Education Affordability and Earnings Inequality

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Abstract

We study the role of education affordability in shaping earnings inequality in the context of an overlapping generations model where agents, heterogenous in terms of learning ability, initial wealth, and productivity, decide whether to attend college, subject to borrowing constraints. After calibrating the model to the US economy, we perform a number of counterfactual experiments. We find that the Gini coefficient for before-tax wage income would decrease by as much of 16.2 percent if the current education policy, the fraction of higher education costs borne by the government, were replaced with its German counterpart. Poor households with medium and medium-high ability would benefit the most from it. Apart from distributional gains, the hypothetical policy reform would also boost macroeconomic activities by increasing labor productivity. In contrast with the existing literature, we find that labor tax progressivity plays a less significant role in explaining earnings inequality.

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1 Introduction

This paper studies the role of education affordability in shaping earnings inequality. We begin by documenting an empirical fact about the correlation between education affordability and earnings inequality across countries. Table 1 reports the Gini index of before-tax gross earnings for full-time male workers, the private and public direct cost of a person attaining tertiary education as well as the fraction of tertiary education costs borne by the government for the United States, the United Kingdom and six continental European countries.[1] It shows a strong correlation between education affordability and earnings inequality: the Pearson correlation coefficient between the Gini index and the private cost of a person attaining tertiary education is 0.939.[2]

This empirical fact motivates us to consider education affordability as a potentially

Table 1: Education affordability and earnings inequality

	Gini index	**Private costs**	**Public costs**	**Subsidy rate**
		c_1	c_2	$z = \frac{c_2}{c_1 + c_2}$
Denmark	0.285	4300	98 400	0.958
Finland	0.268	3400	91 300	0.964
France	-	-	-	-
Germany	0.314	5200	87 500	0.944
Netherlands	0.286	16 900	73 000	0.812
Sweden	0.272	200	97 200	0.998
U.K.	0.341	25 900	27 700	0.517
U.S.	0.410	55 000	55 900	0.503

1. The Gini index is compiled using before-tax gross earnings for full-time male workers for the period from 2005 to 2014.
2. Private and public direct costs of a person attaining tertiary education are in 2011 PPP international dollars.

important determinant of earnings inequality. To evaluate the role of education affordability in driving earnings inequality, we build an overlapping generations model where agents, heterogeneous with respect to learning ability and initial wealth endowment,

[1] The table is compiled using data from OECD.stat online database.

[2] The correlation coefficient between the Gini index and the private cost of education as a fraction of per capita GDP is 0.932.

decide whether to attend college, subject to borrowing constraints and idiosyncratic income risks. To capture the various aspects of government policy, our model features progressive labor income taxation, consumption tax, capital income tax as well as subsidies for college. After calibrating the model to the U.S. economy, we conduct a number of counterfactual experiments. In particular, we replace the status quo US education policy, the fraction of higher education costs borne by the government, with its German counterpart and study the change in earnings inequality. Besides, we also examine the roles of other policy dimensions such as progressive labor taxation. Though this paper is motivated by observations from cross-country comparisons, it focuses squarely on the US.

We find that earnings inequality, as measured by the Gini coefficient for before-tax gross earnings, would decrease by as much of 16.2 percent if the current education policy, the share of higher education costs borne by the government, were replaced with its German counterpart. Two groups of households would benefit from the hypothetical policy reform. First, poor households with medium and medium-high ability would benefit the most from increased government subsidies for college: this group would enjoy an increase in life-time utility equivalent to an increase in consumption by as much as 80%. Those are the households that cannot afford to go to college in the benchmark, although they would benefit greatly from a college education. Second, low ability households would also benefit from the hypothetical education policy reform, albeit for different reasons. They don't go to college anyway. But when more households attend college, the college wage premium decreases. Unskilled workers become relatively scarcer and thus enjoy a higher wage rate. On the other hand, our results suggest that a small fraction of rich and high-ability households would lose out from the hypothetical education policy reform due to compressed college wage premium. However, the utility loss they would suffer is relatively small. For example, a household with an initial wealth at the 90th percentile of the initial wealth distribution and a learning ability at the 99th percentile of the ability distribution would suffer a utility loss equivalent to a 5% decrease in consumption. Finally, in contrast with the existing literature, we find that labor tax progressivity plays a less significant role in explaining earnings inequality.

The rest of the paper is organized as follows. Section 2 relates this paper to the literature. Section 3 sets up the model and defines the equilibrium. Section 4 describes our calibration strategy. We present the results in section 6. We briefly conclude the paper in section 7.

2 Relation to The Literature

A major goal of this paper is to evaluate the role of education affordability in shaping earnings inequality. In terms of modelling choices, our paper is built on the public economics literature on tax and education policy, for example, Abbott, Gallipoli, Meghir, and Violante (2013), Benabou (2002), Bovenberg and Jacobs (2005), Findeisen and Sachs (2015, 2016a, 2016b), Heathcote, Storesletten, and Violante (2017), and Krueger and Ludwig (2013, 2016). This tradition, pioneered by Benabou (2002), emphasizes the distortionary effects of progressive taxation on human capital accumulation; it also recognizes that education subsidies can partially mitigate the tax distortions and therefore serve as a complement to progressive labor income taxation. Most of this literature allows for general equilibrium effects of government policies on relative factor prices. In line with this literature, this paper considers the distortionary effects of taxation, the complementary role of education subsidies as well as the general equilibrium effects of government policy on relative factor prices.

In particular, our paper is closely related to Abbott et al. (2013), which studies, in a similar but more complex framework, the general equilibrium effects of various financial aid policies intended to foster college participation and Krueger and Ludwig (2016), which characterizes the optimal mix of progressive taxation and education subsidies. Our paper overlaps with Abbott et al. (2013) in that college participation, the main variable of interest in their paper, is an intermediate variable of interest for us. Our paper, however, is not solely concerned with college attainment, but also evaluates the importance of various policy dimensions in driving earnings inequality. Moreover, our paper also differs from Abbott et al. (2013) in that we calibrate the model to the latest data (2011) which exhibits higher college wage premium and earnings inequality than those used in their paper. This may partially explain why we come to different conclusions about the impact of increased government spending on higher education on college attainment. Our paper differs from Krueger and Ludwig (2013, 2016) in terms of research questions: while we study the roles of various government policies in shaping earnings inequality, they quantitatively characterize the optimal tax and education policy and are largely silent on earnings inequality.

Our paper is also related to the strand of literature that explores the determinants of cross-countries differences in wage inequality (see, for example, Guvenen, Kuruscu, and Ozkan (2014)) and intergenerational earnings persistence (see, for example, Holter (2015)). Guvenen et al. (2014) attributes the wage inequality gap to differences in labor income tax progressivity: More progressive labor income taxes, as seen in continental European countries, distort the incentives for individuals to accumulate human capital, which compresses the wage income distribution. However, Guvenen et al. (2014) abstracts from the general equilibrium effects of government policy on relative factor prices and it assumes that markets are complete so that individuals that wish to invest in human capital accumulation are always able to do so by borrowing. We instead consider an environment where markets are incomplete and those who wish to attend college may find themselves financially constrained. In addition, we allow for endogenous evolution of college premium. Importantly, while taking inspiration from cross-country comparisons, our paper focuses squarely on the US. The reason is that factors affecting cross-countries differences in earnings inequality may go well beyond government policies.

Finally, our paper is related to the strand of empirical literature on returns to skills, for example, David (2014), Goldin and Katz (2009), Hanushek, Schwerdt, Wiederhold, and Woessmann (2015) and Lemieux (2006). A central message of this literature is that the rising wage premium associated with higher education is a key driver in the evolution of earnings inequality. Although we take a static view, our paper captures the pivotal role of the interplay of supply and demand for skills.

3 The Model Economy

We consider an overlapping generations model. The model economy consists of households that are heterogenous with respect to age, wealth, learning ability, education and labor productivity, firms that produce a final good by hiring labor and capital on competitive spot markets, and a government that operates the tax system and the pension system. Decisions of households differ depending on the phase in which they find themselves. First, in the first period of its life, having drawn its learning ability and education-contingent initial wealth endowment, each household decides whether to attend college. Second, after making their college decisions, households make their consumption and labor supply decisions in each period of their working life. Finally, households retire and live on capital income and pension benefits. We will describe the model environment and household life cycle decisions in detail in the following.

