Redistribution, Education Subsidies and Entrepreneurship*

Vitor Fancio
Insper
vitoratf@al.insper.edu.br

Marcelo Rodrigues dos Santos
Insper
marcelors2@insper.edu.br

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Abstract

The increase in income and wealth inequality has influenced governments to adopt redistributive policies. The close relation between education premium and inequality contributed to the increase of college subsidies financed by progressive taxation. However, once entrepreneurs account for a large share of rich individuals and are disproportionately highly educated compared to the population, these two policy instruments may impact entrepreneurial decisions, changing the composition of workers and entrepreneurs and the distribution of firms in the economy. We evaluate the efficiency and welfare impacts of distinct education and taxation policies in an OLG economy with education and entrepreneurial decisions and calibrate it for the US economy at the beginning of the 2000s.

Keywords: optimal taxation ; redistribution ; skill premium ; human capital ; firm dynamics

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1 Introduction

Income and wealth inequality are important issues nowadays. Recent concentration in the top of the income distribution[1] is often associated with education returns. The usual *'Race between education and technology'* argument says that the increase in the share of college graduates over the last decades was not able to counterbalance the demand, resulting in an increase in the skill premium[2]. While an extensive literature focus on the role of education broadly, little attention is given on how entrepreneurs' education may affect inequality and efficiency. Entrepreneurship is important for three main reasons. First, entrepreneur's education and productivity are positively correlated (see Queiro (2018)). Second, recent literature (Mueller et al. (2017) and Guvenen et al. (2019)) has documented that part of the increase in inequality can be explained by the firm side. Third, entrepreneurs hold a disproportional amount of income and wealth, even though they correspond to a small fraction of the population[3]. Once education and entrepreneurship are channels that affect inequality, public policies that aim to provide insurance and redistribution should consider how these two margins interact.

Two commonly discussed fiscal policies are education subsidies and progressive tax system. At the same time that the former improves the skill distribution and affects the wage premium and government's revenue, the latter provides insurance and may discourage savings, human capital accumulation, and labor supply. The joint impact of these policies is not trivial in the presence of entrepreneurship. On one hand, education subsidies may increase the share of high-skilled agents, workers and entrepreneurs. More educated entrepreneurs may lead to more productive firms impacting efficiency and inequality. On the other hand, this impact may enhance redistributive gains from a more progressive tax system. This paper investigates how education subsidies and a progressive tax system jointly affect entrepreneurship and education and their impact in aggregate variables, distribution of income and wealth, and welfare.

We develop a general equilibrium overlapping generation model (OLG) with endogenous human capital accumulation and entrepreneurial choice. Markets are incomplete

[1] In the United States, from 1977 to 2016, the income held by the top 10% of the income distribution grew from 32.5% to 47.5% according to Kuhn et al. (2020).

[2] Bartscher et al. (2020) documents that average income of college households has increased approximately 50% since the 1980s

[3] According to Cagetti and De 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. In terms of the skill distribution, 41% of entrepreneurs have at least a college degree, while 29% of the population have a college education, according to Mondragon-Velez (2009)

and agents face labor and entrepreneurial idiosyncratic shocks. The model is composed of agents who 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 in which the agent decides whether she goes to college or not. There are three main sources of heterogeneity that influence this decision: initial asset, innate ability, and labor productivity shock. After the education period, agents start to make occupational choices.

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.

The model is 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 economy. We find that a reduction in the education subsidy has an effect on the intensive margin of entrepreneurs, even though the extensive margin remains unchanged. This policy decreases the number of college graduates and increases the college premium. As a consequence, the share of college entrepreneurs decreases and the share of non-college entrepreneurs increases. There is a welfare loss mainly for non-college agents that receive a lower wage in the economy. We find the opposite effect for a college system that is fully subsidized. Distinct tax policies have modest impact in entrepreneurship and education.

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 consider two cases: (i) college is positively correlated to entrepreneur's productivity and (ii) college is not correlated to entrepreneur's productivity. We then compare the Ramsey policy with the competitive equilibrium solution. In the first scenario, both progressivity and subsidy are higher, indicating that they are complementary policies. In the second case, the policies are slightly substitutes. Hence, the inclusion of occupational choice may change the optimal policy design.

