Progressive Taxation and Educational Attainment: An Intergenerational Perspective

Irina Popova*

November 15, 2021

Abstract

Using a quantitative overlapping generations model with intergenerational links, I explore aggregate, distributional and welfare implications of reforming the degree of progressivity of the current US tax and transfer system. Intergenerational linkages take place via human capital formation during childhood and wealth transfers. An explicit modeling of endogenous parental human capital investment decisions allows me to analyze the effect of progressive taxation on the whole human capital accumulation process during childhood and adolescence (*child human capital effect*). Using a simple static model I show that the sign of this effect is theoretically ambiguous. Based on the quantitative model I find that increasing the progressivity of marginal tax rates distorts the aggregate human capital accumulation in the economy more than increasing the progressivity of average tax rates (i.e. public transfer expansions) when financed via labor income tax adjustments. Additionally, if an increase in the progressivity of average tax rates is financed via increasing the consumption tax rate, the overall effect on human capital accumulation is positive which is crucial for the sign of the average welfare effect.

Keywords: tax progressivity, public transfers, welfare benefits, education policies, inequality, intergenerational persistence

*Goethe Universität Frankfurt

1 Introduction

This paper addresses the role of intergenerational linkages for aggregate, welfare and distributional implications of tax and transfer reforms. On the one hand, redistributive policies in general and anti-poverty policies in particular can have positive effects on the human capital accumulation and educational attainment of children living in recipient households. The recent empirical literature on the economic consequences of Earned Income Tax Credit (EITC) expansions has emphasized the relevance of this channel for understanding the overall economic impact of such reforms[1]. At the same time, in a similar fashion as human capital accumulation within the lifecycle of one generation is negatively affected by progressive taxes and public transfers, also parental investment decisions into child human capital can be negatively affected by progressive taxes and public transfers[2]. Therefore, in the aggregate it is not clear whether increasing progressivity of the tax and transfer system has a negative or a positive effect on the average human capital stock in the economy and educational attainment, and how this effect in turn is relevant for the overall welfare and distributional consequences of such reforms.

In this paper I make a step forward in providing a better understanding of the role of human capital accumulation during childhood and a subsequent higher education choice for the analysis of tax and transfer reforms, emphasizing intergenerational consequences of such reforms.

Taking explicitly into account the fact that parental human capital investment decisions into their children are affected by government policies allows me to analyze the implications of tax and transfer reforms for initial conditions at labor market entry. The relevance of this channel is supported by the recent literature on the causes of socioeconomic inequality (see e.g. Huggett et al. (2011)) showing that inequality in initial conditions at labor market entry is a major factor determining the lifetime inequality in earnings and wealth. Additionally, the literature on early childhood human capital formation (see e.g. Cunha and Heckman (2007) and Cunha et al. (2010)) has emphasized the crucial role of the skill formation process before college for later lifetime outcomes. I argue that understanding the implications of tax and transfer reforms for the human capital formation during childhood and, thus, for the inequality in initial conditions at labor market entry is of central importance for correctly assessing the overall macroeconomic impact of redistributive policies.

To address the question how initial conditions are shaped by human capital investment decisions of parents into their children and how macroeconomic aggregates, inequality and welfare are affected by government interventions I develop a quantitative overlapping generations model

[1] See e.g. Dahl and Lochner (2012) and Bastian and Lochner (2020).

[2] Erosa and Koreshkova (2007) using a stylized overlapping generations model emphasize that progressive taxation negatively distorts parental human capital investment decisions, in addition to other distortions considered in the existing literature.

with intergenerational links via human capital accumulation and wealth transfer decisions by parents. In order to expose a key mechanism on the welfare implications of government policy in this model I start the discussion by setting up an analytically tractable static partial equilibrium two-generations model. I use this framework to analyze how public transfers to parental households (financed with a flat labor income tax) affect child human capital. I identify a *three way tradeoff* that the government faces when designing tax and transfer reforms. On the one hand, a higher degree of progressivity has a positive budgetary effect on the recipient parental households and implies that ceteris paribus they increase human capital investments into their children (*current generations effect*). On the other hand, a higher degree of progressivity reduces effective returns to parental investments into child human capital (*future generations effect*). Finally, for the relative strength of the *current generations effect* versus the *future generations effect* it matters whether the government budget has to be rebalanced on a per period basis and via adjusting which fiscal instruments the government budget balancing is achieved (*government budget effect*). I derive an analytical condition when public transfer expansions positively affect human capital accumulation. Particularly, whether parents adjust their investment decisions into child human capital positively or negatively crucially depends on the income level of parents, on the one hand, and the ability of children, on the other hand.