3.1 Demographics

Time is discrete, indexed by t, and it goes forever. At each point in time, the economy is populated by J overlapping generations indexed by $j = 1, 2, \cdots, J$, where J denotes the maximum age. Individuals survive from age j to $j+1$ with probability ψ_{j+1}. For simplicity, we assume that the survival rate before retirement is equal to one; agents face death hazard once they retire, i.e., $\psi_j \in [0, 1)$ for $j \geq j_r$, where j_r denotes the retirement age. Let N_t denote the initial size of the cohort that enters the economy in period t; N_t grows at a constant rate n, i.e., $N_t = (1+n)N_{t-1}$. Since the growth rate of population is constant and the age-specific survival rates are time-invariant, the relative share of population of each age cohort is constant over time. To ease aggregation later on, we define m_j as the size of population of age cohort j relative to the youngest cohort alive in the current period:

$$m_j \coloneqq \frac{N_{t-j+1}\left(\prod_{i=0}^{j-1}\psi_i\right)}{N_t}.$$

3.2 Firms and Production

Firms hire labor and capital on competitive spot markets to produce a final good. Workers come in two skill types, indexed by $s = \{c, n\}$, where we refer to college-educated workers as skilled workers ($s = c$), and those without college education unskilled workers ($s = n$). Within each skill type, labor is perfectly substitutable across ages; but across skill types, labor is imperfectly substitutable in the tradition of Katz and Murphy (1992) and Borjas (2003). Let $L_{t,c}$ and $L_{t,n}$ denote aggregate labor–in terms of efficiency units– of skilled workers and unskilled workers, respectively. Then aggregate labor across skill types is given by

$$L_t \coloneqq \left(L_{t,c}^{\zeta} + L_{t,n}^{\zeta}\right)^{1/\zeta}, \tag{1}$$

where $\frac{1}{1-\zeta}$ is the elasticity of substitution between skilled and unskilled labor.

Final output is produced according to the Cobb-Douglas production function,

$$Y_t = AK_t^{\alpha}L_t^{1-\alpha},$$

where A denotes total factor productivity and α is a parameter that governs the elasticity of output with respect to capital. With perfect competition and a constant return to scale production function, the size distribution of firms is indeterminate; without loss of generality, we assume the existence of a representative firm. The representative firm takes the wage rates of skilled and unskilled labor, $w_{t,c}$ and $w_{t,n}$, and the interest rate r_t as given.

3.3 Endowments, Labor Productivity and Preferences

When a new generation enters the economy, individuals are heterogeneous in their learning ability e and initial wealth a.[3] We assume that college-bound households draw their initial wealth from a different distribution than non-college-bound households; the reason is that inter vivos transfers from parents to their college age children are mainly motivated by parents' preference for their children to attend college. In addition, each household is endowed with one unit of labor in each period of its life.

There are three elements to labor productivity $h_{s,j}$ for each skill type: a deterministic life-cycle productivity profile $\epsilon_{s,j}$, a fixed productivity effect θ_s, and a stochastic component η_s that evolves according to a Markov process π_{η_s} Labor productivity is given by

$$h_{s,j} = \begin{cases} \epsilon_{s,j} \cdot \exp\left(\theta_s + \eta_{s,j}\right), & \text{if } j < j_r \\ 0, & \text{otherwise,} \end{cases}$$

where we assume that labor productivity drops to zero in retirement.

Individuals have preferences over streams of consumption c_j and leisure $\tilde{l}_j$. Except for college students, $\tilde{l}_j = 1 - l_j$, where l_j denotes labor supply. In the case of college students, $\tilde{l}_j = 1 - \xi(e) - l_j$, where $\xi(e)$ is the time cost of college. More precisely, households' preferences are given by

$$u\left(c_1, 1 - \mathbb{1}_s \cdot \xi(e) - l_1\right) + \beta \mathbb{E}_1 \sum_{j=2}^{J} \beta^{j-2} \left(\prod_{i=0}^{j} \psi_i \right) u\left(c_j, 1 - l_j\right),$$

where $\mathbb{1}_s$ is an indicator variable, equal to one for college-bound households, and zero otherwise.

3.4 College Education

At age one, after having drawn her learning ability e and education-contingent initial wealth a, an individual decides whether to attend college. Attending college takes one

[3] We use heterogeneity in initial wealth to capture the family income effect on college attendance. For example, Belley and Lochner (2007) show that the effects of family income on educational achievement increased substantially from the early 1980s to the early 2000s.

period. Moreover, going to college entails a resource cost that is a fraction or multiple, ι, of the wage rate of skilled labor $w_{t,c}$, and a time cost $\xi(e) \in (0,1)$ that depends on learning ability.[4]To accommodate the case where college education is, at least partially, funded by government subsidies, let z denote the fraction of resource cost borne by the government. Upon deciding to go to college, financially constrained individuals can work part-time and/or take out student loans subject to a borrowing constraint.

3.5 Market Structure

Financial markets are incomplete in that there is no insurance against idiosyncratic labor productivity shocks and mortality risks. Individuals can self-insure against those risks by accumulating risk-free assets in the form of capital and government bonds.

Borrowing is allowed only for financing college education. We further assume that student loans are fully paid back before retirement when early death hazard sets in so that we rule out student loan defaults.

3.6 Government

The government runs the tax system and the pension system. First, the government collects taxes on household consumption, capital income, labor income and issues one-period government bonds so as to finance public expenditure G_t, debt service payment on outstanding government bonds B_t and education subsidies. Taxes on consumption and interest income are flat with a tax rate of τ_c for consumption expenditures and τ_k for interest income. Following Heathcote, Storesletten, and Violante (2010), we consider a potentially progressive labor income tax function,

$$\tau_l(y) = 1 - \lambda y^{-m},$$

[4]Ability-based time cost is intended to capture the notion that students of higher ability take less time to reach the same academic achievement. Granted, this involves a high degree of simplification since high-ability students may aspire to achieve more than their peers. Thus we homogenize college education in this sense.

where $\tau_l(y)$ is the tax rate at income level y, $m > 0$ is a measure of progressivity of the tax schedule and λ is a parameter that governs the average tax rate (for a given m).

In addition, the government collects accidental bequests and redistribute them to the generation that has just entered the economy. To come up with a plausible calibration of the initial wealth distribution, we assume that the government fills the gap between accidental bequests and actual transfers in each period.

The pension system operates on a pay-as-you-go basis: it collects contributions from current workers and distributes the revenues directly to current pensioners. In period t, current workers of skill type $s \in \{c, n\}$ contribute a fraction, τ_p, of their labor income to the pension fund, and current retirees receive a pension benefit that is proportional to their average life-time income: $pen_t(s, \theta_s) = \kappa_s w_{t,s} \bar{L}_t(s, \theta_s)$, where $\bar{L}_t(s, \theta_s)$ is the average labor supply, in efficiency unit terms, of working age cohort with characteristics (s, θ_s). The budget constraint of the pension system then reads

$$\sum_{s \in \{c,n\}} \tau_p w_{t,s} L_{t,s} = \sum_{s \in \{c,n\}} \sum_{\theta_s} \sum_{j=j_r}^{J} pen_t(s, \theta_s) m_j(s, \theta_s), \tag{2}$$

where $m_j(s, \theta_s)$ is the relative size of age cohort j that falls into the skill category s and has a fixed productivity component θ_s.

3.7 Life Cycle

In this subsection, we set out the households' life-cycle decisions more precisely.

Decisions at age 1: Before the college decision is made, each household draws its learning ability e from a truncated normal distribution on the unit interval $(0, 1)$ and education-contingent initial wealth $\{a_c, a_n\}$. Then households decide whether to attend college. The college decision is formally defined as

$$\mathbb{1}_s(e, a) = \begin{cases} 1, & \text{if } W(e, a_c, c) > W(e, a_n, n) \\ 0, & \text{otherwise,} \end{cases}$$

where $W(e, a_s, s)$ is the expected present value of life-time utility of a household with college decision s, learning ability e and an initial wealth endowment of a_s. It is formally defined as

$$W(e, a_s, s) = \sum_{\theta}\sum_{\eta} \pi_{\theta_n}(\theta)\pi_{\eta_n}(\eta)V(1, e, s, a_s, \theta, \eta)$$

where $\pi_{\theta_n}(\theta)$ and $\pi_{\eta_n}(\eta)$ are the distributions from which individuals draw their fixed productivity effect θ and stochastic productivity component η, and $V(1, e, s, a_s, \theta, \eta)$ is the expected present value of life-time utility of a household with state vector $(1, e, s, a_s, \theta, \eta)$. While initial wealth is drawn from an education-dependent distribution, initial fixed productivity effect θ and idiosyncratic productivity shock η are drawn from distributions for unskilled workers, whether the household is college-bound or not.[5] Upon finishing college education, skilled workers, those with a college degree, will redraw the fixed productivity effect θ and idiosyncratic shock η from distributions for skilled workers. Thereafter, the stochastic productivity component evolves over time according to $\pi_{\eta_s}(\eta' \mid \eta)$.

