Insper Instituto de Ensino e Pesquisa
Doutorado em Economia dos Negócios

Vitor Augusto Teixeira Fancio

Essays on Redistribution and Entrepreneuship

São Paulo - SP
2024

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Tese apresentada ao programa de pós-graduação
como requisito parcial para obtenção do título
de Doutor em Economia dos Negócios.

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Essays on Redistribution and Entrepreneuship/ Vitor Augusto Teixeira Fancio. - São Paulo - SP: 2024

73 p.

: Insper Instituto de Ensino e Pesquisa

Doutorado em Economia dos Negócios , 2024.

Orientador: Marcelo Rodrigues dos Santos

1. Taxação ótima 2. Redistribuição 3. Capital humano 4. Prêmio salarial 5. Dinâmica das firmas 6. Empreendedorismo 7. Transferência de renda 8. Desigualdade 9. Desemprego I. Vitor Augusto Teixeira Fancio. II. Essays on Redistribution and Entrepreneurship.

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São Paulo - SP
2024

Agradecimentos

I would like to express my sincere gratitude to those who have contributed to the completion of this dissertation.

First and foremost, I am indebted to my advisor, Marcelo Santos, for his invaluable guidance and unwavering support throughout this process. His expertise and patience were instrumental in shaping this work. I would also like to thank the members of my defense committee, Eduardo Correia, Tomás Martinez, Luciene Pereira, and Fernando Barros, for their insightful feedback and constructive criticism. Their careful review significantly improved the quality of this dissertation.

I am grateful to the faculty and staff at Insper for providing an excellent academic environment. I would especially like to thank the members of DOT03, particularly Caio Bloise, for their camaraderie and support. Additionally, I would like to acknowledge the contributions of all the professors who have imparted their knowledge and wisdom during the Ph.D. program, especially those in the macrofinance area. I would also like to express my appreciation to Leonardo Siqueira for the opportunity to serve in the public sector. I am grateful to my colleagues at the Gabinete at Alesp, particularly those at 'Liderança', for their support and collaboration.

Finally, I would like to dedicate this achievement to my family. The love and support of my parents, Soraia, Claudiney, and Caio, have been essential to my success. I am eternally grateful to my wife, Livia Kuga, for her unwavering belief in me and her constant encouragement.

Resumo

Esta tese investiga os impactos de políticas de tributação e transferência de renda na dinâmica das firmas e trabalhadores e seus efeitos sobre as variáveis macroeconômicas do Brasil e dos Estados Unidos. O Capítulo 1 examina a combinação ótima de taxação progressiva e subsídios educacionais na economia americana. Verifica-se que a combinação ótima dessas duas políticas implica maior progressividade do sistema tributário e maiores subsídios educacionais em relação aos valores atuais da economia americana. Essa combinação leva a um percentual maior de trabalhadores e empreendedores com ensino superior, aumentando o produto, o capital, a produtividade e o bem-estar. O Capítulo 2 analisa a relação entre a educação dos principais gestores e a produtividade total dos fatores (TFP) das empresas brasileiras, considerando diferentes níveis de desagregação industrial. Encontra-se uma correlação positiva para o setor industrial como um todo, e correlações significativamente mais altas para algumas indústrias. Observa-se que a correlação positiva entre a TFP da empresa e a escolaridade do gestor é menor para as indústrias mais dependentes de financiamento externo. Por fim, o Capítulo 3 analisa a transição do sistema atual de transferência de renda para um sistema de renda básica universal (UBI) no Brasil. Verifica-se que o valor da renda básica universal que maximiza o bem-estar implica mover o sistema de transferência atual para um sistema de UBI em que os indivíduos recebem 10% da renda média da economia no benchmark. Além disso, reformas com valores elevados de UBI podem reduzir a acumulação de capital e a oferta de trabalho, levando a um aumento do desemprego e uma diminuição do empreendedorismo.

Palavras-chave: taxação ótima; redistribuição; capital humano; prêmio salarial; dinâmica das firmas; empreendedorismo; transferência de renda; desigualdade; desemprego.

Abstract

This thesis investigates the impacts of taxation and income transfer policies on firm and worker dynamics, as well as their effects on macroeconomic variables in Brazil and the United States. Chapter 1 examines the optimal combination of progressive taxation and educational subsidies in the U.S. economy. We find that the optimal combination of these two policies leads to a more progressive tax system and higher educational subsidies compared to current U.S. values. This combination results in a higher percentage of workers and entrepreneurs with higher education, thereby increasing output, capital, productivity, and overall welfare. Chapter 2 analyzes the relationship between the education level of top managers and the total factor productivity (TFP) of Brazilian firms, considering different levels of industrial disaggregation. A positive correlation is found for the industrial sector as a whole, with significantly higher correlations observed in some two-digit industries. Additionally, at the two-digit level, it is noted that the positive correlation between firm TFP and managerial education is lower in industries more dependent on external financing. Finally, Chapter 3 examines the transition from the current income transfer system to a universal basic income (UBI) system in Brazil. The analysis reveals that the level of UBI maximizing welfare would involve moving the current transfer system to to a UBI system in which individuals receive 10% of the average income of the benchmark economy. Furthermore, reforms involving higher UBI values might reduce capital accumulation and labor supply, potentially increasing unemployment and reducing entrepreneurship.

Keywords: optimal taxation; redistribution; human capital; wage premium; firm dynamics; entrepreneurship; income transfer; inequality; unemployment.

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Sumário

1 Redistribution, Education Subsidies, and Entrepreneurship

1.1 Introduction

Income and wealth inequality are relevant issues in the public debate nowadays, mainly due to the rise in the concentration at the top of the income and wealth distribution[1] in the last decades. Two major groups are disproportionately represented among rich individuals: college agents and entrepreneurs. According to (KUHN; SCHULARICK; STEINS, 2020), in 2019, college-educated individuals accounted for 33.2 percent of the U.S. population and represented approximately 84 percent of the top 5 percent of income earners. Similarly, entrepreneurs accounted for 10.8 percent of the U.S. population and represented 36.2 percent of the top 5 percent of income earners.

The high concentration of income is often associated with the rise in education returns. The usual argument states that the increase in the share of college graduates over the last decades was not able to counterbalance the market demand, increasing the skill premium[2] and, consequently, the income inequality. While extensive literature focuses on the role of workers' education, less attention is given to how entrepreneurs' education may affect inequality and efficiency. Entrepreneurship is important for three main reasons.

First, entrepreneurs hold a disproportional amount of income and wealth, even though they correspond to a small fraction of the population.[3] Second, recent literature ((MUELLER; OUIMET; SIMINTZI, 2017) and (GUVENEN et al., 2019)) has documented that firms can explain part of the increase in inequality; that is, within-firm pay inequality is increasing in firm size, and between-firm inequality accounts for two-thirds of the rise in the variance of earnings. Third, entrepreneurs' education and firms' productivity can be positively correlated (see (QUEIRO, 2018)[4]). Once education and entrepreneurship are relevant channels to explain inequality, public policies regarding redistribution should consider how these two margins interact. Thus, this paper investigates how education subsidies and a progressive tax system affect entrepreneurship and education analyzing their impact on aggregate variables, welfare,

[1] In the United States, from 1977 to 2016, the income held by the top 10 percent of the income distribution grew from 32.5 percent to 47.5 percent according to (KUHN; SCHULARICK; STEINS, 2020).

[2] (BARTSCHER; KUHN; SCHULARICK, 2020) documents that the average income of college households has increased approximately 50% since the 1980s.

[3] According to (CAGETTI; NARDI, 2006), entrepreneurs account from 6% to 12% of the population depending on the definition and own 33.2% to 52.9% of total wealth. (MONDRAGON-VELEZ, 2009) documents that 41% of entrepreneurs have at least a college degree, while 29% of the population have a college education.

[4] Queiró finds that, among Portuguese firms, entrepreneur schooling is positively correlated with firm size at entry and life cycle growth.

income and wealth distribution.

The joint impact of these policies is not trivial in the presence of endogenous entrepreneurship and college decision. On the one hand, education subsidies may increase the share of high-skilled agents, not only workers but also entrepreneurs. Hence, more educated entrepreneurs may lead to more productive firms, increasing efficiency and income inequality, even though the skill premium may decrease due to general equilibrium effects. On the other hand, this impact can enhance redistributive gains from a more progressive tax system since there is a higher share of college entrepreneurs.

We develop a general equilibrium overlapping generation model (OLG) in which agents live a finite number of periods, derive utility from consumption and leisure, decide about education level and make entrepreneurial choices. The education choice happens in the first period of the life cycle when the agent decides whether she goes to college or not. Three main sources of heterogeneity influence this decision: initial asset, innate ability, and labor productivity shock. After the education period, agents make occupational choices; that is, they decide to open a firm or become a worker. Entrepreneurs demand capital, high-skilled, and low-skilled labor. They are heterogeneous with respect to asset and managerial ability. Due to financial frictions, capital demand is limited by the amount of assets the entrepreneur holds. We assume that capital and high-skilled labor are complementary in the production function as in (KRUSELL et al., 2000).

We build a stylized model to explain how the optimal combination of education subsidies and tax progressivity is not trivial in this framework. In a one-period general equilibrium model, individuals face college and entrepreneurial decisions. We assume that college is positively correlated to entrepreneurs' productivity. In this case, both tax progressivity and college subsidy are higher than in the case where only progressivity or college subsidy is implemented, indicating that they are complementary policies. Hence, incorporating occupational choice into the analysis may lead to optimal policies that are different from those identified by (KRUEGER; LUDWIG, 2016), who characterized them as substitute policies.

Then, we consider a full quantitative model calibrated to match the U.S. economy in 2000. The occupation decision introduces distinct returns on capital, which allow us to match the income and wealth distribution of the U.S. economy. We analyze three policy experiments: (i) we range the college subsidy from a system without college subsidy to a fully subsidized system, keeping the benchmark level of tax progressivity; (ii) we range the progressivity system from a flat tax system where all the agents pay the same average tax rate to a system where the progressivity maximizes the welfare in terms of consumption equivalent variation (CEV), keeping the college subsidy at the benchmark level; (iii) we combine the two policies considering the ranges from the previous steps. We find that a fully subsidized system maximizes welfare compared to other subsidy levels in the policy experiment (i). There is a welfare gain of 33.7 percent, driven mainly by an increase in non-college wages leading to an increase in consumption.

In this case, the college premium decreases by 36 percent since the share of college agents increases from 33.4 percent to 52.3 percent. Additionally, there is a change in the composition of entrepreneurs, increasing the share of college entrepreneurs. In case (ii), the welfare-maximizing policy implies the same progressivity level observed in the benchmark economy. When we consider a higher progressive tax system, capital accumulation, and output decrease. In this case, the college premium increases by 5.74 percent as a consequence of a decrease in non-college wages. Therefore, there is a welfare loss of 2.37 percent. Moreover, since average tax rates are higher at the top of the income distribution, there is an increase in income redistribution. The composition of entrepreneurs remains close to the observed in the benchmark. Finally, we observe a welfare gain of 34.58 percent when we combine both policies in case (iii). In this case, the college system is fully subsidized, and the government relies on higher tax progressivity than the benchmark, that is, the policies are complementary. The welfare gain comes from the same channels we observed in the previous experiments, that is, a large increase in non-college wages and a better redistribution from the higher average tax rate at the top of the income distribution. Moreover, the share of college entrepreneurs increases by 2.9 percentage points.

Related Literature

This paper is closely related to two branches of the literature: the optimal design of insurance policies and firm dynamics. First, (HECKMAN; LOCHNER; TABER, 1998) examines the impact of different tax structures and college tuition policies on skill formation. He shows that analyses focusing only on partial equilibrium effects tend to overestimate the influence of human capital. This overestimation is particularly evident when comparing the U.S. economy under a less progressive tax system to analyses incorporating general equilibrium effects. Similarly, (BENABOU, 2003) explores the separate impacts of progressive taxation and education subsidies on aggregate economic variables and income distribution. His quantitative model demonstrates that education subsidies yield greater output gains than tax-and-transfer reforms, although the latter is more effective for providing insurance. More recently, (ABBOTT et al., 2019) examines the role of financial aid in shaping educational decisions and economic outcomes within a fully quantitative framework. They find that the current U.S. federal education loan and grant programs enhance welfare compared to an economy without such policies, increasing college attainment by 5 percentage points in the long run. Our paper closely relates to (KRUEGER; LUDWIG, 2016), who quantified the optimal mix between tax progressivity and education subsidies. Focusing on the U.S. economy, they show that progressive taxation and college subsidies can be substitute policies when considering general equilibrium effects. Specifically, higher education subsidies reduce the college premium, which in turn lowers the optimal level of tax progressivity in a welfare-maximizing reform. Our contribution to this literature lies in incorporating the effects of tax and education reforms not only on workers but also on entrepreneurs. We argue that accounting for entrepreneurship can change the optimal policy mix. In short, our findings suggest that including endogenous entrepreneurship can result in a welfare-maximizing reform characterized by larger education subsidies and larger tax progressivity.

Concerning the second branch of the literature, (QUADRINI, 2000) and (CAGETTI; NARDI, 2006) show the role of entrepreneurship in accounting for the observed income and wealth inequality in heterogenous agents and incomplete market models as (AIYAGARI, 1994). Recent literature explains that there is a link between education and entrepreneurial choices, making the analysis of these two margins important when analyzing distinct policy reforms. In a quantitative with endogenous entrepreneurial choice, (GOMES; KUEHN, 2017) find that education composition and average firm size are positively correlated across countries. They show that the education distribution can explain one-third of the difference in average firm size between the US and Mexico. This indicates that education reforms that enhance college attainment can increase firm size. (SALGADO, 2018) documents the decrease in the population share of entrepreneurs, especially among those with a college degree in the U.S. economy in the last decades. Since education and productivity can be positively correlated (e.g. (GOMES; KUEHN, 2017), (GOMES; KUEHN; ALLUB, 2023), (QUEIRO, 2018)), education subsidies could be an instrument to enhance college enrollment. Despite showing the role of entrepreneurship in macro development models, we contribute to this literature by showing the importance of jointly modeling tax and transfer schedule and education system.

We organize the subsequent sections as follows: Section 1.2 presents the channels through which progressive taxation and education subsidies may affect entrepreneurial and education choices. Section 1.3 describes the economic environment. Section 1.4 describes the calibration and Section 1.5 provides the quantitative analysis. Section 1.6 concludes.

1.2 A Stylized Model

The stylized model provides intuition about how to combine education subsidies and tax progressivity. The main goal is to compare the competitive market solution without government intervention and the Ramsey policy. The Ramsey policy consists of a maximization problem in which, given the competitive market allocations, a utilitarian social planner chooses the insurance parameters (taxation, education subsidy, and transfers in this case) in order to maximize the agents' utility.

In the benchmark economy, agents live one period and have to make decisions about consumption, c, labor supply, ℓ, college attainment, 1_s, and occupation. The decisions depend on the agent's general and entrepreneurial abilities which are independent and given by η and z, respectively. Both abilities follow independent uniform distributions given by $\eta \sim U[0, 1]$ and $z \sim U[0, 2]$. Markets are incomplete; that is, agents cannot insure against drawing a low-ability type.

The government provides college subsidies and transfers given by θ and tr, respectively. It balances the budget constraint by collecting income tax τ. When $\tau, d > 0$ the individuals face a progressive labor income tax schedule.

If the agent decides to be a worker, she receives labor income given by:

$$(1-\tau)\ell(1+1_s\eta)w_s,$$

where 1_s indicates if she went to college or not, and w_s represents the wage per efficient unit of labor. $s = \{c, nc\}$ indicates education, where c stands for college and nc for no-college. Now, if the agent decides to be an entrepreneur, she receives profits given by:

$$(1-\tau)\pi_s(\eta, z), \text{ where}$$
$$\pi_s(\eta, z) = \max_{n_{nc}, n_c}\Big\{z\ell(1+\phi_s\eta)(\alpha n_{nc}^{\sigma} + (1-\alpha)n_c^{\sigma})^{\frac{\gamma}{\sigma}} - w_{nc}n_{nc} - w_c n_c\Big\},$$

where α represents the output share of non-college labor, σ determines the elasticity of substitution between college and non-college input, and γ indicates the decreasing returns to scale of the production function. ϕ_s determines the impact of a college relative to a no-college education on the entrepreneur's productivity.

The individual's maximization problem for the competitive market economy and the optimal fiscal policy of the Ramsey policy are represented below. The income subscript oc indicates if the individual is a worker, $oc = w$, or an entrepreneur $oc = e$.

Competitive Markets

$$\max_{\ell(\eta,z), c(\eta,z), 1_s(\eta,z), oc(\eta,z)} log\left(c(\eta, z) - \rho\frac{\ell(\eta, z)^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}\right) \text{ st.}$$

$$c = y_{oc} + tr - \kappa(1-\theta)1_s, \text{ where}$$

$$\begin{cases} y_w = (1-\tau)\ell(1+1_s\eta)w_s \\ y_e = (1-\tau)\pi_s(\eta, z). \end{cases}$$

Ramsey Policy

$$\max_{\tau,\theta,tr} \iint_{AxZ} log\left(c^*(\eta, z) - \rho\frac{\ell^*(\eta, z)^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}\right) d\eta dz \text{ st.}$$

$$\sum_{s\in\{c\}} \kappa\theta \iint_{AxZ} 1_s d\eta dz = \sum_{oc\in\{w,e\}} \iint_{AxZ} \tau y_{oc}^* d\eta dz + \iint_{AxZ} tr\, d\eta dz$$

where $c^*(\eta, z)$, $y_{oc}^*(\eta, z)$ and $\ell^*(\eta, z)$ are the optimal solutions from the competitive equilibrium problem for a given set of parameters (θ, τ, tr).

We consider the case in which $\phi_c = 0.5$ and $\phi_{nc} = 0.0$, that is, college attainment increases the agent's ability as an entrepreneur. Table 2.3 compares the optimal solutions for the competitive equilibrium and three distinct specifications for the Ramsey policy, considering general equilibrium effects. The *benchmark* case considers that there is no tax progressivity and education subsidy. The *progressivity* specification allows for tax progressivity, but not for education subsidy. The *subsidy* case allows for education subsidy, but not tax progressivity. The last specification, *both*, considers the presence of tax progressivity and education subsidy as policy instruments.

Comparing the optimal results, we see that tax progressivity and education subsidy can be complementary policies. Specifically, the government relies on a higher education subsidy and higher tax progressivity. This can be seen from recognizing that the parameters related to tax progressivity (parameter tr shown in the third column) and education subsidy (parameter θ shown in the second) are higher in the experiment labeled *both* compared to the cases *subsidy* and *progressivity.*

This may occur due to two opposing forces: the decrease in the college premium and efficiency gains. Initially, for a given level of tax progressivity, an increase in education subsidies raises the share of agents with a college degree, thereby reducing the college premium. This reduction in income inequality could make the tax system less progressive. However, the decrease in the college premium also positively impacts productivity. By increasing the share of entrepreneurs with a college degree, it enhances firms' productivity. Since high-skilled entrepreneurs tend to earn higher incomes, the resulting concentration of income among rich individuals allows for a more progressive tax system. Hence, when we account for endogenous entrepreneurship and education, the welfare-maximizing policy may involve both higher tax progressivity and education subsidies, even within a simplified framework that incorporates general equilibrium effects.