Related Literature This paper is closely related to three branches of the literature: optimal design of insurance policies, channels that affect the wage premium, and firm size distribution. Heckman et al. (1998) analyze the impact of distinct tax structures and college tuition on skill formation, showing the importance of general equilibrium effects. Abbott et al. (2019) analyze the impact of financial aid on education decisions and economic outcomes. They find that government programs are relevant in terms of welfare and outcome but it may crowd-out parental transfer. Benabou (2003) study how progressive taxation and education subsidy, separately, affect aggregate variables and the distribution among individuals. The current paper is closely related to Krueger and Ludwig (2016), in which the authors analyze optimal social insurance in the context of endogenous human capital accumulation. Examining partial and competitive equilibrium, they find that progressive taxation and college subsidies can be complementary policies in the first case and substitute in the second one. Nonetheless, they do not consider how these policies affect entrepreneurship.

Concerning entrepreneurial choices, some papers incorporate entrepreneur ability in the production function, analogous to Lucas (1978) (e.g, Quadrini (2000), Cagetti and De Nardi (2006)). These papers show that this heterogeneity is important to generate the wealth distribution of the economy. Current literature tries to explain the link between education and entrepreneurial choices. In an infinite agent economy with endogenous entrepreneurial choice, Gomes and Kuehn (2017) find that differences in education composition correlate with average firm size across countries; the model proposed by them can explain one-third of the difference in average firm size between the US and Mexico. Salgado (2018) documents the decrease in the population share of entrepreneurs, especially among those with a college degree. In a life cycle economy with endogenous entrepreneurial choice, he proposes two mechanisms to explain this evidence: the decrease in the cost of capital goods and skill-biased technical change. Besides the fact that both papers consider human capital accumulation as an exogenous process, there is no discussion about how social insurance interacts with the firm side. Gomes et al. (2020) describes how capital-skill complementarity interacts with human capital and financial constraints.

We organize the next sections as follows: Section 3 presents the channels through which progressive taxation and education subsidies may affect entrepreneurial and education choices. Section 4 describes the economic environment and section 5 provides calibration and quantitative analysis. Section 6 concludes.

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 aggregate utility of the agents.

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

The government provides college subsidies and transfers given by θ and d, respectively, and 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:

$$(1-\tau)\ell(1+\mathbb{1}_e pa)w_s$$

where $\mathbb{1}_e$ indicates if she went to college or not, and w_s represents the wage per efficiency 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:

$$(1-\tau)\pi_s(a,z) \text{ where}$$

$$\pi_s(a,z) = \underset{n_{nc},n_c}{max}\{z\ell(1+\phi_s pa)(\delta n_{nc}^{\zeta} + (1-\delta)n_c^{\zeta})^{\frac{v}{\zeta}} - w_{nc}n_{nc} - w_c n_c\}$$

where δ represents the output share of no-college labor, ζ determines the elasticity of substitution between college and no-college input and v indicates the decreasing returns to scale of the production function. ϕ_s determines the impact of a college relative to a no-college education in the entrepreneur's productivity.

The utility function, the maximization problem for the competitive market economy and 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

$$\underset{\ell(a,z),c(a,z),\mathbb{1}_e(a,z),oc(a,z)}{max} log\left(c(a,z) - \rho\frac{\ell(a,z)^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}}\right) \text{ st.}$$

$$c = y_{oc} + d - \kappa(1-\theta)\mathbb{1}_e \text{ where}$$

$$
\begin{cases} y_w = (1-\tau)\ell(1+\mathbb{1}_e pa)w_s \\ y_e = (1-\tau)\pi_s(a,z) \end{cases}
$$

Ramsey Policy

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

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

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 entrepreneur. Table 1 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 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 for the social planner.