Given its initial wealth a, college decision s, fixed labor productivity effect θ and its initial draw of stochastic productivity η, each household then chooses consumption and labor supply so as to maximize its expected present value of life-time utility. Formulated recursively, each household solves the following Bellman equation

$$V(1, e, s, a, \theta, \eta) = \max_{c,\, l} \left\{ u(c, 1 - \mathbb{1}_s(e, a)\xi(e) - l) + \beta\psi_2 \sum_{\eta'} \pi_{\eta_s}(\eta' \mid \eta)V(2, e, s, a', \theta, \eta') \right\} \tag{3}$$

subject to the budget constraint

$$(1 + \tau_c)c + a' + \mathbb{1}_s(1 - z)\iota w_{t,c} = (1 + (1 - \tau_k)r_t)a + (1 - \tau_p)w_{t,s}h_{s,1}l - y\tau_l(y) + Tr, \tag{4}$$

where $y = (1 - \tau_p)w_{t,s}h_{s,1}l$, and the borrowing constraint

$$a' \geq -\underline{A}_1.^6 \tag{5}$$

Decisions at age $j = 2, ..., j_r - 1$: While decisions at age one may differ for college-

[5]Initial idiosyncratic productivity shock, η, is drawn from the corresponding stationary distribution of $\pi_{\eta_n}(\eta' \mid \eta)$.

[6]For college-bound individuals, the Bellman equation is slightly different because they will redraw θ and η at the beginning of period two from $\pi_{\theta_c}(\theta)$ and $\pi_{\eta_c}(\eta)$, where $\pi_{\eta_c}(\eta)$ is the stationary distribution of $\pi_{\eta_c}(\eta' \mid \eta)$.

bound and non-college bound households, decisions during the normal working life are pretty standard: given the current situation $(j, e, s, a, \theta, \eta)$, each household chooses consumption and labor supply so as to maximize its present value of utility.[7] The Bellman equation reads

$$V(j, e, s, a, \theta, \eta) = \max_{c,\, l} \left\{ u(c, 1 - l) + \beta \psi_{j+1} \sum_{\eta'} \pi_{\eta_s}(\eta' \mid \eta) V(j + 1, e, s, a', \theta, \eta') \right\} \quad (6)$$

subject to

$$(1 + \tau_c)c + a' = (1 + (1 - \tau_k)r_t)a + (1 - \tau_p)w_{t,s}h_{s,j}l - y\tau_l(y) + Tr, \quad (7)$$

and

$$a' \geq -\underline{\mathrm{A}}_j. \quad (8)$$

Decisions at age $j_r, ..., J$: After retirement, households' labor productivity drops to zero, and they live on capital income and pension benefits. The associated Bellman equation is given by

$$V(j, e, s, a, \theta, \eta) = \max_{c} \{u(c, 1) + \beta \psi_{j+1} V(j + 1, e, s, a', \theta, \eta)\} \quad (9)$$

subject to

$$(1 + \tau_c)c + a' = (1 + (1 - \tau_k)r_t)a + pen_t(s, \theta) + Tr. \quad (10)$$

3.8 Competitive Equilibrium

To define the general equilibrium of the model economy, it is useful to introduce some additional notation. In particular, we need to define the distribution of households on the state space. Let $\mathcal{E} = [0, 1]$, $\mathcal{J} = \{1, 2, ..., J\}$, $\mathcal{S} = \{c, n\}$, $\mathcal{A} = \mathbb{R}$, $\mathcal{F} = \mathbb{R}$ and $\mathcal{H} = \mathbb{R}$ denote the state space for ability e, age j, education level s, wealth a, fixed productivity effect θ and the stochastic productivity component η. And let Σ denote the Borel σ-algebra defined on the product space $\mathbb{X} = \mathcal{E} \times \mathcal{J} \times \mathcal{S} \times \mathcal{A} \times \mathcal{F} \times \mathcal{H}$. Then for any $X \in \mathbb{X}$, a measure $\phi(X)$ can be properly defined.

[7] From period 2 onward, learning ability e becomes a redundant state variable. We nonetheless keep it in the state vector for consistency. The same is true for θ and η for retirees.

With this preparation, we now define the stationary recursive competitive equilibrium as follows.

Definition 1 *A stationary recursive competitive equilibrium is a collection of: (i) decision rules of households* $\{\mathbb{1}_s(e,a), c(j,e,s,a,\theta,\eta), l(j,e,s,a,\theta,\eta)\}$*; (ii) aggregate capital and labor inputs,* $\{K_t, L_{t,c}, L_{t,n}\}$*, on the part of firms; (iii) value functions* $V(j,e,s,a,\theta,\eta)$*; (iv) government policies* $\{\tau_c, \tau_k, \tau_p, \tau_l(y), pen(s,\theta_s), \kappa_s, z, Tr\}$*; (v) prices* $\{r_t, w_{t,c}, w_{t,s}\}$*; (vi) education system characterized by* $\{\iota, \xi(e)\}$ *; and (vii) a vector of measures* ϕ*, such that:*

1 *The decision rules of households solve their respective life-cycle problems, and* $V(j,e,s,a,\theta,\eta)$ *is the associated value function.*

2 *Aggregate capital and labor inputs,* $\{K_t, L_{t,c}, L_{t,n}\}$*, solve the representative firm's profits maximization problem, which is fully characterized by the following first order conditions:*

$$r_t = \alpha A k_t^{\alpha-1} - \delta, \tag{11}$$

$$w_{t,c} = (1-\alpha)k_t^{\alpha}\left(\frac{L_t}{L_{t,c}}\right)^{1-\zeta} = w_t\left(\frac{L_t}{L_{t,c}}\right)^{1-\zeta}, \tag{12}$$

and

$$w_{t,n} = (1-\alpha)k_t^{\alpha}\left(\frac{L_t}{L_{t,n}}\right)^{1-\zeta} = w_t\left(\frac{L_t}{L_{t,n}}\right)^{1-\zeta}, \tag{13}$$

where $k_t = \frac{K_t}{L_t}$*,* $w_t = (1-\alpha)k_t^{\alpha}$*, and the college wage premium is given by*

$$\frac{w_{t,c}}{w_{t,n}} = \left(\frac{L_{t,n}}{L_{t,c}}\right)^{1-\zeta}. \tag{14}$$

3 *The labor market for each skill type clears:*

$$L_{t,s} = \sum_{j=1}^{J}\iiint_{\mathbb{X}(j,s)} h_{s,j}(\theta,\eta)l(j,s,a,\theta,\eta)\phi(j,s,a,\theta,\eta)\,da\,d\theta\,d\eta, \tag{15}$$

where $\mathbb{X}(j,s)$ *is the subset of the state space* $\mathbb{X}$ *corresponding to age* j *and skill type* s*.*

4 The capital market clears:

$$K_{t+1} + B_{t+1} = A_{t+1}, \tag{16}$$

where B_{t+1} *is the supply of government bonds and*

$$A_{t+1} = \sum_{s\in\{c,n\}} \sum_{j=1}^{J} \iiint_{\mathbb{X}(j,s)} a'(j,s,a,\theta,\eta)\phi(j,s,a,\theta,\eta)\, da\, d\theta\, d\eta.$$

5 The good market clears:

$$Y_t = C_t + G_t + E_t + I_t, \tag{17}$$

where

$$C_t = \sum_{s\in\{c,n\}} \sum_{j=1}^{J} \iiint_{\mathbb{X}(j,s)} c(j,s,a,\theta,\eta)\phi(j,s,a,\theta,\eta)\, da\, d\theta\, d\eta,$$

$$E_t = \iiint_{\mathbb{X}(1,c)} \iota w_{t,c}\phi(1,c,a,\theta,\eta)\, da\, d\theta\, d\eta,$$

G_t *is government spending, and* $I_t = (n+\delta)K_t$ *is gross investment.*

6 The government budget constraint holds:

$$\tau_c C_t + \tau_k r_t A_t + T_{l,t} + (1+r_t)A_{b,t} + (1+n)B_{t+1} = G_t + (1+r_t)B_t + (1+r_t)A_{init,t} + Z_t + Tr_t, \tag{18}$$

where $T_{l,t}$ *denotes labor income tax revenues, as given by*

$$T_{l,t} = \sum_{s\in\{c,n\}} \sum_{j=1}^{j_r-1} \iiint_{\mathbb{X}(j,s)} \tau_l(y)y\phi(j,s,a,\theta,\eta)\, da\, d\theta\, d\eta, \tag{19}$$

with $y = (1-\tau_{t,s})w_{t,s}h_{s,j}(\theta,\eta)l(j,s,a,\theta,\eta)$, $A_{b,t}$ *denotes accidental bequest:*

$$A_{b,t} = \sum_{s\in\{c,n\}} \sum_{j=1}^{J} \iiint_{\mathbb{X}(j,s)} a'(j,s,a,\theta,\eta)(1-\psi_{j+1})\phi(j,s,a,\theta,\eta)\, da\, d\theta\, d\eta, \tag{20}$$