Equipped with this theoretical result, I set up the quantitative overlapping generations model at the core of which is a multi-stage human capital production process that takes parental investments through time and monetary expenditures as well as the government schooling investment as inputs. After the human capital accumulation process during childhood is completed young households in the model also make a discrete higher education decision. College completion is uncertain and depends on the skill level achieved before entering college. Furthermore, since redistributive policies crucially affect household labor supply decisions which can further interact with investment decisions into child human capital the model also features endogenous labor supply. Therefore, the model captures major trade-offs that have been already addressed in the recent quantitative optimal taxation literature (see e.g. Heathcote et al. (2017)) and additionally incorporates intergenerational links via parental human capital investments and wealth transfers. Thus, the main new mechanism in the model is the impact of progressivity on parental investment decisions into the human capital of their children and the associated child human capital accumulation.

Finally, the tax and transfer system in the model is calibrated to capture the actual degree of progressivity embedded in the current US system. Importantly, the tax function employed in the model allows to explicitly differentiate between the progressivity driven by average tax rates, on the one hand, and the steepness of the marginal tax rates schedule, on the other hand.

Using this model as a quantitative laboratory I evaluate a set of stylized tax and transfer reforms. Particularly, I consider public transfer expansions as well as an increase in the progressivity of the marginal tax rates schedule financed either via increasing the labor income tax rate or the consumption tax rate.

Based on the analysis of these stylized reforms I draw the following two main conclusions. First, when increasing the overall progressivity of the tax and transfer system it matters whether the progressivity of average tax rates or the progressivity of marginal tax rates is changed. Increasing progressivity of average tax rates through transfer payments distorts the average human capital accumulation in the economy less than increasing the progressivity of the marginal tax rates schedule. Second, is is also important how these reforms are financed, i.e. which fiscal instruments the government relies on to achieve a balanced budget. Particularly, a public transfer expansion financed via consumption tax increases induces a positive effect on the average human capital stock and results in an average welfare gain while the opposite is true when labor income taxes are used to rebalance the government budget.

Related Literature

This paper is related to several strands of literature. The first strand of related literature concerns optimal tax and transfer policies in a setting with endogenous education choice. In a theoretical analysis using a setting without intergenerational links Bovenberg and Jacobs (2005) derive a strong result that labor income taxation and education subsidies are "Siamese twins". They thus show that since education subsidies offset the adverse effect of taxes on human capital accumulation the optimal subsidy rate should be set equal to the marginal tax rate. This is equivalent to making educational expenses fully tax deductible. Since their setting focuses on one generation only, by construction the parental investment channel is not present.

Using the theoretical result derived in Bovenberg and Jacobs (2005) as a point of departure, Krueger and Ludwig (2013) and Krueger and Ludwig (2016) explore the interplay of the two instruments in a rich quantitative general equilibrium macro model with intergenerational links. They show that while the complementarity between the two instruments holds in a partial equilibrium setting, once general equilibrium effects as well as transitional dynamics are taken into account, redistributive taxation and education subsidies become policy substitutes regarding their redistributive implications. However, also in their setting endogenous parental investment decisions are not modelled and, therefore, the role of tax and transfer policies for educational attainment can be addressed only partially.

A most closely related paper is Erosa and Koreshkova (2007) that explores a proportional tax reform in a stylized model with endogenous parental human capital investment decisions. A crucial difference relative to the current paper is that they consider only progressivity of marginal tax rates and do not model public transfers.

The second strand of related literature concerns the human capital formation during childhood which includes both empirical studies (Cunha et al. (2006), Cunha and Heckman (2007) and Cunha et al. (2010)) and papers that rely on structural models (Caucutt and Lochner (2020), Lee and Seshadri (2019) and Caucutt et al. (2020)). For example, Lee and Seshadri (2019) use a similar structural model to the one employed in this paper to analyze the importance of parental socioeconomic background for intergenerational persistence. More recently, Fuchs-Schündeln et al. (2020) used a two-generations model with endogenous parental human capital investment decisions to analyze the long-term economic costs of Covid-19 school closures.