Comparing the optimal results, we see that the tax progressivity and education subsidy can be complementary policies. Note that the values of the two instruments are higher when analyzed jointly, as in *both*, than separately, as in the *progressivity* and *subsidy* cases. This may happen as a consequence of two opposite forces, the decrease in the college premium and efficiency gains. In the first moment, for a given level of tax progressivity, the increase in education subsidy increases the share of agents with college, decreasing the college premium. This could make the tax system less progressive since income inequality is lower in this case. However, the decrease in college premium may enhance productivity by increasing the share of high-skilled entrepreneurs, allowing the tax system to be more progressive. Hence, this last effect may change the prescription of the optimal policy.

Figures 1 and 2 illustrate how the policies can affect the distribution of entrepreneurs and college educated individuals. The full line indicates the *benchmark* case, in which tax progressivity and college subsidy are set to zero. The dashed line represent the new distribution according to the specific insurance policy described at the top. We can notice that as progressivity increases, the share of college graduates decreases, increasing the college premium. However, the share of high-skilled entrepreneurs decreases, decreasing the productivity.

Table 1: Summary statistics - stylized model

Policy	d	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

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.

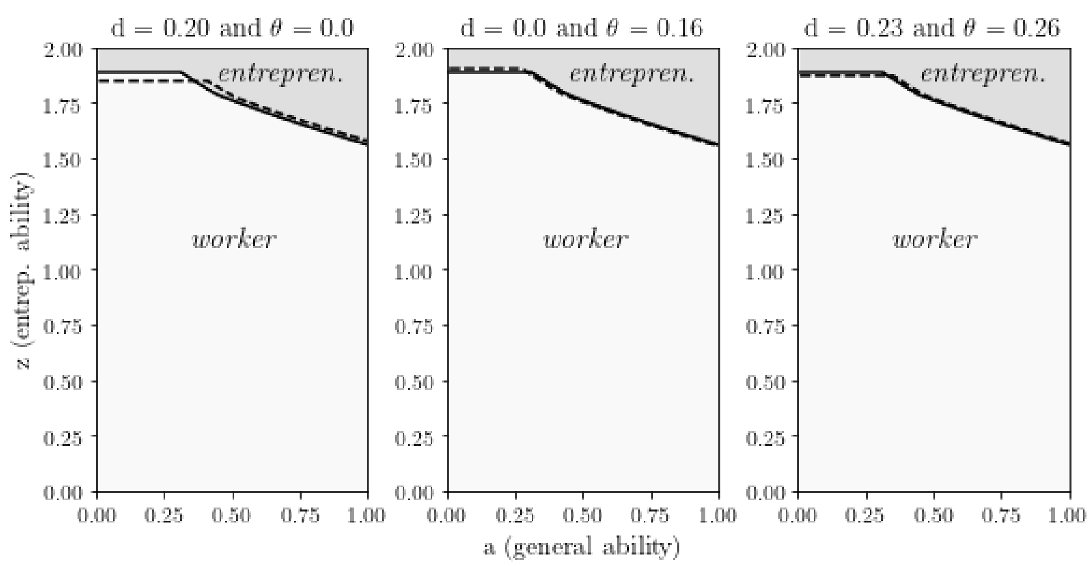

Figure 1: Occupational choice

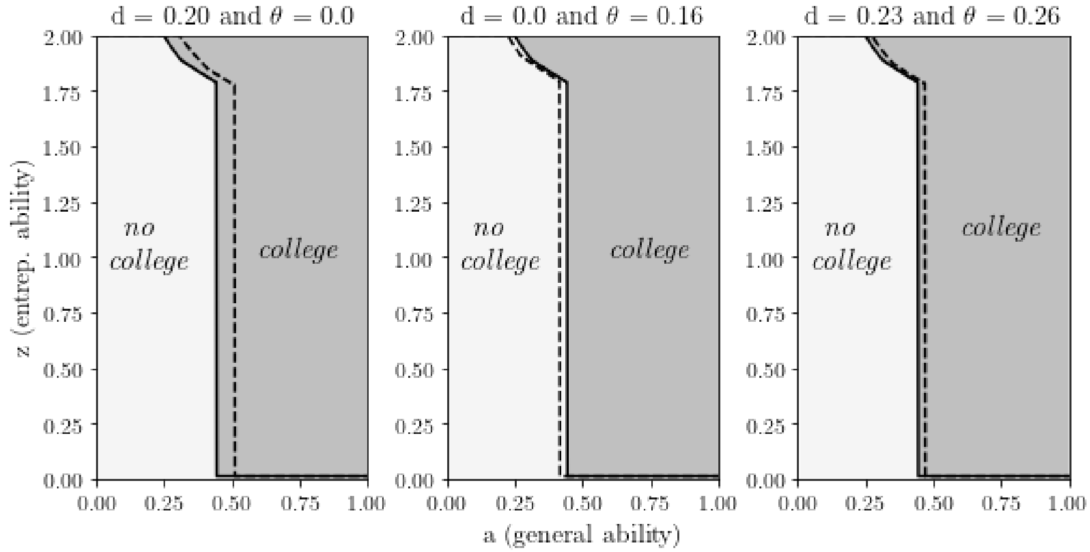

Figure 2: Education

3 The Environment

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 have that $0 < \psi_t \leq 1$ and in the last life 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 in the population 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 $\mu_t \geq 0$.

Each period in the model maps to one year in the data such that life our model starts at $j = 18$ and ends at $j = 100$.

Preferences

- *Expected utility:*

$$\mathbf{E}_1 \left[\sum_{j=1}^{J} \beta^{j-1} \left(\prod_{k=1}^{j} \psi_k \right) u(c_j, \ell_j) \right]$$

where

$$u(c,\ell) = \frac{[c^{v}(1-\ell)^{1-v}]^{1-\mu}}{1-\mu}$$