Tabela 1.1 – Summary statistics - stylized model

Policy	*tr*	θ	τ	c	$s_{w,nc}$	$s_{w,c}$	$s_{e,nc}$	$s_{e,c}$	w_c/w_{nc}	*gini y*	*gini c*
Benchmark	0.0	0.0	0.0	0.81	42.2	45.7	1.7	10.4	1.41	0.325	0.292
Progressivity	0.20	0.0	0.20	0.75	48.0	39.8	3.1	9.1	1.66	0.361	0.226
Subsidy	0.0	0.16	0.05	0.80	39.8	48.0	1.3	10.9	1.33	0.311	0.289
Both	0.23	0.26	0.30	0.73	44.6	43.3	2.3	9.8	1.52	0.339	0.206

Notes: The parameters/results are given by d: income subsidy, θ: education subsidy, τ: income tax, c: average consumption, $s_{oc,s}$: share of agents in occupation oc with education s; w_c/w_{nc}: college premium in terms of wage efficiency, y: income Gini coefficient pos tax, Gini c: consumption Gini coefficient pos tax.

1.3 Environment

1.3.1 Demography

The economy is inhabited by J overlapping generations. In each period, j, a continuum of new agents is born. Time of death is uncertain so that agents face a probability ψ_{t+1} of surviving to the age $t+1$ conditional on being alive at age t. During the working stage, $j \in \{1, ..., j_r - 1\}$, we assume that $\psi_t = 1$. From retirement onward, $j \in \{j_r, ..., J-1\}$, we assume that $0 < \psi_t \leq 1$ and in the last period, $j = J$, $\psi_t = 0$. The age profile of the population, denoted by $\{\mu_t\}_{t=1}^{T}$, characterizes the share of agents at age j according to the following law of motion $\mu_t = \frac{\psi_t}{1+g_n}\mu_{t-1}$ where g_n represents the population growth with $\sum_{t=1}^{T} \mu_t = 1$ and $\mu_t \geq 0$.

1.3.2 Preferences

Expected utility:

Agents choose consumption, c_t, and labor, ℓ_t, to maximize their expected discounted lifetime utility given by:

$$\mathbf{E}\left[\sum_{j=1}^{J} \beta^{j-1} \left(\prod_{k=1}^{j} \psi_k\right) u(c_j, \ell_j)\right], \tag{1.1}$$

where the instantaneous utility function is

$$u(c, \ell) = \frac{[c^{\upsilon}(1-\ell)^{1-\upsilon}]^{1-\xi}}{1-\xi}, \tag{1.2}$$

the parameter $\beta \in (0, 1)$ is the time discount parameter, and $\mathbf{E}$ is the expectation operator conditional on information at birth.

1.3.3 Career and educational choices

In the first period, agents make the decision about going to college or not. The educational choice happens only in this period, so the schooling level remains the same in the life cycle. Agents make this decision based on three states: initial asset, innate ability, and labor productivity shock. They draw their initial wealth from a log-normal distribution.[5] Agents with a college degree are called skilled workers, as opposed to non-skilled workers. During the education stage, $j \in \{1, ..., 4\}$, agents are only allowed to participate in the labor market. They pay college costs and may receive government subsidies. After the education period, $j \in \{5, ..., j_r - 1\}$, agents can decide to become a worker or an entrepreneur. Finally, there is no occupational choice during the retirement period, $j \in \{j_r, ..., J\}$, and agents receive a pension that is proportional to average earnings according to their education.

[5]We assume that accidental bequest goes to individuals at the first period of the life cycle.

1.3.4 Labor productivity

Each agent has one unit of time endowment and an education[6] level $s \in \{nc, c\}$, where *s*=*c* indicates a college degree, and *s*=*nc* non-college degree. During the education stage, $j \in \{1, ..., 4\}$, an agent at age *j* supplies low-skilled labor $s = nc$, either attending college or not. Hence, earnings are given by,

$$w_{t,s}\ell_t\epsilon_{j,s}e^{u+\eta_{t,s}}, \tag{1.3}$$

where $w_{t,s}$ is the education-specific equilibrium wage; ℓ indicates hours worked; $\epsilon_{j,s}$ represents the deterministic age-efficiency profile; $u \sim N(0, \sigma_u^2)$ is a fixed component drawn in the first period and indicates agent's ability. This ability will also affect the utility cost of attending college. Moreover, η_t is the individual idiosyncratic shock that follows an AR(1) process, $\eta_{t,s} = \rho_{\eta_s}\eta_{t-1,s} + \varepsilon_{t,s}$ with $\varepsilon_{t,s} \sim N(0, \sigma_{\eta_s}^2)$.

After the education period until pre retirement, $j \in \{5, ..., j_r - 1\}$, an agent at age *j* with education $s \in \{nc, c\}$ earns

$$w_{t,s}\ell_t\epsilon_{j,s}e^{\varphi_s+\eta_{t,s}}, \tag{1.4}$$

where $\varphi_s \in \{\varphi_{l,s}, \varphi_{h,s}\}$ denotes agent's ability with $\varphi_s = \varphi_{l,s}$ indicating low ability and $\varphi_s = \varphi_{h,s}$ high ability for an individual with education *s*. Compared to the previous earnings equation (1.3), there is a change in the earnings fixed component. The change from *u* to φ incorporates the uncertainty component associated with a college education.[7] Given education, s, the probability to move from a particular ability level u to $\varphi_{l,s}$ is given by

$$\begin{cases} \pi(\varphi_c = \varphi_{h,c}|u) = g(u) \\ \pi(\varphi_{nc} = \varphi_{h,nc}|u) = \omega g(u), \end{cases}$$

where $g(u)$ is a linear function such that $g(u_{min}) = 0, g(u_{max}) = 1$.

1.3.5 Technology

The firm consists of a single entrepreneur facing decreasing returns to scale technology measured by γ_p, as in (LUCAS, 1978). Each entrepreneur has an idiosyncratic managerial ability z that is drawn from a Pareto distribution with probability density function $\mu(z) = \eta_p z^{\eta_p - 1}$. In each period, with probability γ, the entrepreneur keeps her current ability, and with probability $1 - \gamma$, she draws a new ability from $\mu(z)$. Labor supply ℓ is an element of the production function and is fixed. We assume that education attainment impacts the entrepreneur's productivity by

[6] We consider the terms education and skill as synonymous throughout the paper.

[7] It also allows us to move from the discretized process with fifty grid points (*u*) to a process with two grid points (φ) making computation less costly.

$\phi(s)$, that is, entrepreneurs with a college degree are more productive. The entrepreneur demands capital (*K*), skilled-labor (N_c), and non-skilled labor (N_{nc}). The production function is given by,

$$Y = Bz\ell\phi(s)F(K, N_c, N_{nc}), \tag{1.5}$$

where

$$F(K, N_c, N_{nc}) = \left\{\alpha N_{nc}^{\sigma} + (1-\alpha)\left[\lambda K^{\rho} + (1-\lambda)N_c^{\rho}\right]^{\frac{\sigma}{\rho}}\right\}^{\frac{\gamma p}{\sigma}}. \tag{1.6}$$

The parameter ρ indicates the elasticity of substitution between capital and high-skilled labor and σ determines the elasticity of substitution between low-skilled labor and the combination of capital and high-skilled labor. The parameter α determines the output share of low-skilled labor, and λ determines the output share of capital. B is a productivity parameter common to all firms.

Hence, the profit maximization problem is given by,

$$\pi^e = \max_{N_{nc}, N_c, K} Y - w_{nc}N_{nc} - w_c N_c - (r+\delta)K \quad \text{s.t. } K \leq d\text{a}, d \geq 1, \tag{1.7}$$

where δ is the depreciation rate of capital. The entrepreneur faces a collateral constraint given by *d*, meaning that capital demand is a multiple of the assets held by the entrepreneur, denoted by *a*.

1.3.6 Government sector

The government is responsible for three sources of expenditures: exogenous non-education expenditures, G, endogenous education expenditures, E, and a social security system. In order to finance these expenditures, the government levies taxes on consumption, τ_c, on capital income, τ_k, and on labor/profit income by the following function similar to (HEATHCOTE; STORESLETTEN; VIOLANTE, 2017):

$$T(y) = \max\{y - \lambda_1 y^{1-\tau_1}, 0\}, \tag{1.8}$$

The parameters λ_1 and τ_1 measure the level and progressivity of the tax function, respectively. The tax system is progressive if the average tax rate is strictly increasing for all income levels y, that is, $\lambda_1\tau_1 > 0$. We say that the marginal tax rate is strictly increasing if $\tau_1(1-\tau_1)\lambda_1 > 0$.

Additionally, there is social security tax given by τ_{ss}. The exogenous non-education spending is a share of total output, $G = g_y Y$, and the endogenous education spending is a consequence of equilibrium conditions.

1.3.7 Recursive formulation of individuals' problems

Enrollment and education stage - $j = \{1, ..., 3\}$**:** First, the agent draws $u \sim N(0, \sigma_u^2)$ and $\eta \sim N(0, \sigma_{\eta_{nc}}^2)$ regarding innate ability and idiosyncratic labor productivity shock, respectively.

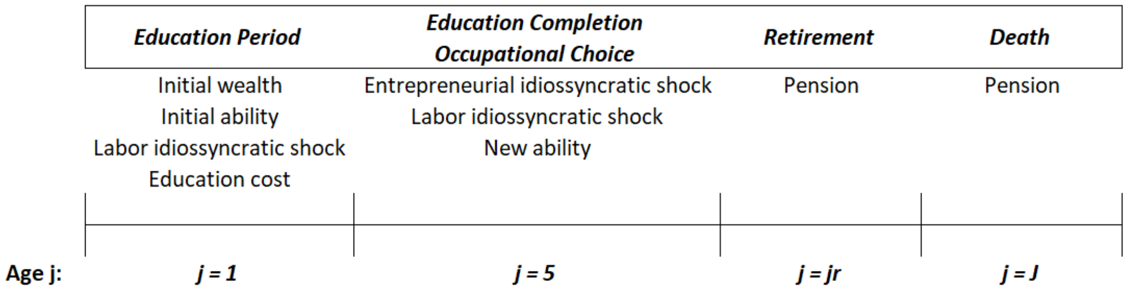

Figura 1.1 – Timeline

Individuals in this period receive non-college wage in the labor market. The agent receives inter-vivos transfers Tr and then decides about education, consumption, labor supply, and asset accumulation. If she decides to go to college, she pays net cost $(1-\theta_{pub})\kappa$, where κ is the total monetary cost and θ_{pub} the subsidy provided by the government. For a particular education level $s \in \{nc, c\}$, the value function of the worker is defined as $V^{s,w}$. The education decision is given by:

$$V_1(a, u, \eta_{nc}) = \max\{V_1^{nc,w}(a, u, \eta_{nc}), V_1^{c,w}(a, u, \eta_{nc})\}$$

where the Bellman equation is defined as follows:

$$V_j^s(a, u, \eta_{nc}) = \max_{c,\ell,a'}\{u(c, 1-\ell-1_s\bar{\ell}(u)) + \beta\psi_j\, \mathbf{E}_{\eta'|\eta}\, V_{j+1}^s(a', u, \eta_{nc}')\},$$

subject to

$$(1+\tau_c)c + a' + 1_s(1-\theta_{pub})\kappa = (1+(1-\tau_k)r)a + (1-\tau_{ss})y - T[(1-\tau_{ss})y] + Tr,$$

where

$$y = w_{nc}\ell\epsilon_{j,nc}e^{u+\eta_{nc}},$$

$$0 \leq \ell \leq 1 - 1_s\bar{\ell}(u),\ \bar{\ell}(u) = \exp(-\lambda_u u),$$

$$a' \geq -\underline{A}_j,$$

where the indicator function 1_s is one if the agent goes to college and zero otherwise. The function $\bar{\ell}(u)$ determines the disutility of attending college, and we calibrate the parameter λ_u to match the share of college graduates.

Pre occupational choice - $j = 4$: In the next period ($j = 5$), the agent starts to make occupational choice so that she may open a firm or stay as a worker. There is uncertainty about her entrepreneurial ability z, which appears in the continuation value. Moreover, she faces uncertainty associated with the change from u to φ.

$$V_j^s(a,u,\eta_{nc}) = \max_{c,\ell,a'}\{u(c,1-\ell-1_s\bar{\ell}(u))+$$

$$\beta\psi_j \mathop{\mathbf{E}}_{\varphi}\mathop{\mathbf{E}}_{z}\mathop{\mathbf{E}}_{\eta'|\eta} \max\{V_{j+1}^{s,w}(a',\varphi_s,z,\eta_s'),V_{j+1}^{s,e}(a',\varphi_s,z,\eta_s')\}$$

subject to

$$(1+\tau_c)c+a'+1_s(1-\theta_{pub})\kappa = (1+(1-\tau_k)r)a+(1-\tau_{ss})y-T[(1-\tau_{ss})y]+Tr,$$

where,

$$y = w_{nc}\ell\epsilon_{j,nc}e^{u+\eta_{nc}},$$

$$0 \leq \ell \leq 1-1_s\bar{\ell}(u),\ \bar{\ell}(u) = \exp(-\lambda_u u),$$

$$a' \geq -\underline{A}_j.$$

Occupational choice stage - $j = \{5,...,j_r-1\}$: agents make occupation decisions. $oc = \{w,e\}$ indicates the choice of becoming a worker or entrepreneur. The Bellman equation in this stage is

$$V_j^{s,oc}(a,\varphi,z,\eta_s) = \max_{c,\ell,a'}\{u(c,1-\ell)+$$

$$\beta\psi_j\{\gamma \mathop{\mathbf{E}}_{\eta'|\eta} V_{j+1}^s(a',\varphi_s,z,\eta_s')+(1-\gamma)\mathop{\mathbf{E}}_{z'}\mathop{\mathbf{E}}_{\eta'|\eta} V_{j+1}^s(a',\varphi_s,z',\eta_s')\}$$

subject to,

$$(1+\tau_c)c+a' = (1+(1-\tau_k)r)a+(1-\tau_{ss})y_{s,oc}-T[(1-\tau_{ss})y_{s,oc}]+Tr,$$

$$y_{s,oc} = \begin{cases} w_s\ell\epsilon_{j,s}e^{\varphi_s+\eta_s} \text{ if } oc = w \\ \pi_s \text{ if } oc = e, \end{cases}$$

$$a' \geq -\underline{A}_j,\ 0 \leq \ell \leq 1.$$

The occupational choice is given by the maximum between the two options.

$$V_j^s = \max\{V_j^{s,e},V_j^{s,w}\}.$$

Retirement period - $j = \{j_r, ..., J\}$: After retirement, there is no occupational choice. As a consequence, the labor supply is zero, and the agent's income is composed of capital income and pension $p(s)$. The Bellman equation is given by

$$V_j^s(a, s) = \max_{c,a'}\{u(c, 1) + \beta\psi_j V_{j+1}^s(a', s)\}, \text{ subject to}$$

$$(1 + \tau_c)c + a' = (1 + (1 - \tau_k)r)a + p(s) + Tr.$$

1.3.8 Recursive competitive equilibrium

Agents at age j are characterized by the state $\varrho_j = (a, \eta, \varphi, z) \in P$ [8]. A recursive competitive equilibrium is given by a list of value functions $V_j(\varrho_j)$; policy functions for consumption $c_j(\varrho_j)$, asset holdings $a'_j(\varrho_j)$, labor supply $\ell_j(\varrho_j)$, education $s_j(\varrho_j)$, and occupational choice $oc_j(\varrho_j)$; aggregate variables K, N_c, N_{nc}, Y; prices r, w_c, w_{nc} and measures $\lambda_j(\varrho_j)$ such that:

1. The value function $V_j(\varrho_j)$ solves the Bellman equations above with the associated policy functions $c_j(\varrho_j)$,$a'_j(\varrho_j)$, $\ell_j(\varrho_j)$, $s_j(\varrho_j)$ and $oc_j(\varrho_j)$, for a given set of prices.
2. The aggregates K, N_c, N_{nc} solve the profit maximization problem for a given set of prices.
3. Good and factor markets clear.

$$K = \sum_{oc\in\{w,e\}}\sum_{s\in\{c,nc\}}\sum_{j=1}^{j_r-1}\mu_j\int_P k_j(\varrho_j)d\lambda_j = \sum_{oc\in\{w,e\}}\sum_{s\in\{c,nc\}}\sum_{j=1}^{J}\mu_j\int_P a'_j(\varrho_j)d\lambda_j,$$

$$L_c = \sum_{j=1}^{j_r-1}\mu_j\int_P n_{c,j}(\varrho_j)d\lambda_j = \sum_{j=1}^{j_r-1}\mu_j\int_P \epsilon_{j,c}e^{\varphi+\eta_c}\ell_c(\varrho_j)d\lambda_j,$$

$$L_{nc} = \sum_{j=1}^{j_r-1}\mu_j\int_P n_{nc,j}(\varrho_j)d\lambda_j = \sum_{j=1}^{j_r-1}\mu_j\int_P \epsilon_{j,nc}e^{\varphi+\eta_{nc}}\ell_{nc}(\varrho_j)d\lambda_j,$$

$$Y = C + G + \delta K + E,$$

where,

$$C = \sum_{oc\in\{w,e\}}\sum_{s\in\{c,nc\}}\sum_{j=1}^{J}\mu_j\int_P c_j(\varrho_j)d\lambda_j,$$

$$E = \sum_{j=1}^{4}\mu_j\int_{P:s=c}\theta_{pub}\kappa d\lambda_j.$$

[8]Agents at age $j < 5$ are characterized by the state $\varrho_{j,1} = (a, \eta, u, s) \in P_1$ and at age $j \geq 5$ $\varrho_{j,2} = (a, \eta, \varphi, z) \in P_2$. For the sake of simplicity, we write the state space as $\varrho_j = (a, \eta, \varphi, z)$.

4. Government budget constraint condition is satisfied.

$$G+\sum_{j=1}^{4}\mu_j\int_{P:s=c}\theta_{pub}\kappa\lambda_j+\sum_{s\in\{c,nc\}}\sum_{j=j_r}^{J}\mu_j\int_P p(s)d\lambda_j$$

$$=\tau_cC+\tau_krK+\sum_{oc\in\{w,e\}}\sum_{s\in\{c,nc\}}\sum_{j=1}^{J}\mu_j\int_P T[(1-\tau_{ss})y]d\lambda_j+\sum_{oc\in\{w,e\}}\sum_{s\in\{c,nc\}}\sum_{j=1}^{j_r-1}\tau_{ss}\mu_j\int_P y_{s,oc}(\varrho_j)\lambda_j.$$

5. Accidental bequests are given by

$$Tr=\sum_{1}^{J}\int_P(1-\psi_j)a'_j(\varrho_j)d\lambda_j.$$

1.4 Quantitative Analysis

1.4.1 Calibration

Model period and age distribution:

Each period in the model maps to one year in the data. We assume that agents enter the economy at the age of 18, retire at 65, and can live up to a maximum of 90 years.