$A_{init,t}$ *is the aggregate wealth transfer to the newly arrived generation:*

$$A_{init,t} = \sum_{s\in\{c,n\}} \phi(1,s) \int_{\mathcal{A}} af(s,a)\, da, \tag{21}$$

where $\phi(1,s)$ is the measure of households at age one with college decision s and $f(s,a)$ is the distribution from which initial wealth is drawn, and Z_t is the aggregate education subsidies

$$Z_t = \iint_{\mathcal{E}\times\mathcal{A}} \mathbb{1}_s(e,a) z \iota w_{t,c} \phi_0(e,a)\, da\, de. \tag{22}$$

7 *The pension budget (2) holds.*

8 *Individual behaviors are consistent with aggregate behavior: measure ϕ is a fixed point of $\phi(X) = \Pi(X,\phi)$, for any $X \in \mathbb{X}$, where $\Pi(X,\cdot)$ is the transition function generated by the decision rules of households, the process of exogenous states, and the survival probabilities.*

9 *All aggregate variables are constant over time.*

4 Calibration

This section discusses our parameter choices. We calibrate the model to the US economy. The majority of parameters are either estimated directly from the data or calibrated internally by matching certain aggregate moments in the US data. The rest of the parameters are taken from the literature. In addition, parameters that pertain to the education system and government policy are also estimated for Germany–these counterfactual values are then used in the policy experiments to assess the roles of various policy dimensions in shaping wage inequality.

4.1 Demographics

A period in the model corresponds to four years. New generations enter the economy at the age of 18. It takes four years to complete college. Households retire at the age of 66 and the maximum age is 94. In addition, the size of the population grows at a constant rate $n = 1\%$ annually, which is consistent with the long run population growth rate of the US. Survival probabilities $\{\psi_j\}$ are computed from the actuarial life tables for the US. Consistent with our focus on full time male workers, we consider survival probabilities for male workers. The reference year is 2011.

4.2 Preferences

We consider a fairly standard utility function

$$u(c, 1 - \mathbb{1}_s \xi(e) - l) = \frac{\left[c^{\nu}(1 - \mathbb{1}_s \xi(e) - l)^{1-\nu}\right]^{1-\frac{1}{\gamma}}}{1 - \frac{1}{\gamma}},$$

where ν is a taste parameter for consumption, $\frac{1}{\gamma}$ is risk aversion parameter. The two parameters ν and γ jointly determine (i) the average labor supply, (ii) the intertemporal elasticity of substitution of consumption, and (iii) the Frisch labor supply elasticity. γ is set to 0.5 (see, for example, Krueger and Ludwig (2016)). ν is chosen such that households on average work one-third of their time endowment. The subjective discount factor β is set so as to target a capital-output ratio of around 2.4, which falls in the range commonly used in the literature.

4.3 Technology

The aggregate production function is of Cobb-Douglas form. The capital share α is set to 0.33. Total factor productivity A is set to one. We set the elasticity of substitution between skilled labor and unskilled labor such that in equilibrium college wage premium is in line with the data. This leads to an elasticity of substitution of 1.5 – in accordance with the estimate in Katz and Murphy (1992) and Ciccone and Peri (2005). In addition, we set the annual depreciation rate to 7.55%, as in Krueger and Ludwig (2016).

4.4 Labor Productivity

Recall that the labor productivity of workers with education s and of age j is given by

$$h_{s,j} = \begin{cases} \epsilon_{s,j} \cdot \exp\left(\theta_s + \eta_{s,j}\right), & \text{if } j < j_r \\ 0, & \text{otherwise.} \end{cases}$$

To estimate the processes that govern labor productivity, we first run cross-sectional regressions of log earnings on education s and age j:

$$\ln(w_j) = f\left(X_j; x\right) + \tilde{w}_j, \tag{23}$$

where $f\left(X_j; x\right)$, a function of age and education, captures the life-cycle productivity profile, X_j is a vector of observables including education dummies and a cubic polynomial in age, and $\tilde{w}_j$ is a residual term. Estimates for $\epsilon_{s,j}$ are then obtained by normalizing $f\left(X_j; x\right)$ such that the mean labor productivity of skilled workers at age two–when college education is completed–is normalized to one. The residual term $\tilde{w}_{t,s}$ captures the fixed effect and stochastic component of the labor productivity process. More precisely, we consider the following process:

$$\tilde{w}_j = \theta + \eta_j,$$

$$\eta_j = \rho\eta_{j-1} + \epsilon_{\eta,j}.$$

We estimate this process using the Panel Study of Income Dynamics data under the assumption that θ and $\epsilon_{\eta,j}$ are normaly distributed with mean zero and variance σ_θ and σ_η, respectively.[8] Our estimation strategy is similar to Guvenen et al. (2014), Karahan and Ozkan (2013) and Krueger and Ludwig (2016). The estimates are reported in Table 2. Then we approximate the AR(1) process that governs the evolution of η using a two-state Markov chain with transition matrix

$$\pi_{\eta,s} = \begin{bmatrix} p_s & 1-p_s \\ 1-p_s & p_s \end{bmatrix}.$$

The estimated Markov process is reported in Table 2.[9]

This leaves us with the fixed effect component of labor productivity. We assume

[8] We restrict the sample to male heads of households, aged 18-66, over the period 1978-2015. As of 1997, variables are available biennially. To minimize the impact of changes in hours worked, we consider only full-time full-year workers.

[9] We use the Rouwenhorst method. See Kopecky and Suen (2010) for a discussion of the Rouwenhorst method.

	AR(1)		Markov Chain		
	ρ	σ_η^2	p_s	η_s	σ_θ^2
College	0.963	0.011	0.982	{-0.041, 0.041}	0.048
Non-college	0.926	0.019	0.963	{-0.050, 0.050}	0.065

Table 2: Estimates for the labor productivity process

that the skill-specific fixed effect θ_s takes on two values $\{\theta_{s,l}, \theta_{s,h}\}$ and that the probability of drawing a high fixed effect $\theta_{s,h}$ depends on one's ability. More precisely, we assume that

$$\pi(\theta_c = \theta_{c,h}|e) = e$$

and

$$\pi(\theta_n = \theta_{n,h}|e) = \omega e,$$

where ω is a parameter to be calibrated. Finally, we choose the free parameter ω such that the steady state of the model economy matches the college earnings premium of marginal students, which is primarily determined by ω, see, e.g., Findeisen and Sachs (2015) and Krueger and Ludwig (2016).

4.5 Education Costs and Subsidies

For the benchmark calibration, we assume that the fraction of educational costs borne by the government is the same for all individuals, regardless of their learning ability and financial situation.[10] To pin down the two parameters concerning the resource costs of college and government subsidies, ι and z, we rely on the data in Education at a Glance (OECD 2014, 2015). The year of reference is 2011. Table A7.3a(b) and Table A7.4a(b) (Education at a Glance, 2015) report, respectively, the private and public costs for a person attaining tertiary education. The private costs for a person attaining tertiary education are $55,000$ US dollars, while public costs stand at 55900 US dollars (in 2011 dollars).[11] From this, we can infer the fraction of resource costs borne

[10] Need-based grants and merit-based scholarships are considered later on as extensions.

[11] The cost of higher education is slightly lower in Germany– the private and public costs for a person attaining tertiary education are 5200 US dollars and 87500 US dollars, respectively.

by the US government: $z = \frac{55900}{55000+55900} = 0.504$. In addition, Table B1.3a. (Education at a Glance, 2014) reports that the average duration of tertiary studies is 3.17 years. Furthermore, GDP per capita in 2011 is 49791 dollars. Combining all information, we have:

$$\frac{\iota w_{t,c}}{\hat{Y}} = \frac{(55000 + 55900)/3.17}{49791} = 0.703,$$

where $\hat{Y}$ denotes GDP per capita. We calibrate the cost parameter ι such that in the benchmark model the ratio of the resource costs of college to GDP per capita is 0.703.[12]

4.6 Initial Wealth Endowment

Heterogeneity in initial wealth in this paper is intended to capture the family income effects on college attendance. An appropriate calibration requires micro-level data on college expenses. Fortunately such data exist. To calibrate the initial wealth distribution, we use the Consumer Expenditure Survey (2015) public-use microdata (PUMD) collected by the US Bureau of Labor Statistics. The public-use microdata contains detailed data on college expenses such as tuition and fees.[13] After consolidating the data, we estimate the distribution of college expenses. This distribution is then used in the model for college-bound individuals to draw their initial wealth.[14] Since our focus is on initial transfers for educational purposes, those who do not go to college receive zero initial wealth.