Labor productivity Each agent has one unit of time endowment. During the education stage, $j \in \{1,...,4\}$, a agent of age j with skill $s \in \{nc, c\}$ supplying ℓ hours earns

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

where $w_{t,s}$ is the skill specific equilibrium wage; $\epsilon_{j,s}$ represents the deterministic age-skill profile; $u \sim N(0,\sigma_u^2)$ is a fixed component drawn in the first period and indicates household's ability that is constant over the lifetime. 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, $j \in \{5,...,j_r - 1\}$, a agent of age j with skill $s \in \{nc, c\}$ earns

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

where $\varphi_s \in \{\varphi_{l,s}, \varphi_{h,s}\}$ denotes college ability. Given education $s \in \{nc, c\}$, the probability to move from a particular 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 $g(u_{min}) = 0, g(u_{max}) = 1$. The change from u to φ incorporates the uncertainty component associated with the college education.

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, and the human capital accumulated remains the same in the life cycle. 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. 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 after retirement, $j \in \{j_r,...,J\}$, and agents receive a pension depending of their education.

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 productivity 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 productivity and with probability $1 - \gamma$ she draws a new productivity 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 $\phi(s)$, such that $\phi(c) > \phi(nc)$.

$$Y = A_p z \ell \phi(s) f(K, N_c, N_{nc})^{\gamma_p} = A_p z \ell \phi(s) \{\alpha N_{nc}^{\sigma} + (1-\alpha)[\lambda K^{\rho} + (1-\lambda) N_c^{\rho}]^{\frac{\sigma}{\rho}}\}^{\frac{\gamma_p}{\sigma}}$$

$$\pi^e = \max_{N_{nc}, N_{nc}, K} Y - w_{nc} N_{nc} - w_c N_c - (r + \delta) K$$

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

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 the expenditures, the government levies taxes on consumption, τ_c, on capital income, τ_k, and on labor/profit income by the following function:

$$T(y) = y - a_0 y^{1-a_1}$$

The parameters a_0 and a_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, $a_0 a_1 > 0$. We say that the marginal tax rate is strictly increasing if $a_1(1 - a_1)a_0 > 0$. 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.