The age distribution of the population, denoted by $\{\mu_j\}_{j=1}^{J}$, is determined by both the population growth rate, g_n, and the survival probabilities, ψ_t. Data on survival probability by age were based on (BELL; MILLER, 2005). Given the survival probabilities, the population growth rate is chosen so that the age distribution in the model replicates the dependency ratio observed in the data. By setting $g_n = 0.0105$, the model generates a dependency ratio of 17.27%, which is close to the dependency ratio observed in the data for the year 2000.

Utility:

We define the coefficient related to risk aversion, ξ, to 4 according to the literature and set υ so that agents work on average one-third of their time endowment over the occupational choice stage. We choose β to target the real interest rate of 4.5%.

Production technologies:

The elasticity of substitution between capital and high-skilled labor and the elasticity of substitution between this component and low-skilled labor follows (KRUSELL et al., 2000). Hence, we set $\rho = -0.49$ and $\sigma = 0.40$, indicating capital-skill complementarity, that is, $\sigma > \rho$. We normalize the productivity parameter common to all, B, firms to one.

We set the parameter λ equal to 0.65 to achieve the capital-output ratio as 2.0. The parameter α is selected to match a college premium of 80 percent. Two parameters relate to entrepreneurship: the span-of-control parameter γ_p is equal to 0.78, aligning with an entrepreneurial share of 7.8 percent, and $\phi(c)$, which is related to the share of entrepreneurs with a college degree, 3.0 percent. Additionally, the borrowing limit d is set to 15.0 to match an external finance-to-output ratio of 1.8. We consider the depreciation rate, δ, as 7.7 percent. This value is consistent with an investment-output ratio equal to 0.25, a capital-output ratio equal to 2.0, and an economic growth rate of 2.3 percent. The Pareto parameter η_p is set to 4.84 to ensure that firms in the top percentile account for 69 percent of total employment.

Stochastic process on labor productivity:

The labor income is given by

$$w_{t,s}\ell_t\epsilon_{j,s}e^{u+\eta_{t,s}},$$

where η_t is the stochastic component that follows an AR(1) process, $\eta_{t,s} = \rho_{\eta_s}\eta_{t-1,s} + \varepsilon_{t,s}$ with $\varepsilon_{t,s} \sim N(0, \sigma^2_{\eta_s})$.

We consider estimates from (KRUEGER; LUDWIG, 2016), in which, for college individuals $\rho_c = 0.969$ and $\sigma^2_{\eta_c} = 0.010$, and for non-college individuals $\rho_{nc} = 0.928$ and $\sigma^2_{\eta_{nc}} = 0.0192$. The deterministic age-efficiency profile, $\epsilon_{j,s}$ captures age and education components that affects wages over the life-cycle. This term results in an inverted U-shapped pattern of wages as a function of age, which varies by education level. We take the estimated parameters from (ABBOTT et al., 2019). We set the standard deviation of initial ability, σ_u, to 0.05 to target the income Gini of 0.43. This term accounts for idiosyncratic factors that affect wages and are determined before individuals enter the labor market.

Education policy:

Total education costs correspond to κ per period in college. Due to subsidies, agents pay only $(1-\theta_{pub})\kappa$, where θ_{pub} represents government subsidies. We do not consider psychic costs.

We compute education costs and subsidies based on *Trends in College Pricing* published by the College Board. Total cost of four-year public and four-year private college were $\$8,439$ and $\$22,239$, respectively, considering tuition and fees in the period 2000-2001. Hence, college education costs on average $\$12,789$ per year.[9] Moreover, the average net college cost is $\$8,952$. Therefore, total subsidies constitute 30.0% of the total cost.

The average labor income from age 23 to 65 in 2000 is $\bar{y} = \$37,959$.[10] Hence,

$$\frac{(1-\theta_{pub})\kappa}{\bar{y}} = \frac{8,952}{37,959} = 0.2358,$$

Therefore, we choose κ so that,

[9] We consider the share of individuals in public four-year colleges as 68.5% and the share agents in private nonprofit four-year colleges as 31.5%, according to *Trends in College Pricing*.

[10] We use CPS (FLOOD et al., 2020).

$$\frac{\kappa}{\bar{y}} = \frac{0.2358}{(1-0.30)} = 0.34.$$

Agents may finance a share ζ of the net college cost $(1-\theta_{pub})\kappa$. Based on the Stafford loan program, the maximum amount that an agent can borrow is $\$23,000$ for four-year college.[11] Since the average college cost is $\$8,952$, agents can finance approximately 64% of education expenditure. Therefore, we set $\zeta = 0.64$.

In each period, agents repay a constant amount rp so that there is no loan after retirement.

$$\begin{cases} A_j = \zeta(1-\theta_{pub})\kappa \text{ for } j = 1, ..., 4 \\ A_j = (1+r)A_{j-1} - rp \text{ for } j = 5, ..., 48. \end{cases}$$

Government policy:

Government consumes a fixed amount of GDP denoted by $G_t = gY_t$ where $g = 0.17$. Total government expenditures, including education subsidies and social security expenses, are financed by taxes on consumption, labor income, and capital income. We choose consumption and capital tax rates $\tau_c = 0.06$ percent and $\tau_k = 0.30$ percent, respectively, as in (FUSTER; IMROHOROGLU; IMROHOROGLU, 2007). Labor income tax is given by the non-linear function governed by the parameters τ_1 and λ_1. The parameter τ_1 measures the progressivity of the tax schedule and is equal to 0.10 to match the average tax rate of 17 percent as in (VARDISHVILI; WANG, 2021). The parameter λ_1 affects the post-tax earnings and is chosen such that the government balances its budget constraint.

Model and Data:

The model fit is described in Table 3.2 and Table 3.3. Table 3.2 shows the parameters calibrated internally and externally, and Table 3.3 compares the model outcomes with the data moments. Figure 3.2 describes the income earnings and wealth distribution.

Table 3.3 shows that the model closely replicates the target moments observed in the data, especially standard aggregate variables as capital and hours worked, and those related to education as the share of college graduates and the college premium. The share of entrepreneurs is in the range of the literature, usually between 7 percent and 12 percent. The model can also replicate some non-target moments, such as the high concentration of income and wealth on entrepreneurs. Even though we do not directly target the concentration of income and wealth distribution for all quintiles, Figure 3.2 shows a close fit compared to data gathered by (KUHN; RIOS-RULL, 2016).

[11] Assuming the student is eligible for the unsubsidized program, which leads to a borrowing limit of $5.750 per year.

Tabela 1.2 – Estimation and calibration of model parameters

	External calibration		
Parameter	**Description**	**Values**	**Source**
ξ	Risk aversion	4	Micro evidence
δ	Depreciation	0.077	I/Y = 0.25
σ	Capital-low-skill Elasticity	0.401	(KRUSELL et al., 2000)
ρ	Capital-high-skill Elasticity	-0.495	(KRUSELL et al., 2000)
τ_c	Consumption tax rate	0.06	(FUSTER; IMROHOROGLU; IMROHOROGLU, 2007)
τ_k	Capital tax rate	0.30	(FUSTER; IMROHOROGLU; IMROHOROGLU, 2007)
θ_{pub}	Public education subsidy	0.30	Micro evidence
τ_{ss}	Social security payroll tax	0.06	Micro evidence
	Internal calibration		
Parameter	**Description**	**Values**	**Target**
β	Discount factor	0.95	Real interest rate (4.5%)
$\phi(nc)$	TFP non college entrepreneur	1	Normalization
$\phi(c)$	TFP college entrepreneur	1.30	Share of college entrepreneurs (3.0%)
υ	Leisure share	0.40	Fraction of hours worked (0.33)
γ_p	Span-of-control parameter	0.78	Share of entrepreneurs (7.4%)
λ	Capital share	0.65	Capital to output ratio (2.0)
α	Labor share	0.35	College premium (80%)
d	Borrowing limit	15.0	External finance to GDP (1.8)
κ	Resource cost of college	0.15	Education cost to avarage worker's income
λ_1	Tax level	0.85	Government balanced budget
τ_1	Tax progressivity	0.10	(VARDISHVILI; WANG, 2021)
σ_u	Std deviation initial ability	0.05	Income Gini 0.43
η_p	Pareto tail	4.84	Employment top percentile (69%)

Tabela 1.3 – Model and Data

Moment	**Data**	**Model**
Calibrated moments		
Capital to output	2.0	2.05
Interest rate	4.50	4.0
Hours worked	0.33	0.36
External finance	1.8	1.5
Share of entrepreneurs	7.6%	7.4%
Share of coll. entrepreneurs	3.1%	2.5%
Share of non-coll. entrepreneurs	4.5%	4.9%
Exit rate	10.0%	10.10%
Top ten-percentile employment share	70.0%	55%
Wealth of top 5%	53.0%	61.22%
Income Gini	0.46	0.52
Share college	0.33	0.33
College premium	1.8	1.75
College cost	0.34	0.35
Non-calibrated moments		
Share Wealth entrep.	33.0%	30.7%
Share entrep. top 1%	33.0%	44.01%
Wealth Gini	0.78	0.83
Average tax rate	17.1%	16.92%

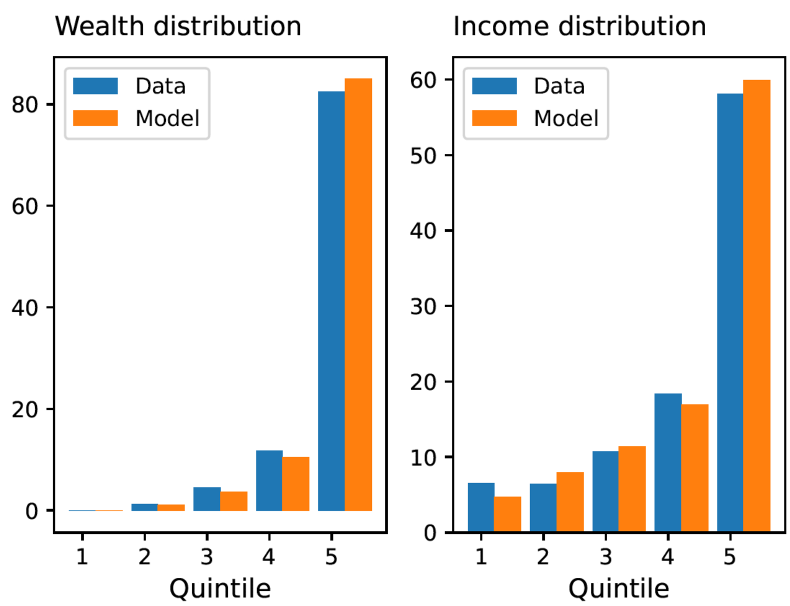

Figura 1.2 – Distribution by quintile (calibration)

1.5 Counterfactual exercises

This section examines the policy implications regarding education subsidies and tax progressivity. We focus the analysis in two results concerning optimal policies. First, we describe an economy where the government fully subsidizes the education system ($\theta_{pub} = 1$), the welfare-maximizing case in terms of CEV when the government maintains the benchmark level of tax progressivity. Then, we present the results for the optimal combination of both policies, education subsidy and tax progressivity. In this case, the government also relies on a fully subsidized education system ($\theta_{pub} = 1$), but increases the tax progressivity, ($\tau_1 = 0.15$) compared to the benchmark ($\tau_1 = 0.10$). When the government maintains the benchmark level of education subsidy and maximizes aggregate welfare relying only on tax progressivity, it finds that the current U.S. tax and transfer system is the welfare-maximizing case. In all policy experiments, we assume that the government keeps exogenous spending fixed and balances the budget constraint by adjusting the parameter tax λ_1 in equation (1.8).

1.5.1 Aggregate results

Table 1.4 reports the main findings for the welfare maximizing cases when the government relies only on education subsidies (column 2), or both policies (column 3). We can notice that the share of college agents and the skill composition of entrepreneurs are highly affected by education subsidies, as seen in column (2). A fully subsidized college system leads to an increase of 18.9 percentage points in the share of college agents. There is an increase in the share of entrepreneurs, and the skill composition changes with an increase in the share of high-skilled entrepreneurs of 2.9 percentage points and a decrease in the share of low-skilled entrepreneurs of 2.3 percentage points. The change in wages impacts entrepreneurial choice and helps to explain this change. The increase in the share of college graduates decreases the education premium with a decrease in college wages and an increase in non-college wages. Therefore, high-skilled agents have higher incentives to open firms, as opposed to low-skilled agents. The shift in the entrepreneurial sector and the higher share of high-skilled agents leads to an increase in output of 17.9 percent.[12]

Column (3) shows the welfare-maximizing combination of both policies: a fully subsidized education system and a higher progressivity level compared to the benchmark. In line with the results mentioned above, the education subsidy drives the increase in the share of college workers and entrepreneurs. In this case, the government increases tax revenues from a higher share of high-skilled agents and a higher tax progressivity. Therefore, the tax level is lower than the benchmark, resulting in higher post-tax earnings for the individuals. This policy experiment

[12]The opposite result happens with an education system with no college subsidy. Since the monetary college cost is higher, we observe a decrease in the share of college agents, including college entrepreneurs. The increase in the college premium with the rise in high-skill wages and the decrease in low-skill wages contribute to the change in the entrepreneur's skill composition. The increase in the share of low-skilled workers and entrepreneurs leads to a decrease in capital accumulation and output. This case leads to a welfare loss compared to the benchmark.

has the strongest effect on capital accumulation and output, leading to an increase of 29.08 percent and 18.1 percent, respectively.[13]

Tabela 1.4 – Policy experiments

		Education Subsidy	Both Policies
	Benchmark	$\theta_{pub} = 1.0$	$\theta_{pub} = 1.0$, $\tau_1 = 0.15$
	(1)	(2)	(3)
Output	100	+17.9%	+18.1%
Capital	100	+28.8%	+29.08%
w_c	1.02	0.92	0.828
w_{nc}	0.584	0.82	0.760
College premium	1.75	1.12	1.089
Interest rate (%)	4.0	4.8	4.1
College agents (%)	33.4	52.3	51.9
College. Entrep. (%)	2.5	5.4	5.4
Non-college. Entrep. (%)	4.9	2.6	2.7
Tax level (λ_1)	0.853	0.93	0.925

Note: The table displays the values for the main aggregate variables, prices, and inequality under different policy experiments. Column (1) shows the results for the benchmark economy. Column (2) considers the optimal education subsidy. Column (3) shows the results for the optimal combination of education subsidy and tax progressivity compared to the benchmark economy. We normalize output and capital to 100 in the benchmark. Recall that the optimal tax progressivity is the current U.S. value.

1.5.2 Welfare analysis

Table 1.5 and Table 1.6 show the welfare gains for the policy experiments above. We compute welfare in terms of consumption-equivalent variation (CEV). The CEV measures how much an agent is willing to change her lifetime consumption to make her indifferent between the benchmark and the counterfactual economy, given her current state. First, consider $V_1^1(\omega_1)$ the expected lifetime utility of an agent who starts life at state ω_1 under the alternative policy experiment we aim at evaluating, that is, in an economy with distinct tax progressivity or education subsidy. Then, we define,

[13] Keeping the benchmark level of education subsidy, increases in tax progressivity have weak effects, slightly affecting education and entrepreneurial decisions. The tax system mainly affects capital accumulation. On the one hand, a higher progressive tax system disincentivizes capital accumulation leading to a decrease in capital and output. There is a slight increase in the share of college entrepreneurs as the average tax level is lower in this case. Since the government raises more tax revenues with an increase in tax progressivity, it can reduce the average tax to balance the budget constraint. This case leads to a welfare loss compared to the benchmark.

$$V_1^0(\omega_1) \equiv \mathbf{E}_0\left[\sum_{t=1}^{T}\beta^t\prod_{s=1}^{t}\psi_s(1+\Delta_{cev})^{\upsilon(1-\xi)}u_0\right], \tag{1.9}$$

where the function u_0 represents the flow utility of the individual at the benchmark policy.[14] Thus, the aggregate welfare measure we are interest is calculated by

$$CEV \equiv \underset{\Delta_{cev}}{\text{argmin}}\,[\mathbf{E}_{\omega_1}V_1^0(\omega_1) - \mathbf{E}_{\omega_1}V_1^1(\omega_1)] \tag{1.10}$$

The variable Δ_{cev} indicates the percentage change in an agent's lifetime consumption that would make them indifferent, on average, between the benchmark and alternative policy. A positive Δ_{cev} indicates a welfare gain in the alternative economy compared to the benchmark, while a negative Δ_{cev} indicates welfare loss.

Moreover, we follow (FLODEN, 2001) and (HEATHCOTE; STORESLETTEN; VIOLANTE, 2008) and decompose the welfare effect Δ_{cev} in two terms: a level effect, denoted as Δ_{lev}, and an uncertainty effect, represented as Δ_{unc}. The level effect is associated with welfare change due to changes in the size of aggregate consumption. The uncertainty effect is related to the welfare change due to the distinct stochastic process for idiosyncratic productivity in the alternative economy. The decomposition is described below and holds as an approximation, $\Delta_{cev} \approx \Delta_{lev} + \Delta_{unc}$. The efficiency component is calculated as

$$\sum_t \beta^{t-1}\prod_{s=1}^{t}\psi_s\left[\Big((1+\Delta_{lev})C_{0,t})^{\upsilon}(1-L_{0,t})^{1-\upsilon}\Big)^{1-\xi}\right] =$$

$$\sum_t \beta^{t-1}\prod_{s=1}^{t}\psi_s\Big(C_{1,t}^{\upsilon}(1-L_{1,t})^{1-\upsilon}\Big)^{1-\xi},$$

where $C_{0,t}$ and $L_{0,t}$ denote the average consumption and hours worked, respectively, of t-year-old agents at the benchmark. $C_{1,t}$ and $L_{1,t}$ denote the same statistics in the alternative policy experiment.

