to guarantee that corporate profits are zero in equilibrium.

where $\delta \in (0,1)$ is the capital depreciation rate. Following Buera and Shin (2013), we assume that there is limited contract enforceability for firms in the entrepreneurial sector so that entrepreneurs' capital rental is limited by a collateral constraint of the form

$$k \leq \lambda a \tag{4}$$

where a stands for the individual financial wealth, and $\lambda \geq 1$ measures the degree of financial imperfections. In particular, $\lambda = \infty$ corresponds to perfect capital markets, while $\lambda = 1$ denotes financial autarky. The latter case describes the financing regime of an informal entrepreneur, who has no access to credit and therefore can only self-finance capital with her accumulated wealth, i.e.,

$$k_i \leq a \tag{5}$$

3.4 Government

The government levies flat taxes τ_c and τ_y on consumption and personal income to finance wasteful public expenditures. Additionally, to discourage tax evasion, the government carries out random audits of individuals and requires detected informal entrepreneurs to pay the taxes due, augmented by a penalty surcharge factor $s > 1$. We assume that the probability of being audited in a given period, denoted by $p(k_i)$, increases with the amount of capital used by an informal firm. This assumption is common in the literature on informality and tax evasion (Leal Ordoñez, 2014; Di Nola *et al.*, 2021; Franjo *et al.*, 2022; Fernández-Bastidas, 2023) and can be rationalized by the fact that large establishments are more visible to tax authorities, making it harder for them to hide production compared to smaller ones.

3.5 Life cycle

3.5.1 Education

At the beginning of her life (i.e., at age 0), an individual makes a discrete choice regarding human capital investment, choosing between pursuing a college degree ($h = s$) or maintain a lower level of schooling ($h = u$). We assume that human capital accumulation through college education enhances the innate individual's occupational skills in two ways. First, college-educated individuals are recognized, and paid, as highly skilled workers in the labor market. Second, completing a college degree improves the individual's managerial skills according to the following technology

$$e_s = e_u + \psi e_u^{\epsilon} \tag{6}$$

where $\epsilon > 0$ controls for the curvature of the ability-improvement function, and $\psi > 0$ determines the extent to which college education translates into human capital accumulation. The assumption that the enhanced skill e_s positively depends on the innate talent e_u captures the notion of self-productive investment in skill formation popularized by Cunha and

Heckman (2007), and is consistent with the empirical observation that talented individuals may be more effective in accumulating human capital through schooling (e.g. Belzil and Hansen, 2002).

We also assume that each individual faces an idiosyncratic utility cost of attending college, given by

$$\zeta\left(e_u, \kappa\right) = \kappa e_u^{-\phi} \tag{7}$$

where $\phi > 0$, and κ denotes a stochastic component drawn from a time-invariant distribution with CDF $\Gamma(\kappa)$. This specification extends the formulation proposed by Hea (2010) by assuming that the educational cost decreases with the individual's innate ability e_u.[11] Regarding the stochastic component κ, we instead maintain the original interpretation of Heathcote, Storesletten and Violante by viewing the distribution $\Gamma(\kappa)$ as accounting, in a reduced form, for psychological and pecuniary costs of education (e.g. variations in parental income, government aid programs, tuition fees).

Under the above assumptions, an individual decides whether to invest in human capital by considering three factors: (i) her draw for the stochastic component of the educational cost, κ; (ii) her innate talent, e_u; and (iii) the college earning premia she expects to receive in the future working stage. More formally, let $\mathbb{V}^{e_u}(h)$ denote the expected lifetime utility of an individual with innate ability e_u who chooses education level h. The optimal schooling decision for an individual with stochastic educational cost κ can then be described as:

$$h(e_u, \kappa) = \begin{cases} s & \text{if } \mathbb{V}^{e_u}(s) - \zeta\left(e_u, \kappa\right) \geq \mathbb{V}^{e_u}(u) \\ u & \text{otherwise} \end{cases}$$

3.5.2 Work

During the working stage (i.e., for $j = 1, ..., J_R - 1$), an individual decides at the beginning of each period whether to be a worker or to run an entrepreneurial activity, considering her education level, her managerial ability, e_h, and the amount of financial wealth accumulated in the previous period, a. The individual then decides how much to consume and save, and, if she chooses to become an entrepreneur, whether to comply or not with business regulations and how much output to produce with capital and labor inputs, taking borrowing constraints into account.

The associated decision problem for an individual with educational status $h = \{u, s\}$ can be conveniently written in a recursive formulation with the beginning-of-period value

[11] The assumption that the cost of acquiring a college degree depends on e_u introduces additional heterogeneity into the model and, to some extent, links a worker's productivity to her innate talent. To see this, consider two different individuals who both decide to remain workers throughout their entire life cycle and have drawn the same κ. Since the cost of attending college decreases with e_u, these individuals, despite not benefiting from the improvement in managerial ability, may still choose different education levels due to their distinct innate talents and, as a result, earn different wages. In other words, the assumed specification for the cost of education establishes a connection between the formation of a worker's skills through schooling and her ability endowment e_u. This property, coupled with the ability-improvement technology (6), allows us to interpret more broadly the stochastic variable e_u as innate talent rather than merely as managerial ability.

function, $V(a, e_h)$, given by the maximum between the value of being a worker, $V^W(a, e_h)$, the value of being a formal entrepreneur, $V_f^E(a, e_h)$, and the value of being informal entrepreneur, $V_i^E(a, e_h)$, i.e.,

$$V(a, e_h) = max\{V^W(a, e_h), V_f^E(a, e_h), V_i^E(a, e_h)\}$$

As worker, an individual chooses how much to consume, c, and save, a', so as to maximize the continuation value under the period budget constraint, i.e.,

$$\begin{aligned} V^W(a, e_h) = &\max_{c,a' \geq 0} \{u(c) + \beta V(a', e_h)\} \\ &s.t. \quad (1 + \tau_c)c + a' = (1 - \tau_y)y^w + a \end{aligned}$$

where $y^w = w_h + ra$ denotes the worker's personal income.

As an entrepreneur, an individual first has to decide whether to run her firm formally or informally. Compliance with business regulations allows access to credit but ensures that production activities are observable by the government, preventing registered firms from evading taxation. Consequently, the value function of being a formal entrepreneur is given by

$$\begin{aligned} V_f^E(a, e_h) = &\max_{k_f, lu_f, ls_f, c, a' \geq 0} \{u(c) + \beta V(a', e_h)\} \\ &s.t. \quad y^E = f(e_h, lu_f, ls_f, k_f) - w_s ls_f - w_u lu_f - (r + \delta)k_f + ra \\ &\qquad (1 + \tau_c)c + a' = (1 - \tau_y)y^E + a \\ &\qquad k_f \leq \lambda a \end{aligned}$$

where y^E denotes the formal entrepreneur's declared income, which amounts to her actual earnings.

In contrast, informal entrepreneurs evade taxation by hiding their production activities and reporting to the fiscal authorities only their capital gains, but they face a probability of detection $p(k_i)$. We assume, in addition, that (i) the government conducts audits and imposes fines after entrepreneurs have made their production decisions; and (ii) informal entrepreneurs decide how much to consume and save after observing whether they have been caught or not. Accordingly, let $V_d^E(a, e_h)$ and $V_{nd}^E(a, e_h)$ denote the informal entrepreneur's value functions corresponding to the cases of detection and non-detection, respectively. The expected value of being an informal entrepreneur can then be written as follows

$$\begin{aligned} V_i^E(a, e_h) = &\max_{k_i, lu_i, ls_i \geq 0} \{p(k_i)V_d^E(a, e_h) + (1 - p(k_i))V_{nd}^E(a, e_h)\} \\ &s.t. \quad k_i \leq a \end{aligned}$$

where the constraint on the capital rental captures that informal firms operate in a financial

autarky regime. The value function in the case of non-detection is given by

$$\begin{aligned} V_{nd}^{E}(a, e_h) = \max_{c,a' \geq 0} & \{u(c) + \beta V(a', e_h)\} \\ s.t. \quad & y^E = ra \\ & (1+\tau_c)c + a' = (1-\tau_y)y^E + \pi + a \end{aligned}$$

where π represents profits from business activities, i.e.,

$$\pi = f(e_h, lu_i, ls_i, k_i) - w_s ls_i - w_u lu_i - (r+\delta)k_i \tag{8}$$

Note that the informal entrepreneur is able to hide profit income π from the tax authorities. However, in the case of detection, the government forces the informal entrepreneur to pay taxes on the undeclared income, augmented by the penalty surcharge factor s. Consequently, the value function of an informal entrepreneur who has been detected by the government is given by:

$$\begin{aligned} V_{d}^{E}(a, e_h) = \max_{c,a' \geq 0} & \{u(c) + \beta V(a', e_h)\} \\ \text{s.t.} \quad & y^E = ra \\ & (1+\tau_c)c + a' = (1-\tau_y)y^E + \pi + a - (1+s)\tau_y \pi \end{aligned}$$

where π is defined as in Equation (8).

3.5.3 Retirement

During retirement (i.e., for $j = J_R, J_R+1, ..., J$), an individual consumes and saves on the basis of the financial wealth accumulated during the working stage. Hence, the value function of a retired individual is given as follows

$$\begin{aligned} V(a, e_h) = \max_{c,a' \geq 0} & \{u(c) + \beta V(a', e_h)\} \\ s.t \quad & (1+\tau_c)c + a' = (1-\tau_y)y^R + a \end{aligned}$$

where $y^R = ra$ is the retired individual's declared income.

3.6 Equilibrium and definition of measured GDP

Let us define with $\omega = \{e_h, a, b(e_h, a), h\}$ the vector containing managerial ability e_h, financial wealth a, occupational status $b(e_h, a)$ (i.e., retired, worker, formal entrepreneur and informal entrepreneur), and education attainment $h = h(e_u, \kappa)$ of an agent with innate talent e_u and the idiosyncratic cost of education κ. A stationary equilibrium is given by a price vector $\{r, w_u, w_s\}$, allocations $\{c(\omega), a(\omega)\}$, occupational choices $b(e_h, a)$, decision rules for

education $h(e_u, \kappa)$, unskilled and skilled labor employed by formal and informal entrepreneurs $\{lu_f(\omega), ls_f(\omega), lu_i(\omega), ls_i(\omega)\}$, formal and informal capital $\{k_f(\omega), k_i(\omega)\}$, labor and capital in the corporate sector $\{Lu_c, Ls_c, K_c\}$ and a distribution of individuals over ω, $\xi(\omega)$, such that given the free-risk interest rate r, the wage rates w_s and w_u and the tax system (i.e., s, $p(\cdot)$, τ_c and τ_y):

- The vector of policy functions $\{c(\omega), a(\omega), k_f(\omega), k_i(\omega), lu_f(\omega), ls_f(\omega), lu_i(\omega), ls_i(\omega), b(e_h, a), h(e_u, \kappa)\}$ solve the agents' decision problems described in Section 3.5.
- Capital and labor inputs $\{Lu_c, Ls_c, K_c\}$ are allocated optimally in the corporate sector.
- Capital market clears:

$$\int (k_f(\omega) + k_i(\omega)) d\xi(\omega) + K_c = \int a(\omega) d\xi(\omega)$$

- Market for skilled labor clears:

$$\int (ls_f(\omega) + ls_i(\omega))\, d\xi(\omega) + Ls_c = \int \mathbb{1}_{Ws} d\xi(\omega)$$

  where $\mathbb{1}_{Ws}$ is an indicator function that takes value of 1 if the agent is a skilled worker and 0 otherwise.

- Market for unskilled labor clears:

$$\int (lu_f(\omega) + lu_i(\omega))\, d\xi(\omega) + Lu_c = \int \mathbb{1}_{Wu} d\xi(\omega)$$

  where $\mathbb{1}_{Wu}$ is an indicator function that takes value of 1 if the agent is a unskilled worker and 0 otherwise.

- The government budget constraint is balanced, i.e.,

$$G = \int \left\{\tau_c c(\omega) + \tau_y y^E(\omega) + \mathbb{1}_D (1+s)\tau_y \pi(\omega))\right\} d\xi(\omega)$$

  where G are public expenditures, and $\mathbb{1}_D$ stands for an indicator function that takes a value of 1 if the individual is an informal entrepreneur that has been audited, and 0 otherwise.

- Financial intermediaries earn zero profit, i.e., Equation (3) is satisfied.
- The distribution $\xi(\omega)$ is the invariant distribution for the economy.