Recursive formulation of individuals' problems

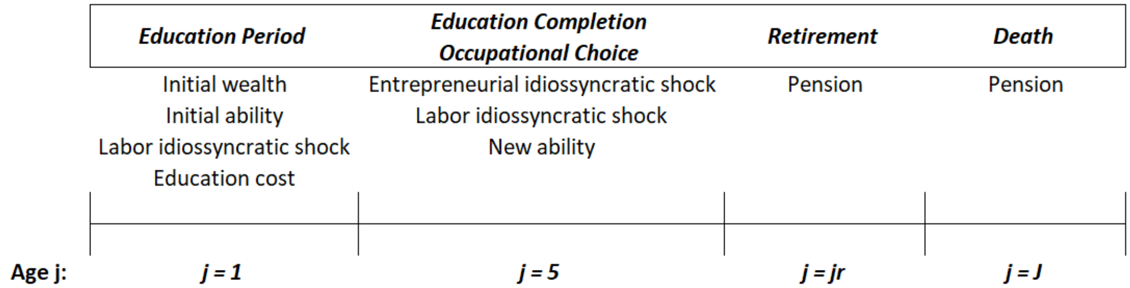

Figure 3: Timeline

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. The agent receives inter-vivos transfers Tr depending on u and then decide about education, consumption, labor supply and asset accumulation. If she decides to go to college, she pays net cost $(1-\theta_{pub})\kappa w_c$, where κw_c 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:

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

subject to

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

where

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

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

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

where the indicator function $\mathbb{1}_s$ is one if the agent goes to college and zero otherwise.

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

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

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

subject to

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

where

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

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

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

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, labor supply is zero and agent earnings are composed of capital income and pension. The Bellman equation is given by

$$V_j^s(a,s) = \underset{c,a'}{max}\{u(c,1) + \beta\psi_j V_{j+1}^s(a',s)\}$$

subject to

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

Recursive competitive equilibrium.

Agents at age j are characterized by the state $\varrho_j = (a,\eta,\varphi,z) \in P$ [4]. A recursive competitive equilibrium is given by a list of value functions $V_j(\varrho_j)$; policy functions for consumption $c_j(\varrho_j)$, for asset holdings $a_j'(\varrho_j)$, for labor supply $\ell_j(\varrho_j)$, for education $s_j(\varrho_j)$, for occupational choice $oc_j(\varrho_j)$; aggregate variables K, N_c, N_{nc}, Y; policy a_0; prices r, w_c, w_{nc} and measures $\lambda_j(\varrho_j)$ such that:

(i) 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.

(ii) The aggregates K, N_c, N_{nc} solve the profit maximization problem, for a given set of prices.

(iii) Good and factor markets clear.

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

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

[4] 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 $\varrho_j = (a,\eta,\varphi,z)$.

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

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

where,

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

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

(iv) Government budget constraint condition is satisfied.

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

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

(v) Accidental bequests are given by

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

4 Quantitative Analysis

4.1 Calibration and estimation

Model period and age distribution:
Utility:

We define $\mu = 4$ according to the literature and set v so that agents work on average $1/3$ 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, $\sigma > \rho$.

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 and 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 component $\epsilon_{j,s}$ is based on Abbott et al. (2019).

Education policy:

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

We compute education costs 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[5]. Moreover, average net college cost is \$8,952. Therefore, total subsidies constitute 30.0% of total cost.

[5] 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*.

The average labor income from age 23 to 65 in 2000 is $\bar{y} = \$37,959$[6]. Hence,

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

Therefore, we choose κ so that,

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

Agents may finance a share ϕ of the net college cost $(1-\theta_{pub})\kappa w_c$. Based on the Stafford loan program, the maximum amount that a agent can borrow is $\$23,000$ for four year college[7]. Since average college cost is $\$8,952$, agents can finance approximately 64% of education expenditure. Therefore, we set $\phi = 0.64$.

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

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

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 is financed by taxes on consumption, labor and capital income. Following the literature, we choose as consumption and capital tax rates $\tau_c = 6\%$ and $\tau_k = 30\%$, as in Fuster et al. (2007). Labor income tax is given by the non-linear function:

$$T(y) = y - a_0 y^{1-a_1}$$

where a_1 measures the progressivity of the tax schedule and is equal to 0.10 according to *OECD* (2018). a_0 commonly affects the pre-tax earnings and is chosen such that the government balances its budget constraint.

Model and Data:

The model fit is described in Table 2 and Table 3. Table 2 shows the parameters calibrated internally and externally and Table 3 compares the model outcomes with the data.

[6] We use CPS Flood et al. (2020).