The uncertainty component is $\Delta_{unc} = \dfrac{1-p_1}{1-p_0} - 1$, where

$$\sum_t \beta^{t-1}\prod_{s=1}^{t}\psi_s\left[\Big((1-p_0)C_{0,t})^{\upsilon}(1-L_{0,t})^{1-\upsilon}\Big)^{1-\xi}\right] =$$

[14] $\mathbf{E}_0\left[\sum_{t=1}^{T}\beta^t\prod_{s=1}^{t}\psi_s\; u\Big((1+\Delta)c,\ell\Big)\right] = \mathbf{E}_0\left[\sum_{t=1}^{T}\beta^t\prod_{s=1}^{t}\psi_s\frac{[(1+\Delta)c^{\upsilon}(1-\ell)^{1-\upsilon}]^{1-\xi}}{1-\xi}\right] = \mathbf{E}_0\left[\sum_{t=1}^{T}\beta^t\prod_{s=1}^{t}\psi_s(1+\Delta)^{\upsilon(1-\xi)}u_0\right] = V_1^{\Delta}(\omega_1)$

$$\mathbf{E}\left[\sum_t \beta^{t-1}\prod_{s=1}^{t}\psi_s\Big(c_{t,0}^{v}(1-\ell_{t,0})^{1-v}\Big)^{1-\xi}\right],$$

and

$$\sum_t \beta^{t-1}\prod_{s=1}^{t}\psi_s\left[\Big((1-p_1)C_{1,t})^{v}(1-L_{1,t})^{1-v}\Big)^{1-\xi}\right] =$$

$$\mathbf{E}\left[\sum_t \beta^{t-1}\prod_{s=1}^{t}\psi_s\Big(c_{t,1}^{v}(1-\ell_{t,1})^{1-v}\Big)^{1-\xi}\right].$$

Table 1.5 displays the welfare decomposed in aggregate terms, and Table 1.6 displays the welfare decomposed by education. The welfare-maximizing policy experiment is a combination of higher tax progressivity compared to the benchmark, and a fully subsidized education system, as seen in column (2) of Table 1.5 and Table 1.6. Two main margins drive this welfare gain: an increase in non-college wages due to an expansion in college subsidies and a decrease in uncertainty due to a more progressive tax system.

The expansion of college subsidies leads to a decrease in the college premium with an increase in low-skill wages. Therefore, there is an increase in income and consumption of low-skilled agents and, consequently, a rise in the level component of the CEV. On the other hand, a decrease in the wages of college agents leads to a decrease in the level component of this education level. This mechanism can be seen in column (1) of Table 1.5 and Table 1.6 where only a fully subsidized system is analyzed. There is also a welfare gain for college and non-college agents from the uncertainty component. Since there is an increase in capital demand from the higher share of entrepreneurs, we observe an increase in the interest rate. Therefore, there is a welfare gain from better consumption smoothing related to the uncertainty component. In short, there is a welfare loss mainly due to a decrease in non-college wages and, consequently, the level component associated with this education level.

The combination of higher tax progressivity than the benchmark and a fully subsidized college system leads to a welfare-maximizing policy, as seen in Column (2). It incorporates the welfare gain from the level component associated with the education subsidy and the welfare gain from the uncertainty component associated with the tax progressivity. In this case, welfare increases by 34.58 percent, which is higher than the policy experiments in which the government only relies on education subsidy or tax progressivity. The main welfare gain is related to the level term of non-college agents since there is a large decrease in the college premium.

Tabela 1.5 – CEV: $\Delta_{lev} + \Delta_{unc} \approx \Delta_{cev}$

	Education Subsidy	Both Policies
	$\theta_{pub} = 1.0$	$\theta_{pub} = 1.0$, $\tau_1 = 0.15$
	(1)	(2)
Δ_{cev}	33.7%	34.58%
Δ_{lev}	24.3%	23.73%
Δ_{unc}	7.4%	8.7%

Note: The table displays the values of the CEV decomposed into two terms: level and uncertainty. Column (1) considers the optimal education subsidy. Column (2) shows the results for the optimal combination of education subsidy and tax progressivity.

Tabela 1.6 – CEV by education: $\Delta_{lev} + \Delta_{unc} \approx \Delta_{cev}$

	Education Subsidy	Both Policies
	$\theta_{pub} = 1.0$	$\theta_{pub} = 1.0$, $\tau_1 = 0.15$
	(1)	(2)
College		
Δ_{cev}	0.49%	2.19%
Δ_{lev}	-1.51%	-2.06%
Δ_{unc}	2.06%	4.35%
Non-College		
Δ_{cev}	27.54%	28.02%
Δ_{lev}	26.01%	26.26%
Δ_{unc}	1.21%	1.38%

Note: The table displays the values for the CEV decomposed into two terms: level and uncertainty. We also decompose the CEV according to education groups (non-college and college). Column (1) considers the education subsidy. Column (2) shows the results for the optimal combination of education subsidy and tax progressivity.

1.6 Concluding remarks

We build an OLG model with endogenous education and entrepreneurship to quantify the impact of education subsidies and tax progressivity. We find that education policies change not only the share of college workers but also the share of college entrepreneurs. A fully subsidized college system increases the share of college agents from 33.4 percent to 52.3 percent. Moreover, the share of college entrepreneurs increases from 2.5 percent to 5.4 percent; and the share of non-college entrepreneurs increases from 4.9 percent to 2.6 percent. The decrease in the college premium contributes to the shift in the skill distribution of entrepreneurs. In this case, output increases by 17.9 percent, and the college premium reduces from 1.75 to 1.12, with a significant increase in low-skill wages. The opposite effect happens when the government eliminates education subsidies.

We also find that changes in tax progressivity have negligible effects on the share of college agents and the skill distribution of entrepreneurs. Higher progressivity disincentives capital accumulation leading to a decrease in capital and output. Nonetheless, inequality decreases, measured by the wealth and post-tax income Gini coefficients. The opposite effect happens when the government reduces tax progressivity.

The welfare-maximizing policy, in terms of CEV, combines a fully subsidized college system with a more progressive tax system compared to the benchmark. In this case, the increase in the college premium impacts welfare mainly due to an increase in low-skill wages (reduction in college premium) and, consequently, an increase in consumption. Also, the increase in tax progressivity provides better insurance in the economy and reduces inequality. Hence, it improves welfare mainly due to a reduction in the uncertainty component. Therefore, the combination of both policies has a higher welfare effect than when they are implemented independently, so the government could enhance welfare by providing more education subsidies and increasing tax progressivity.

2 Manager Education and Firm Productivity - Evidence from Brazil

2.1 Introduction

The role of education in economic development is usually assessed in terms of aggregate human capital and labor productivity. Less attention is given to how managers' education impacts firms' productivity. As has been argued theoretically by (NELSON; PHELPS, 1966) and (BLOOM; SADUN; REENEN, 2012), this is likely an important channel because managers are responsible for production technique, organizational and strategic decisions at the firm level. Our paper addresses this gap in the literature by investigating the relation between manager education and firm productivity in the Brazilian manufacturing sector, thus providing some of the earliest empirical evidence for a critical mechanism driving economic growth.

First, we estimate production function parameters and obtain firm-level total factor productivity (TFP) estimates. To do that, we rely both on the standard Solow residual and on control function methodology, such as proposed by (OLLEY; PAKES, 1996), (LEVINSOHN; PETRIN, 2003), and (ACKERBERG; CAVES; FRAZER, 2015). Next, we investigate the correlation between top managers' education and firms' TFP at different levels of industry disaggregation.

When we seek to go beyond this correlation and establish a causal effect running from manager education to firm productivity, a potential endogeneity (reverse causality) concern arises because managers are not randomly selected: Firms with better growth prospects will likely hire, from the beginning, more educated managers. We thus propose using the firm's "initial investment"as a proxy for its growth prospects, and controlling for initial investment when we regress the firm's TFP growth on its initial manager's human capital.

Our findings, for the 1996-2017 period, reveal a positive and statistically significant relation between manager education and firm productivity. The estimated elasticity of firm TFP with respect to manager human capital is 11.9%. This is broadly equivalent to a 1.5% increase in TFP for each additional year of manager education. This result is robust to alternative TFP estimation methods and different measures of manager education. Furthermore, we find that firms started by more educated managers display faster TFP growth, even after controlling for initial investment. Finally, we show that the correlation between firm TFP and manager's education varies according to industry characteristics such as the R&D intensity and the dependence on external finance.

Our paper contributes to two strands of literature. First, recent studies like (FENIZIA,

2022) and (METCALFE; SOLLACI; SYVERSON, 2023) seek to establish a causal effect of managers' characteristics on firms' productivity by observing managers moving between stores (or offices) of the same company. Our paper differentiates itself from this literature by its comprehensive data sample (covering virtually all Brazilian industrial firms) and by its more rigorous estimation of firm-level productivity.

Second, the macro development literature highlights the significance of managerial quality in explaining cross-country differences in productivity and income. (GOMES; KUEHN, 2017) use a quantitative model to evaluate that educational composition disparities can account for 37% of the variation observed in average firm size between the United States and Mexico. (GUNER; PARKHOMENKO; VENTURA, 2018) present a model where variations in managerial quality across firms arise from a combination of selection and investments in skill formation over the life-cycle. This, in turn, increases firms' productivity.[1] (QUEIRó, 2021) finds that, for the Portuguese manufacturing sector, firms started by more educated entrepreneurs exhibit higher growth throughout the life-cycle. Our paper seeks to give this literature a stronger empirical causal status.

The paper is structured as follows. Section 2.2 presents data description and the productivity measurement. Section 2.3 describes the empirical strategy. Section 2.4 shows the results, including robustness checks, a causal effect test and industry heterogeneity evidence. Section 2.5 concludes.

2.2 Data and productivity measurement

We rely on two datasets: the Annual Social Information Report (*Relação Anual de Informações Sociais - RAIS*) of the Ministry of Labor and Employment, and the Annual Industrial Survey (*Pesquisa Industrial Anual - PIA*) of the Brazilian Institute of Geography and Statistics. RAIS is an employer-employee dataset that covers the Brazilian formal labor market, including information on employee education, age, tenure and occupation.[2] PIA provides information on value-added, physical capital, and labor employment for Brazilian industrial firms. It covers all firms with 30 or more employees, and it randomly selects firms with 5 to 29 employees.

The merging of the two databases is possible because they share a common firm identifier, the *National Registry of Legal Entities (Cadastro Nacional de Pessoa Jurídica - CNPJ)*. Because every year there are some firms entering as well as other firms leaving the datasets, our sample is an unbalanced panel. It comprises, on average, 32,720 firms per year appearing in both RAIS and PIA between 1996 and 2017.

Different from other studies on Brazilian firms, such as (ROCHA; PERO; CORSEUIL,

[1] The models in this literature are usually extensions of the (LUCAS, 1978) span-of-control model.

[2] RAIS follows a classification of occupations similar to ISCO 08. The information on employee occupation is particularly important for separating managers from other workers.

2019) that estimate the TFP using only the physical capital and the number of workers as inputs, here we control for workers' human capital. Omitting this variable would produce a spurious correlation between manager human capital and firm TFP when (as seems reasonable) there exists a cross-firm positive correlation between workers' and managers' education.

We assume a Cobb Douglas production function $Y_{jt} = A_{jt}K_{jt}^{\alpha}H_{jt}^{\beta}$. The subscripts j and t indicate firm and time, respectively. Y_{jt} represents value-added, A_{jt} TFP, K_{jt} physical capital and H_{jt} total human capital for each firm. Total human capital is defined as $H_{jt} = h_{jt}L_{jt}$ where h_{jt} is the firm's average human capital and L_{jt} is the number of employees, including both workers and managers. Table 2.1 reports firm-level summary statistics of value-added and input factors.

We use RAIS to compute the average human capital as

$$h_{jt} = \frac{\sum_{i \in j} h_{ijt}}{L_{jt}}, \tag{2.1}$$

where $h_{ijt} = e^{\psi u_{ijt}}$ indicates the human capital of individual i in firm j at time t. u_{ijt} represents the number of schooling years. We set ψ to 0.13 according to (FILHO; PESSôA, 2008), who estimate returns to education in Brazil. We compute the value-added and physical capital using PIA data.

Next, separately for each industry s , we estimate by LSDV (least-squares dummy-variable)[3]

$$\ln Y_{jst} = \gamma_{0s} + \gamma_{1s} \ln K_{jst} + \gamma_{2s} \ln H_{jst} + \gamma_{3st} + \gamma_{4sj} + \varepsilon_{jst}, \tag{2.2}$$

where γ_{3st} and γ_{4sj} are respectively time and firm fixed-effects.

The firm's TFP is then calculated as a Solow residual:

$$\ln TFP_{jst} = \ln Y_{jst} - \hat{\gamma}_{1s} \ln K_{jst} - \hat{\gamma}_{2s}(\ln h_{jst} + \ln L_{jst}), \tag{2.3}$$

where $\hat{\gamma}_{1s}$ and $\hat{\gamma}_{2s}$ are the sample estimates of the corresponding coefficients in (2.2).

In Figure 2.1, we set the TFP in 1996 equal to one and depict its evolution until 2017. The left panel shows the cross-firm average[4], and the right panel the quantiles. Notice that firms at the bottom of the TFP distribution *(p5)* are more volatile than firms at the top *(p95)*.

[3]The industry classification we use here is the version 2.0 of the *National Classification of Economic Activities (Classificação Nacional de Atividades Econômicas - CNAE)* at the 2-digit disaggregation level, comprising 4 extractive and 25 manufacturing industries.

[4]It may seem counterintuitive that our average industrial firm's TFP displays a fall between 1996 and the early 2000s, when we recall that in this period the Brazilian economy underwent a significant liberalization process, including trade and deregulation reforms. However, a simultaneous fall in the Brazilian aggregate TFP has already been documented in the literature. See, for example, (FERREIRA; PESSôA; VELOSO, 2013).

Tabela 2.1 – Summary statistics (production function)

Variable	Mean	Std. dev.	p5	p25	p50	p75	p95
Value-Added	28.17	830.07	0.14	0.81	2.18	7.24	64.87
Physical Capital	54.31	2093.26	0.15	0.78	2.75	11.45	114.83
Human capital	3.34	0.80	2.03	2.81	3.35	3.89	4.57
Years of Schooling	9.28	1.72	5.44	7.95	9.30	10.45	11.69
Labor	157.79	782.29	15	34	52	101	475

Notes: summary statistics for the whole universe of 114,234 firms that have yet appeared in both PIA and RAIS, regardless they have managers or not. Value-added and capital are in millions of 2017 Reais (the Brazilian currency), and labor corresponds to the total number of employees. Notes: Columns p5 to p95 report values for the firm located in the corresponding quantile.

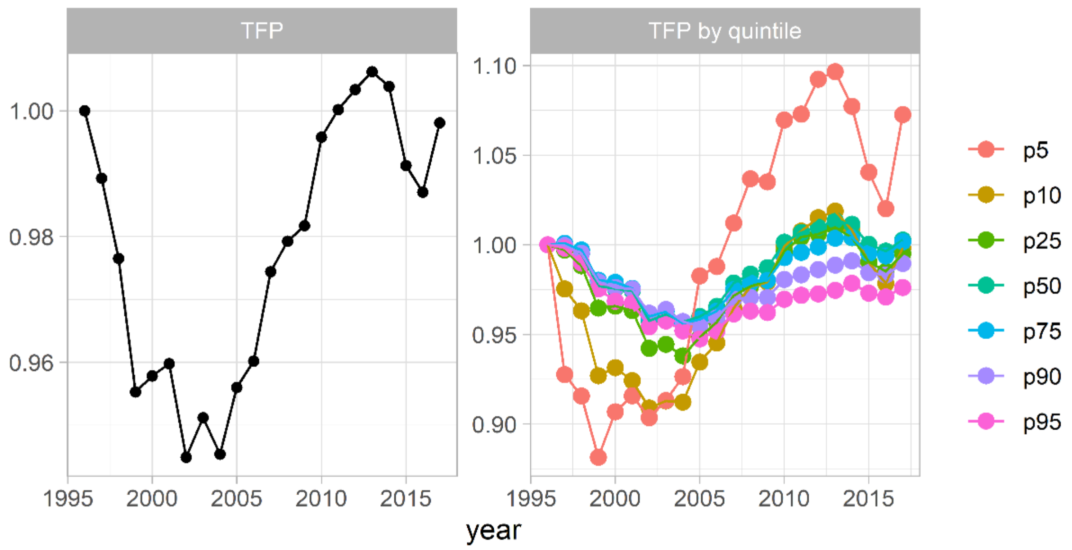

Figura 2.1 – TFP evolution

2.3 Empirical strategy

Having estimated the firm's TFP, the next step is to identify in the data the top managers who presumably are responsible for decisions affecting the TFP. Here we consider as a top manager everyone in the firm who is a "director"according to RAIS and its underlying *Brazilian Classification of Occupations*. This leaves out all other managers, such as "production supervisors", "production managers", "sales managers", etc. With this top manager selection we cover 16,418 firms (that have one or more directors) in the 1996-2017 period.[5]

In line with this top manager selection, we define $hceo$ as the average human capital of the directors in each firm-period:

[5]This top manager selection provides better coverage than the alternative of considering only single manager firms, with which we got only 9,667 firms in the 1996-2017 period. For reference, recall that we have, on average, 32,720 firms per year appearing in both RAIS and PIA between 1996 and 2017.

$$hceo_{jt} = \frac{\sum_i m_{ijt} hceo_{ijt}}{\sum_i m_{ijt}} \quad \text{where} \quad m_{ijt} = \frac{\text{number of months director } i \text{ worked at firm } j \text{ in year } t}{12}, \tag{2.4}$$

where the individual director's human capital $hceo_{ijt}$ is computed using the years of schooling just as we did for workers in general (see the definition of h_{ijt} right below equation 2.1) .[6]

We now consider the "second stage regressions", where we regress firm productivity on top managers' human capital considering several specifications. The baseline is given by

$$\ln TFP_{jt} = \beta_0 + \beta_1 \ln hceo_{jt} + \beta_{2t} + \epsilon_{jt}, \tag{2.5}$$

where TFP_{jt} is the TFP of firm *j* at period *t* estimated in (2.3). β_{2t} is a time fixed-effect.

Notice that we do not include in (2.5) a firm fixed-effect because, in view of how the TFP is estimated in (2.2) and (2.3), if we did so there would remain too little (namely, just random shocks) of the TFP for $hceo$ to explain.

In the next two specifications, we control for other top manager characteristics:

$$\ln TFP_{jt} = \beta_0 + \beta_1 \ln hceo_{jt} + \beta_{2t} + \beta_3 \ln ten_{jt} + \epsilon_{jt}, \tag{2.6}$$

$$\ln TFP_{jt} = \beta_0 + \beta_1 \ln hceo_{jt} + \beta_{2t} + \beta_3 age_{ceo_{jt}} + \beta_4 age^2_{ceo_{jt}} + \epsilon_{jt}. \tag{2.7}$$

In (2.6) ten_{jt} is the average tenure of firm *j*'s directors (with the tenure of each director measured as the accumulated number of months from his/her taking the job until the end of year *t*), and in (2.7) age_{jt} is the average age of firm *j*'s directors.

Regressions (2.5), (2.6) and (2.7) are run in the pooling of all Brazilian industrial firms (as long as the firm has at least one director). We also estimate versions of these regressions using a finer 2-digit industry classification[7], so that (2.5), for example, becomes

$$\ln TFP_{jt} = \beta_0 + \{\beta_{1s}\}_{s=1}^{29} \ln hceo_{jt} + \beta_{2t} + \epsilon_{jt}, \tag{2.8}$$

where there are 29 2-digit industries.

Table 2.2 shows summary statistics for the variables appearing on regressions (2.5) to (2.8).[8] In order to make the relation between TFP and top managers' human capital immediately

[6] In our sample, the cross-firm correlation between h_j as defined in (2.1) and $hceo_j$ as defined in (2.4) is 0.52. As we argue in section 2 above, this positive correlation between workers' and managers' human capital is an important reason to control for workers' human capital when we measure the firm's TFP.