Finally, another strand of related literature concerns reforming existing social assistance programs in the US (see e.g. Conesa et al. (2020) and Guner et al. (2019)). In a contemporaneous work Daruich and Fernández (2020) study an unconditional basic income reform using a structural model that shares several similarities with my setting, however, with many differences in modeling assumptions and calibration strategy. Importantly, in contrast to their paper I model not only monetary investments of parents into child human capital but also explicitly consider the time input of parents importance of which has been emphasized in the literature on early childhood interventions (see e.g. García et al. (2020)). Second, I consider three education categories instead of only two in their setting and explicitly model college dropouts which implies that college completion is risky. This means that policies that are designed to affect the college enrollment decision have a smaller scope if the skill levels acquired at earlier stages of childhood were not sufficiently high (see e.g. Blandin and Herrington (2018)). Last but not least, for the baseline parametrization of the tax and transfer system I rely on the estimates provided in Boar and Midrigan (2020) which imply a considerably larger role of public transfers in the baseline as compared to the parameterization used in Daruich and Fernández (2020). Apart from these important differences in the modeling framework, my paper goes beyond evaluating one single popular reform proposal and provides more general conclusions about the intergenerational implications of tax and transfer reforms.

The rest of the paper is organized in the following way. First, I document a set of stylized facts on the role of family background for parental human capital investment decisions into children as well as child human capital outcomes using the Child Development Supplement (CDS) to PSID. In the second section using a simple dynastic model I analyze the effect of public transfers (financed by a flat income tax) and parental human capital investment and child human capital. Thereafter, I set up an overlapping generations model with intergenerational links and use it as a quantitative laboratory to evaluate a set of stylized policy reforms.

2 Family Background and Child Human Capital Accumulation

In this section using data from the Panel Study of Income Dynamics (PSID) I document a set of stylized facts on the role of socioeconomic family background for human capital accumulation of children. The purpose is to illustrate a substantial correlation between the socioeconomic family background, on the one hand, and child outcomes as well as parental human capital investments, on the other hand.

The data shows that there is a pronounced socioeconomic gradient both in child test scores as well as in parental investments. In other words, empirical evidence confirms that there exists a correlation between parental total income, on the one hand, and parental investments into the child human capital and child educational outcomes, on the other hand. Therefore, policies that affect total resources of parents are likely to have implications also for human capital accumulation in the medium and long run.

2.1 Data

I use three waves of the Child Development Supplement (CDS) to PSID (1997, 2002 and 2007) and merge them with PSID family files of the respective years. I keep both married and single parents in the sample. For single households children for whom the household head is the primary caregiver are considered. For married households children for whom primary and secondary caregivers correspond to the household head and the spouse (wife) in the PSID household and for whom at least one of the caregivers is a biological parent are considered.

2.2 Child Human Capital Outcomes

Table 1 shows Letter Word test scores of children for the age bin 16-18 by quintiles of the total family income. In the quantitative model described in Section 4 the childhood human capital accumulation is completed at the biological age 17. Therefore, I refer to the child test scores for the age bin 16-18 as a proxy for acquired human capital in the model. As can be seen from the table, there is a pronounced socioeconomic gradient in acquired child human capital with children of poorest parents having almost 20% lower average test scores than children of most affluent parents.

Table 1: Child Test Scores by Total Family Income Quintile

Total Income Quintile	Test Scores
1	47.33
2	52.05
3	54.60
4	56.96
5	58.05

Notes: Child Letter Word test scores are shown for the age bin 16-18.

2.3 Parental Investments and School Type

As a next step I look at the inputs into the production of child human capital by the socioeconomic background of parents. Table 2 shows the active time that parents spend with their children per week again by quintiles of the total family income. Similarly, Table 3 shows the monetary expenditures of parents on childcare, school fees as well as extracurricular activities. From both tables it can be seen that parental human capital investments feature a pronounced socioeconomic gradient.

Table 2: Parental Time Input by Total Family Income Quintile

Total Income Quintile	Time Input
1	20.71
2	26.87
3	28.48
4	31.05
5	58.05

Notes: Active parental time with children is reported on a per week per child basis.

Finally, Table reports a fraction of children attending a private school by quintiles of total family income. The data shows that among children whose parents are in the lowest total income quintile private school attendance is the lowest (4.98%) while for children whose parents are in the highest total income quintile it is the largest (18.12%).

The takeaway from the descriptive statistics presented above is that children who grow up in poor households start adolescence with lower human capital levels than their counterparts from more affluent family backgrounds. Also, parental inputs in terms of money and time as well as the school type that children attend are strongly correlated with parental socioeconomic background.

Table 3: Parental Monetary Input by Total Family Income Quintile

Total Income Quintile	Monetary Input
1	$607
2	$820
3	$1,200
4	$2,134
5	$3,309

Notes: Monetary investment into child human capital is composed by expenditures on childcare costs, schooling fees and extracurricular activities. Monetary expenditures are reported on a per year per child basis.

Table 4: Fraction of Children in Private School by Total Family Income Quintile

Total Income Quintile	Fraction
1	4.98%
2	5.43%
3	12.02%
4	14.57%
5	18.12%

Notes: The fraction of children attending private school is computed based on the school type reported by parents.