To close the model, we need to establish a precise definition of official−or measured −GDP. Since informal production activities are hidden from the government, official GDP does not necessarily reflect the total output of the economy. This paper adopts the assumption that official GDP is represented by total formal output, i.e.,

$$GDP = \int \mathbb{1}_f y(\omega) d\xi(\omega) + Y_c$$

where $\mathbb{1}_f$ is an indicator function taking value 1 if the agent is a formal entrepreneur and 0 otherwise, while $y(\omega)$ stands for the output of a firm operating in the entrepreneurial sector.[12] In what follows, we will likewise refer to measured TFP as total factor productivity in the formal sector.

4 Calibration

We calibrate the model to the Brazilian economy. Parameter values are assigned based on either external sources or by targeting key macro and micro statistics, including estimates for the size of the informal economy, firm size distributions, college rates, and earnings premia. A description of how parameters are identified is provided below.

4.1 Identifying restrictions

Time period, life cycle duration and retirement age. The time period in the model corresponds to one year. We assume that each individual is economically active from age 20, retires at age 65, and lives up to 74 years. Therefore, each individual's life cycle in the model spans 55 periods ($J = 55$), with the retirement stage beginning at period $J_R = 46$. Consistent with World Bank estimates, the age of death in the model corresponds to the average life expectancy in Brazil during the 2010-2018 period, while the retirement age is set according to the Brazilian pension system.

Parameters in the inter-temporal utility function. There are two preference parameters, (β, σ). The subjective intertemporal discount factor β is chosen so that the formal capital-to-GDP ratio in the steady state equilibrium equals 2.10, which corresponds to the average capital-output ratio in Brazil during the 2004-2010 period (World Bank). The relative risk aversion coefficient σ is set to 1.5, consistent with most of the literature on occupational choice models with financial frictions (e.g. Buera *et al.*, 2011; Buera and Shin, 2013). This value also aligns with available empirical estimates for Brazil, which suggest a range for σ from 1 to 3 (Fajardo *et al.*, 2012).

[12]The definition of GDP in the model is not entirely consistent with its counterpart in the data. This discrepancy arises because the Brazilian statistical institute adjusts the official GDP by incorporating estimates for the so-called non-observed economy, which includes underground production, home production, and illegal activities. Among these three components, the informal output in the model corresponds to the underground production. As discussed in Franjo *et al.* (2022), the quantitative importance of the latter may be significantly underestimated in the adjustment procedure used by the Brazilian statistical institute. For this reason, we do not include informal production in the definition of GDP in the model.

Distribution of innate talents. We assume that the innate talent, e_u, is drawn from a generalized Pareto distribution with CDF:

$$\Phi(e_u) = 1 - \left(1 + \frac{\eta_p(e_u - \mu_p)}{\sigma_p}\right)^{-1/\eta_p}$$

where μ_p, σ_p and η_p are, location, scale and shape parameters, respectively. The support of the talent distribution is discretized into 20 grid points. The first point in the grid, denoted as $e_{u,min}$, is set to the value where the cumulative probability equals $\Phi(e_{u,min})$, with the latter treated as a parameter to be calibrated. The largest value corresponds to the 99.93rd percentile of $\Phi(e_u)$, while the remaining grid points are determined such that they are equidistant in probability space. We chose to calibrate $\Phi(e_u)$ to match data on the firm size distribution in the formal sector. Specifically, we use four moments to identify the four parameters $(\mu_p, \eta_p, \sigma_p, \Phi(e_{u,min}))$, targeting the share of formal firms with up to 5, 5 to 10, 11 to 20, and 21 to 50 employees. Estimates for the size distribution of formal establishments in Brazil are taken from Ulyssea (2018).

Penalty surcharge factor and probability of detection. According to Brazilian legislation, the penalty surcharge factor applied to a fraudulent taxpayer is equal to 75% of the total tax due. Therefore, we set $s = 0.75$. For the endogenous probability of detection, we follow Di Nola *et al.* (2021), Franjo *et al.* (2022) and Fernández-Bastidas (2023) by parameterizing $p(k_i)$ with a logistic function of the form

$$p(k_i) = \frac{1}{1 + p_1 exp(-p_2 k_i)}$$

where $(p_1, p_2) \in \mathbb{R}^2_+$. A property of this specification is that the probability of detection decreases with p_1. Consequently, all else being equal, the higher this parameter, the higher the expected returns from tax evasion, and thus, the larger the share of total output produced in the informal sector. We therefore set p_1 so that, in the model, the informal output to GDP ratio is equal to 37.6%. According to the Medina and Schneider (2018) estimates, this last number corresponds to the average informal output to GDP ratio in Brazil over the 1991-2015 period. To identify parameter p_2, we note that another property of the logistic specification is that the probability of detection declines quickly as capital increases, and therefore the expected gains from tax evasion decreases with the firm's size. Depending on the magnitude of parameter p_2, this property implies that informal firms optimally decide to stay small in equilibrium. A value to p_2 is therefore assigned so that share of informal firms with up to 5 workers in the model matches its empirical counterpart of 99.8% (ECINF 2003).

Production technologies and borrowing constrains. Following Allub and Erosa (2019) and Franjo *et al.* (2022), the span of control parameter η is set to 0.198. For the elasticities of substitution between capital and labor inputs, we rely on the estimates reported in FON (2022), setting $\theta = 0.61$ and $\rho = -0.25$.[13] This calibration implies that production technolo-

[13]FON (2022) report estimates for the parameters of a CES production function in each 2-digit sector of

gies in our model exhibit capital-skill complementarity. The remaining share parameters in the CES production function (1), ι and μ, are set to match a wage-skill premium (w_s/w_u) of 3.55 and a share of skilled workers in the total labor force of 7.64%. As described in Section 2, these values are both computed using data from PNAD 2003. Regarding the sector-specific technology (2), we set the productivity parameter, A, such that the share of total formal capital absorbed by the corporate sector equals 0.30.[14,15] Finally, the capital depreciation rate, δ, is set to 0.06, as in Cavalcanti and Santos (2020), while the parameter controlling for the degree of financial frictions, λ, is calibrated to match a credit-to-GDP ratio of 0.42. According to the World Bank's financial structure database, this value corresponds to the average private credit-to-GDP ratio in Brazil for the period 1991-2015.[16]

Taxes. The consumption tax rate, τ_c, is set to 0.15 as in Jung and Tran (2012), who also calibrate an overlapping generations model for the Brazilian economy. The personal income tax rate, τ_y, is instead chosen to match a total fiscal revenue-to-GDP ratio of 32.4%. According to OECD revenue statistics for Latin America, this figure corresponds to the average value of Brazil's total tax revenue-to-GDP ratio over the 2000–2018 period.

The cost of attending college and the ability-improvement function. To parameterize the cost of attending college, we follow Hea (2010) by assuming a lognormal distribution for the idiosyncratic component κ, i.e.,

$$ln(\kappa) \sim \mathcal{N}(\bar{\kappa},\, \sigma_\kappa^2)$$

We set the mean $\bar{\kappa}$ to match a population college-education rate of 8.36%, based on PNAD 2003. As for the standard deviation σ_κ, we note that in the model, this parameter controls the dispersion of educational costs among individuals with the same innate talent. Consequently, it also influences the overall dispersion of population earnings conditional on education. We take advantage of this property and identify the parameter σ_κ by matching a measure of earnings volatility. Specifically, we use the standard deviation of earnings among Brazilian entrepreneurs, which according to the PNAD 2003 survey is equal to 1.053. Information on population earnings is also useful to assign a value to the curvature parameter ϕ. According to Equation (7), for a given κ, the cost of attending college decreases with ϕ for any innate talent e_u. Hence, all else being equal, the higher this parameter, the larger the share of college-educated individuals, and, in equilibrium, the lower the earnings skill premia. Consequently, we calibrate ϕ by matching the college earnings premium for entrepreneurs. In the data, we compute this as the ratio of the average earnings of college-educated entrepreneurs to the average earnings of non-college-educated entrepreneurs. As described in Section 2, we estimate the entrepreneurial skill premium to be 3.93. Finally, the specification of the improvement-ability function (6) introduces two additional education-related parameters, (ϵ, ψ). We calibrate these by targeting the share of educated entrepreneurs in firms with 6 to

the Brazilian economy. The values we assigned to the parameters θ and ρ are unweighted averages across these sector estimates.

[14]The statistic on the capital share absorbed by Brazil's corporate sector is taken from Antunes *et al.* (2015).

[15]The fixed cost, ϕ_f, is instead determined in equilibrium by imposing a zero-profit condition in the corporate sector.

[16]The average credit-to-GDP ratio is calculated using the variable *private credit by deposit money banks and other financial institutions.*

Table 3: Calibration Results: Parameter Values

Parameters	Description	Source/ Targeted Moment	Value
(A) Externally calibrated			
σ	Relative risk aversion coefficient	Standard	1.500
δ	Capital depreciation rate	Cavalcanti and Santos (2021)	0.060
s	Surcharge factor	Brazilian law	0.750
τ_c	Consumption tax	Jung and Tran (2012)	0.150
η	Span of control	Allub and Erosa (2019)	0.198
ρ	Substitutability: capital and skilled labor	Fonseca and Van Doornik (2022)	-0.250
θ	Substitutability: capital and unskilled labor	Fonseca and Van Doornik (2022)	0.610
(B) Internally calibrated			
β	Subjective discount factor	Capital-output ratio	0.966
λ	Degree of financial frictions	Credit-output ratio	1.391
$\bar{\kappa}$	Education cost: mean of idiosyncratic component	Share of educated population	7.113
σ_κ	Education cost: s.d. of idiosyncratic component	S.d. of entrepreneurial earnings	1.746
ϕ	Education cost: curvature	Entrepreneurial skill premium	0.549
ψ	Productivity jump: coefficient	Share of educated entrepreneurs by firm size	2.376
ϵ	Productivity jump: curvature	Share of educated entrepreneurs by firm size	0.923
τ_y	Income tax rate	Total fiscal revenues to GDP	0.206
A	TFP in the corporate sector	% of K used by corporations	2.249
p_1	Probability of detection	Informal output to GDP	1.1e7
p_2	Probability of detection	Size distribution informal firms	5.990
μ_p	Location Pareto distribution	Size distribution formal firms	2.587
σ_p	Scale Pareto distribution	Size distribution formal firms	1.362
η_p	Shape Pareto distribution	Size distribution formal firms	0.198
$\Phi(e_{min})$	Probability mass in the minimum ability	Size distribution formal firms	0.546
μ	Weight of unskilled labor in production	Wage skill premium	0.480
ι	Weight of capital in production	Share of educated workers	0.683

10, and more than 10 employees (PNAD 2003). Since college education boosts managerial productivity, in the model, educated entrepreneurs tend to be concentrated in medium- and large-sized enterprises. Consequently, the targeted moments are reasonably informative in identifying parameters ϵ and ψ.

In summary, our calibration strategy partitions the model's parameters into two subvectors: one containing those that are fixed according to external sources (i.e., σ, s, η, θ, ρ, δ, τ_c), and another containing the internally calibrated parameters (i.e., β, μ_p, κ_p, ν_p, $\Phi(e_{u,\min})$, p_1, p_2, ι, μ, A, λ, τ_y, $\bar{\kappa}$, σ_κ, ϕ, ϵ, ψ). Values for the latter are jointly assigned by minimizing a loss function that computes the distance between the model's predicted moments and the targeted moments from the data. The results are provided in Tables 3, 4, and 5. Table 3 reports the values of the calibrated parameters, while Tables 4 and 5 provide a comparison between the model and the data for targeted and non-targeted moments, respectively.[17]

[17]We have also tested more formally whether the calibration restrictions described above allow for the identification of parameters. Details on the procedure and results are provided in the Online Technical Appendix B.