[7] Here we use the same industry classification as in (2.2) . See footnote 2.

[8] The only exception is the percentage of directors with a Bachelor's degree or more. This variable will be used later, in a robustness check.

apparent, all manager characteristics (except their mean and standard deviation) are displayed by the TFP quantile. In spite of a small variability[9], we notice that both $hceo$ and the top managers' years of schooling are increasing in the TFP quantiles.

Tabela 2.2 – Summary statistics (regressions)

Variable	Mean	Std. dev.	p5	p25	p50	p75	p95
TFP	6.86	1.48	4.60	6.24	6.96	7.67	8.85
Top managers' human capital ($hceo$)	6.33	1.49	6.18	6.12	6.25	6.29	6.47
Top managers' years of schooling	14.19	3.07	13.67	13.58	13.78	13.81	14.08
Top managers with Bachelor's degree or more (%)	71.92	41.03	66.67	66.74	70.31	71.68	78.37
Top managers' age	46.61	9.77	45.48	46.16	46.70	46.49	46.96
Top managers' tenure (in months)	94.90	86.97	82.88	93.23	100.61	98.57	92.81

Notes: Columns p5 to p95 report values for the firm located in the corresponding TFP quantile. "Years of schooling"is the within-firm cross-directors' average, which we add just for reference.

Figures 2.2 and 2.3 show the cross-firm distribution (in 1997 and in 2017) of the variables "TFP"and "top managers' years of schooling"from Table 2.2. We notice that while the average manager's number of years of schooling clearly increased from 1997 to 2017, the average TFP remained practically the same. As can also be gauged by comparing the TFP's standard deviation with its mean in Table 2.2, the TFP dispersion for the Brazilian industrial sector is not so big as we would have expected for a developing country full of allocative distortions.

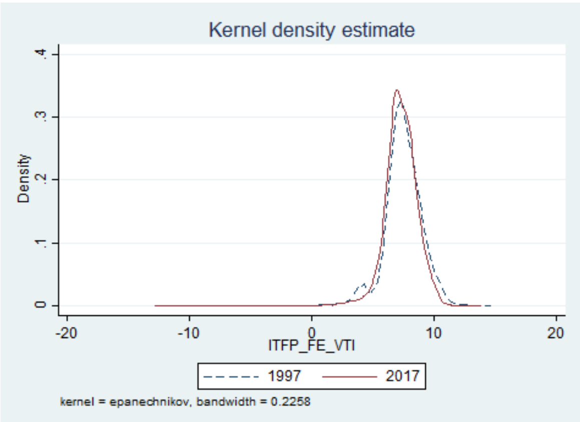

Figura 2.2 – TFP distribution

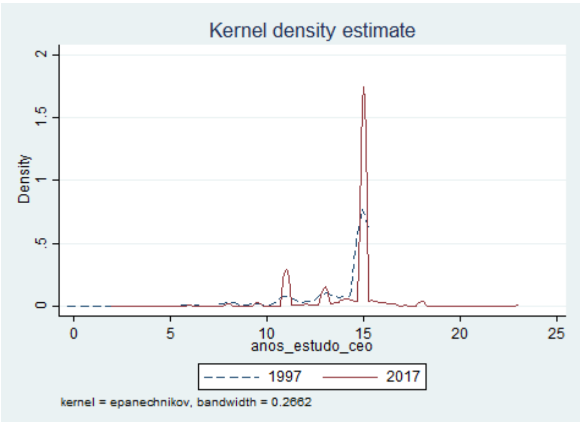

Figura 2.3 – Managers' years of schooling distribution

[9]Of course, when we observe manager characteristics by their own (not the TFP's) quantiles, there is much more variability. For years of schooling, for example, we have p5=10.21 (which corresponds to incomplete high school) and p95=15.35 (slightly above a Bachelor's degree).

2.4 Results

2.4.1 Top manager education and firm TFP

In Table 2.3 we report the results from estimating specifications (2.5), (2.6) and (2.7). The main results are in the first panel, "TFP FE". There we find an elasticity of firm TFP with respect to manager human capital ranging from 9.37% to 12.70%.

Given the 0.13 value of the returns to education parameter ψ in $h_{ij} = e^{\psi u_{ij}}$, the 11.9% elasticity result in (2.5) is roughly equivalent to saying that the firm's TFP increases 1.5% per additional year of the average top manager's schooling.[10] This is considerably less than the 5% Portuguese corresponding figure in (QUEIRó, 2021). However, when we inspect Table 2.2 we find that the cross-firm standard deviation in top managers' years of schooling is 3.07. So, if a firm were to increase its top managers' years of schooling in one standard deviation, it could achieve a 3.07 X 1.5% = 4.6% increase in its TFP, which is sizable.[11]

Inspecting the columns for (2.6) and (2.7) in panel "TFP FE", we further find that the top managers' tenure and their age are positively correlated with the firm's TFP. This finding is consistent with the model in (GUNER; PARKHOMENKO; VENTURA, 2018), where managers invest in their skills over the life-cycle, with a positive impact on firm productivity.[12]

[10]Equation (2.4) implies that $hceo_j$ is approximately equal to $e^{\psi u_{ceoj}}$, where u_{ceoj} is the top managers' average years of schooling for firm *j*. This, in turn, implies $dhceo_j/hceo_j = \psi du_{ceoj}$. On the other hand, in equation (2.5) we estimate an elasticity of the kind $\beta_1 = \frac{dTFP_j/TFP_j}{dhceo_j/hceo_j}$. Plugging in this equation the previous result for $dhceo_j/hceo_j$ yields $\beta_1 = \frac{dTFP_j/TFP_j}{\psi du_{ceoj}}$. Therefore, the semi-elasticity of TFP with respect to the top managers' average years of schooling is $\frac{dTFP_j/TFP_j}{du_{ceoj}} = \beta_1\ \psi$ = 11.9% X 0.13 = 1.5%.

[11]Because of the emphasis on *entrepreneurship* in the literature, we also estimate specifications (2.5), (2.6) and (2.7) in the subsample of firms that have just one manager in the year. Not shown in 2.3, the results point to a 1.15% increase in the firm's TFP by additional year of manager schooling.

[12]Our result holds controlling for managers' education. Analogously, (GUNER; PARKHOMENKO; VENTURA, 2018) estimate positively sloped age-earnings profiles controlling for manager education.

Tabela 2.3 – TFP X hceo - Regressions

	TFP FE			TFP ACFEST		
	(2.5)	(2.6)	(2.7)	(2.5)	(2.6)	(2.7)
Human capital$_{ceo}$	0.119***	0.127***	0.0937***	0.167***	0.167***	0.139***
Tenure$_{ceo}$		0.044***			0.0177*	
Age$_{ceo}$			0.0308***			0.0265***
Age$^2_{ceo}$			-0.0003***			- 0.0003***
Constant	7.098***	6.930***	6.420***	5.630***	5.559***	5.107***
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	No	No	No	No	No	No
Observations	92,055	92,055	92,055	83,021	82,985	83,021
Number of firms	16,418	16,418	16,418	14,526	14,522	14,526
*** p0.01, ** p0.05, * p0.1						

One objection that may be raised against our results is whether they are robust to alternative production function estimation methods. Truly, our naïve estimation in (2.2) did not return low and insignificant capital coefficients which, according to (COLLARD-WEXLER; LOECKER, 2020), typically plague LSDV with firm fixed-effects.[13] However, there may be a component of the productivity shock ϵ_{jst} in (2.2) that is not observed by the econometrician but is observed by the firm, and to which the firm may adjust some of its inputs (such as the labor input). In this case, OLS estimates of the production function are biased and inconsistent, and our LSDV estimator may deal with the labor-productivity correlation but at the cost of imposing productivity shocks with no time variation.

To solve this problem, (OLLEY; PAKES, 1996), (LEVINSOHN; PETRIN, 2003), and (ACKERBERG; CAVES; FRAZER, 2015) developed production function estimation methods based on "control functions", whereby investment or intermediate inputs flows serve as a proxy for the (unobserved by the econometrician but observed by the firm) productivity shocks.

In Table 2.3, panel "TFP ACFEST", we present our second stage regression results when the production function and the TFP are estimated by the (ACKERBERG; CAVES; FRAZER, 2015) method, using the STATA program e-class command developed by (MANJóN; MAñEZ, 2016), with intermediate inputs as the proxy variable.[14] There we see that we get elasticities of

[13] Indeed, when we estimate (2.2) we get statistical significance (at 1%) for γ_1 in 28 out of 29 2-digit industries. Furthermore, the cross-industry average of γ_1 is equal to 0.35, in line with standard values for the aggregate capital coefficient.

[14] Actually, we use the PIA's "cost of industrial operations"variable, which comprises intermediate materials plus

TFP with respect to $hceo$ that are statistically significant and even higher than the ones we had obtained using our LSDV ("TFP FE") estimator.[15]

Are our second-stage results robust to alternative measures of top manager education? In Table 2.4, instead of regressing the firm TFP on $hceo$, we regress it on the percentage of top managers with a Bachelor's degree or more. As suggested by the cross-TFP quantiles depicted in Table 2.2, this alternative measure of top manager education is also positively correlated with TFP.

Tabela 2.4 – TFP X share of directors with bachelor's degree or more - Regressions

	TFP FE			TFP ACFEST		
	(2.5)	(2.6)	(2.7)	(2.5)	(2.6)	(2.7)
Share college$_{ceo}$	0.181***	0.183***	0.150***	0.130***	0.130***	0.107**
Tenure$_{ceo}$		0.0442***			0.0168*	
Age$_{ceo}$			0.0291***			0.0268***
Age$^2_{ceo}$			-0.0002***			-0.0003***
Constant	7.225***	7.068***	6.560***	5.848***	5.790***	5.293***
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	No	No	No	No	No	No
Observations	92,151	92,020	92,058	83,107	82,986	83,022
Number of firms	16,432	16,415	16,418	14,542	14,522	14,526
*** p0.01, ** p0.05, * p0.1						

2.4.2 Causal Effect

As it happens to most of the relevant phenomena in macroeconomics, to our best knowledge, there is no aggregate natural or quasi-natural experiment involving an exogenous variation in managers' education for the Brazilian manufacturing sector.[16] Other studies, like (FENIZIA, 2022) and (METCALFE; SOLLACI; SYVERSON, 2023) seek to establish a causal

consumption of energy and fuels.

[15] Not shown here, similar second-stage estimates obtain when we use the ACFEST estimator having the firm's investment in physical capital as the proxy variable.

[16] Truly, there are episodes of policy intervention in the Brazilian manufacturing sector that render a clean identification possible. For example, (CAVALCANTI; VAZ, 2017) study the effects of credit subsidies provided by the Brazilian Development Bank (BNDES) on investment and productivity of manufacturing firms. Their identification strategy relies on an exogenous variation in access to a targeted loan program to small firms from BNDES.

effect of managers' characteristics on firms' productivity by observing managers moving between stores (or offices) of a same company. But these are clearly micro-level evidences. More on the macro side, (QUEIRó, 2021) shows that, for the Portuguese manufacturing sector, firms started by more educated entrepreneurs exhibit higher growth throughout the life cycle.

The trouble with Queiró's causal evidence is that it is likely contaminated by reverse causality. Managers are not randomly selected: Firms with better growth prospects hire, at the start, more educated managers. To circumvent this problem, we propose using the firm's "initial investment"as a proxy for its growth prospects, and controlling for initial investment when we regress the firm's TFP growth on its initial manager human capital. Formally,

$$g_{TFPj} = \beta_0 + \beta_1 hceo_{jt_{initial\ j}} + \beta_2 \frac{inv_{jt_{initial\ j}} - inv_{st_{initial\ j}}}{inv_{jt_{initial\ j}}} + \epsilon_{jt}, \tag{2.9}$$

where firm j's average annual TFP growth rate is defined as

$$g_{TFPj} = \frac{\ln TFP_{jt_{final\ j}} - \ln TFP_{jt_{initial\ j}}}{t_{final\ j} - t_{initial\ j}}, \tag{2.10}$$

and $t_{initial\,j}$ and $t_{final\,j}$ are respectively the first and the last year in which firm j appears in PIA's sample.

The first regressor in (2.9) is firm j's directors' average human capital, as defined in (2.4), and calculated at $t_{initial\,j}$. The second regressor in (2.9) is the percentage deviation of firm j's investment rate in physical capital from the sectoral (s) average.[17] Taking this deviation, instead of simply firm j's investment rate, allows us pooling firms from all sectors in the same regression.

Table 2.5 shows the results from estimating specification (2.9). To calculate the TFP growth in (2.10), we use the "naïve"version of TFP ("TFP FE") defined in equation (2.3).[18]

[17]Recall from (2.2) that we define s as the industrial sector to which firm j belongs. The investment rate is the investment/value-added ratio. For investment in physical capital, we consider PIA's bookkeeping "acquisitions"+ "improvements- "write-offs"entries for variation in permanent assets.

[18]Unfortunately, when we use our "TFP ACFEST"in (2.10), we don't get statistically significant results in (2.9).

Tabela 2.5 – g_{TFP} X hceo - Regressions

	Whole Sample		Positive Investment		After 1996	
Initial human capital$_{ceo}$	0.023***	0.023***	0.017***	0.016***	0.026***	0.026***
Initial investment		-0.0001		0.004***		0.0001
Constant	- 0.124***	- 0.124***	-0.077**	- 0.072***	0.099***	0.097***
Observations	6,388	6,388	4,607	4,607	3,297	3,297
*** p0.01, ** p0.05, * p0.1						

In Table 2.5, notice that the number of observations is equal to the number of firms. In the panel "whole sample"we estimate (2.9) for all firms in PIA's universe, provided that they had a top manager (director) and data on investment at their initial year.

Because IBGE's PIA starts in 1996, in this year a disproportionate big number of firms appear for the first time in the sample. In order to filter out firms that existed prior to 1996, Table 2.5's "after 1996"panel considers only those firms that appeared for the first time in PIA's sample from 1997 on. Of course, with this trimming we inevitably lose some firms that started exactly in 1996.

Another potential source of "initial year"measurement error is the old firms that became big enough to enter the censitary universe of PIA only at some point from 1996 on. To deal with this problem, in Table 2.5's "positive investment"panel, we implement a trimming that consists of including in the sample only those firms that had a positive value for physical capital investment at the first year they appeared on PIA. Conceivably, for a new firm the depreciation and the accounted write-offs shouldn't be bigger than the acquisitions of buildings, machinery and equipment.

The results in Table 2.5's "positive investment"panel show that the initial investment in physical capital is a good proxy for "growth prospects", because it is positively correlated with the firm's TFP growth. And after controlling for initial investment, we still find a positive correlation between the firm's TFP growth and its initial manager human capital, thus suggesting a causal effect of this latter.

2.4.3 Industry heterogeneity and industry characteristics

Beneath the 0.119 elasticity of firm TFP with respect to top manager human capital that we found for the pooling of all Brazilian industrial firms in Table (2.3), there is considerable heterogeneity at the 2-digit industry level. When we estimate (2.8), we find a 1.15 elasticity for "miscellaneous products", 0.92 for "transport equipment"and for "printing and recording media", 0.759 for "Coke and petroleum", 0.694 for "metallic minerals", 0.52 for "pharmaceuticals", etc. But we also find some high negative elasticities: -1.438 for "computers and eletronic products", -1.262 for "oil and gas extraction"and -0.525 for "chemicals".[19]

How does the elasticity of firm TFP with respect to manager human capital relate to industry characteristics? In Figure 2.4 we take the coefficient associated to $hceo$ from (2.8) and plot it against: i) the 2-digit industry's Herfindahl-Hirschman index; ii) the industry's Research and Development (R&D) intensity; and iii) the industry's dependence on external finance, as defined in (KLAPPER; LAEVEN; RAJAN, 2006) .[20]

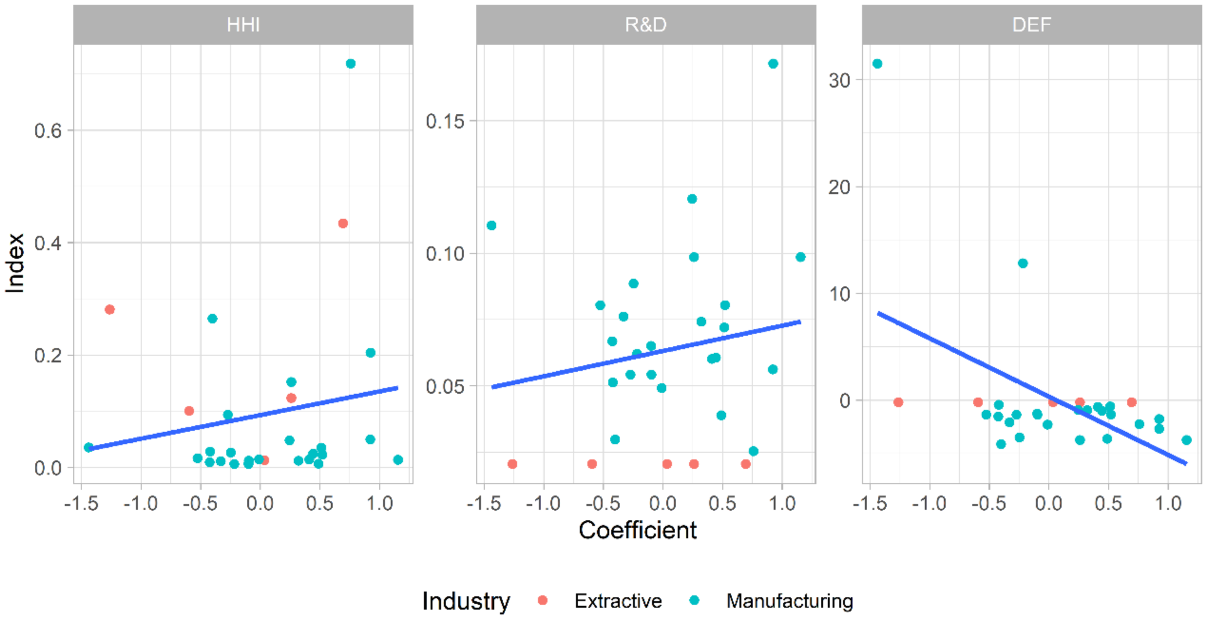

Figura 2.4 – Correlations TFP-hceo coefficients X sector characteristics

The cross-industry correlation between the elasticity of firm TFP with respect to manager human capital and the Herfindahl-Hirschman index is only 0.16. The correlation between the TFP X $hceo$ elasticity and the industry R&D intensity is 0.17. Neither correlation is statistically significant.[21]

For the dependence on external finance, we find a statistically significant -0.49 correlation with the elasticity of firm TFP with respect to manager human capital. The interpretation we give to this result is: in more credit constrained sectors, the connection between the firm's TFP and

[19] Out of 29 2-digit industries, we find 22 statistically significant (at 1%) elasticities, of which 13 are positive and 9 negative.