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

Table 2: **Estimation and calibration of model parameters**

External calibration			
Parameter	Description	Values	Source
g_n	Population growth	1.008	Micro evidence
μ	Risk aversion	4	Micro evidence
δ	Depreciation	0.065	I/Y = 0.20
σ	Capital-low-skilled Elasticity	0.401	Krusell et al. (2000)
ρ	Capital-high-skilled Elasticity	-0.495	Krusell et al. (2000)
τ_c	Consumption tax rate	0.06	Fuster et al. (2007)
τ_k	Capital tax rate	0.30	Fuster et al. (2007)
a_1	Tax progressivity	0.10	Ferriere and Navarro (2020)
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%)
v	Leisure share	0.40	Fraction of hours worked (0.33)
γ_p	Span-of-control parameter	0.80	Share of entrepreneurs (7.4%)
λ	Capital share	0.65	Capital to output ratio (2.0)
α	Labor share	0.35	College premium (80%)
ϕ	Borrowing limit	5.5	External finance to GDP (1.8)
κ	Resource cost of college	0.15	Education cost/avarage worker's income
a_0	Tax level	0.85	Govern. budget balanced
σ_u	Std deviation initial ability	0.05	Income Gini 0.43
η_p	Pareto tail	4.84	Employment top percentile (69%)

Table 3: **Model and Data**

Moment	Data	Model
Calibrated moments		
Capital to output	2.0	2.07
Interest rate	4.50	4.5
Hours worked	0.33	0.36
External finance	1.8	1.5
Share of entrepreneurs	7.6%	8.8%
Share of coll. entrepreneurs	3.1%	3.8%
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%	62.15%
Income Gini	0.46	0.52
Share college	0.33	0.31
College premium	1.8	1.93
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	0.88
Average tax rate	17.1%	16.92%

4.2 Counterfactual exercises

In this section, we examine some policy implications regarding education subsidies and tax progressivity. Regarding education subsidies, we consider two possibilities. First, we analyze an economy in which the government provides no college subsidies, that is, $\theta_{pub} = 0$. Second, we consider a fully subsidized education system, that is, $\theta_{pub} = 1$. Concerning tax progressivity, we consider a more progressive tax system where $a_1 = 0.25$, leading to a higher average tax rate for the individuals at the top of the income distribution. This level is close to the German tax progressivity as indicated by Vardishvili and Wang (2021). We then analyze an economy with lower progressivity where $a_1 = 0.0$. In this case, the net income is simply $y - T(y) = a_0 y$.

Table 4 reports the main results. A fully subsidized education system (1) increases the share of college agents in 30%, decreasing the college premium in 21.45%. Since the wage for college agents is lower in equilibrium, the incentive to become an entrepreneur is higher, increasing the share of entrepreneurs holding a college degree. Similarly, the increase in wage for non-college agents lead to a decrease in the share of non-college entrepreneurs. For the no subsidy case (2), we observe the opposite effect. A reduction in the share of college agents leads to an increase in the college premium of 7.2%. A more progressive tax system (3) disincentives capital accumulation leading to a lower level of capital to output ratio. It affects entrepreneurship as it decreases the wages for college and non-college individuals, increasing the share of entrepreneurs with both education levels. For the less progressive case (4), we observe the opposite effect, that is, a reduction in the share of entrepreneurs with both education levels.

Table 4: **Counterfactuals**

Variable	Benchmark	More subs. (1)	Less sub. (2)	More prog. (3)	Less prog. (4)
Y	0.459	0.513	0.443	0.443	0.490
K	0.959	1.091	0.920	0.859	1.1327
K/Y	2.07	2.12	2.06	1.96	2.29
w_c	0.822	0.755	0.843	0.819	0.851
w_{nc}	0.425	0.498	0.408	0.409	0.429
College premium	1.93	1.516	2.069	2.005	1.986
r	4.5%	4.9%	4.4%	5.0%	3.3%
% Entrepreneurs	8.8%	8.8%	8.9%	9.5%	8.2%
% coll. entrep.	3.8%	5.7%	3.4%	4.0%	3.6%
% non-coll. entrep.	4.9%	3.2%	5.6%	5.5%	4.6%
% College agents	31.0%	40.0%	28.7%	31.0%	31.0%
Tax level (a_0)	0.819	0.817	0.820	0.807	0.834

Figure 4 shows the distribution of employment by decile. Firms at the top 10% concentrate 64% of the employment share. An increase in the progressivity level affects mainly entrepreneurs at the top of the income distribution, paying higher average tax relative to poorer entrepreneurs. Therefore, this will generate less concentration of production factors at larger firms. The opposite effect happens for a lower progressivity level. Education policies do not have large effects on the employment share since their main impact on factor demand comes from change in prices due to general equilibrium effect.