Table 4: Calibration Results: Targeted Moments

Moments	Source	Data	Model
Capital-Output ratio (formal)	Allub and Erosa (2019)	2.100	2.107
Credit-Output ratio	World Bank Database	0.420	0.413
Informal output to GDP	Medina and Schneider (2018)	0.376	0.356
% of K used by corporations	Antunes et al. (2015)	0.300	0.302
Total fiscal revenues to GDP	OECD revenues statistics	0.320	0.325
Share of educated individuals	PNAD 2003	0.084	0.079
Share of educated workers	PNAD 2003	0.076	0.086
S.d. entrepreneurial earnings	PNAD 2003	1.053	1.035
Entrepreneurial skill premium	PNAD 2003	3.927	3.929
Wage skill premium	PNAD 2003	3.546	3.547
Share of educated entrepreneurs by firm size			
6-10 workers	PNAD 2003	0.285	0.278
$>$ 10 workers	PNAD 2003	0.368	0.373
Size distribution: informal firms			
$\leq$ 5 workers	ECINF 2003	0.998	0.979
Size distribution: formal firms			
$\leq$ 5 workers	Ulyssea (2018)	0.701	0.695
6-10 workers	Ulyssea (2018)	0.141	0.159
11-20 workers	Ulyssea (2018)	0.083	0.123
21-50 workers	Ulyssea (2018)	0.048	0.023

4.2 Goodness of fit and external validation of the model

As Table 4 illustrates, the model replicates the targeted moments quite well. In particular, it accurately captures the earnings skill premium for both workers and entrepreneurs, as well as the share of college-educated entrepreneurs by firm size, with the model's moments almost perfectly matching their counterparts in the data. The model also does a good job in replicating the size difference between formal and informal firms, with an implied aggregate informal output that accounts for around 36% of the Brazilian measured GDP, as estimated in the data. Similarly, all other targeted *great ratios* in the steady state equilibrium of the model are virtually identical to their empirical counterparts.

Regarding non-targeted moments, Table 5 shows that the model performs fairly well in capturing all the considered dimensions of the data. In particular, the model aligns perfectly with the data in predicting that (i) the informal sector is relatively more intensive in less educated entrepreneurs (see panel A); (ii) informality is more prevalent among unskilled workers (see panel B); and (iii) informal production is less capital intensive than formal production (see capital-output ratios in Tables (4) and (5)). These findings highlight that combining endogenous probability of detection with capital-skill complementarity in a het-

Table 5: Calibration Results: Non-targeted Moments

Moments	Source	Data	Model
(A) *Share of non-college-educated entrepreneurs*:			
All firms	PNAD 2003	0.898	0.948
In formal firms	ECINF 2003	0.826	0.892
In informal firms	ECINF 2003	0.937	0.997
(B) *Share of informal workers*:			
All workers	PNAD 2003	0.269	0.286
Unskilled workers	PNAD 2003	0.277	0.294
Skilled workers	PNAD 2003	0.171	0.195
(C) *Formal earnings premium*:			
Entrepreneurs	ECINF 2003	2.440	2.005
Workers	ECINF 2003	1.386	1.084
Share of informal firms	Ulyssea (2018)	0.698	0.538
Gini index for wealth	Franjo *et al.* (2022)	0.784	0.759
Average capital-output ratio across informal firms	Erosa *et al.* (2023)	1.040	0.914

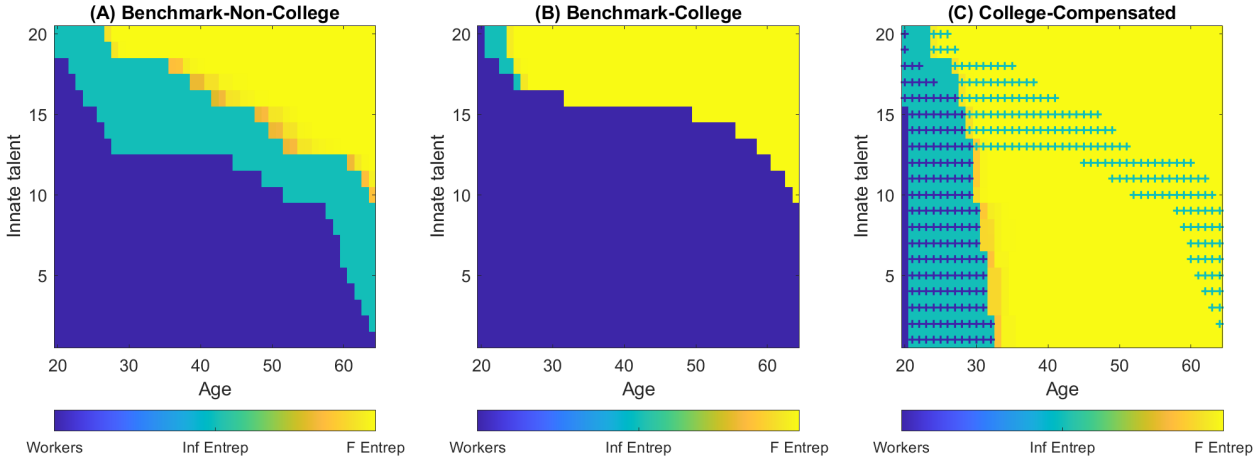
erogeneous agents model of entrepreneurship with financial frictions successfully reproduces the differences in skill intensity between formal and informal firms discussed in Section 2.[18] In this respect, it is also worth highlighting that the model accurately captures the main features of the formal earnings premia in the data. Although it slightly underestimates their magnitude, the model predicts−consistent with data− that operating in the formal sector yields earnings gains for both entrepreneurs and workers, with the premium for the latter being approximately 1.8 times higher than that for the former (see panel C).

5 Results

In this section, we first characterize the properties of the calibrated model (i.e., benchmark economy) with a special focus on occupational choices, human capital accumulation, and informality. We then investigate how individual access to college education and firms' access to credit interact with the informal sector and influence overall economic performance, identifying the distinct channels through which these factors impact individual and sectoral outcomes.

[18]Intuitively, the calibration of the endogenous probability of detection implies that informal firms are predominantly smaller in size compared to formal firms. As shown in Tables 4 and 5, this characteristic is reflected in the capital-output ratio, which is, on average, lower among informal firms (i.e., 0.91 vs. 2.10). Due to capital-skill complementarity, this difference in capital intensity leads to a relatively higher demand for unskilled workers in informal firms. Consequently, although we have assumed that firms have access to the same production technology, in equilibrium, the informal sector is relatively more intensive in unskilled labor than the formal sector. Regarding the educational attainment of entrepreneurs, in the next section, we will show that the difference between formal and informal firms in the model arises from the self-selection of talent into entrepreneurship, a property that is mainly driven by the combined effects the wage-skill premium and the boost in managerial skills induced by college education.

Figure 3: Occupational maps



Notes: The figure illustrates occupational choices over the life cycle for: (A) non-college-educated individuals, (B) college-educated individuals, and (C) college-educated individuals with compensated labor income differentials. The color gradient represents occupational status: blue for workers, turquoise for informal entrepreneurs, and yellow for formal entrepreneurs. In Panel C, blue markers identify points in time in which individuals with the same innate talent operate as skilled workers in the benchmark equilibrium and as informal entrepreneurs in the experiment where labor income differentials are offset. Similarly, the turquoise markers refer to ages in which individuals with the same innate talent operate as college-educated formal entrepreneurs in the compensated experiment and as non-college-educated entrepreneurs in the benchmark equilibrium.

5.1 Drivers of firm informality in the benchmark economy

For each level of innate talent, Figure 3 illustrates the occupational maps across the working life for individuals in the benchmark economy, differentiating between non-college-educated (panel A) and college-educated (panel B) agents. The reported occupational patterns reveal substantial behavioral heterogeneity conditional on education. In particular, the figure shows that informality is predominantly concentrated among firms run by entrepreneurs without a college education. While this observation confirms the findings highlighted in the previous section regarding the model's ability to replicate key features of the data, the analysis of occupational maps provides additional insights into the underlying mechanisms. Specifically, Figure 3 shows that virtually all non-college individuals operate as informal entrepreneurs for a portion of their working lives. In contrast, only the most talented college-educated managers find it optimal to run their enterprises informally for a brief period before complying with business regulations. All other college individuals either choose to work as skilled employees before transitioning directly to formal entrepreneurship or remain skilled workers throughout their entire working lives.

In the benchmark economy, this heterogeneity in occupational choice is due to the combined effects of two channels: the wage-skill premium and the entrepreneurial human capital accumulation associated with college education, which influence the self-selection of talent into entrepreneurship. To see this, notice first that in the calibrated model, college individuals benefit from higher wages, which (i) make paid employment the optimal oc-

cupational choice for agents with low managerial abilities, and (ii) facilitate more efficient asset accumulation for individuals in the middle range of the innate talent distribution before transitioning directly to formal entrepreneurship.[19] This last pattern is not optimal for non-college-educated formal entrepreneurs because the unskilled wage is too low, leading them to prefer starting their firms informally and engaging in tax evasion as a more effective means of accumulating financial wealth to overcome borrowing constraints.[20] Depending on the innate talent, panel A of Figure 3 shows that, for these individuals, engaging in informal entrepreneurship can either occur immediately−as in the case of the highly talented entrepreneurs−or later in life, after operating for a certain period as unskilled workers.[21]

The low unskilled wage also explains why some non-college individuals in the lower range of the innate ability distribution find it optimal to switch occupations over the life cycle, transitioning from unskilled employment to informal entrepreneurship (i.e., they never formalize their businesses). In contrast to their college-educated counterparts, who remain as skilled workers throughout their careers, these individuals earn substantially lower wages and, consequently, despite their limited managerial skills, find it more profitable to engage in informal entrepreneurship−and take advantage of the additional resources coming from tax evasion−once they have accumulated sufficient financial wealth to self-finance a small firm.

In addition to the above effects driven by labor earnings differential, in the calibrated model, human capital accumulation through schooling also enhances managerial productivity (i.e., $\psi > 0$), leading firms run by educated entrepreneurs to be optimally larger than those managed by non-college-educated business owners. This property is evident in Table 6, which reports various statistics characterizing firm dynamics in the benchmark economy. As panel A of the table illustrates, for all reported measures of size, entrant firms run by college-educated entrepreneurs are, on average, larger than those operated by non-college individuals, regardless of whether the businesses are formalized or not. Moreover, the table

[19] Age−or, equivalently, wealth accumulation−plays a crucial role in determining occupational choices in our model. Panels A and B of Figure 3 illustrate that nearly all individuals begin their careers as workers and, over time, a subset transitions into entrepreneurship, conditional on their ability. This pattern emerges due to financial frictions in the model economy and the assumption that all individuals start their working lives with zero assets. Together, these conditions generally make it optimal for individuals to begin their working lives as paid employees, as this allows them to accumulate sufficient wealth to overcome financial barriers to entrepreneurship.

[20] Panel A of Figure 3 illustrates that most of these individuals are highly productive managers who, motivated by a strong incentive to engage in entrepreneurship, start operating businesses early in life despite having accumulated limited financial wealth. Under such circumstances, financial frictions require individuals to choose between operating a small business in the formal sector, where its size is constrained by collateral requirements, or operating a small business in the informal sector, where they can avoid taxation. When the probability of detection is low, as is the case for entrant firms with minimal physical capital, the benefits of tax evasion often outweigh the advantages of access to credit, making delayed formalization the more profitable choice for these entrepreneurs. By leveraging the additional resources gained from avoiding tax payments, this strategy also enables entrepreneurs to accumulate financial wealth more quickly than they would through paid employment. This mechanism explains why the most talented entrepreneurs among college-educated individuals, despite benefiting from a high skilled wage, prefer to start their businesses informally rather than working as paid employees for a longer period (see panel B of Figure 3).

[21] The outcome that the highest-ability non-college-educated individuals optimally start their working lives directly as informal entrepreneurs is driven by the assumption of a CES production technology (see Equation 1), which permits positive production even with zero capital.

Table 6: Firm dynamics in the calibrated model

(A) *Relative size among entrants*	Ratio
(1) **Formal firms run by college-educated entrepreneurs**:	
Number of workers	2.61
Capital	1.73
Sales	2.45
(2) **Informal firms run by college-educated entrepreneurs**:	
Number of workers	5.21
Capital	1.38
Sales	4.61
(B) *Average firm growth*	Percentage
(1) **Formal firms**:	
College-educated entrepreneurs	2.03
Non-college-educated entrepreneurs	1.45
(2) **Informal firms**:	
College-educated entrepreneurs	5.34
Non-college-educated entrepreneurs	2.60

Note: In panel A, each size measure is reported as a ratio relative to the average value for entrant firms managed by non-college-educated entrepreneurs. In panel B, average firm growth rates are calculated as the mean of annual percentage changes in firm output.

shows that firms run by college-educated entrepreneurs grow faster over the life cycle (see panel B).[22] Since the probability of detection, $p(k_i)$, increases with a firm's capital size, these differences in firm dynamics imply that the expected returns from informality are generally lower for college-educated entrepreneurs, giving them a stronger incentive to formalize their businesses. This is the second channel through which human capital accumulation may affect firm informality in our model.