[20] We extract R&D intensities for the 2-digit industries from the Brazilian PINTEC, a survey on technology and innovation. (KLAPPER; LAEVEN; RAJAN, 2006) define dependence of external finance as the ratio total investment expenditure/free cash flow, which we calculate from the Brazilian PIA and PINTEC.

[21] For the Portuguese industrial sector, (QUEIRó, 2021) finds that the positive correlation between firm TFP and manager schooling is higher for more R&D intensive industries. This evidence accords with the view that having more educated managers is important for firms' technology adoption.

the managers' schooling is weaker. This pattern is rationalized by (CASTRO; ŠEVčíK, 2016), in whose model credit frictions cause schooling investments to get misallocated: entrepreneurs with the best productivity potential are the ones compelled to reduce schooling investments the most. To our knowledge, we are the first to empirically document this pattern.

2.5 Concluding remarks

In this paper, we investigated the correlation between firm TFP and top manager education in the Brazilian industry. To do that, it was important to have a TFP measure that controls for workers' human capital, which we constructed by merging the RAIS and PIA databases.

At the 2-digit industry level, we found considerable heterogeneity in the size of the elasticity of firm TFP with respect to manager human capital. This elasticity is negatively correlated with the industry's dependence on external finance.

For the industrial sector as a whole, we estimated that the firm's TFP increases 1.5% per additional year of the top managers' schooling. The importance of this finding can be gauged when we consider long-run trends in education: Since the 90's, Brazil has experienced a remarkable increase in school attainment. In our data, this is reflected in employees' years of schooling, whose average grew from 7.23 in 1996 to 10.39 in 2017. Compared to this, the growth in managers' years of schooling was much slower: from 13.63 to 14.51 in the same period. A back-of-the-envelope calculation using these figures together with our estimate suggests that the Brazilian industrial productivity could be 7.5% higher if the evolution in manager education had matched the evolution in workers' education.

Finally, we sought to establish a causal effect of manager education on firm productivity. Here, the identification challenge is that in the history of the Brazilian industrial sector there is no natural experiment representing an exogenous variation in manager education. The causal evidence we produced is that firms started by more educated managers displayed faster TFP growth, even after controlling for "growth prospects"(proxied by the initial investment in physical capital).

3 Redistribution and Entrepreneurship in Developing Economies

3.1 Introduction

The issue of increasing income inequality has been a subject of both academic and public debate. Governments often rely on progressive tax and transfer systems to mitigate income inequality and provide insurance against labor market shocks, affecting agents at the top and bottom of the income distribution. While it is well-documented that entrepreneurs are disproportionately concentrated at the top of the income distribution, less attention has been paid to their concentration at the lower end of the income distribution as self-employed individuals, particularly in developing economies.[1] This means that government transfers often target poor self-employed agents who can be out of the labor market as workers due to low productivity or as a transitory state due to an unemployment shock, at the same time that the government collects tax revenues from rich entrepreneurs. This raises questions about how government transfers should design its tax and transfer system taking into account the equilibrium impact of these policies on entrepreneurship and job creation. This paper aims to fill this gap by studying the aggregate consequences of distinct tax and transfer systems using an equilibrium model of occupational choice and labor market frictions.

In light of the convoluted transfer programs and inefficiencies accompanying eligibility checks, Universal Basic income has gained traction amongst certain politicians and interest groups.[2] The underlying idea is that each person receives the same pre-specified amount irrespective of a household's or aggregate economic circumstances. It is argued that the universal nature of UBI eliminates the monitoring costs associated with means-tested programs, and since employed and unemployed agents receive the same value, a UBI policy – if not set too high – provides no ex-ante disincentive to work. In addition, UBI could encourage entrepreneurial activity by alleviating financial constraints and providing individuals with financial security, which is essential for taking risks and starting a business.

However, since transfers would accrue to all individuals, the budgetary concerns of UBI might be aggravated in developing economies. Tax revenue collection as a share of GDP is only 15 to 20 percent in lower and middle-income countries as opposed to over 30 percent in upper-income countries, and most of the tax revenue is paid by the top earners. This gap is important

[1](HERRENO; OCAMPO, 2022) document the share of self-employment agents by earnings decile for several developing economies, indicating the 'U' shaped pattern.

[2]For instance, Andrew Yang, a candidate in the 2020 Democratic Party presidential primaries, advocates for the "freedom dividend" of $1,000 per month for all American adults. In our analysis, we do not factor in the potential savings that could be made by replacing the administrative apparatus

since it implies that developing countries have less tax revenue to spend on public goods and redistribution. Thus, because of the small tax base, it is argued that a UBI reform would increase marginal tax rates substantially more for highly productive workers and entrepreneurs, generating disproportionately larger efficiency consequences.

We consider these key trade-offs to assess the aggregate and welfare consequences of moving the current tax and tranfer system to a UBI system. To guide our quantitative analysis, we develop a general equilibrium model with incomplete market and uninsurable idiosyncratic shocks as (AIYAGARI, 1994) with endogenous entrepreneurial choice and labor market frictions.

The model includes individuals who live infinite periods, derive utility from consumption and leisure, and make entrepreneurial and labor market choices. Households are heterogeneous in the following aspects: assets, occupation, labor productivity, and entrepreneurial ability. Labor supply is endogenous for workers, while entrepreneurs supply a fixed amount of labor, as (BRUGGEMNANN, 2021). Entrepreneurs face financial frictions, limiting the capital demand as (KITAO, 2008), and operate decreasing returns-to-scale production functions, as (LUCAS, 1978). They can be classified as employers who demand labor in addition to their own time endowment or self-employed who rely solely on their own labor supply. The agents only realize their entrepreneurial ability once they decide to open a firm, making starting a business risky.

We use microdata for Brazil to inform the model and proceed with a quantitative analysis. The model matches key facts concerning unemployment, wage and wealth distributions, and the distribution of transfers. The calibrated model allows us to conduct several counterfactual experiments to shed light on the impacts of existing and new transfer regimes on inequality and welfare. The UBI reform is such that every household receives a lump-sum transfer defined as a share of output per capita in the benchmark economy, irrespective of the household's economic circumstances. We evaluate the welfare implications of our experiment by considering a social welfare function given by the expected utility of a newborn agent under the veil of ignorance. This welfare criterion considers the policymaker's concern for insurance against idiosyncratic shocks and the distortions the policy instruments impose on labor supply, capital accumulation, and occupational choices. The costs associated with government transfers are financed by adjusting the level of labor income taxation.

We find that the welfare-maximizing UBI reform is achieved at an income transfer corresponding to 10 percent of GDP per household. Welfare in terms of consumption equivalent variation (CEV) increases by 3.3 percent in this case. Notably, this reform results in a slightly lower government transfer payments for agents at the bottom of the income distribution, who are predominantly unemployed and self-employed. Conversely, workers and entrepreneurs at the middle and top of the income distribution, constituting the majority of the individuals, receive a higher transfer amount. This increase disincentivizes capital accumulation. Hence, unemployment increases by approximately 10 percent, and the share of employers declines by roughly 12 percent. As a result, aggregate capital stock diminishes by 19.6 percent, and aggregate output falls by 10.4 percent. Furthermore, the reduction in capital, combined with its interaction with financial frictions and the tax burden required to finance the UBI scheme, incentivizes the transition from employer to self-employment. Results are qualitatively similar but quantitatively stronger with larger UBI reform, such as 15 percent of GDP per household. In both scenarios, there is a reduction in consumption and post-tax-and-transfer income inequality.

Conversely, the results differ significantly when the government maintains the same amount of transfers of the benchmark economy (expenditure-neutral experiment) or eliminates transfers entirely. In both scenarios, the large decrease in government transfers to poor individuals, without a corresponding increase for other income brackets, strengthens the precautionary saving motive. This leads to an increase in aggregate capital and output. In the expenditure-neutral case, aggregate capital increases by 2.96 percent, and output increases by 3.07 percent. Moreover, the share of self-employed agents decreases by 4.64 percent, and the share of employers increases by 36.6 percent. This shift in occupational composition can be attributed to the substantial reduction in transfers received by poor unemployed individuals. The incentives to stay in the current occupation are higher, conditional on not receiving an unemployment shock. This leads to a lower transition from employer to self-employment. In general, there is an increase in consumption and post-tax-and-transfer income inequality, contributing to a welfare loss in these cases. In short, the design of the transfer system can significantly influence agents' occupational choices, consequently impacting output and welfare.

3.2 Related Literature

We contribute to the macroeconomic development literature by integrating three branches: entrepreneurship, self-employment, and tax and transfer systems. First, (QUADRINI, 2000) and (CAGETTI; NARDI, 2006) show the role of entrepreneurship in accounting for the observed income and wealth inequality in heterogenous agents and incomplete market models as (AIYAGARI, 1994). Several papers depart from (CAGETTI; NARDI, 2006) model to investigate the role of occupational choice in explaining observed aggregate variables or to explore the implications for counterfactual policies. For example, (İMROHOROGLU; ZHAO, 2020) describe the importance of entrepreneurship as a channel to explain the increase in wealth inequality in the U.S. in the last decades. Declining interest rates decrease financing costs, increasing entrepreneurs' profits and savings while decreasing workers' capital income. (SALGADO, 2018) documents the decline in the share of entrepreneurs since the 1980s, especially among college agents. The decline in the price of capital increases high-skill wages due to capital-skill complementarity, incentivizing high-skilled entrepreneurs to become workers. (BRUGGEMNANN, 2021) finds that the top marginal tax rate that maximizes aggregate welfare is 57 percent in a model with entrepreneurship and 67 percent in a model without occupational choice, indicating that the top marginal tax rate is overestimated in the absence of entrepreneurs. Our paper contributes to this branch of the literature by clarifying the impact not only on wealthy, high-skilled entrepreneurs but also on poor self-employed individuals, who may respond differently depending on the magnitude of government transfers.

Second, (POSCHKE, 2012) and (POSCHKE, 2013) empirically document the concentration of self-employment at the bottom and top of the income distribution, showing that self-employment can be an alternative to unemployment. (POSCHKE, 2022) shows that larger labor market frictions make wage employment harder to find and self-employment more attractive, explaining the high share of self-employment in poor countries. (FENG; REN, 2022) analyze the importance of financial frictions and skill-biased technological change to explain cross-country patterns in entrepreneurship. They show that the share of own-account entrepreneurs decreases with increased productivity and financial development since higher wages push workers from own-account entrepreneurship to the labor market. Our paper aligns closely with (HERRENO; OCAMPO, 2022), who explore the role of subsistence self-employment on the aggregate impact of credit supply expansions. Their findings highlight how insurance policies can reduce the incentives for low-productivity agents to go to self-employment. Our paper distinguishes itself from previous research by analyzing the effects of a range of unconditional cash transfer values rather than focusing on a single specific amount. Additionally, we extend our analysis beyond aggregate economic variables to include impacts on inequality and welfare, distinguishing entrepreneurs by employers and self-employed agents.

Third, despite the growing interest in Universal Basic Income (UBI), it has not been implemented on a large scale, leaving its long-term impacts uncertain[3]. Recent papers quantify the macroeconomic impacts of UBI reforms on the U.S. economy, focusing on distinct margins. (DARUICH; FERNANDEZ, 2020) build an OLG model with a comprehensive human capital accumulation framework and intergenerational skill transmission, finding that an alternative economy with UBI transfers generates welfare loss due to its negative effect on parental investment in child skills. Similarly, (FERREIRA; PERUFFO; VALERIO, 2021) construct an OLG model to compare a UBI system to a conditional cash transfer in Brazil, finding that UBI may lead to welfare loss in the long run due to a decrease in human capital. (CONESA; LI; LI, 2021) compute the welfare-maximizing UBI reform financed by different fiscal instruments in an economy with two types of consumption goods and find a welfare loss in all cases for most individuals. Conversely, (LUDUVICE, 2021) develop an OLG model with a detailed U.S. tax and transfer system, finding that an alternative economy with UBI transfers generates welfare gains provided by the insurance the UBI offers. (SANTOS; RAUH, 2022) also find welfare gains for large UBI experiments in an environment with labor market frictions. Our paper contributes to this branch of the literature by providing the relevance of entrepreneurship to quantify the overall effect of a UBI system that has been ignored so far.

We organize the subsequent sections as follows: Section 3.3 provides empirical evidence

[3](MARINESCU, 2018), (GENTILINI et al., 2020), and (HOYNES; ROTHSTEIN, 2019) provide comprehensive descriptions of UBI policies and evidence from transfer programs closely aligned with the UBI concept

of entrepreneurship at the bottom and at the top of the income distribution in the Brazilian economy. Section 3.4 describes the economic model. Section 3.5 presents the calibration and Section 3.6 shows the quantitative analysis of distinct UBI reforms. Finally, Section 3.7 concludes the paper with the main arguments.

3.3 Empirical Analysis

We rely on the Brazilian household survey data POF 2017/2018 (*Brazilian Consumer Expenditure Survey*) to document the main characteristics of the Brazilian labor force. POF provides detailed information about occupation, labor income, and, especially, government transfers[4]. Table 3.1 reports summary statistics by occupation. Individuals are classified as self-employed, workers, employers, or unemployed[5]. We restrict the sample to the head of households from 22 to 65 years old and classify the individuals without information about their occupation as unemployed. Self-employed agents represent 27.8 percent of the Brazilian labor force and receive 20.8 percent of total federal government transfers. This share is significant since, as expected, unemployed agents receive the largest amount of transfers. Also, it indicates that self-employed agents are not necessarily talented entrepreneurs at the beginning of their entrepreneurial life but agents with low income. Moreover, the share of self-employed individuals with a completed college degree is lower than workers and employers, suggesting that they may be out of the 'wage employment' market due to lower productivity. This evidence is in line with (POSCHKE, 2013). Also, the average income of the self-employed agents is lower than workers, and employers' average income is the highest among the different occupations as in other countries. On average, workers and self-employed agents work a similar amount of hours per week, which is lower than employers.

[4]POF is a cross-sectional survey conducted every ten years by IBGE (Brazilian Institute of Geography and Statistics). We rely on the latest available data, 2017/2018. We consider as government transfers the non-labor income classified as federal social programs (programas sociais federais). It includes the programs Brasil Família, Brasil Carinhoso, Auxílio Gás, Bolsa Escola, Bolsa Alimentação, Cartão do Programa Nacional de Acesso à Alimentação, Programa de Erradicação do Trabalho Infantil, Benefício de Prestação Continuada, Auxílio a Portadores de Deficiência Física, and Auxílio Morte. The results are similiar when we consider as government transfers the federal social programs (*programas sociais federais*) and other transfers (*outras Transferências*).

[5]Throughout the paper, we use the terms own account workers and self-employed agents interchangeably. We consider entrepreneurs as self-employed or employers.

Tabela 3.1 – Summary statistics

	Self-Employed	**Worker**	**Employer**	**Unemployed**
Share in the labor force	28.3	63.4	4.54	3.81
Federal government transfers (*share*)	20.8	30.8	0.27	48.2
Federal government transfers (*mean*)	$215,0	$190,0	$251,0	$350,0
College degree (*share)*	12.3	21.8	37.2	1.1
Labor income monthly (*mean*)	$1,825	$2,505	$7,784	-
Labor income per hour (*mean*)	$12.7	$16.2	$44.1	-
Hours per week (*mean*)	40.6	41.2	47.5	-
35+ weekly hour (*share*)	69.7	84.2	87.1	-

Note: POF 2017.

Figure 3.1 shows the share of entrepreneurs by labor income decile separated by self-employed and employers. In this case, we restrict the sample to individuals classified as self-employed, workers, and employers. We define entrepreneurs as the sum of self-employed and employers. Even though entrepreneurs are concentrated at the bottom and the top of the income distribution, the composition is different. Employers represent high-talent entrepreneurs who concentrate a disproportionate share of income, and self-employed represent low-talent entrepreneurs facing entrepreneurship as an alternative to unemployment or low-paid jobs. The prevalence of self-employed entrepreneurs at the first deciles of income distribution explains the large share of federal government transfers to agents in this occupation.

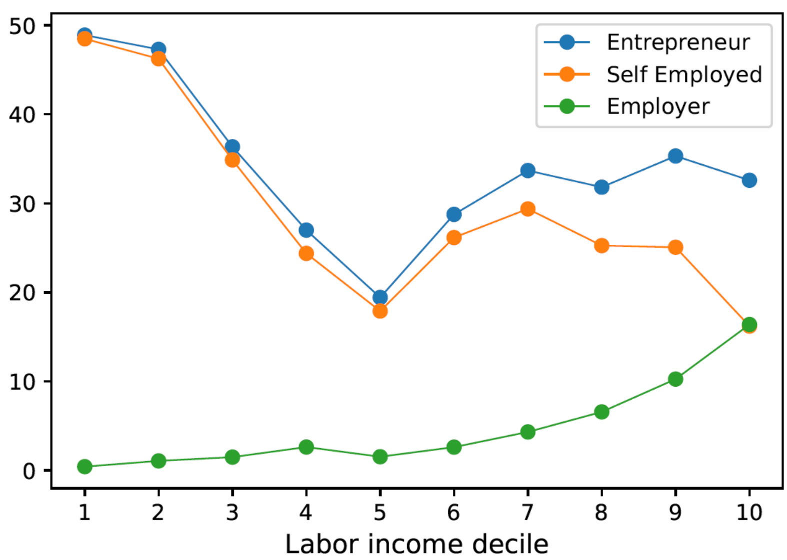

Figura 3.1 – Share of entrepreneurs by labor income decile.
Note: This figure provides the share of entrepreneurs by labor income decile. Hence, it does not consider unemployed agents. 'Entrepreneur' considers the sum of 'Self-Employed' and 'Employer'.

3.4 The Environment

3.4.1 Demography

The economy is inhabited by infinitely-lived heterogeneous agents as in (AIYAGARI, 1994). Agents are heterogeneous regarding assets, labor productivity, entrepreneurial ability, and occupation. In each period, workers are subject to unemployment shocks, and unemployed agents and entrepreneurs receive a job offer with a given probability. Workers and unemployed individuals do not know their entrepreneurial ability, and only realize it after deciding to open a firm.

Preferences

Agents choose consumption, c_t, and labor, h_t, to maximize their expected discounted lifetime utility given by:

$$\mathbf{E_0} \sum_{t=0}^{\infty} \beta^t u(c_t, h_t), \tag{3.1}$$

where $\beta \in (0, 1)$ is the time discount parameter and $\mathbf{E_0}$ is the expectation operator conditional on information at $t = 0$. The flow utility function is given by

$$u(c_t, h_t) = \frac{c_t^{1-\mu}}{1-\mu} - \chi \frac{h_t^{1+\xi}}{1+\xi}. \tag{3.2}$$

3.4.2 Worker's labor productivity

Agents have a fixed time endowment per period. Worker's labor income is given by,

$$w_t h_t e^{z_t}, \tag{3.3}$$

where w_t is equilibrium market wage; h_t is the endogenous labor supply, and z_t is the individual's productivity that follows an AR(1) process, $z_t = \rho z_{t-1} + \varepsilon_t$ with $\varepsilon_t \sim N(0, \sigma_z^2)$. Entrepreneurs' labor productivity is described below.