4.7 Learning Ability and Time Costs of College

We assume that learning ability follows a truncated normal distribution over the unit interval. The probability density function is given by

$$\pi_e(e) = \frac{\psi_{sn}\left(\frac{e-\mu_e}{\sigma_e}\right)}{\sigma_e\left(\Psi\left(\frac{1-\mu_e}{\sigma_e}\right) - \Psi\left(-\frac{\mu_e}{\sigma_e}\right)\right)}, \tag{24}$$

[12] Our estimate of $\frac{\iota w_{t,c}}{\hat{Y}} = 0.703$ is slightly higher than the estimate (0.694) in Krueger and Ludwig (2016).

[13] Student loan payments are not included as educational expenses.

[14] Initial endowment is expressed in terms of per capita GDP. When implementing this in the code, we start with an initial guess for GDP per capita and update it in each iteration.

where ψ_{sn} and Ψ denote, respectively, the probability density function and the cumulative distribution function of standard normal distribution, μ_e and σ_e denote the mean and the standard deviation of the un-truncated distribution. Without loss of generality, we set μ_e to 0.5. The standard deviation, σ_e, is chosen such that 95% of the probability mass falls in the unit interval.

In addition, we model the time cost of attending college as a parametric function of learning ability:

$$\xi(e) = \exp(-\lambda_e e), \tag{25}$$

where λ_e is a parameter. Given the specification for the distribution of learning ability, λ_e is chosen in an attempt to match tertiary education attainment in the data (see OECD (2018)).

4.8 Government Policy

We choose the government debt level and government spending to target a debt-to-GDP ratio of 60% and a government spending to GDP ratio of 17%, as observed in the data. The consumption tax rate is estimated from the U.S. National Income and Product Accounts data set, which gives rise to an estimate of $\tau_c = 7.3\%$. The capital income tax rate is taken from Chari and Kehoe (2006). Consistent with the current social security configuration, pension benefits are set to be 45% of the average income of each skill group, i.e., $\kappa_s = 45\%$. Payroll tax rate τ_p is then set to balance the budget. To estimate the two parameters associated with the labor income tax function m and λ, note that m is a natural measure of progressivity and λ governs the average tax rate (for a given m). More precisely, let $\tilde{y}$ denote the post-tax wage earnings, then $\tilde{y} = \lambda y^{1-m}$, where y is the pretax wage earnings. The elasticity of post-tax earnings to pre-tax earnings is then given by

$$\frac{d\tilde{y}/\tilde{y}}{dy/y} = 1 - m. \tag{26}$$

We rely on the estimates for m of OECD (see, Taxing Wages (2013), Table I.8.). λ is then chosen such that the average tax rate in the model is in line with the data.[15]

4.9 Borrowing Constraints

The borrowing constraint for age one is set such that college-bound individuals can finance up to a fraction, Φ, of their college tuition and fees with student loans:

$$\underline{\mathrm{A}}_j = \Phi(1 - z(e))\iota w_{t,c}.$$

Borrowing constraints for $j \geq 2$ are set such that borrowers repay at least a minimum amount, P, in each period, and that the loan is fully paid back by the age of retirement. More precisely, for $j = 2, 3, \cdots, j_r$:

$$\underline{\mathrm{A}}_j = (1 + r_t)\underline{\mathrm{A}}_{j-1} - P,$$

and $\underline{\mathrm{A}}_{j_r} = 0$.

To calibrate Φ, we rely on the National Postsecondary Student Aid Survey (2011-2012) from which we estimate an average loan size of $\$21,300$. We then choose Φ such that in equilibrium an average loan covers $\frac{21300}{55000}$ of the college costs borne by individuals.

5 Model Dynamics

Before conducting policy experiments and drawing policy conclusions, it is useful to first examine the model dynamics. In this section, we examine the life-cycle profiles of average earnings, consumption and labor supply by education, investigate the role of initial wealth in college attendance and look at the ability-composition of college students. In addition, this section shows that our model matches the earnings distribution remarkably well.

[15] The average tax rate is 17.1% for the US.

Table 3: Baseline parameterization: parameter values in parentheses are estimated from German data.

Parameter	Description	Value
Calibrated externally		
Demographics		
n	Population growth rate (annually)	1%
ψ	Survival probabilities	Actuarial Life Tables
j_r	Retirement age (age 66)	13
J	Maximum age (94)	20
Preferences		
γ	Risk aversion parameter	0.5
Technology		
α	Capital share of output	0.33
A	Total factor productivity	1
δ	Depreciation rate (annually)	7.55%
Labor productivity		
$\epsilon_{s,j}$	Life-cycle productivity profile	Supplementary data
θ_s	Fixed productivity effect	Table 2
η_s	Idiosyncratic productivity shocks	Table 2
ρ_s	Persistence parameter	Table 2
p_s	Transition probability	Table 2
Edu. costs and subsidies		
z	Subsidy rate	0.504 (0.944)
Ability and time cost of college		
μ_e	Mean of learning ability	0.5
σ_e	Standard deviation of learning ability	0.255
Government policy		
τ_c	Consumption tax	7.3% (19%)
τ_k	Capital income tax	28.3% (30.5%)
τ_p	Payroll tax	14% (33.7%)
κ_s	Pension benefits	45% (50%)
m	Progressivity	0.1 (0.27)
λ	Labor tax parameter	0.857
Calibrated internally(target)		
Preferences		
ν	Parameter for leisure (hours worked)	0.374
β	Discount factor (K/Y)	0.906
ζ	Elasticity of substitution (college premium)	0.285
Labor productivity		
ω	Scale parameter (see Section 4.4)	0.850
Ability and time cost of college		
λ_e	Time cost parameter (college attainment)	1.43
Edu. costs and subsidies		
ι	Cost parameter ($\frac{\iota w_{t,c}}{\hat{Y}}$)	0.196
Borrowing constraints		
Φ	Student loan parameter	0.657

5.1 Life-Cycle Profiles

Figure 1 plots the life cycle profile of average consumption, asset holdings, hours worked and earnings for skilled workers and unskilled workers, respectively.

Consumption rises steadily over the working life for both skilled and unskilled workers. It dips slightly when workers retire because pension benefits are only a fraction of average earnings. Then consumption decreases gradually as they age and face rising death hazards.

Wealth exhibits the typical hump-shaped profile. For young households who are not attending college, initial wealth is slightly positive. College students, on the other hand, take out loans and therefore have negative wealth. On average, it takes about eight years to pay off student loans.

Labor supply does not differ much across skill types. At age one, when the young generation enters the economy, labor supply is low not only for college-bound households but also for non-college-bound households. For college students, the reason is obvious because attending college takes time. For those who are not attending college, the relatively low level of labor supply reflects their low productivity, which is in line with the data.

Finally, the life cycle earnings profile also matches the data pretty well. Earnings are relatively low for young households as they enter the economy. College students don't have much time to work; those who are not attending college have low productivity. Earnings rise more rapidly for college-educated workers than unskilled workers. Average earnings decline gradually before retirement and drop to zero at the time of retirement. Tough the wage rate for college students is the same as unskilled workers, college students earn more than their non-college attending peers. This is because college students have higher probabilities of drawing a high fixed productivity effect θ (see Section 4.4) .