One way to assess the separate impacts of the two channels is to analyze how the occupational choices of college-educated individuals would change over the life cycle if, as skilled workers, they received the same disposable labor income as unskilled employees. To this end, we fix factor prices (i.e., r_k, w_u, and w_s) and college rates across innate abilities to their benchmark equilibrium values and recompute the occupational choices of college-educated individuals by artificially reducing their disposable labor income to fully offset the wage-skill premium. By compensating for labor income differentials while holding all other factors constant, we can compare the resulting occupational maps with those of non-college-educated individuals in the benchmark equilibrium to disentangle the partial effect of entrepreneurial human capital on firm informality. Similarly, the effect driven by the wage-skill premium can be isolated by comparing the *compensated* occupational maps with those of college-educated individuals in the benchmark equilibrium.

[22] Differences in firm dynamics conditional to the entrepreneur's level of education predicted by the model align perfectly with the evidence documented in Queiró (2021).

The results of the experiment are reported in panel C of Figure 3 and show, unsurprisingly, that offsetting the skill premium in labor income causes all college-educated individuals, who have enhanced managerial skills, to engage in entrepreneurship over their life cycles. In particular, the figure illustrates that these agents follow the same pattern as formal entrepreneurs among non-college-educated individuals: they start their businesses informally before transitioning to formal entrepreneurship. This finding provides two main insights. First, compared to college-educated individuals in the benchmark equilibrium (panel B), the *compensated* occupational maps confirm that human capital accumulation affects firm informality through the wage-skill premium. With a higher skilled wage, in fact, we find that most college-educated individuals prefer to operate as workers rather than engage in informal entrepreneurship, as they do when the wage-skill premium is offset (panel C). This is an indirect effect that reduces firm informality in the equilibrium, with an overall impact that is illustrated in panel C of Figure 3 by the area marked with blue crosses, where, for each level of innate ability, we identify points where a college-educated individual is a worker in the benchmark equilibrium but an informal entrepreneur in the compensation experiment.

Second, when labor income differentials are offset, we observe that college individuals, once engaged in entrepreneurship, formalize their businesses much earlier than their non-college counterparts in the benchmark equilibrium (compare panel C with panel A). This difference is driven by the effect of entrepreneurial human capital accumulation on firm dynamics discussed above, which causes firms run by college-educated entrepreneurs to enter the market at a larger scale and grow faster than those managed by less-educated entrepreneurs. As a result, the probability of detection increases more quickly for college-educated entrepreneurs, allowing them to reach the point where the returns from formalization (i.e., access to credit) outweigh the expected benefits of tax evasion much earlier (the orange areas in the graphs). Put differently, this effect highlights that, in our model, a lack of entrepreneurial human capital accumulation increases the persistence of informality over the firm life cycle. This is a direct effect that contributes to higher levels of firm informality in the benchmark equilibrium, with an overall impact that, as shown by panel C of Figure 3, is significant (see the area marked with turquoise crosses).

To summarize, our analysis shows that college education affects firm informality in two ways: indirectly, through the wage-skill premium, which affects the opportunity cost of entrepreneurship; and directly, through entrepreneurial human capital accumulation, which impacts expected returns from tax evasion by modifying firm dynamics. In our benchmark economy, these two forces interact with financial frictions, which represent an additional driver of firm informality. In the next section, we conduct a series of counterfactual experiments to assess how these different channels influence the aggregate economy.

5.2 The role of human capital in the aggregate economy

The economic literature has consistently highlighted a positive correlation between the proportion of college-educated individuals and the level of economic development, a relationship documented in seminal works such as Schultz (1961), Barro (1991), or Mankiw *et al.* (1992), and further explored in more recent studies like Barro and Lee (2013) and

Allub *et al.* (2023).[23] Additionally, La Porta and Shleifer (2014) document a cross-country negative correlation between educational attainment in the population and the size of the informal economy. Moreover, as shown in Section 2, this negative correlation persists when focusing specifically on the college attainment rate among entrepreneurs and levels of informality. In this section, we analyze these patterns through the lens of our quantitative model to assess the role of human capital in shaping informality at the aggregate level and explore how this relationship translates into changes in income per capita and aggregate productivity.

Specifically, we investigate the role of human capital by carrying out a counterfactual exercise. In particular, we bring the college rate in the calibrated benchmark economy up to the one observed in the U.S. economy. This value is based on Barro and Lee (2013), who reports that the proportion of the U.S. population above 15 years old with completed tertiary education in 2015 was around 30%. To raise the proportion of college-educated individuals to this level, we decrease the average cost of tertiary education in the model (i.e., parameter $\bar{\kappa}$) while keeping all the other parameters to their calibrated values.[24] By comparing the resulting steady state equilibrium with the benchmark, this experiment allows us to disentangle the aggregate implications of limited access to college education.

The results are presented in Table 7 and Figure 4. Table 7 reports several key statistics for the benchmark economy (first column) and the counterfactual economy with higher human capital (second column). Figure 4 illustrates the distribution of individuals across occupations by innate ability, differentiating between college (first column) and non-college individuals (second column) in the benchmark economy (panels A and B) and in the counterfactual with cheaper access to college education (panels C and D).

5.2.1 The informal economy

As shown in Table 7, increasing the proportion of college-educated individuals in the long-run equilibrium leads to a substantial reduction in the size of the informal economy, with the ratio of informal output to official GDP falling from 35.6% to 4.1%. This outcome is driven by the combined effects of several forces that simultaneously affect both informal production and measured GDP. On the one hand, in the counterfactual scenario with higher human capital, both the proportion of informal entrepreneurs in the population and the share of informal firms decline significantly, leading to a 78.8% reduction in aggregate informal production. On the other hand, despite the share of formal entrepreneurs in the population increasing by only 4 percentage points, the model predicts that raising the population's college rate to the level observed in the U.S. economy would imply a 42.6% increase in official GDP. Our results highlight that these two effects profoundly impact the Brazilian informal economy, reducing

[23] In 2005, the share of individuals aged 25 to 64 with completed tertiary education in the United States was five times higher than in Brazil, according to Barro and Lee (2013). This disparity underscores Brazil's status as a developing economy with relatively limited access to higher education.

[24] We follow a supply-driven approach, as it aligns more closely with the evidence documented in the literature. In Brazil, the expansion of college education in recent decades has been largely attributed to policy reforms, notably the 1996 education law (see Cox, 2024). Similar trends have been observed in other Latin American countries (see Firpo and Portella, 2019). In contrast, demand-driven explanations—such as skill-biased technological change—are more relevant for developed economies, where they have been associated with rising educational attainment and increasing wage dispersion (e.g., Autor, 2014; Van Reenen, 2011).

its size by approximately 31 percentage points. Thus, according to the model, around 89% of the current size of the informal economy in Brazil can be attributed to limited human capital accumulation compared to a more economically developed benchmark. This result is particularly important because emphasizes the critical role of education in shaping the structure of the aggregate economy.

To shed light on the mechanisms underlying these findings, Table 7 presents several statistics that offer insights into the general equilibrium effects of human capital accumulation. Specifically, the table shows that, in the counterfactual economy, where the average cost of college education is lower, the share of skilled workers in the population increases, while the proportion of unskilled employees decreases relative to the benchmark economy. This shift in the human capital composition of the labor force results in a lower skilled wage and, simultaneously, a higher unskilled wage in equilibrium, leading to a 45.6% reduction in the wage-skill premium.[25] Consequently, the opportunity cost of entrepreneurship rises for non-college-educated individuals while falling for those with a college degree. Put differently, in the general equilibrium, the adjustment in the wage structure induced by a higher college rate encourages entrepreneurship among college-educated individuals while incentivizing paid employment among non-college-educated ones. This pattern is clearly illustrated in panels A-D of Figure 4, which show that, in the equilibrium with higher human capital accumulation, (i) entrepreneurship becomes more prevalent among individuals with tertiary education, and (ii) the distribution of non-college agents becomes more concentrated in paid employment. These effects are also evident in Table 7, which reveals that the observed decline in the overall entrepreneurship rate (from 19.8% to 15.8%) masks a heterogeneous response by education: the rate drops significantly among non-college-educated individuals, from 20.4% to 7.0%, while it increases substantially among their college-educated counterparts, rising from 13.0% to 36.2%.

These opposing effects on entrepreneurship rates contribute to reducing the size of the informal economy through two main channels. On the one hand, since informality in the benchmark economy is predominantly concentrated among less educated entrepreneurs, a decline in the entrepreneurship rate among non-college individuals directly reduces firm informality. This effect is illustrated in panels B and D of Figure 4, which show that, in the counterfactual economy, where the unskilled wage is higher, the share of non-college individuals engaged in informal entrepreneurship declines across all levels of innate talent. By reducing the mass of informal firms operating in the market (from 53.8% to 11.7% of total firms), this effect contributes to the decline in informal production observed in our experiment.

On the other hand, due to the effect of entrepreneurial human capital on firm dynamics discussed in Section 5.1, a higher entrepreneurship rate among individuals with tertiary education−driven by the decrease in skill wages in general equilibrium−promotes the creation of optimally larger firms with stronger incentives to operate formally.[26] This effect is clearly

[25]There is substantial evidence in the literature documenting that changes in the relative labor supply, driven by higher college rates, play a critical role in explaining the declining wage-skill premium observed in several developing countries in Latin America during the 2000s (see, e.g., Soares and Haanwinckel, 2017; Fernández and Messina, 2018; Haanwinckel and Soares, 2021). The predictions of our model are clearly consistent with this evidence.

[26]Empirical support for this mechanism is provided by Cox (2024), who, using Brazilian data, documents

Table 7: The role of human capital

Statistic	Benchmark	Higher Human Capital	No Entrep Human Capital
Education metrics			
College rate (% of population)	7.9%	30.0%	21.2%
Informality metrics			
Size informal economy (% of official GDP)	35.6%	4.1%	18.4%
Informal firms (% of total firms)	53.8%	11.7%	35.9%
Changes relative to benchmark (%)			
(i) Macro aggregates and prices			
Informal production		-78.8%	-38.7%
Official GDP		+42.6%	+20.2%
Measured TFP		+15.0%	+2.8%
Skilled wage		-34.3%	-46.6%
Unskilled wage		+21.0%	+13.9%
Wage skill premium		-45.6%	-53.1%
Entrepreneurial skill premium		-51.3%	-48.0%
(ii) Fiscal metrics			
Fiscal revenues		+43.2%	+18.9%
Tax evasion		-83.8%	-42.4%
Entrepreneurship rates (%)			
Total entrepreneurs in population	19.8%	15.8%	23.7%
Entrepreneurs among college-educated individuals	13.0%	36.2%	4.2%
Entrepreneurs among non-college-educated individuals	20.4%	7.0%	29.0%
Formal entrepreneurs (% of population)	9.1%	13.9%	15.2%
Informal entrepreneurs (% of population)	10.6%	1.8%	8.5%
College-educated formal entrepreneurs (% of formal entrepreneurs)	10.8%	74.6%	5.4%
Workers shares (% of population)			
Total workers	80.2%	84.2%	76.3%
Skilled workers	6.9%	19.1%	20.3%
Unskilled workers	73.4%	65.1%	55.9%