3.4.3 Technology

The economy is divided into two sectors: corporate and non-corporate. The first sector consists of large firms with constant returns to scale technology operating in a competitive market. The static profit maximization problem is given by

$$\max_{K_c, N_c} \{AK_c^{\alpha} N_c^{1-\alpha} - wN_c - (r + \delta)K_c\}, \tag{3.4}$$

where α indicates the share of capital in the production function, w is the market wage rate, r is the rental rate of capital, and δ indicates the depreciation. K_c represents capital, and N_c is the effective labor. Therefore, from the firm's first order condition, we have the following market prices,

$$r = A\alpha\frac{Y_c}{K_c} - \delta, \quad \text{where} \quad Y_c = AK_c^{\alpha}N_c^{1-\alpha}, \tag{3.5}$$

$$w = A(1-\alpha)\frac{Y_c}{N_c}. \tag{3.6}$$

The non-corporate sector consists of single entrepreneurs facing decreasing-returns-to-scale production function measured by the span-of-control parameter ν, as in (LUCAS, 1978). Each entrepreneur has an idiosyncratic managerial ability s that follows an AR(1) process,

$$s_t = \eta s_{t-1} + \epsilon_t \text{ with } \epsilon_t \sim N(0, \sigma_s^2). \tag{3.7}$$

They supply a fixed amount of labor $\bar{h}$, and their capital demand is limited by their current wealth a. Entrepreneurs choose to become employers or self-employed. As in (ALLUB; EROSA, 2019), employers pay a per-period fixed cost and maximize profits as follows,

$$\pi_{emp.} = \max_{n,k} \; A_e e^s (k^{\alpha}(\bar{h}+n)^{1-\alpha})^{\nu} - wn - (r+\delta)k - c_e \tag{3.8}$$

$$\text{s.t. } k \leq da, \quad d \geq 1.$$

Self-employed agents operate their firms by choosing only the capital input as follows,

$$\pi_{self-emp.} = \max_{k} \; A_e e^s (k^{\alpha}\bar{h}^{1-\alpha})^{\nu} - (r+\delta)k \tag{3.9}$$

$$\text{s.t. } k \leq da, \quad d \geq 1.$$

3.4.4 Government sector

The government is responsible for three sources of expenditures: exogenous spending G, government debt D, and targeted transfers Tr. To finance total spending, the government levies proportional taxes on consumption, τ_c, and capital income, τ_k. Taxes on labor income are raised by the following non-linear function:

$$T(y_e) = \max\{y_e - \lambda y_e^{1-\tau}, 0\}, \tag{3.10}$$

where y_e represents labor earnings, that is, the worker's labor income or the entrepreneur's profits. As in (HEATHCOTE; STORESLETTEN; VIOLANTE, 2008), the parameters λ and τ measure the level and progressivity of the tax function, respectively. The tax function is progressive if the average tax rate is strictly increasing for all income levels y, that is, $\lambda\tau > 0$. We say the marginal tax rate is strictly increasing if $\tau(1-\tau)\lambda > 0$.

The targeted transfer function is based on (FERRIERE et al., 2022),

$$\omega(y_i) = m\bar{y}_i \frac{2\exp\left\{-\zeta\dfrac{y_i}{\bar{y}_i}\right\}}{1+\exp\left\{-\zeta\dfrac{y_i}{\bar{y}_i}\right\}}, \tag{3.11}$$

where y_i represents total income $ra + y_e$, that is, labor and capital income. Average income is denoted by $\bar{y}_i$, *m* indicates transfers to an agent with no income, and ζ measures the phase-out rate. Therefore, the tax and transfer function is,

$$T(y_e, y_i) = \max\{y_e - \lambda y_e^{1-\tau}, 0\} - \omega(y_i). \tag{3.12}$$

3.4.5 Recursive formulation of individual's problem

Let $V_w(a,z)$, $V_u(a,z)$, and $V_e(a,s,z)$ indicate the value functions of worker, unemployed, and entrepreneur agents, respectively. The individual's problem can be characterized as follows:

Worker: In the current period, agents choose consumption, asset accumulation, and labor supply. In the next period, agents receive an unemployment shock with probability γ_u. Workers know their labor productivity but do not know their entrepreneurial ability. The workers' Bellman equation is

$$\begin{aligned} V_w(a,z) = \max_{c,h,a'} u(c,h) + \beta \mathop{\mathbf{E}}_{z'|z} \Bigg[&\gamma_u \max\Big\{V_u(a',z'), \mathop{\mathbf{E}}_{s'} V_e(a',s',z')\Big\} + \\ &+ (1-\gamma_u)\max\Big\{V_w(a',z'), V_u(a',z'), \mathop{\mathbf{E}}_{s'} V_e(a',s',z')\}\Big\}\Bigg] \end{aligned} \tag{3.13}$$

subject to

$$\begin{aligned} &(1+\tau_c)c + a' = [1+(1-\tau_k)r]a + y_w - T(y_w, ra + y_w), \qquad (3.14)\\ &a' \geq 0, \quad 0 \leq h \leq 3, \\ &y_w = whe^z. \end{aligned}$$

Entrepreneur: In the current period, agents choose consumption and asset accumulation. In the next period, entrepreneurs receive a job offer with probability γ_s. Entrepreneurs know their labor productivity and entrepreneurial ability and can be self-employed or employers. When agents move from unemployment or wage-employment to entrepreneurship, they draw their ability from a stationary distribution associated with the process (3.7). $\varphi(e,u')$ is the cost of switching from entrepreneurship to unemployment. The entrepreneurs' Bellman equation is

$$V^e(a,s,z) = \max_{c,a'} u(c,\bar{h}) + \beta \mathop{\mathbf{E}}_{z'|z} \mathop{\mathbf{E}}_{s'|s} \Big[\gamma_s \max\Big\{ V^w(a',z'), V^u(a',z'), V^e(a',s',z') \Big\} + \quad (1-\gamma_s)\max\Big\{ V^u(a',z'), V^e(a',s',z') \Big\} \Big] \tag{3.15}$$

subject to

$$\begin{aligned} &(1+\tau_c)c + a' = [1+(1-\tau_k)r]a + y_w - T(y_w, ra+y_w) - \varphi(e,u'), \\ &a' \geq 0, \quad \bar{h} = 1, \\ &y_w = \max\{\pi_{emp.}, \pi_{self-emp.}\}. \end{aligned} \tag{3.16}$$

Unemployed: In the current period, agents choose consumption and asset accumulation. In the next period, unemployed agents receive a job offer with probability γ_e. Unemployed individuals know their labor productivity but do not know their entrepreneurial ability. Since they do not receive labor income, their earnings come from a home production *b*. The unemployed agents' Bellman equation is

$$V^u(a,z) = \max_{c,a'} u(c,0) + \beta \mathop{\mathbf{E}}_{z'|z} \Big[\gamma_e \max\Big\{ V^w(a',z'), V^u(a',z'), \mathop{\mathbf{E}}_{s'} V^e(a',s',z') \Big\} + \quad +(1-\gamma_e)\max\Big\{ V^u(a',z'), \mathop{\mathbf{E}}_{s'} V^e(a',s',z') \Big\} \Big] \tag{3.17}$$

subject to

$$\begin{aligned} &(1+\tau_c)c + a' = [1+(1-\tau_k)r]a + b - T(0, ra), \\ &a' \geq 0. \end{aligned} \tag{3.18}$$

Recursive competitive equilibrium.

Individuals are characterized by the state variables $\omega_1 = (a,z,s)$ or $\omega_2 = (a,z)$, and occupation $oc = \{w,u,e\}$. A recursive competitive equilibrium is given by a set of value functions $\{V_w(\omega_2), V_u(\omega_2), V_e(\omega_1)\}$; policy functions for consumption $c_{oc}(\omega)$, asset holdings $a'_{oc}(\omega)$, and labor supply $h_{oc}(\omega)$[6]; aggregate variables K, N, Y; prices r, w and measures $\lambda(\omega)$ such that:

1. The value function $V_{oc}(\omega)$ solves the Bellman equations above with the associated policy functions $c_{oc}(\omega)$, $a'_{oc}(\omega)$, $h_{oc}(\omega)$ for a given set of prices.

[6] $\omega = \omega_2$ if $oc = \{w,u\}$ and $\omega = \omega_1$ if $oc = \{e\}$.

2. Good and factor markets clear.

$$K_c + \int_{\Omega} k(\omega) d\lambda = \int_{\Omega} a(\omega) d\lambda,$$
$$N_c + \int_{\Omega} n(\omega) d\lambda = \int_{\Omega} h(\omega) d\lambda,$$
$$Y = C + G + \delta K.$$

3. The market wage and the interest rate are equal to the firms' profit maximization problem in the corporate sector as in (3.6) and (3.5), respectively.

4. Government budget constraint condition is satisfied in each period.

$$G + D + Tr = \tau_c \int_{\Omega} c(\omega) d\lambda + \tau_k r \int_{\Omega} a(\omega) d\lambda + \int_{\Omega} T(y(\omega)) d\lambda,$$

   where government spending is composed of exogenous expenditure, debt, and transfer. Government revenue is composed of taxes on consumption, capital income, and labor income.

3.5 Calibration

We calibrate the model to the Brazilian economy in the benchmark. We describe below the parameters that we set exogenously according to literature or available data, and the parameters that we set endogenously to match the model with the data.

Utility:

We set the parameter associated with risk aversion, μ, to 1.5 as (ATTANASIO O. P.; WEBER, 1999). We consider ξ as 1.7, leading to a Frish elasticity of labor supply of 0.59. χ measures the disutility of labor supply and is chosen so households work on average one-third of their time endowment. Finally, we choose β to target the capital-output ratio of 2.55 as in (CAVALCANTI; SANTOS, 2021).

Technology and financial friction:

We set the parameter related to the share of capital income, α, to 0.36 as (GOMES V.; ELLERY-JR., 2005). This parameter is the same in the corporate and non-corporate sectors. We set the span-of-control parameter in the non-corporate sector, ν, to 0.90 as in (EROSA A.; MARTINEZ, 2024), which is in the range of the literature and close to the value calibrated in (CAGETTI; NARDI, 2006). The parameter associated with the collateral constraint, *d*, is 0.5 and targets the credit-to-GDP ratio of 42.0 percent.

Stochastic process of labor productivity:

The entrepreneurs' labor income is given by π_t^e as indicated in (3.9), where s_t is a stochastic component that follows an AR(1) process. We approximate the stochastic process following (ROUWENHORST, 1995) and use twenty grid points in the discretization process. We calibrate the standard deviation $\sigma_s = 0.175$ such that households in the top percentile of the labor income distribution hold 40.0 percent of labor income and the persistence parameter $\eta = 0.90$ to match the persistence of entrepreneurs. The fixed cost paid by employers c_e equals 0.05 and it is chosen to match the share of employers.

The workers' labor productivity, z_t, indicated in (3.3) follows an AR(1) process with persistence ρ and variance σ_z^2. We choose σ_z^2 to match the variance of log earnings among workers. The parameter ρ is set according to $\sigma_\epsilon^2 = \dfrac{\sigma_z^2}{1-\rho^2}$, where σ_ϵ^2 is the residual variance from the Mincerian regression and is equal to 0.40 as estimated in PNAD 2014 (*Pesquisa Nacional por Amostra de Domicílios*).[7] This leads to $(\rho_z, \sigma_z^2) = (0.96, 0.031)$. We use the (ROUWENHORST, 1995) method to discretize the idiosyncratic component of each labor productivity by a first-order Markov chain with 5 grid points.

Occupational switching costs:

We choose the switching cost paid to move from entrepreneurship to unemployment, $\varphi(e, u')$, to be 0.10 to match the transition from entrepreneurship to unemployment. In the absence of this resource cost, we would overestimate the transition from entrepreneurship to unemployment and, consequently, underestimate the share of individuals who remain unemployed from one period to another.

Government policy and transfer programs:

We follow (AZEVEDO; BETTONI; SANTOS, 2024) and consider that the government debt is 33.1 percent of total output. Target transfer corresponds to 0.6 percent of GDP. To finance total expenditure, the government taxes consumption, labor income, and capital income. We follow (PAES; BUGARIN, 2006) and choose a consumption tax rate of 29 percent and a capital tax rate of 15 percent.

The parameter that measures the degree of progressivity in the non-linear tax function (3.10), τ, is set to 0.087 as in (AZEVEDO; BETTONI; SANTOS, 2024). The parameter λ affects the pos-tax earnings and is chosen such that the government balances its budget constraint. The parameter ζ of the transfer function (3.11) is set to 7.5 to match the share of transfers over GDP of 0.6 percent.

Model and Data:

Table 3.2 summarizes the parameters calibrated both internally and externally, as previously discussed. Table 3.3 and 3.4 compare the outcomes of the model with Brazilian data.

[7]PNAD Contínua is a rotating panel data at quarterly frequency conducted by IBGE from 2012 onwards.

Tabela 3.2 – Calibration of the parameters of the model

External calibration

Parameter	Description	Values	Source
ξ	Labor elasticity	1.7	Frisch Elasticity - 0.59
μ	Risk aversion	1.5	(ATTANASIO O. P.; WEBER, 1999)
α	Capital Share	0.36	(GOMES V.; ELLERY-JR., 2005)
$\bar{h}$	Entrep. labor supply	1.0	1/3 of time endowment
τ_c	Consumption tax	0.29	(AZEVEDO; FASOLO, 2015)
τ_k	Capital income tax	0.15	(PAES; BUGARIN, 2006)
ν	Span-of-control	0.90	(EROSA A.; MARTINEZ, 2024)
τ	Income tax progressivity	0.087	(AZEVEDO; BETTONI; SANTOS, 2024)
m	Government Transfer unemployed	0.12	PNAD Contínua

Internal calibration

Parameter	Description	Values	Target
β	Discount factor	0.945	$K/Y = 2.55$
χ	Labor disutility	0.75	Average hours = 1.0
d	Borrowing limit	1.5	Credit to GDP = 42%
c_e	Fixed cost	0.05	Share of employers = 5%
A_e	TFP entrepreneurs	0.5	Share of self-employed = 29%
σ_s	Std deviation initial ability	0.175	Earnings top 10% = 40%
η	Auto-correlation z	0.90	Transition Entrep.-Entrep.
γ_u	Unemployment shock	0.15	Unemployment rate = 6.5%
γ_s	Job offer - unemployed	0.70	Transition Unemp.-Employment.
γ_e	Job offer - entrepreneur	0.50	Transition Entrep.-Employment.
$\varphi(e, u')$	Switching cost	0.10	Transition Entrep.-Unemp.
ζ	Phase-out transfer	7.5	Government transfer to GDP = 0.6%
λ	Income tax level	0.825	Balance govt. budget constraint

Table 3.3 indicates that the model closely replicates the target moments observed in the data, particularly the distribution of agents by occupation. This accurate representation of the high proportion of entrepreneurs, including employers and self-employed agents, is relevant for the subsequent policy experiments.

Tabela 3.3 – Calibration results: Baseline economy. Source: PNAD Contínua

Calibrated moments	**Data**	**Model**
Overall economy		
Capital-output	2.55	2.42
Credit-output	0.42	0.40
Hours worked	1.0	1.0
Income top decile (%)	40.0	38.0
Occupation (%)		
Unemployed	6.5	6.5
Worker	58.5	59.45
Employer	5.0	5.2
Self-employed	29.0	29.9

Table 3.4 shows the transition rate between occupations. Four transition rates are specifically targeted, as indicated by an asterisk: entrepreneur to entrepreneur, unemployment to worker, entrepreneur to worker, and self-employment to unemployment. The model replicates these transitions reasonably well, though it overestimates the share of individuals who transition from unemployment to employment between two periods.

Tabela 3.4 – Calibration results: Transition between occupations

Model/Data	**Unemployed**	**Worker**	**Employer**	**Self Employed**
Unemployment	34.5 / 30.92	58.0* / 51.35	0.1 / 1.16	7.2 / 16.57
Worker	6.5 / 3.06	75.4 / 90.0	0.3 / 1.12	17.6 / 5.81
Employer	1.0 / 0.69	6.2 / 9.9	79.9 / 67.5	12.8 / 21.8
Self-Employed	1.3* / 1.9	20.6* / 14.7	2.4 / 6.4	75.7* / 76.9

Note: The table specifies target and untargeted moments. An asterisk indicates target moments. We compute the transition rate on a yearly basis.

Figure 3.2 shows the share of entrepreneurs, considering self-employed and employers, by labor income decile generated by the model. The empirical analog is represented by Figure 3.1. The model can generate a high concentration of entrepreneurs in the first and last deciles. Still, it does not capture the presence of entrepreneurs in the middle of the labor income distribution. Moreover, it overestimates (underestimates) the share of self-employment at the bottom (top) of the labor income distribution. Consequently, since self-employment is highly prevalent at the bottom of the labor income distribution, they concentrate a disproportionate amount of government transfer compared to the data. In the model, they receive 40 percent of government transfers, and in the data, they concentrate 39.3 percent, as shown in Table 3.1. Nonetheless, unemployed agents receive 48.2 percent of government transfers in the data and 46.9 percent in the model. Moreover, overall government transfer by income quintile matches the data reasonably well, as seen in Figure 3.3.