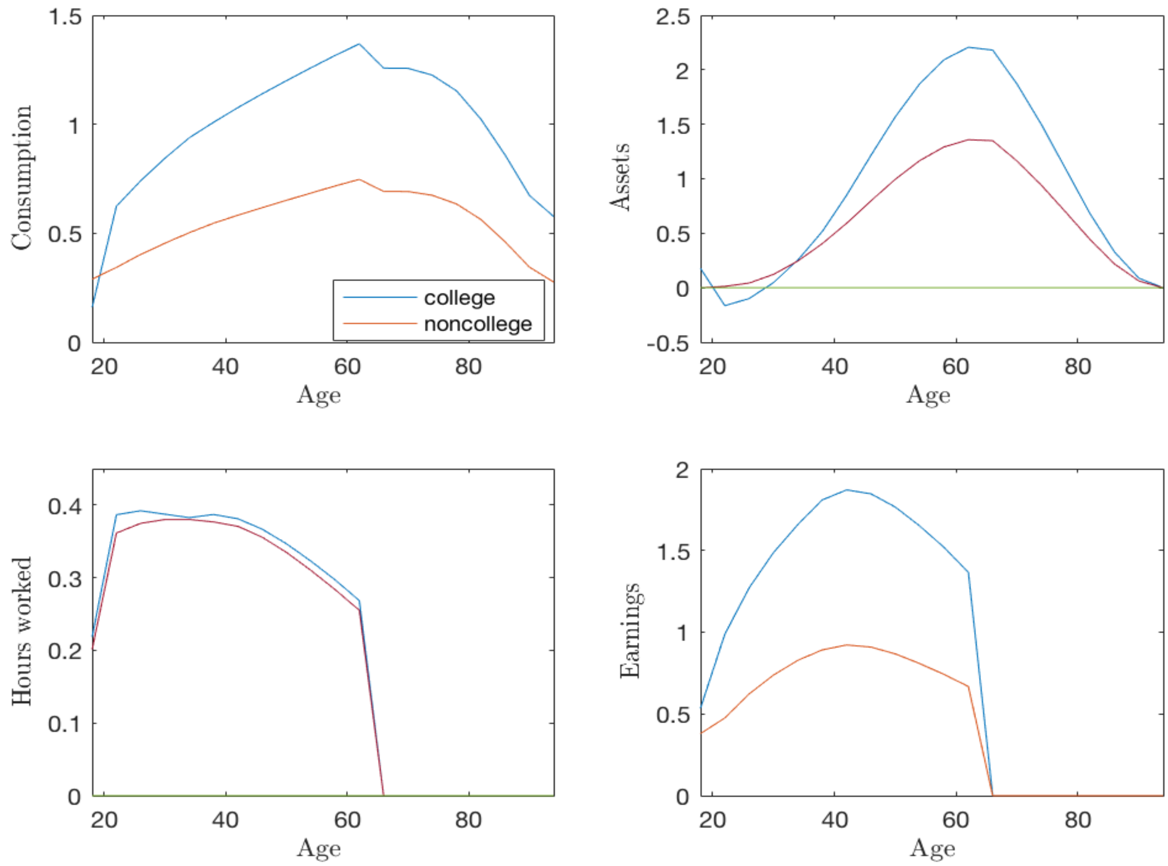

Figure 1: Life cycle profile of average consumption, asset holdings, hours worked and earnings for skilled workers (blue) and unskilled workers (red), respectively.

5.2 Initial Wealth, ability and College Attendance

Heterogeneity in initial wealth endowment is a shortcut to capture the family income effect on higher education attendance. It is calibrated to reflect heterogeneity in family contribution to higher education expenditures. From a policy maker's point of view, it is particularly important to know whether there are still high ability individuals left behind merely because they were born into low income families. For this reason, we plot the college decisions of households by learning ability and initial wealth endowment and the fraction of households in college by ability.

Figure 2 plots the expected lifetime utility of a household if it decides to attend college and receives an initial endowment at the 10th (yellow), 50th (red) and 90th (blue) percentile of the initial wealth distribution and the expected lifetime utility of the household if it decides not to attend college (dashed line). Since initial wealth endowment for non-college bound households is zero, they differ only in terms of learning ability. Household will attend college if and only if attending college delivers a higher expected lifetime utility. Figure 2 shows that even relatively low ability individuals can benefit from a college education if they can afford to do so.[16] On the other hand, some medium-high ability individuals with low initial wealth are unable to reap the benefits of college education. Figure 3 plots the fraction of college-age households in college by ability. It shows that a substantial fraction of medium- to high-ability households cannot afford to attend college although they would benefit from a college education.

Finally, to get a sense of the ability composition of college students, we also plot (see Figure 4) the cumulative fraction of college age individuals in college. It shows that, in the benchmark model, college students consist of mainly high and medium ability agents (consistent with the data), and that low ability individuals constitute only a small fraction of college students. The reason is twofold. First, assuming that ability follows a truncated normal distribution, low ability households constitute only a small fraction of the population. Second, for those low ability households, only a small fraction is rich enough to attend college. While high ability households can pay their way through college by working part time, this option is not viable for low ability households because they face higher time cost of college and earn less when working part time.

Later we will show that changes in government policy in general and education policy in particular would affect earnings inequality primarily through their effects on the ability composition of college students. We will also show that a well designed education policy can reduce earnings inequality without compromising efficiency.

[16] It is important to note that this is because college wage premium is high in the benchmark model. If medium and high ability households who cannot afford to go to college were enrolled into college through increased government financial aid, college wage premium would drop and low ability households would find it not optimal to go to college.

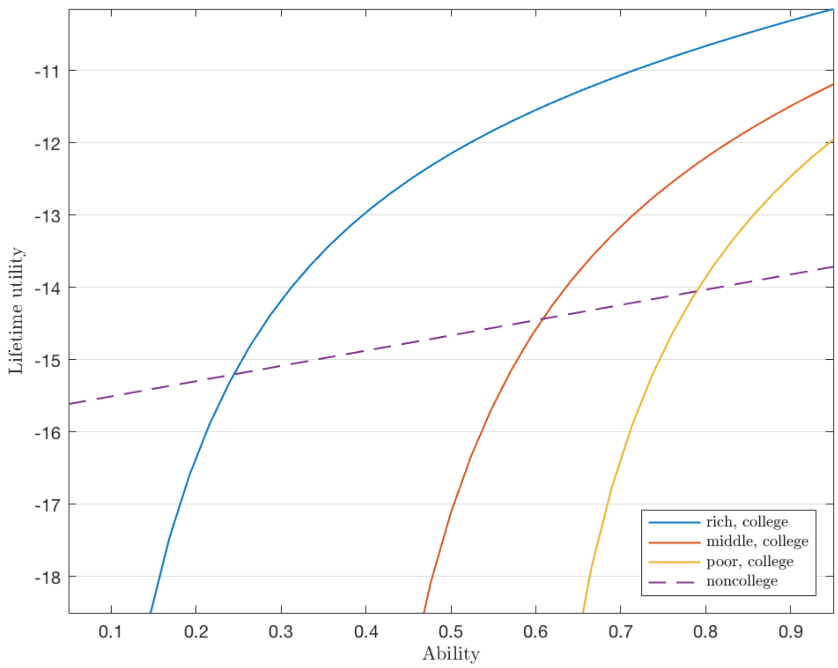

Figure 2: Expected lifetime utility of a household if it decides to attend college and receives an initial endowment at the 10th (yellow), 50th (red) and 90th (blue) percentile of the initial wealth distribution and the expected lifetime utility of the household if its decides not to attend college (dashed line)

5.3 Earnings Inequality: Model vs Data

Since earnings inequality is a major variable of interest of this paper. It is therefore important to know how far the model can go in generating realistic earnings distribution. For this reason, we report two different measures of earnings inequality, wage ratios and Gini coefficients for wage income, and compare them with before tax earnings inequality observed in the data (Table 4).[17]

The benchmark model generates a Gini coefficient slightly lower than that observed in the data. On the other hand, the model slightly overshoots overall earnings inequality when it is measured by the wage ratio between the 90th percentile and 10th

[17]Both the Gini index and wage ratios are used in the literature to measure earnings inequality. The Gini index is typically a more robust measure since wage differentials are based on only two data points across the wage income distribution. Moreover, survey data on earnings are typically top-coded. Nonetheless we report both measures. See Burkhauser, Feng, and Jenkins (2009) for more discussions on different measures of inequality.