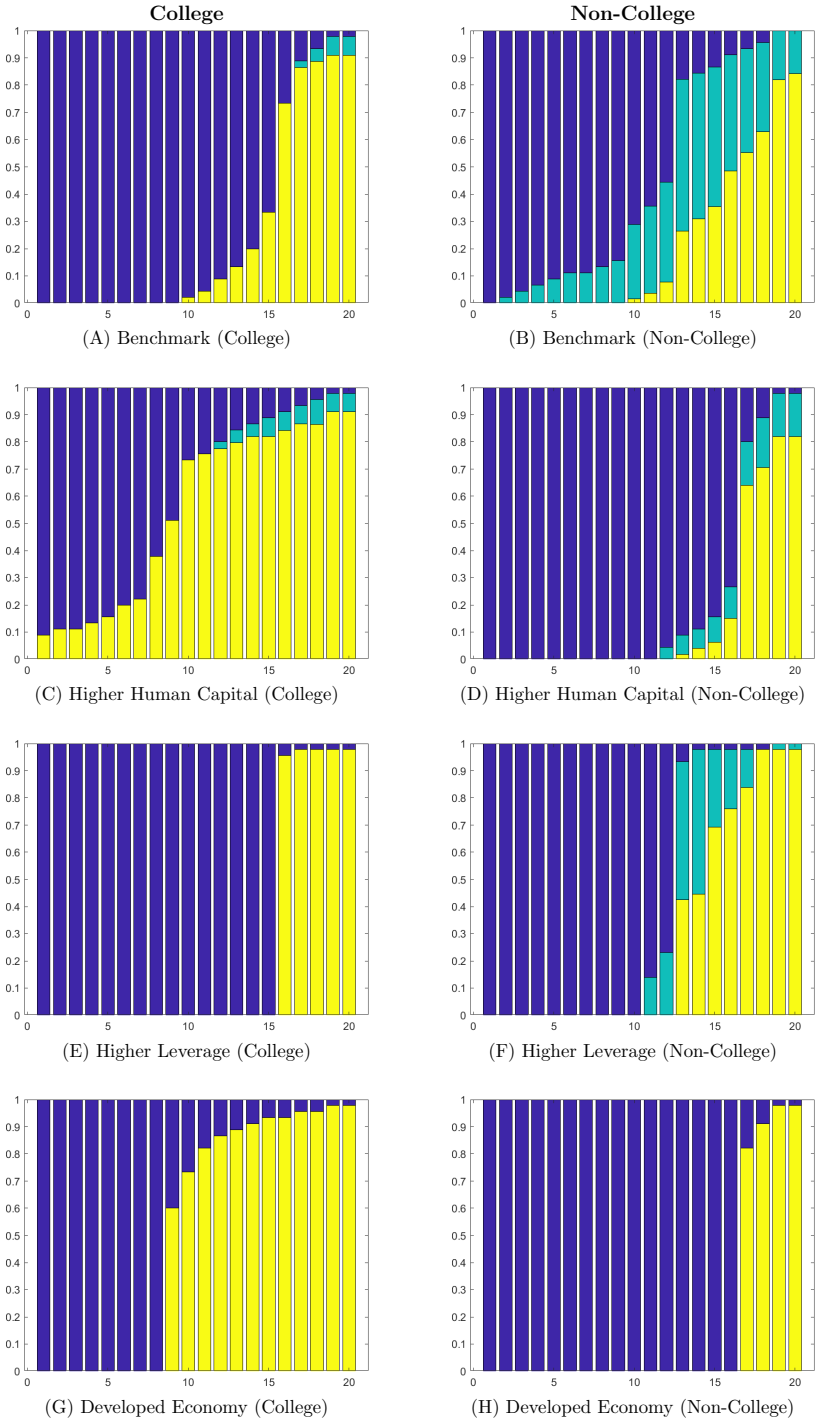
illustrated in panels A and C of Figure 4, which show that, in the counterfactual economy, the share of college-educated individuals engaging in formal entrepreneurship increases across all levels of innate ability compared to the benchmark equilibrium. By boosting formal production, these distributional shifts further contribute to the decline in the size of the informal sector.

In addition to the above channels, facilitating individuals' access to college education reduces the extensive margin of informality through two other mechanisms. First, in our model, formal firms are larger in size relative to informal firms and, as a result, rely more heavily on skilled labor due to capital-skill complementarity. Consequently, by reducing the relative production costs, the decline in the wage-skill premium observed in the counterfactual equilibrium strengthens entrepreneurs' incentives to formalize their businesses, particularly among agents with high managerial ability. This general equilibrium mechanism explains why, in our experiment, despite the increase in the unskilled wage, formalization rates increase not only among college-educated individuals but also among highly talented managers who have not completed tertiary education, as illustrated in panels B and D of Figure 4.

Second, a higher college rate in the population increases the share of individuals with enhanced managerial abilities in the economy. These agents accumulate higher entrepreneurial human capital compared to their non-college-educated counterparts in the benchmark equi-

that an increase in college attainment within the population leads to a rise in the total number of large firms.

Figure 4: Distribution of college and non-college individuals across occupations.



(A) Benchmark (College)
(B) Benchmark (Non-College)
(C) Higher Human Capital (College)
(D) Higher Human Capital (Non-College)
(E) Higher Leverage (College)
(F) Higher Leverage (Non-College)
(G) Developed Economy (College)
(H) Developed Economy (Non-College)

Notes: The figure shows the distribution of individuals across occupations by innate ability, distinguishing between college graduates (left column) and non-college individuals (right column). Yellow, turquoise, and dark blue represent the share of formal entrepreneurs, informal entrepreneurs, and workers, respectively. Panels A and B depict the benchmark economy. Panels C and D represent the counterfactual scenario with cheaper access to college education ("Higher Human Capital"), while panels E and F illustrate improved credit access ("Higher Leverage"). Panels G and H show the scenario combining both better access to credit and improved access to college education ("Developed Economy").

librium and, therefore, as discussed in Section 5.1, face lower expected returns from tax evasion when engaging in entrepreneurship. By fostering firm formalization (see Panel C of Figure 3), this mechanism further contributes to reducing the size of the informal economy in the counterfactual equilibrium.

Beyond their impact on aggregate informal production and measured GDP, the importance of the above channels in promoting formal entrepreneurship is clearly illustrated in Table 7, which shows an increase in the share of formal entrepreneurs in the population from 9.1% to 13.9%. Additionally, the critical role of entrepreneurial human capital in reducing the extensive margin of informality is evident in the substantial rise in the proportion of college-educated individuals among formal entrepreneurs, which grows from 10.8% in the benchmark economy to 74.6% in the counterfactual scenario. Moreover, the table highlights a significant decline in the share of informal entrepreneurs in the population, dropping from 10.6% to 1.8%. These findings indicate, among other things, that the proportion of individuals under-reporting income to fiscal authorities decreases as human capital levels rise in the economy, leading to an 83.8% reduction in tax evasion. This effect, coupled with the expansion of formal production, generates substantial fiscal gains, with total government revenues increasing in the long run by 43.2%.[27]

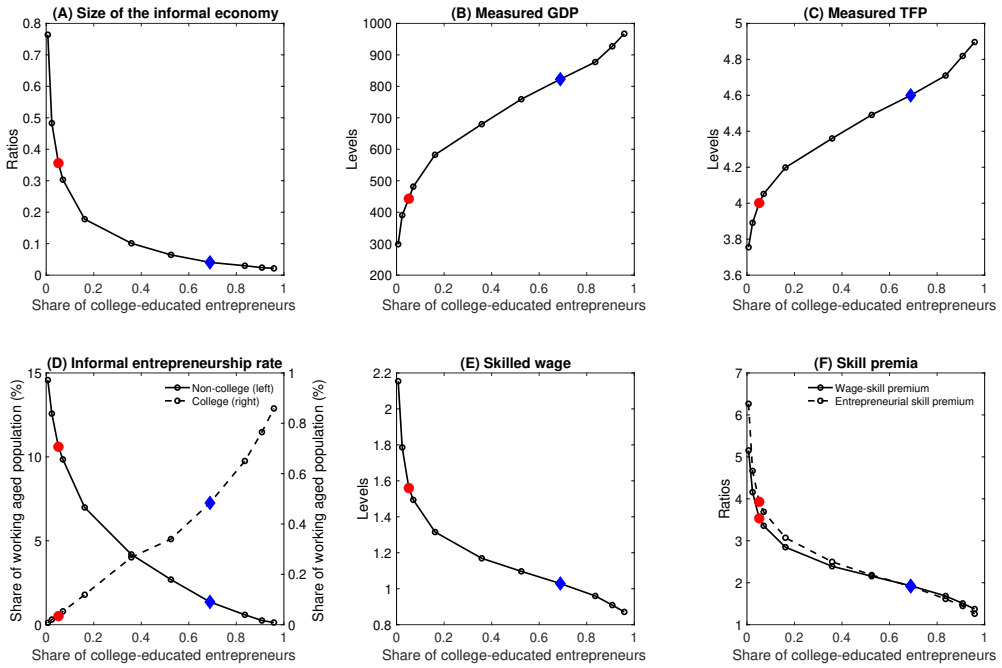
To conclude, it is important to highlight that, despite the quantitatively significant effects discussed so far, the model suggests that increasing the college rate to the level observed in the U.S. economy alone is not sufficient to completely eliminate firm informality in Brazil. As shown in Table 7, in the economy with higher human capital, 11.7% of firms remain informal. This persistence is further illustrated in panels A-D of Figure 4, which show that, in the counterfactual economy, informality remains present among non-college-educated entrepreneurs and even increases among educated managers with high innate talent. These findings are primarily due to financial frictions, which are still present in the counterfactual economy with cheaper access to college education. As discussed in Section 5.1, with limited access to credit, highly talented entrepreneurs with low financial wealth may decide to start their firms informally and take advantage of tax evasion as a more efficient way to accumulate assets compared to paid employment. This behavior is independent of the average cost of education and, therefore, persists in the counterfactual scenario. Furthermore, the decline in the skilled wage in the general equilibrium strengthens this incentive for college-educated entrepreneurs in the upper part of the innate ability distribution. As a result, firm informality persists in the counterfactual economy, and, moreover, informality rates increase among highly talented individuals with a college education.

To evaluate the robustness of these predictions, we conduct an additional experiment by computing the long-run equilibrium for various values of the parameter governing the average cost of education, $\bar{\kappa}$, while holding all other parameters at their calibrated values. Figure 5 presents the results, illustrating how key macroeconomic aggregates and prices respond to changes in the average cost of education.[28] To facilitate comparison with the data discussed

[27]From the perspective of fiscal policy, these results are particularly interesting because they show that, in developing countries, an education reform that facilitates access to college education can be highly effective in combating tax evasion and firm informality. In this regard, our analysis complements and extends the findings of Soares and Haanwinckel (2017), who suggest that improvements in the labor force's schooling and skill level may be a very effective policy in reducing labor informality in developing countries.

[28]For the sake of comparison, the figure also highlights equilibrium values for the calibrated benchmark

Figure 5: Cost of college education and the aggregate economy



Notes: In each panel, a red circle refers to values in the calibrated benchmark economy, whereas a blue diamond refers to the counterfactual equilibrium with a population college rate of 30%.

in Section 2, the figure plots steady state values against the share of college-educated entrepreneurs, which increases monotonically with $\bar{\kappa}$. Two main results emerge. First, the experiment confirms that increasing college attainment alone is insufficient to eliminate firm informality (see panel A), which persists even in an economy where nearly all entrepreneurs are college educated. The figure shows that this outcome is driven by the rising rate of informal entrepreneurship among college-educated individuals as the cost of education decreases (panel D). Combined with the monotonically declining trend in skilled wages (panel E), this finding confirms the above discussion regarding the primary role of financial frictions in sustaining firm informality in an economy with widespread educational attainment. Second, Figure 5 generalizes the insights from our counterfactual exercise, highlighting a robust negative relationship in the model between the size of the informal economy and the share of college-educated entrepreneurs. This result aligns perfectly with the cross-country evidence documented in Section 2, which shows that countries characterized by lower educational attainment among entrepreneurs also tend to have larger informal sectors (see Figure 2).

5.2.2 Official GDP and measured TFP

An interesting result of the above experiment is the significant impact of higher human capital on Brazil's official GDP, which increases by 42.6%. Additionally, measured TFP rises

economy and the counterfactual economy with a college rate of 30% in the population.

substantially−by 15.0%−as shown in Table 7.[29] The mechanisms driving the increase in official GDP have been discussed in the previous subsection. Regarding the rise in aggregate TFP, several margins operate in different directions. On the one hand, there is a substantial increase in formal entrepreneurship among college-educated individuals, which boosts aggregate productivity. On the other hand, this expansion is accompanied by a decline in the average ability of college-educated entrepreneurs, as shown by comparing the yellow areas in Panels A and C of Figure 4. In contrast, as shown in Panels B and D, the average ability of formal non-college-educated entrepreneurs increases, as higher unskilled wages raise the opportunity cost of entrepreneurship for lower-ability individuals, prompting them to remain unskilled workers throughout their entire careers. As reported in Table 7, the net effect of these opposing forces is a sizable improvement in aggregate productivity.