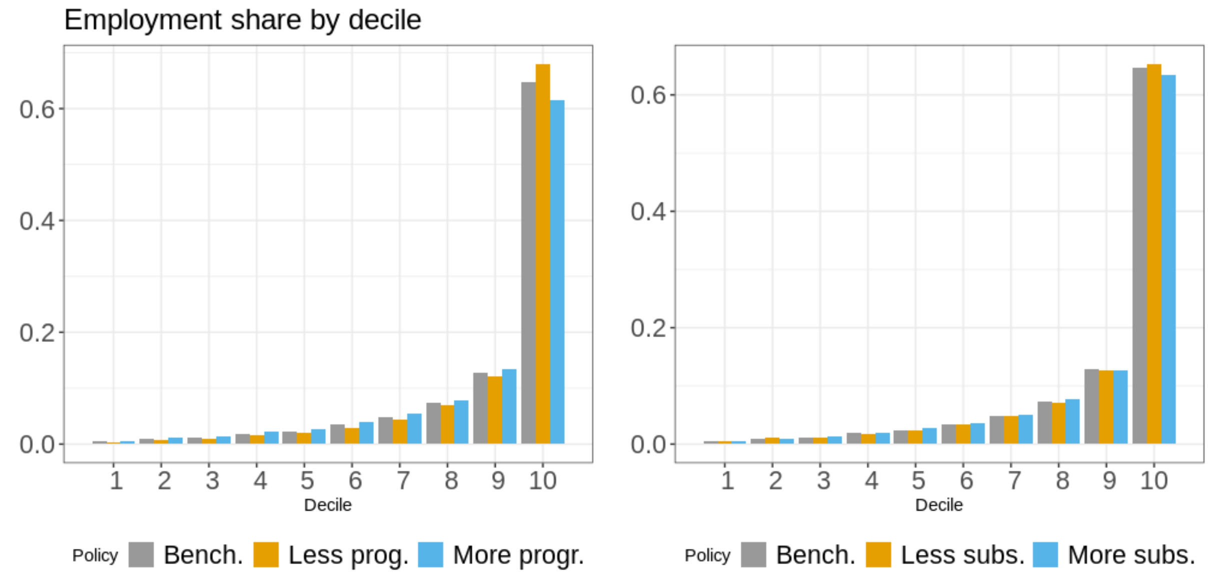

Figure 4: Employment Share

Tables 5 and 6 describe welfare gains and losses for the policies described. We calculate the welfare measure in terms of consumption-equivalent variation (CEV) as follows,

$$V_1^{\Delta}(\omega_1) = \mathbf{E}_0 \left[\sum_{t=1}^{T} \beta^t \prod_{s=1}^{t} \psi_s (1+\Delta)^{\nu(1-\mu)} u_0(t) \right]$$

where, V_1 denotes the expected life-time utility of an individual born at state ω_1 under the alternative policy we aim to evaluate. $u_0(t)$ indicates the flow utility of the individual at the benchmark policy. The welfare measure is,

$$\Delta = \left[\frac{\mathbf{E}_{\omega_1} V_1^{\Delta}(\omega_1)}{\mathbf{E}_{\omega_1} V_1^{1}(\omega_1)} \right]^{\frac{1}{\nu(1-\mu)}} - 1$$

The value of Δ indicates how much an agent is willing to increase or decrease her lifetime consumption in percentage terms to be indifferent between the benchmark and the alternative policy, on average. Positive Δ indicates welfare gain and negative Δ indicates welfare loss.