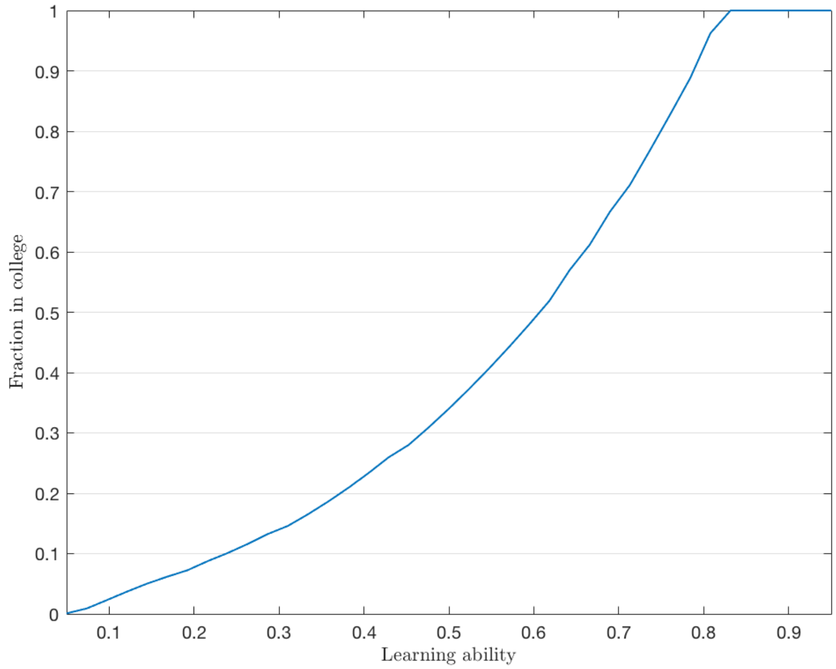

Figure 3: Fraction in college by learning ability

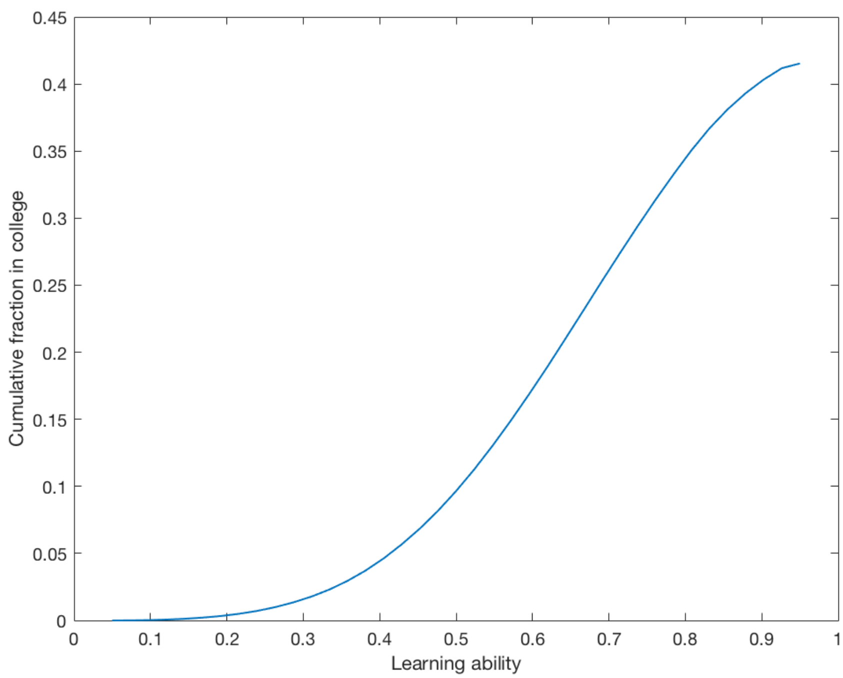

Figure 4: Cumulative fraction of college age individuals in college

percentile of the wage income distribution. But overall, the model does a reasonably good job in matching earnings inequality in the data.

Table 4: *Earnings Inequality: Model vs Data*

	Data	Model
Gini	0.41	0.37
P90/P10	5.16	6.18
P90/P50	2.36	2.45
P50/P10	2.18	2.52

6 Policy Experiments

To evaluate the roles of the various aspects of government policy in shaping earnings inequality, we conduct several policy experiments. First, we replace the benchmark education subsidy rate with the one estimated from German data. To allow for the crowding-out effect of increased government subsidies for higher education, we consider the extreme case that initial wealth transfers completely vanish. Relaxing this assumption can only strengthen the role of education policy. Second, keeping everything else unchanged, we replace the benchmark labor income tax progressivity parameter with the one estimated for Germany. This experiment allows us to evaluate the role of tax progressivity. Finally, we also consider deviations from the benchmark along policy dimensions other than education policy and tax progressivity. In each of these experiments, the government budget is balanced through lump-sum taxes. We report the results of these policy experiments in this section.

6.1 Education Inequality and Earnings Inequality

In this subsection, we examine the roles of various policy dimensions in driving college attendance and consequently in shaping earnings inequality. In Table 5, we report college attendance and various measures of earnings inequality for the benchmark model

Table 5: Policy Experiment Results

	Benchmark	Education	Progressivity	Edu. & Prog.	Other taxes
Gini	0.370	0.310	0.342	0.304	0.357
		16.2%	7.6%	18.1%	3.6%
P90/P10	6.184	4.371	5.486	4.363	5.696
		29.3%	11.3%	29.5%	5.7%
P90/P50	2.440	2.126	2.381	2.099	2.340
		13.2%	2.79%	14.3%	2.3%
P50/P10	2.524	2.056	2.303	2.078	2.435
		18.6%	8.75%	17.7%	2.4%
% in college	41.5	59.6	46.1	59.9	47.6

as well as for model variants that deviate from the benchmark in various policy dimensions. We first report the results for the benchmark model (2nd column). Then we report the results for the education policy experiment (3rd column), where we replace the status quo subsidy rate (z) with its counterpart estimated from German data. In the fourth column, we report results for the model variant where we only change the labor income tax progressivity parameter (m) and keep other policy dimensions the same as in the benchmark. Note that since the average labor income tax rate also depends on the progressivity parameter, when conducting this experiment, we adjust λ such that the average tax rate remains the same as in the benchmark. In the fifth column, we report results for the experiment in which we change both the college subsidy rate and labor tax progressivity. Finally, we report results for the experiment where we change other policy dimensions other than education policy and labor income tax, including capital income tax and consumption tax. The numbers below each measure are percentage reductions in the respective measure of earnings inequality from the benchmark model. A negative number therefore indicates an increase in that measure.

The results suggest that raising college subsidy rate from the US status quo to the German level would reduce earnings inequality, as measured by the Gini index, by as much as 16.2% (see also Figure 5). It would greatly boost college attendance–from 41.5% to 59.6%. Besides, such a move would shift the ability composition of college students. Figure 6 shows the fraction of college-age households in college in the bench-

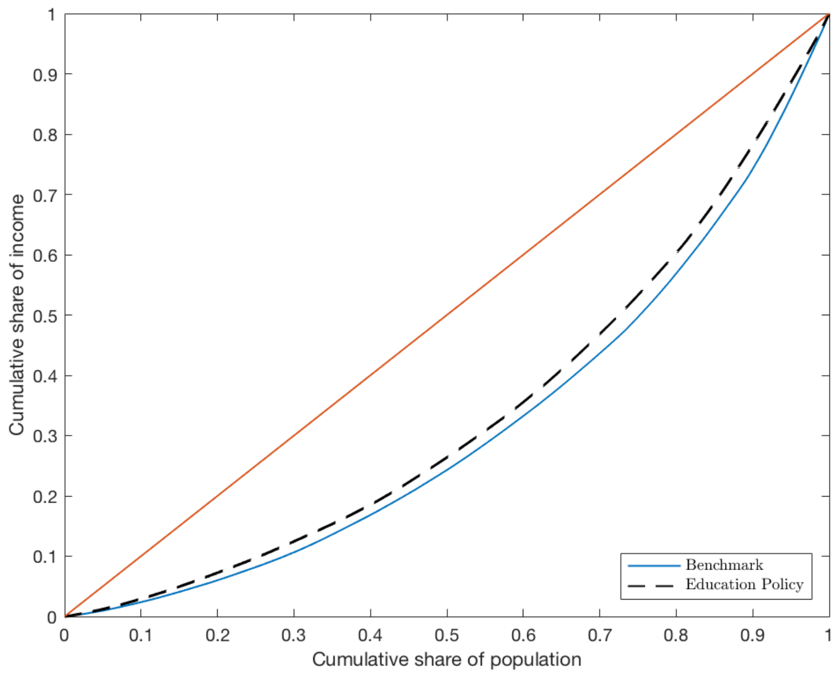

Figure 5: Lorenz curve under the benchmark model (solid blue line) and the education policy experiment (dashed line).

mark model (solid line) and that in the counterfactual experiment (dashed line) where education subsidy is raised to the German level. Interestingly, such a reform would not only have distributional gains, in the next section, we will show that it would also lead to more efficient aggregate outcomes.

On the other hand, increasing labor tax progressivity has only a modest impact on inequality. For example, replacing the US status quo progressivity with its German counterpart can reduce earnings inequality by 7.6%, about half of the reduction that can be achieved by increased government subsidies for higher education. This finding is in stark contrast to Guvenen et al. (2014), who single out labor tax progressivity as the most important determinant of earnings inequality.[18] Moreover, increased labor tax progressivity necessarily leads to lower economic efficiency, a topic we will address in the next subsection. In addition, our results suggest more progressive labor income

[18]Guvenen et al. (2014) consider a model with complete markets. Thus they are silent on the role of education affordability.

tax may actually increase college attendance. The reason is that the additional government revenues are transferred to households in a lump-sum manner, which can be used by credit-constrained young households to finance college education.

In line with the literature (see, e.g., Krueger and Ludwig (2016)), our results also suggest that education policy and labor tax progressivity constitute a policy substitute for each other in terms of reducing earnings inequality. In the next subsection, we show that education policy can partially offset the distortion of increased labor tax progressivity.

Finally, our results suggest that the consumption tax and the capital income tax only have a minimal effect on earnings inequality.