Figure 5 illustrates that the positive effects on official GDP and measured TFP remain robust across different values of $\bar{\kappa}$, the parameter governing the average cost of education. In particular, Panels B and C show a positive relationship in the model between the share of college-educated entrepreneurs and both official GDP and measured TFP. This pattern aligns with a well-established literature that documents a positive correlation between human capital, GDP per capita, and aggregate productivity (see, e.g., Benhabib and Spiegel, 1994).

To assess the role of informality in shaping these relationships, Table 8 reports results from a version of the model with perfect tax enforcement.[30] We find that informality amplifies the gains from a higher college completion rate in terms of both GDP per capita and TFP. In particular, comparing Tables 7 and 8, we find that official GDP rises by roughly 5 percentage points more in the model with informality, and the effect on TFP is nearly twice as large as in the perfect tax enforcement framework.

These effects are driven by the formalization of production activities that, in the equilibrium with a higher average cost of education, were concealed from fiscal authorities by non-college-educated informal entrepreneurs. This channel triggers an extensive margin effect that amplifies the response of GDP and TFP to improved access to college education. The mechanism operates as follows. In an economy with a higher college attainment rate, formal production expands as a larger number of large formal firms—managed by college-educated entrepreneurs—enter the market. In contrast, in the model with perfect tax enforcement, non-college-educated entrepreneurs were already operating formally. As a result, easier access to college does not reallocate production from the informal to the formal sector, thereby attenuating the aggregate gains in output and productivity.

A related finding is that, in the economy with higher human capital, the entrepreneurial earnings skill premium is lower than in the benchmark equilibrium, declining by 51.3% (see Table 7).[31] This effect is clearly driven by the heterogeneous self-selection of innate talent into

[29]Measured TFP in the model is defined as $TFP = Y\left(\left[\mu Lu^{\theta} + (1-\mu)(\iota K^{\rho} + (1-\iota)Ls^{\rho})^{\frac{\theta}{\rho}}\right]^{\frac{1-\eta}{\theta}}\right)^{-1}$, where Y, K, Lu, and Ls refers to, respectively, total output, total capital, total unskilled labor, and total skilled labor. All variables are aggregate measures in the formal sector.

[30]The equilibrium in the economy with perfect tax enforcement is computed by setting the penalty surcharge factor $s = \infty$ in the benchmark model. To ensure comparability, the parameters λ and $\bar{\kappa}$ are adjusted so that the steady-state credit-to-GDP ratio and the college attainment rate match their calibrated values in the benchmark economy with informality, while all other parameters remain fixed.

[31]In Brazil, data from PNAD 2003 and PNAD 2012 indicate that the entrepreneurial earnings skill

Table 8: Model with perfect tax enforcement

Statistic	Benchmark	Higher Human Capital
Education metrics		
College rate (% of population)	8.1%	30.0%
Changes relative to benchmark (%)		
(i) Macro aggregates and prices		
Official GDP		+37.9%
Measured TFP		+8.1%
Skilled wage		-34.9%
Unskilled wage		+23.2%
Wage skill premium		-47.2%
Entrepreneurial skill premium		-49.7%
(ii) Fiscal metrics		
Fiscal revenues		+35.5%
Entrepreneurship rates (%)		
Total entrepreneurs in population	17.1%	15.1%
Entrepreneurs among college-educated individuals	13.8%	35.8%
Entrepreneurs among non-college-educated individuals	17.4%	6.3%
College-educated formal entrepreneurs (% of formal entrepreneurs)	6.5%	70.9%
Workers shares (% of population)		
Total workers	82.9%	84.9%
Skilled workers	7.0%	19.2%
Unskilled workers	75.9%	65.6%

entrepreneurship across education levels. Specifically, while the average ability of college-educated formal entrepreneurs decreases, that of their non-college-educated counterparts increases. As shown in Tbale 7, these opposing shifts in entrepreneurial ability result in a quantitatively important reduction in the entrepreneurial average earnings skill premium.

In summary, our model highlights the crucial role of human capital in shaping the economic structure—a mechanism that leads to significant adjustments in GDP per capita and aggregate TFP. Panels B and C in Figure 5 further show that these effects are quantitatively more pronounced when the initial share of college-educated entrepreneurs is low, underscoring the importance of human capital accumulation for economic development in countries with lower educational attainment.

5.2.3 Entrepreneurial human capital

In our model, both workers and entrepreneurs accumulate human capital through college attendance. As such, the results discussed so far reflect the combined aggregate effects of a higher college attainment rate on informality and other key macroeconomic outcomes. While the role of the skill composition of the labor force in economic development has been extensively studied (see, e.g., Allub *et al.*, 2023; Haanwinckel and Soares, 2021), the contribution of entrepreneurial human capital to firm dynamics—though well-documented empirically (Queiró, 2021)—has received comparatively less attention in quantitative macroeconomic

premium declined by nearly 30%. As documented by Fernández and Messina (2018) and Haanwinckel and Soares (2021), this period was also marked by a substantial increase in the college attainment rate.

models.

In this section, we isolate the quantitative importance of entrepreneurial human capital accumulation in driving the results discussed above by conducting a counterfactual experiment. Specifically, we reassess the effects of improving access to college—by reducing the parameter $\bar{\kappa}$—under the assumption that tertiary education does not enhance managerial ability, implemented by setting $\psi = 0$. The contribution of entrepreneurial human capital can then be isolated by comparing the resulting steady-state equilibrium to that of the counterfactual scenario featuring both improved access to college and enhanced managerial ability (i.e., $\psi > 0$), which we refer to as *the higher human capital economy*.[32]

The results of this experiment are presented in the third column of Table 7. Without entrepreneurial human capital accumulation, the model predicts an informal sector size equal to 18.4% of official GDP—a considerably smaller reduction compared to the higher human capital economy, where informality falls to 4.1%. Accordingly, the difference of approximately 14 percentage points captures the contribution of entrepreneurial human capital to the overall decline in firm informality driven by increased college attainment. Relative to the benchmark calibrated model, this finding suggests that limited entrepreneurial human capital is a key driver of firm informality in Brazil, accounting for roughly 40% of the actual size of the informal sector.

To build intuition for the significant role of entrepreneurial human capital, note that in the model without this channel—just as in the higher human capital scenario—a lower average cost of college still shifts the skill composition of the labor supply, resulting in a 53.1% decline in the wage-skill premium.[33] Given capital-skill complementarity in production, the increased supply of skilled labor leads to greater capital utilization. The resulting increase in average firm size reduces incentives to operate informally, thereby boosting formal output. This mechanism is further amplified by the rise in the unskilled wage (+13.9%), which increases the cost of informal production−since it is more intense in unskilled labor−and contributes to a decline in aggregate informal output. As a result, the size of the informal sector shrinks in response to a lower average cost of education.

However, although these mechanisms operate similarly in the higher human capital economy, when $\psi = 0$, the incentive for entrepreneurs to acquire a college degree is significantly weakened, as tertiary education no longer enhances managerial ability. In this counterfactual economy, the only benefit of college arises from the wage-skill premium. This is reflected in the markedly low entrepreneurship rate among college-educated individuals—just 4.2%, compared to 36.2% in the scenario with entrepreneurial human capital. Conversely, the entrepreneurial rate among non-college-educated individuals rises to 29.0%, compared to 7.0% in the higher human capital economy. As a result, entrepreneurship remains heavily concentrated among less-educated individuals, where firm informality is most prevalent.

This composition effect leads to a substantially milder decline in informal activity, which

[32]To facilitate comparison between the two frameworks, in the model without entrepreneurial human capital accumulation we set $\bar{\kappa}$ to the same level used in the counterfactual scenario with $\psi > 0$, which, as discussed in the previous section, yields a college attainment rate equal to that observed in the U.S. economy. All remaining parameters are kept fixed at their calibrated values.

[33]All changes in the third column of Table 7 are computed relative to a counterfactual economy with $\psi = 0$ and $\bar{\kappa}$ set to its benchmark value, in order to isolate the effect of improved access to college education in an economy without entrepreneurial human capital.

falls by only 38.7%, compared to 78.8% in the higher human capital scenario. Similarly, the share of informal firms declines to 35.9%, as opposed to 11.7% when entrepreneurial human capital is present. As a result, the proportion of individuals under-reporting income to fiscal authorities also decreases less sharply, resulting in a smaller reduction in tax evasion (42.4% vs. 83.8%). These effects are further reinforced by the much lower share of educated formal entrepreneurs among all formal entrepreneurs—just 5.4% in the absence of entrepreneurial human capital, compared to 74.6% with it. This disparity translates into significantly weaker gains in official GDP (20.2% vs. 42.6%) and aggregate TFP (2.8% vs. 15.0%). Furthermore, the more limited expansion of formal activity results in smaller fiscal gains, with total government revenues rising by only 18.9%, compared to 43.2% in the higher human capital economy.

Altogether, these results highlight the critical role of entrepreneurial human capital accumulation not only in shaping firm informality but also in driving gains in official GDP and aggregate TFP. In other words, accounting for the role of entrepreneurial human capital in firm dynamics amplifies the aggregate returns to education by enhancing firm productivity. This finding underscores the potentially crucial role of cross-country differences in entrepreneurial human capital accumulation in explaining disparities in income per capita and aggregate productivity.

5.3 Interaction between human capital and credit

A large body of literature emphasizes the critical role of financial frictions in shaping firm informality (see, e.g., Amaral and Quintin, 2006; Antunes and Cavalcanti, 2007; Quintin, 2008; D'Erasmo and Boedo, 2012; Franjo *et al.*, 2022). In this section, we examine how this relationship interacts with the population educational attainment, given that both credit constraints and limited human capital are pervasive features of developing economies (Buera *et al.*, 2011; Barro and Lee, 2013).

To explore this interaction, we consider two counterfactual scenarios. In the first, we examine the implications of a permanent improvement in credit contract enforceability, implemented by increasing the parameter governing the severity of borrowing constraints, λ. In the second, we jointly increase λ and reduce $\bar{\kappa}$, capturing a setting in which access to credit and college education improve simultaneously. In both scenarios, λ is increased to raise the long-run credit-to-GDP ratio to the level observed in the U.S. economy. This value is taken from the World Bank's Financial Structure Database, which reports an average private credit-to-GDP ratio of 1.6 for the U.S. over the period 1991–2015 (Beck *et al.*, 2000). In the second counterfactual, $\bar{\kappa}$ is reduced—following the procedure in Section 5.2—to match the college attainment rate in the U.S. economy. All other parameters are held fixed at their calibrated values.

Several key statistics from these experiments are reported in the third and fourth columns of Table 9.[34] We label the counterfactual with a higher credit-to-GDP ratio as *"Higher Leverage"*, and the scenario combining higher leverage with enhanced human capital as *"Developed Economy"*. The distribution of occupational choices by education level in these

[34]To facilitate comparison, the second column of Table 9 reproduces the results from the higher human capital experiment discussed in Section 5.2.

two scenarios is illustrated in Panels E and F—for the case with increased λ—and Panels G and H—for the joint increase in λ and reduction in $\bar{\kappa}$—of Figure 4.

As shown in the third column of Table 9, relaxing collateral constraints has a substantial impact on all informal sector aggregates. Specifically, relative to the benchmark economy, both the share of informal firms and the proportion of informal entrepreneurs in the population decline, leading to a 55.1% reduction in aggregate informal output. At the same time, the share of formal entrepreneurs increases by approximately 4 percentage points, contributing to an 8.5% rise in official GDP. As a result, the informal economy shrinks from 35.6% to 12.2% of official GDP in the counterfactual scenario.

To build intuition for these results, note that relaxing the collateral constraint has an asymmetric effect on formal and informal entrepreneurs. While formal entrepreneurs gain improved access to external credit, informal entrepreneurs remain in financial autarky. This asymmetry strengthens the incentive to operate formally, especially among highly productive individuals. With looser borrowing constraints, productive entrepreneurs face a choice between managing a small informal business or scaling up a larger formal enterprise. In this context, the prospect of operating at a more efficient scale can be sufficiently attractive to justify compliance with business regulations, even during the entry phase. Crucially, this incentive applies to more productive individuals regardless of their education level. This outcome is clearly visible in Panels E and F of Figure 4, which show a sharp decline in the share of informal entrepreneurs across the entire upper range of the ability distribution, relative to the benchmark (Panels A and B). At the aggregate level, these changes reallocate resources from informal to formal producers, shifting activity toward more productive entrepreneurs. This reallocation drives an increase in total formal output and a decline in informal production.