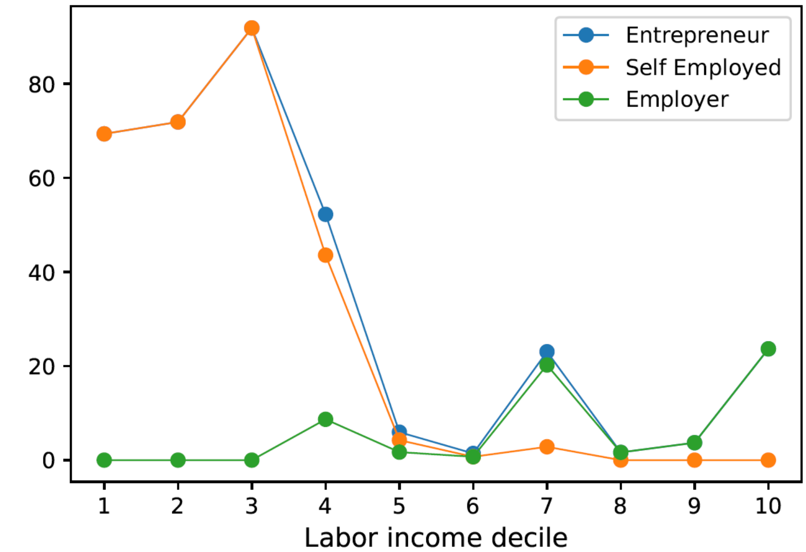

Figura 3.2 – Share of entrepreneurs (model)

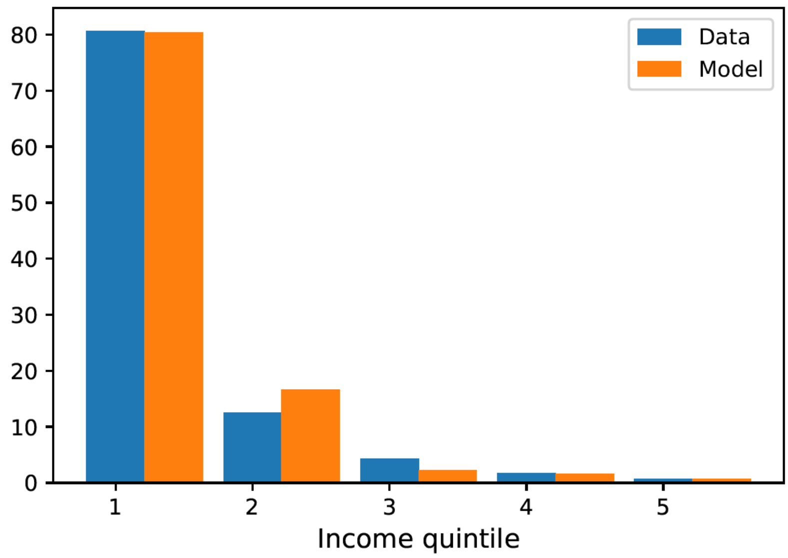

Figura 3.3 – Government transfer by income quintile

3.6 UBI reforms

This section compares the benchmark economy in which government transfers depend on the agent's income and assets to an economy with Universal Basic Income. We assume that the government moves from the benchmark economy to an alternative economy by replacing the transfer function (3.11). In the counterfactual exercises, ω does not depend on income or asset level; instead, every household receives an equal income transfer, $\omega(y_i) = \bar{\omega}$, where $\bar{\omega}$ represents a fraction of the output in the benchmark economy. The UBI replaces the existing targeted transfer system rather than supplementing it. Therefore, the new tax and transfer function is defined as follows:

$$T(y_e, y_i) = \max\{y_e - \lambda y_e^{1-\tau}, 0\} - \bar{\omega}. \tag{3.19}$$

Our analysis focuses on five specific UBI levels as a percentage of benchmark output: 0, 0.68, 5, 10, and 15 percent.[8] The first case represents a scenario with no government transfers. The second case maintains the same total transfer amount as the benchmark but adopts a universal system. The third case is an intermediate level between the previous one and the welfare-maximizing UBI level. The fourth case represents the welfare-maximizing UBI level. The fifth case reflects a UBI level close to the value proposed by Andrew Yang. In all scenarios, exogenous government expenditure and debt remain at the benchmark level. The analysis focuses on three main aspects: aggregate variables, inequality, and welfare.

3.6.1 Aggregate outcomes

Table 3.5 displays the main aggregate variables and the CEV for the five distinct UBI reforms compared to the benchmark economy. Column (1) indicates an economy without government transfers, while Column (2) represents an economy with the same amount of total transfers as the benchmark. In both cases, the amount of government transfer received by low-income agents decreases significantly. This reduction increases the precautionary savings motive, leading to higher capital accumulation and lower interest rates. Capital increases by 11.35 percent and 9.96 percent in the first and second UBI reforms, respectively. Additionally, the share of employers increases by almost 2 percentage points due to lower interest rates and the reduced attractiveness of unemployment and self-employment given the lower transfers to poor agents. This mechanism, along with an increase in wages, explains why there is a lower share of self-employed individuals in these cases. Moreover, since individuals are less likely to transition to unemployment, the unemployment rate decreases by approximately 5.5 percent in both cases.

[8] To determine the optimal UBI level, we conduct a search over a discrete number of grid points with intervals of 0.10 percentage points, ranging from zero to 15 percent of the benchmark economy's output. For clarity, we focus on these five levels as they represent the most interesting cases.

Column (3) displays the main results for an intermediate UBI experiment of 5 percent. As in the previous cases, agents with low assets and income receive a smaller amount of government transfers. As reported in Table 3.2, poor agents receive government transfers of approximately 12 percent of average income in the benchmark. Note that, to receive this amount, the agent must have neither labor nor capital income. Thus, being unemployed is insufficient to receive the highest amount of government transfer. Therefore, the unemployment rate is still lower than the benchmark. Additionally, this amount of government transfer is sufficient to disincentivize capital accumulation, since the insurance against productivity shocks increases. Hence, capital decreases by 6.10 percent, and output decreases by 3.43. The share of employers is lower than in the previous UBI experiments. Finally, we observe a decrease in average hours worked as a consequence of the income effect related to government transfers. Recall that only workers are allowed to adjust labor supply in the model.

Next, Column (4) presents the main results for a UBI experiment set at 10 percent, which is identified as the welfare-maximizing policy. The welfare, calculated as CEV and detailed below, increases by 3.33 percent. The effects observed with a UBI experiment of 5 percent are amplified. There is a significant drop in capital by 19.66 percent, leading to a decrease in output by 10.30 percent. As before, this reduction is due to a lower precautionary saving motive. Since transfers for all agents are similar to those received by poor agents in the benchmark economy, the unemployment rate increases by 11 percent. Additionally, there is a reduction of 12.24 percent in the share of employers. This outcome is mainly due to the lower share of capital, its interaction with financial frictions, and the higher income taxes required to finance the UBI policy. Notably, the share of self-employed agents remains almost the same, owing to a higher transition from employer and unemployed status to self-employment. Consequently, there is a fall in TFP of 4.14 percent due to a larger share of entrepreneurs who are financially constrained.[9]

Finally, Column (5) shows the results for UBI experiments of 15 percent. The outcomes are qualitatively similar to a UBI reform of 10 percent but quantitatively stronger. Specifically, as the government increases the amount of transfer the agents receive, capital accumulation decreases further. Capital and output decrease by 30.60 percent and 17.16 percent, respectively. As a consequence, the interest rate increases by 67.21 percent, reducing entrepreneurs' profitability. Additionally, in contrast to the situation where the government reduces or eliminates transfers, large UBI experiments make unemployment more attractive, resulting in a higher likelihood of transitioning to unemployment, especially for self-employed agents.

Thus, UBI experiments may have different effects depending on their magnitude. Large UBI experiments may lead to a decrease in capital, average hours worked, and output. Although low-income agents may receive a lower government transfer compared to the benchmark, as UBI

[9] We follow (GARCIA-SANTANA M., 2014) and impose a Cobb-Douglas representative firm. Then, we use the aggregate data generated by the model to measure the change in TFP.

levels increase, insurance against bad productivity shocks increases. Therefore, precautionary savings decrease, and overall capital accumulation declines. On the other hand, simply replacing the current tax and transfer system with an expenditure-neutral UBI policy may increase aggregate output by increasing the share of capital and employers.

Tabela 3.5 – UBI reform

		Policy experiments (UBI)				
Variable	Benchmark	0%	0.6%	5%	10%	15%
		(1)	(2)	(3)	(4)	(5)
Output, Y	1.0	+3.07%	+3.07%	-3.43%	-10.39%	-17.16%
Capital, K	1.0	+11.35%	+9.96%	-6.1%	-19.66%	-30.60%
TFP	1.0	+2.45%	+2.23%	-0.85%	-4.14%	-7.08%
Avg. hours worked	1.0	1.0	1.0	0.98	0.93	0.87
w	1.14	1.18	1.17	1.12	1.07	1.04
Interest rate, r (%)	3.5	2.86	2.92	3.83	4.94	5.88
Unemployed (%)	6.5	6.14	6.14	6.33	7.20	7.56
Self-Employed (%)	29.9	28.45	28.51	30.23	29.99	30.51
Employers (%)	5.29	7.23	7.18	5.24	4.64	3.37
Tax level (τ)	0.79	0.81	0.79	0.70	0.58	0.45
CEV (%)	-	-0.06	-0.02	1.25	3.33	1.52

Note: Columns (1) to (5) correspond to the percentage of average income in the benchmark economy. CEV (consumption equivalent variation) is the welfare measure. Some variables are normalized to one hundred since their level does not have a clear economic interpretation.

3.6.2 Inequality

This study employs the Gini coefficient as a measure of inequality. Table 3.6 presents the Gini coefficients for consumption, assets, labor income, and total income. We further differentiate between pre-tax and post-tax and transfer (t&t) scenarios.

Similar to the previous analysis, Columns (1) and (2) display results for an economy without government transfers and one with a UBI of 0.68 percent, respectively. In both cases, the Gini coefficients remain close to benchmark values. However, the Gini coefficient for assets is most affected. Due to an increase in the precautionary savings motive, asset accumulation increases, leading to a decrease in asset inequality. Conversely, a slight increase in the Gini coefficient of labor income and total income after tax and transfer is observed. This occurs because agents at the bottom of the income distribution receive a lower transfer amount.

Column (4) presents the welfare-maximizing UBI policy, which significantly reduces most Gini coefficients. Here, government transfers increase for a majority of individuals, even if those at the bottom receive slightly less. Consequently, the Gini coefficients for consumption and income after tax and transfer decrease substantially.

Column (5) exhibits similar effects compared to the optimal UBI policy in Column (4). The Gini coefficients most impacted are those related to consumption and income after tax and transfer. As expected, higher government transfers directly reduce consumption inequality. However, it is important to note that the Gini coefficient of total income rises as UBI reforms increase from 0.68 percent to 15 percent. This can be attributed to rising interest rates as capital dampens, leading to higher capital income in this scenario.

Tabela 3.6 – Gini coefficient

Variable	Bench.	UBI reform 0% (1)	0.6% (2)	5% (3)	10% (4)	15% (5)
Gini assets	0.684	0.649	0.648	0.678	0.707	0.719
Gini labor income	0.504	0.503	0.503	0.505	0.502	0.501
Gini labor income after t&t	0.453	0.463	0.458	0.422	0.367	0.305
Gini total income	0.514	0.510	0.510	0.512	0.516	0.518
Gini total income after t&t	0.466	0.473	0.468	0.438	0.401	0.357
Gini consumption	0.370	0.374	0.363	0.350	0.330	0.297

Note: This table exhibits the Gini coefficient for different variables. The UBI policy is a fraction of the output per household in the benchmark model. Total income corresponds to labor and capital income, and t&t corresponds to tax and transfer.

3.6.3 Welfare

We measure welfare in terms of consumption-equivalent variation (CEV). The CEV measures how much an agent is willing to change her lifetime consumption to make her indifferent between the benchmark and the counterfactual economy, given her current state. The CEV can be expressed as follows:

$$\int_{\mathbf{P}} \mathbf{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u\Big((1+\Delta_{cev})c_t^0, h_t^0\Big) \right] d\lambda(\mathbf{P}) = \int_P \mathbf{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u\Big(c_t^1, h_t^1\Big) \right] d\lambda(\mathbf{P}), \tag{3.20}$$

where the sequences $\{c_t^0, h_t^0\}_{t=0}^{\infty}$ and $\{c_t^1, h_t^1\}_{t=0}^{\infty}$ represent the competitive equilibrium allocations in the benchmark and the counterfactual economy, respectively. A positive Δ_{cev} indicates that there is an average welfare gain from moving from the benchmark to the counterfactual economy where the government implements a distinct policy.

We follow (FLODEN, 2001) and (HEATHCOTE; STORESLETTEN; VIOLANTE, 2008) and decompose the welfare effect Δ_{cev} in two terms: a level effect, denoted as Δ_{lev}, and an uncertainty effect, represented as Δ_{unc}. The level effect is associated with welfare change due to changes in the size of aggregate consumption. The uncertainty effect is related to the welfare change due to the distinct stochastic process for idiosyncratic productivity in the alternative economy. The decomposition is described below and holds as an approximation, $\Delta_{cev} \approx \Delta_{lev} + \Delta_{unc}$.

Let C_0 and H_0 denote population averages of consumption and labor in the benchmark economy. Similarly, C_1 and H_1 denote average consumption and average labor in the alternative UBI experiment. We then define the level component, Δ_{lev}, as:

$$u((1+\Delta_{lev})C_0, H_0) = u(C_1, H_1) \tag{3.21}$$

Then, given the utility function in (3.2), we have the following closed-form solution,

$$\Delta_{lev} = \left[\frac{u(C_1, H_1)}{u(C_0, H_0)}\right]^{1/(1-\mu)} - 1. \tag{3.22}$$

We consider two terms to define the uncertainty component, Δ_{unc}.

$$u((1-p_0)C_0, H_0) =_{\mathbf{P}} \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^0, h_t^0) d\lambda(\mathbf{P}), \tag{3.23}$$

and

$$u((1-p_1)C_1, H_1) = \int_{\mathbf{P}} \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t^1, h_t^1) d\lambda(\mathbf{P}). \tag{3.24}$$

Thus, the uncertainty component is defined as,

$$\Delta_{unc} = \frac{1-p_1}{1-p_0} - 1. \tag{3.25}$$

Table 3.7 presents the welfare effects of distinct UBI reforms relative to the benchmark economy.

The welfare gain observed in Column (4) for the optimal policy of 10 percent UBI is primarily driven by the uncertainty component of the CEV. Despite receiving lower transfers upon unemployment, the overall increase in government transfers acts as insurance against uninsurable idiosyncratic shocks in labor and entrepreneurial productivity. This positive effect outweighs the welfare loss arising from the efficiency term, which reflects reduced capital accumulation and output. Consequently, the CEV increases by 3.33 percent, with the uncertainty component contributing 11.59 percent, despite a decrease of 7.40 percent associated with the level term. Larger UBI reforms exhibit a similar pattern: a welfare gain from improved insurance (uncertainty term) and a welfare loss from lower consumption (level component). However, as seen in Column (5) for the 15 percent UBI reform, the net effect starts to decrease compared to the optimal level, even though it is still positive in this case.

Columns (1) and (2) depict the welfare changes under two alternative scenarios: eliminating transfers entirely and maintaining the total transfer amount as in the benchmark (expenditure-neutral). Both scenarios exhibit welfare losses attributable to the uncertainty component. Lower government transfers in these experiments provide less insurance against bad, uninsurable idiosyncratic shocks. The level component, however, contributes positively to CEV due to increased capital accumulation and, consequently, consumption.

Tabela 3.7 – CEV decomposition: $\Delta_{cev} \approx \Delta_{lev} + \Delta_{unc}$

	UBI reform				
Variable	0% (1)	0.6% (2)	5% (3)	10% (4)	15% (5)
Δ_{cev}	-0.06	-0.02	1.25	3.33	1.52
Δ_{lev}	2.14	1.89	-2.31	-7.40	-13.49
Δ_{unc}	-2.76	-2.11	3.65	11.59	17.36

Notes: This table displays the CEV decomposed in terms of efficiency and uncertainty for different UBI policies. The UBI policy is a fraction of the output per household in the benchmark model. The UBI transfer that maximizes welfare is 10 percent of output per household.

Table 3.8 presents the CEV decomposition for four occupational groups (workers, unemployed, employers, and self-employed) focusing on non-switching households – those remaining in the same occupation after transitioning from the benchmark to the UBI economy. The UBI reforms demonstrate distinct quantitative impacts on each group, but the overall pattern remains consistent. Larger UBI experiments generate a welfare gain from the uncertainty component, counterbalanced by a welfare loss from the level component. The mechanisms driving these effects are similar to those described previously.

Interestingly, self-employed non-switchers are the only group to experience a welfare gain (11.62 percent) with large UBI reforms (15 percent). In this case, both the level and uncertainty components increase (2.91 percent and 8.46 percent, respectively). The level component rises due to the presence of self-employed agents at the lower end of the income distribution, leading to an overall increase in average consumption despite larger UBI reforms. Additionally, higher interest rates and increased insurance associated with larger government transfers contribute to a positive uncertainty component. Conversely, unemployed agents experience a welfare loss from the level component. Recall that government transfers are conditional on labor and capital income. Thus, wealthy individuals who become unemployed do not receive transfers. Consequently, large UBI reforms translate to a welfare loss for unemployed agents due to significant reductions in capital accumulation and consumption, without necessarily being offset by larger transfers, as seen in the case of self-employed agents.

Another seemingly counterintuitive finding is the 0.11 percent welfare gain for unemployed agents with a UBI level of 0.68 percent (Column 2). This can be attributed to the increase in capital accumulation among unemployed individuals, ultimately leading to higher consumption. As a result, the positive level component outweighs the negative uncertainty component, which decreases due to reduced government transfers, particularly for those initially at the bottom of the income distribution. It is important to reiterate that unemployed agents may also be represented by high-income individuals, who can be benefited by a higher amount of government transfer in this case.

Tabela 3.8 – CEV decomposition by occupation: $\Delta_{cev} \approx \Delta_{lev} + \Delta_{unc}$

Variable	UBI reform				
	0%	0.68%	5%	10%	15%
	(1)	(2)	(3)	(4)	(5)
Unemployed					
Δ_{cev}	0.38	0.11	-2.15	-4.70	-10.45
Δ_{lev}	4.30	3.37	-5.50	-16.29	-26.35
Δ_{unc}	-3.75	-3.15	3.54	13.84	21.58
Worker					
Δ_{cev}	-0.13	0.02	0.15	0.59	-2.78
Δ_{lev}	1.74	1.64	-1.76	-6.95	-13.40
Δ_{unc}	-1.84	-1.59	1.96	8.11	12.26
Employer					
Δ_{cev}	1.79	1.90	-0.71	-3.76	-10.20
Δ_{lev}	2.36	1.42	-5.79	-16.04	-29.53
Δ_{unc}	-0.55	0.47	5.38	14.62	27.41
Self-employed					
Δ_{cev}	-2.14	-1.14	3.71	9.75	11.62
Δ_{lev}	2.74	3.63	2.74	2.60	2.91
Δ_{unc}	-4.75	-4.61	0.84	6.96	8.46

Notes: The table displays the CEV decomposed in terms of efficiency and uncertainty for different UBI policies and considers distinct occupational groups. The UBI policy is a fraction of the output per household in the benchmark model. The UBI transfer that maximizes welfare is 10 percent of output per household.

3.7 Concluding remarks

This paper investigates the impact of Universal Basic Income (UBI) reforms within a general equilibrium model that incorporates endogenous entrepreneurship and labor market frictions. Notably, we distinguish between self-employed and employer entrepreneurs due to their differing characteristics. Self-employed individuals are concentrated at the lower end of the income distribution, while employers tend to be at the top.

We compare the steady-state equilibrium of a benchmark economy with an alternative one where the government replaces its current transfer system with a UBI reform. Our UBI experiments reveal that an equal transfer of 5 percent or more of the benchmark's average income leads to a decrease in capital and output. However, this is accompanied by a reduction in inequality as measured by the Gini coefficient for consumption and income after tax and transfer. The welfare-maximizing UBI reform, corresponding to a transfer of 10 percent, yields a 3.33 percent increase in welfare compared to the benchmark. This improvement stems from enhanced insurance against labor and entrepreneurial productivity shocks.

This paper emphasizes the importance of considering entrepreneurship, particularly for large UBI reforms, as it informs the design of government transfer policies. Employers are crucial for job creation, productivity, and output growth, while self-employment provides labor opportunities for low-skilled individuals or those facing unemployment. Policymakers should, therefore, take into account the potential impact of UBI reforms on entrepreneurship and labor market dynamics.

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