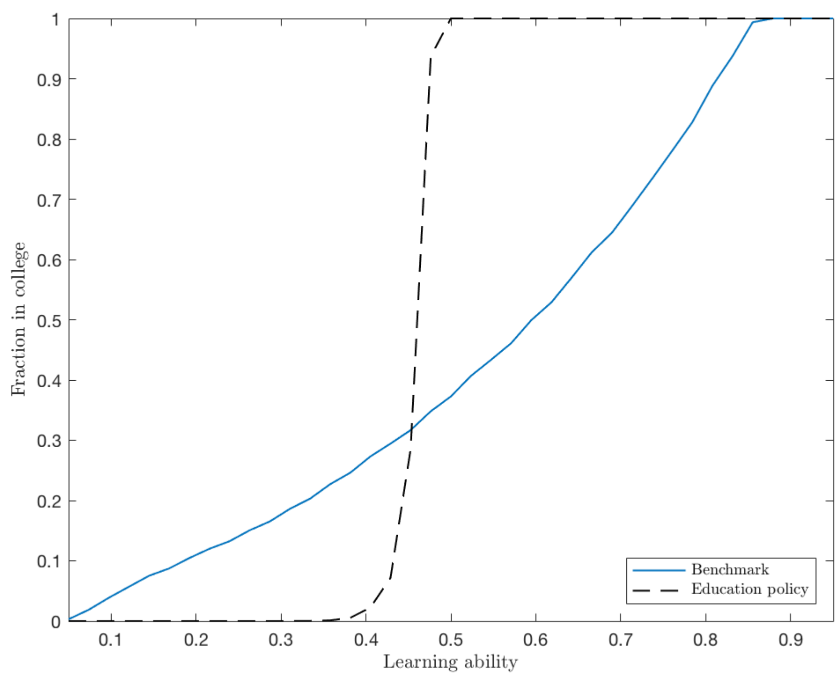

Figure 6: Fraction of college-age households in college: education reform (dashed line) vs the benchmark (solid line).

6.2 Equality, Efficiency and Welfare

In the previous subsection, we focus on the importance of various policies in shaping earnings inequality. In this subsection, we bring the other component of social welfare, efficiency, into the picture, and examine the welfare gains of each policy reform.

Table 6 reports a few key macroeconomic variables under the benchmark and deviations from it along the education policy dimension and the labor income tax dimension. Three observations can be made. First, raising government spending on education not only reduces earnings inequality, it also increases macroeconomic efficiency: output, capital stock and aggregate labor (in efficiency units) are higher than those in the benchmark. Second, not surprisingly, more progressive labor income taxes lower earnings inequality but also lead to greater distortions: workers work fewer hours, and output, capital stock and aggregate labor (in efficiency units) are lower compared with the benchmark. Third, higher subsidies for higher education partially offset the distortions induced by progressive labor taxation. This is not because higher subsidies provide workers better incentives to work, but rather because higher subsidies for education boost labor productivity through increased college attendance.

Table 7 reports the welfare gains of each hypothetical policy reform relative to the benchmark. It shows that, in line with Krueger and Ludwig (2016), a combination of more generous subsidies for college and more progressive labor income taxation is most desirable in terms of social welfare. Specifically, replacing the college subsidy rate and labor tax progressivity with their German counterparts would increase social welfare by an amount equivalent to a 21.25% increase in consumption.

6.3 Winners and Losers

In this subsection, we examine the winners and losers of increased government subsidies for college. For this purpose, we plot the welfare gains, in consumption-equivalent terms, from the hypothetical education policy reform (see Figure 7). It shows that poor households with medium and medium-high ability would benefit the most from increased government subsidies for college: this group would enjoy an increase in lifetime utility equivalent to an increase in consumption by as much as 80%. Those are the households that cannot afford to go to college in the benchmark, although they would benefit greatly from a college education. Somewhat surprisingly, low ability households

Table 6: Macroeconomic variables under the benchmark and deviations from it along the education policy dimension and the labor income tax dimension. The number below each variable is the percentage increase of that variable relative to the benchmark.

	Benchmark	Education Policy	Progressivity	Edu. & Prog.
$\hat{Y}$	1.241	1.338	1.194	1.226
		7.816%	−3.787%	−1.209%
$\hat{K}$	0.748	0.806	0.722	0.738
		7.754%	−3.476%	−1.337%
$\hat{C}$	0.726	0.762	0.694	0.699
		4.959%	−4.408%	−3.719%
$\hat{L}$	1.650	1.778	1.584	1.631
		7.758%	−4.000%	−1.152%
$\hat{h}$	0.349	0.359	0.331	0.330
		2.865%	−5.158%	−5.444%
w	0.481	0.481	0.482	0.481
		0.000%	0.200%	0.000%
r	0.295	0.295	0.293	0.296
		0.000%	−0.678%	0.339%
$\frac{w_c}{w_n}$	1.747	1.029	1.511	1.021
		−41.099%	−13.509%	−41.557%

Table 7: Social Welfare. The first row shows the average life-time utility. The second row reports the welfare gains, in consumption-equivalent terms, of each hypothetical policy reform compared with the benchmark.

	Benchmark	Education Policy	Progressivity	Edu. & Prog.
$\bar{V}$	−13.723	−12.869	−13.309	−12.769
		18.74%	8.53%	21.25%

would also benefit from the hypothetical education policy reform, albeit for different reasons. They don't go to college anyway. But when more households attend college, the college wage premium decreases. Unskilled workers become relatively scarcer and thus enjoy a higher wage rate. Finally, our results suggest that a small fraction of rich and high-ability households would lose out from the hypothetical education policy reform due to compressed college wage premium. However, the utility loss they would suffer is relatively small. For example, a household with an initial wealth at the 90th percentile of the initial wealth distribution and a learning ability at the 99th percentile of the ability distribution would suffer a utility loss equivalent to a 17.5% decrease in consumption.

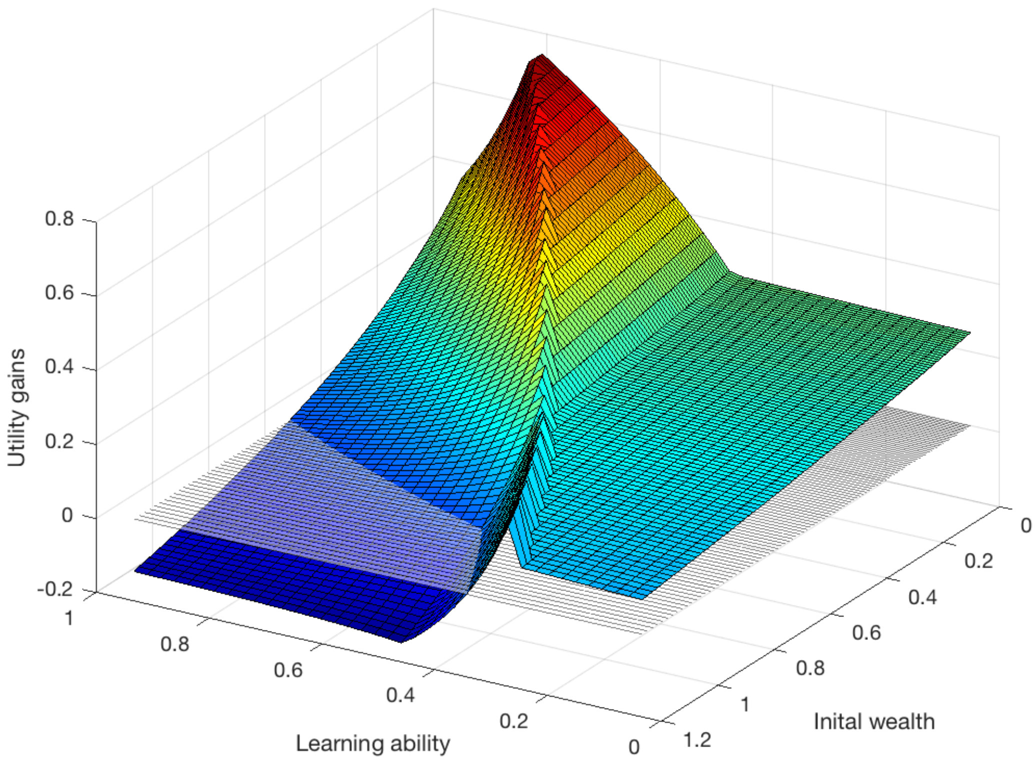

Figure 7: Welfare gains, in consumption-equivalent terms, from the hypothetical education policy reform.

7 Conclusion

We study the role of education affordability in shaping earnings inequality in the context of an overlapping generations model. We find that earnings inequality, as measured by the Gini coefficient for before-tax gross earnings, would decrease by as much of 16.2 percent if the current education policy, the share of higher education costs borne by the government, were replaced with its German counterpart. Two groups of households would benefit from the hypothetical policy reform. First, poor households with medium and medium-high ability would benefit the most from increased government subsidies for college. Those are the households that cannot afford to go to college in the benchmark, although they would benefit greatly from a college education. Second, households of low ability would also benefit from the hypothetical education policy reform, albeit for different reasons. They don't go to college anyway. But when more households attend college, the college wage premium decreases. Unskilled workers become relatively scarcer and thus enjoy a higher wage rate. On the other hand, our results suggest that a small fraction of rich and high-ability households would lose out from the hypothetical education policy reform due to compressed college wage premium. In line with the literature, we find that a combination of more generous subsidies for college and more progressive labor income taxation is most desirable in terms of social welfare. Finally, in contrast with the existing literature, we find that labor tax progressivity plays a less significant role in explaining earnings inequality.

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