Additionally, better access to credit substantially increases the demand for capital in the economy, leading to a notable rise in the capital rental rate. Due to capital-skill complementarity in production, this effect also boosts the demand for skilled labor, which—combined with the decline in informal output—results in a 7% increase in the skilled wage and in a 0.6% decrease in the unskilled wage.

There are several general equilibrium effects induced by these changes in factor prices. First, the relative cost of formal production—which relies more intensively on skilled labor—increases, thereby partially dampening the gains in official GDP generated by improved access to credit.[35] Second, the absolute cost of entrepreneurship rises, regardless of a firm's formalization status. In addition to the above reallocation mechanism involving more productive individuals, this effect also reduces the attractiveness of informal entrepreneurship among non-college-educated agents with low managerial abilities. For these individuals, the increase in input costs outweighs the modest decline in the unskilled wage, leading them to optimally switch to paid employment under looser borrowing constraints (see Panels F and B of Figure 4). Third, the simultaneous decline in unskilled wages and the rise in

[35]This result aligns with Allub *et al.* (2023), who show that output gains from financial development are more modest in economies with low educational attainment and low TFP. In our framework, which features human capital accumulation and capital-skill complementarity, the GDP response to relaxed collateral constraints is substantially milder compared to findings in the financial development literature that abstracts from human capital. See, for example, Buera *et al.* (2011), Buera and Shin (2013), or Allub and Erosa (2019).

Table 9: Experiment Results

Statistic	Benchmark	Higher Human Capital	Higher Leverage	*Developed Economy*
Credit and education metrics				
Credit-to-GDP (%)	41.3%	50.9%	159.0%	160.0%
College rate (% of population)	7.9%	30.0%	7.9%	30.2%
Informality metrics				
Informal economy size (% of official GDP)	35.6%	4.1%	12.2%	0.0%
Informal firms (% of total firms)	53.8%	11.7%	27.3%	0.0%
Changes relative to benchmark (%)				
(i) Macro aggregates and prices				
Informal production		-78.8%	-55.1%	-100.0%
Official GDP		+42.6%	+8.5%	+54.3%
Measured TFP		+15.0%	+7.4%	+19.3%
Capital rental rate		+11.3%	+112.3%	+133.2%
Skilled wage		-34.3%	+7.0%	-32.8%
Unskilled wage		+21.0%	-0.6%	+22.1%
Wage skill premium		-45.6%	+7.6%	-45.0%
Entrepreneurial skill premium		-51.3%	-2.5%	-52.9%
(ii) Fiscal metrics				
Fiscal revenues		+43.2%	+8.8%	+55.0%
Tax evasion		-83.8%	-62.7%	-100.0%
Entrepreneurship rates (%)				
Total entrepreneurs in population	19.8%	15.8%	17.4%	12.9%
Entrepreneurs among college-educated individuals	13.0%	36.2%	10.8%	30.1%
Entrepreneurs among non-college-educated individuals	20.4%	7.0%	18.0%	5.5%
Formal entrepreneurs (% of population)	9.1%	13.9%	12.7%	12.9%
Informal entrepreneurs (% of population)	10.6%	1.8%	4.8%	0.0%
College-educated formal entrepreneurs (% of formal entrepreneurs)	10.8%	74.6%	6.7%	70.3%
Workers shares (% of population)				
Total workers	80.2%	84.2%	82.6%	87.1%
Skilled workers	6.9%	19.1%	7.1%	21.1%
Unskilled workers	73.4%	65.1%	75.5%	65.9%

relative formal production costs leads to a persistence of informality among mid-skilled, non-college-educated individuals. This is reflected in the modest drop in the entrepreneurship rate for non-college-educated individuals—only 2 percentage points in the higher leverage scenario—alongside a still-high 27.3% share of firms operating outside the formal sector. Finally, the increase in the skilled wage incentivizes paid employment among college-educated individuals reducing the share of college-educated formal entrepreneurs among all formal entrepreneurs from 10.8% in the benchmark economy to 6.7% in the counterfactual with improved credit access.

Most importantly, the last column of Table 9 shows that the effects of easing financial frictions are substantially reshaped when combined with improved access to college education. In particular—and in contrast to the results discussed so far—we find that, in the *"Developed Economy"* scenario, firm informality is entirely eradicated. This outcome is not merely an amplification of previous effects, but rather the result of a fundamental change in the underlying general equilibrium effects driving formalization. First, better access to credit enables financially constrained but highly-talented college-educated individuals to open their businesses in the formal sector, without having to transition through informality to overcome borrowing constraints. Second, enhanced access to college education raises unskilled wages, thereby making informal entrepreneurship a less attractive option for non-college-educated individuals. These channels are clearly reflected in Table 9, which shows that the share of entrepreneurs among non-college individuals drops sharply from 18.0% in the *"Higher*

Leverage" scenario to just 5.5% in the *"Developed Economy"*, while among college-educated individuals it increases from 10.8% to 30.1%. As shown in Panels G and H of Figure 4, these two forces jointly eliminate the residual informality that persists when access to either credit or education is improved in isolation.

Beyond the complete eradication of firm informality, our results show that the long-run gains in terms of per capita GDP, TFP, and fiscal revenues observed in the *Higher Human Capital* scenario are substantially amplified when improved access to college education is combined with better functioning financial markets. For instance, in the *Developed Economy* counterfactual, official GDP and measured TFP rise by an additional 12 and 5 percentage points, respectively, compared to the *Higher Human Capital* economy. These findings clearly highlight the critical importance for developing countries of addressing financial and educational barriers jointly in order to foster sustained firm formalization and long-run economic growth.

6 Empirical evidence

In this section, we test model implications using Brazilian data. In particular, we are interested in understanding whether the implications of human capital accumulation on firm informality predicted by the model are consistent with the data. Brazil has seen significant advancements in tertiary education completion rates throughout the 2000s, presenting a compelling case study. Specifically, the proportion of individuals who have completed at least short-cycle tertiary education nearly doubled from 2004 to 2023, while the gross enrollment rate in tertiary education more than tripled between 1999 and 2022 (UNESCO Institute for Statistics (UIS), 2024).[36]

This growth in enrollment can be primarily attributed to the expansion of private for-profit higher education institutions following the 1996 education law, which simplified entry for higher education providers (Cox, 2024). Specifically, private institutions were allowed to operate on a for-profit basis, and the requirements for establishing new colleges were streamlined. Furthermore, as highlighted in Cox (2024), this expansion—driven largely by private institutions—lowered barriers to college attainment in two key ways: by reducing commuting distances and easing capacity constraints. In light of this, the reform provides a natural setting to test whether the model's predictions align with observed patterns of informality in the data.

We structure our empirical analysis using a two-step approach. First, we leverage census data to document a negative correlation between human capital and informality at the municipal level. Furthermore, we show that municipalities with larger increases in college attainment rates have experienced larger reductions in informal entrepreneurship, in line with the predictions of our model. Next, we move beyond correlational analysis to establish a causal link between college attainment and firm informality by employing a difference-

[36]School enrollment in tertiary education is defined as a ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education. The population of the official age for tertiary education is estimated to be the 5-year age group immediately following upper secondary education. If the official entrance age to upper secondary is 15 years and the duration is 3 years, then a is the age group 18-22 years.

in-difference approach. Specifically, following Cox (2024), we exploit the 1996 educational reform, which lowered barriers to college attainment, to identify its impact on informal entrepreneurship. One of the features of this reform is that the expansion of higher education in Brazil was primarily driven by for-profit institutions, making college entry largely dependent on market forces rather than centralized planning. This setting allows us to classify areas into high- and low-intensity exposure to higher education, based on the potential demand for college education, following the approach of Duflo (2001). Leveraging variation in both age and geographical exposure to excess college entry, we find that individuals in areas with relatively higher college entry rates were less likely to engage in informal entrepreneurship. These results further support the implications of our model.

6.1 Reduced form evidence

In the model, there is a negative relationship between college attainment and firm informality. To test empirical plausibility of the relationship, we utilize data from the Brazilian 2000 and 2010 censuses, focusing on the period prior to the effects of the expansion of higher education in 1996 and after.[37] Our findings confirm that this relationship holds at both the municipality and commuting zone levels (*Áreas Mínimas Comparáveis*).[38] In particular, this level of granularity allows us to capture how variations in local educational expansion correspond to differences in informal entrepreneurship.

We compute municipality and commuting zone-level rates of college attainment and informal entrepreneurship among the working-age urban population, and run the following cross-sectional regressions for 2000 and 2010:

$$Infe_{m,t} = \alpha + \beta_1 CollegeShare_{m,t} + \beta_2 log(GDP_{m,t}) + \beta_3 log(Credit_{m,t}) + \epsilon_{m,t} \qquad (9)$$

where $CollegeShare_{m,t}$ denotes rates of college attainment in a municipality (commuting zone) m for year t, $log(GDP_{m,t})$ and $log(Credit_{m,t})$ represent the logarithm of GDP per capita and credit per capita, respectively, for a municipality (commuting zone) m in year t. $Infe_{m,t}$ denotes the rates of informal entrepreneurship in a municipality (commuting zone) m in year t.

Estimation results are presented in Table 10. As observed, there is a strong statistically significant negative relationship between college attainment and informality. In particular, our results indicate that at the municipality (commuting zone) level, after controlling for economic development through GDP per capita and credit availability, a 1 percentage point increase in the college share is associated with a 0.326 (0.271) percentage point decrease in the informal entrepreneurship rate in 2000 and a 0.213 (0.319) percentage point decrease in 2010. Additionally, the negative coefficient on credit per capita suggests that greater

[37] Chamber of higher education of Brazilian Ministry of Education establishes guidelines for completion of higher education degree. In Brazil college attainment requires 4-5 years. The 2000 census was chosen as a reference year because it is sufficiently close to the time of the higher education reform but still precedes the period when the reform's effects would have fully materialized.

[38] As noted by Cox (2024) and Dix-Carneiro and Kovak (2017), commuting zones represent stable and comparable labor markets over time, providing reassurance of the relationship across different geographic units.

Table 10: Negative correlation between rates of informal entrepreneurship and college-attainment (cross-municipality)

	Municipality Level		CZ Level	
	(1)	(2)	(3)	(4)
	Inf Entr Rates	Inf Entr Rates	Inf Entr Rates	Inf Entr Rates
College Rates	-0.326***	-0.213***	-0.271**	-0.319***
	(0.0475)	(0.0339)	(0.113)	(0.0887)
log(Creditpc)	0.000811	-0.00275**	-0.00774*	-0.00400
	(0.00116)	(0.00118)	(0.00415)	(0.00422)
log(GDPpc)	-0.0766***	-0.0573***	-0.0748***	-0.0465***
	(0.00292)	(0.00226)	(0.00572)	(0.00435)
Constant	0.387***	0.357***	0.458***	0.357***
	(0.00771)	(0.00797)	(0.0232)	(0.0260)
Agg. level	Municipality	Municipality	CZ	CZ
Year	2000	2010	2000	2010
N	3223	3426	470	469
F	372.0	441.6	151.2	144.3
r2	0.373	0.347	0.563	0.478

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are reported in parentheses.

credit availability is linked to lower rates of informal entrepreneurship. Overall, these findings support a statistically significant negative relationship between human capital and firm informality across Brazilian municipalities and commuting zones, both before and after the effects of higher educational policies materialized.