Following Heathcote et al. (2008), the welfare measure can be decomposed in two components, efficiency, Δ_{lev}, and uncertainty, Δ_{unc}. The efficiency channel is calculated as

$$\sum_t \beta^{t-1} \prod_{j=1}^{t} \psi_t \left[\left((1+\Delta_{lev}) C_{0,t} \right)^{\nu} (1-L_{0,t})^{1-\nu} \right)^{1-\mu} \right] =$$

$$\sum_t \beta^{t-1} \prod_{j=1}^{t} \psi_t \Big(C_{1,t}^{\nu} (1 - L_{1,t})^{1-\nu} \Big)^{1-\mu}$$

and the uncertainty channel is $\Delta_{unc} = \dfrac{1-p_1}{1-p_0} - 1$, where

$$\sum_t \beta^{t-1} \prod_{j=1}^{t} \psi_t \left[\Big(((1-p_0)C_{0,t})^{\nu} (1 - L_{0,t})^{1-\nu} \Big)^{1-\mu} \right] =$$

$$\mathbf{E}\left[\sum_t \beta^{t-1} \prod_{j=1}^{t} \psi_t \Big(c_{t,0}^{\nu} (1 - \ell_{t,0})^{1-\nu} \Big)^{1-\mu} \right]$$

and

$$\sum_t \beta^{t-1} \prod_{j=1}^{t} \psi_t \left[\Big(((1-p_1)C_{1,t})^{\nu} (1 - L_{1,t})^{1-\nu} \Big)^{1-\mu} \right] =$$

$$\mathbf{E}\left[\sum_t \beta^{t-1} \prod_{j=1}^{t} \psi_t \Big(c_{t,1}^{\nu} (1 - \ell_{t,1})^{1-\nu} \Big)^{1-\mu} \right]$$

Table 5 displays the welfare decomposed in aggregate terms and table 6 displays the welfare decomposed by education. Only the the policy with more subsidies increases welfare. This increase mainly comes from the efficiency channel associated with higher wage for the agents without college degree. The increase in the progressivity level improves the risk sharing but it worsens the efficiency in the economy. The big welfare loss associated with a system without redistribution, $a_1 = 0$, comes from the higher tax paid by non-college workers. In this alternative system, all agents pay 16.6% of taxes on average. Since non-college individuals are concentrated at the bottom of the income distribution, they are more affected by this tax rate relative to the benchmark.

Table 5: **CEV.**The decomposition is only approximate: $\Delta_{lev} + \Delta_{unc} \approx CEV$

Variable	Benchmark	More subs.	Less sub.	More prog.	Less prog.
Δ_{lev}	-	7.09%	-4.46%	-1.8%	-4.55%
Δ_{unc}	-	1.12%	-0.16%	0.04%	-7.66%
CEV	-	8.29%	-4.62%	-1.4%	-11.87%

Table 6: **CEV by education.** The decomposition is only approximate: $\Delta_{lev} + \Delta_{unc} \approx CEV$

Variable	Benchmark	More subs.	Less sub.	More prog.	Less prog.
Non-college	-				
Δ_{lev}	-	5.09%	-2.62%	-1.1%	-10.01%
Δ_{unc}	-	3.63%	-2.01%	-0.08%	-3.07%
CEV	-	8.91%	-4.58%	-2.03%	-12.77%
College	-				
Δ_{lev}	-	-3.46%	-2.33%	2.18%	-0.73%
Δ_{unc}	-	-0.03%	1.30%	0.27%	-4.06%
CEV	-	-3.50%	-1.05%	3.09%	-4.76%

5 Concluding remarks

We build an OLG model with 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. The wages for high and low education are the main channel that affect the composition of entrepreneurs. Policies that increase wages lead to a reduction in entrepreneurship. Even though the two tax policies considered do not change the share of highly educated individuals, they change the composition of entrepreneurs in the economy.

The tax policies analyzed generate welfare loss compared to the benchmark. The only welfare gain comes from the risk sharing channel that a more progressive tax system induces. The education policies generate opposite welfare. On one hand, an increase in subsidies improve overall welfare due to an increase in the efficiency channel. The opposite happens for a decrease in subsidies.

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