We complement our empirical analysis with a further test of the model predictions. According to the model, higher rates of college attainment should lead to a substantial reduction in the size of the informal sector. Consequently, we examine whether municipalities with larger increases in college attainment also experienced larger reductions in informality rates, controlling for changes in economic development and the initial levels of college attainment and informality. To this end, we estimate the following regression model at the municipality (commuting zone) level m:

$$\Delta Infe_m = \alpha + \beta_1 Y_{m,2000} + \beta_2 College_{m,2000} + \beta_3 logCreditpc_{m,2000} + \beta_4 logGDPpc_{m,2000} + \beta_5 \Delta College_m + \beta_6 \Delta logCreditpc_m + \beta_7 \Delta logGDPpc_m + \epsilon_m \quad (10)$$

where $\Delta Infe_m$ represents the change in informal entrepreneurship rates between 2000 and 2010, and $Y_{m,2000}$ denotes the initial rate in municipality (CZ) m in 2000. Results are presented in Table 11. The first row indicates that, after controlling for initial levels of college attainment and GDP per capita, municipalities that experienced larger increases in college

Table 11: Regression coefficients for Equation 10

	(1) Diff Inf Entr		(1) Diff Inf Entr	
Diff College	-0.120***	(0.0386)	-0.194**	(0.0887)
Diff LogCreditpc	0.00182	(0.00147)	0.00924**	(0.00382)
Diff LogGDPpc	-0.00797***	(0.00270)	-0.00175	(0.00554)
Constant	0.0989***	(0.00803)	0.0531***	(0.0200)
Agg Level	Municipality		CZ	
College2000	Yes		Yes	
LogGDPpc2000	Yes		Yes	
LogCreditpc2000	Yes		Yes	
N	3012		466	
F	151.0		46.50	
r2	0.415		0.579	

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are reported in parentheses.

attainment between 2000 and 2010 also saw greater reductions in informal entrepreneurship rates. A similar pattern emerges at the commuting zone level. The observed negative and statistically significant relationship corroborates predictions of the model. While this analysis remains correlational, we take this evidence as additional support for the role of human capital in shaping firm informality.

6.2 Difference-in-difference approach

This section explores the link between human capital and firm informality in a more causal framework. While previous empirical analyses have primarily been correlational, Brazilian data and institutional context provide an opportunity to evaluate the potential causal impact of college attainment on the incentives to operate an informal firm. However, despite the considerable interest, evidence of the causal influence of tertiary education—unlike that of elementary education—on economic development remains limited.[39] A common concern in the literature studying the effects of educational attainment on socio-economic outcomes is the presence of confounding factors (see, e.g., Duflo, 2001; Osili and Long, 2008; Akresh *et al.*, 2022). To address this challenge, studies often rely on quasi-experimental approaches such as regression discontinuity, difference-in-differences, and instrumental variables (Khanna, 2023; Machado *et al.*, 2023).

In line with this, we exploit the quasi-natural experiment created by the 1996 educational reform to assess its impact on the probability of running an informal firm. Our identification strategy leverages variation in exposure to the reform based on individuals' age and place of residence. Since college attendance in Brazil typically occurs between ages 16 and 30, we define the treatment group as individuals aged 16–30, who were exposed to the reform during their prime college years, and the control group as individuals aged 31–45, who were

[39]Notable exceptions include Cox (2024) and Machado *et al.* (2023).

older than the typical college-going age at the time of the reform.

Beyond age-based variation, we also account for geographical differences in treatment intensity. We define place of residence at the level of commuting zones, which serve as relevant geographic units for local labor and education markets.[40] As noted earlier, the expansion of higher education was primarily driven by market demand. Leveraging this feature, we measure the intensity of college entry into commuting zones based on the potential demand for higher education. Using higher education census data from 1995 and 2005, we classify commuting zones into high- and low-intensity treatment areas, following the approach of Duflo (2001). Specifically, we hypothesize that individuals in commuting zones with disproportionately high college entry rates relative to the potential pool of college students are more likely to pursue and complete higher education, thereby reducing their likelihood of engaging in informal entrepreneurship.

6.2.1 Data

We use Brazilian decennial censuses from 2000 and 2010, which provide detailed information on education, migration, demographics, and occupational characteristics (Instituto Brasileiro de Geografia e Estatística (IBGE), 1991, 2000, 2010). To evaluate the outcomes of the educational reform, we use individual-level data on socio-economic and demographic characteristics from the 2010 census. To classify commuting zones into high- and low-intensity treatment groups, we rely on higher education census data from 1995 and 2005 (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP), 1995,2005), which allows us to determine the total number of colleges in each commuting zone. To estimate the potential demand for higher education prior to the reform, we use the 2000 census to approximate the applicant pool at the commuting zone level.[41]

6.2.2 Empirical Specification

To provide an initial benchmark, we begin by estimating an OLS regression at the individual level:

$$Infe_{ij} = \alpha + \boldsymbol{X'_{ij}\theta} + \beta College_{ij} + \phi_j + \epsilon_{ij} \tag{11}$$

where $Infe_{ij}$ is a binary indicator for informal entrepreneurship, equal to 1 if individual i in commuting zone j is an informal entrepreneur and 0 if the individual is a worker or a formal entrepreneur. The key explanatory variable, $College_{ij}$, equals 1 if the individual has completed a college degree. This estimation controls for commuting zone fixed effects (ϕ_j) and a set of individual characteristics, including gender, race, marital status, and whether the individual has always resided in the commuting zone. As shown in Table 12, the OLS

[40] Brazil has experienced an increase in the number of municipalities since 1991. Because we rely on higher education census data from 1995, it is essential to define a stable geographical unit that remains comparable over time. To achieve this, we follow the methodology in Ehrl (2016), which constructs consistent commuting zones. This approach balances geographic granularity with migration dynamics, ensuring that migration flows across commuting zones are minimized within the chosen classification.

[41] The potential applicant pool is defined as the weighted mass of individuals aged 19–33 in 2000 who had completed high school but did not hold a college degree.

Table 12: OLS Regression Results for Equation 11.

	(1) Infe	(2) Infe	(3) Infe	(4) Infe	(5) Infe
College Degree	-0.061***	-0.064***	-0.061***	-0.059***	-0.054***
	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)
Single=1					-0.009***
					(0.001)
White=1					0.013***
					(0.001)
Always lived CZ=1					-0.004***
					(0.001)
Male=1					0.054***
					(0.001)
FE	CZ	UF	CZ	CZ-Age	CZ-Age
Cluster	Robust	CZ	CZ-Age	CZ-Age	CZ-Age
Observations	1,836,554	1,836,554	1,836,554	1,836,554	1,836,553

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are reported in parentheses. Population weights are applied. UF corresponds to state fixed effects.

estimates suggest that individuals with college education are significantly less likely to engage in informal entrepreneurship. However, these results may suffer from endogeneity issues, including self-selection into college and unobserved factors that influence both educational attainment and occupational choice.

To establish a causal relationship between college attainment and firm informality, we employ a difference-in-differences approach, estimating the following equation:

$$Infe_{ij} = \alpha + \boldsymbol{X_{ij}'\theta} + \beta T_i + \gamma(T_i \times HI_j) + \phi_j + \epsilon_{ij} \tag{12}$$

where $Infe_{ij}$ is as defined before. T_i is an indicator for whether an individual belonged to the younger cohort, taking a value of 1 for those aged 16–30 in the reform year, 1997, and 0 for those aged 31–45, who represent the older cohort.[42] HI_j is an indicator of whether a commuting zone j experienced disproportionate entry of colleges relative to the pool of potential college applicants. This estimation controls for commuting zone fixed effects, ϕ_j, and observable individual characteristics, as in the previous regression.

We classify commuting zones (CZs) into high- and low-intensity treatment groups following Duflo (2001), using the residuals from the following regression:

$$C_j = \alpha_0 + \beta StudentPool_j + \epsilon_j \tag{13}$$

[42] 1997 is taken as the reference year since the educational law was passed in 1996, with additional decrees enacted in 1997 that established the foundation for the reform (Cox, 2024).

Table 13: Regression coefficients for Equation 12.

	(1) Infe	(2) Infe	(3) Infe	(4) Infe	(5) Infe
Born 1967-1981=1	-0.036***	-0.028***	-0.036***	-0.035***	
	(0.001)	(0.002)	(0.002)	(0.002)	
HI × Born 1967-1981=1	-0.006***	-0.020***	-0.006***	-0.006***	-0.006***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)
Single=1				-0.009***	-0.008***
				(0.001)	(0.001)
Always lived CZ=1				-0.009***	-0.007***
				(0.000)	(0.000)
Male=1				0.051***	0.051***
				(0.001)	(0.001)
White=1				-0.000	-0.000
				(0.000)	(0.000)
FE	CZ	UF	CZ	CZ	CZ-Age
Cluster	Robust	CZ-Age	CZ-Age	CZ-Age	CZ-Age
Observations	4,345,473	4,345,473	4,345,473	4,345,467	4,345,467

Notes: Significance levels: * 0.10 ** 0.05 *** 0.01. Standard errors are reported in parentheses. Population weights are applied. High-intensity treatment is defined in terms of the number of colleges in 2005. UF corresponds to state fixed effects.

where C_j represents a number of colleges in CZ j in 2005.[43] $StudentPool_j$ is measured as a mass of individuals aged 19-33 years in the year 2000 within commuting zone j who have obtained a high school diploma but have not obtained a college degree. We assign $HI_j = 1$ to commuting zones that experienced an excessive entry of colleges relative to the potential pool of applicants. Specifically, commuting zones with positive residuals from the regression, after controlling for the potential applicant pool, are classified as high-intensity treatment areas.[44]

The estimation results are reported in Table 13. The first row presents the coefficient for exposure (T_i), which captures whether an individual was young enough to be affected by the reform in 1997. The coefficient is negative and statistically significant, suggesting that, all else equal, the younger cohort was 3.5 percentage points less likely to engage in informal entrepreneurship relative to other occupational categories. Our main coefficient of interest, the interaction term between high-intensity exposure and the treated cohort, is also negative and statistically significant across all specifications. This indicates that the decline in informal entrepreneurship was more pronounced among young individuals in high-intensity commuting zones compared to their counterparts in low-intensity commuting zones.[45] Specifically,

[43]As robustness, we use an alternative measure of intensity, defining C_j as a change in the number of colleges between 1995 and 2005. Results are reported in Table C.3 in the Online Technical Appendix C.2.

[44]Figure C.1 in the Online Technical Appendix C.2 plots the spatial distribution of high-intensity commuting zones.

[45]For robustness, we also run the regression for an extended sample beyond occupational categories, defined as workers, formal, and informal entrepreneurs. See Tables C.4 and C.5 in the Online Technical

the magnitude of the effect *relative to the treated cohort* is $0.006/0.035 = 0.1714$, meaning that young individuals in high-intensity areas were 17.14% less likely to engage in informal entrepreneurship compared to their counterparts in low-intensity areas. To provide support to the validity of our method, we assess the plausibility of the parallel trends assumption by conducting placebo tests using fake treatment groups and alternative reform dates. The results, which provide evidence in favor for our identification strategy, are presented in the Online Technical Appendix C.2.1. To summarize, our findings demonstrate that the reform reducing barriers to college attainment led to a decline in informal entrepreneurship, particularly in commuting zones with excessive college entry. Coupled with the results of the reduced form estimations, these findings lend further support to the main predictions of our model.

7 Conclusions

This paper builds a life cycle general equilibrium model to investigate how entrepreneurial human capital—shaped by endogenous education decisions—affects firm informality in developing economies. By embedding capital-skill complementarity and financial frictions into a model of occupational choice under imperfect tax enforcement, we show that access to college education plays a central role in determining the size of the informal sector.

In particular, beyond enforcement and credit constraints, our results underscore that the endogenous distribution of entrepreneurial human capital plays a first-order role in shaping occupational choices and patterns of firm formalization. Calibrated to Brazilian data, the model shows that college-educated individuals are more likely to become formal entrepreneurs running larger, more productive firms, while less-educated individuals are disproportionately represented among informal enterprises.

Importantly, our model highlights a key novel mechanism: entrepreneurial human capital accumulation leads to faster firm growth and larger scale. As firms expand, they face higher detection risk and greater need for access to formal credit, both of which reduce the relative attractiveness of informality. Thus, it is through its impact on firm dynamics that human capital accumulation reshapes occupational choices and drives formalization.

Counterfactual analysis reveals that increasing college attainment to developed-country levels would reduce informality by 31 percentage points, raise official GDP by 43%, and substantially improve productivity and fiscal revenues. However, the model shows that educational improvements alone are insufficient: financial frictions continue to drive informality among educated entrepreneurs unless credit constraints are simultaneously relaxed. Full formalization, therefore, requires simultaneous improvements in access to education and credit markets.

Our findings are supported by empirical evidence from Brazil's 1996 Higher Education Reform, which reduced barriers to entry for private higher education institutions and led to differential expansion of college access across cohorts and regions. Using a difference-in-differences framework, we exploit variation in exposure to the reform—proxied by excess college entry—to show that individuals in more exposed areas were significantly less likely

Appendix C.2.

to become informal entrepreneurs. We also document a negative correlation between college attainment and informality across Brazilian municipalities, both in levels and in growth rates. These results provide empirical validation for the model's main mechanism and confirm that expanding access to higher education is an effective lever for shifting occupational choices away from informality.

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