In the quantitative model I explicitly take into account that public policies can affect parental human capital investment decisions which in turn crucially determine the human capital distribution of young adults at the labor market entry.

3 Public Transfers and Human Capital: Simple Model

3.1 Simple Model

3.1.1 Overview

The simple model below illustrates that in a dynastic framework tax progressivity has not only a distortionary effect on human capital accumulation but also positively affects parental human capital investments via increasing resources of low-income parents. This positive effect of progressive taxation on parental resources and their human capital investments into children is of interest because its explicit consideration makes the sign of the aggregate affect of tax progressivity on human capital accumulation ex ante ambiguous. Progressive taxes are modeled as a lump-sum transfer financed by a flat income tax.

While on the one hand, higher tax progressivity reduces returns to human capital and, thus, negatively affects respective investments, on the other hand, it has a favorable effect on budgets of low-income parents and by these means positively affects investments of those parents into the human capital of their children. I label the latter effect the *current generation* effect and refer to the former as the *future generation* effect. For the relative strength of the two effects it is important whether the government budget is rebalanced on a per period basis (*government budget* effect).

I derive an analytical condition for the overall effect of higher tax progressivity on parental human capital investments and, thus, child human capital to be positive. In words, this condition states that child ability should exceed an ability threshold for the effect of tax progressivity on acquired child human capital to be positive. Importantly, this ability threshold is increasing in the income of parents and decreasing in their altruism.

Therefore, ultimately, whether tax progressivity affects average human capital in the economy positively or negatively depends on the ability distribution of the child generation and the income distribution of the parent generation and is therefore a quantitative question.

3.1.2 Model Description

The model below has a simple dynastic structure where each generation lives for one period and parents are altruistic towards their children. The problem of children is close to the model in Bovenberg and Jacobs (2005) and the simple model in Krueger and Ludwig (2016).

The household spends one period as a child and one period as an adult. Children are not making any decisions while parents can invest monetary resources into the child human capital. Children themselves have no children and only consume. For tractability, I abstract from endogenous labor supply[3].

Parents are ex-ante heterogeneous in their (pre-tax) labor income. Children, in turn, are ex-ante heterogeneous in their innate ability level A.

Given the innate ability level, acquired child human capital h is determined according to the following production function:

$$h = A(i + i^g)^\varrho \tag{1}$$

[3]Observe that all statements below would also go through with endogenous labor supply under Greenwood-Hercowitz-Huffmann preferences but this specification is not of interest because it by construction abstracts from wealth effects on labor supply.

where i is the input of parents and i^g determines the government schooling investment.

The tax and transfer system consists only of two elements: a linear labor income tax τ and a lump-sum transfer T. In the discussion below I index both instruments by the generation that they affect: children or parents (p for parents and k for children). Thus, de facto these are four instruments: τ^p, τ^k, T^p, T^k. Whenever τ and T are used without a superscript they affect both generations. In addition, the government spends monetary resources i^g on child education.[4]

Parents are altruistic towards their children and, thus, the lifetime utility of children directly enters the maximization problem of parents with a parameter ν determining the strength of the altruism channel.

The only two state variables are parental income y and child innate (learning) ability A.

The child value function is denoted by $\hat{V}(\cdot)$ and can be written as

$$\begin{aligned} &\hat{V}(A,i) = \log(w^k h(1-\tau^k) + T^k) \\ \Leftrightarrow\ &\hat{V}(A,i) = \log(w^k A(i+i^g)^{\varrho}(1-\tau^k) + T^k) \end{aligned} \tag{2}$$

where I restrict $\tau^k \geq 0$ and $T^k \geq 0$.

Parents maximize their lifetime utility given by:

$$V(y,A) = \max_i \Big\{ \log(y(1-\tau^p) + T^p - i) + \nu \hat{V}(A,i) \Big\}$$

subject to the constraints

$$\begin{aligned} &i \geq 0, \\ &\tau \geq 0,\ T \geq 0. \end{aligned}$$

Thus, using eq. (2) the parental maximization problem can be written as

$$V(y,A) = \max_i \Big\{ \log(y(1-\tau^p) + T^p - i) + \nu \log(w^k A(i+i^g)^{\varrho}(1-\tau^k) + T^k) \Big\}. \tag{3}$$

3.2 Optimal Parental Investment i

Take the first order condition with respect to i to get:

$$\frac{1}{y(1-\tau^p) + T^p - i} = \frac{\nu \varrho w^k A(i+i^g)^{\varrho-1}(1-\tau^k)}{w^k A(i+i^g)^{\varrho}(1-\tau^k) + T^k}.$$

[4] In the simple model education expenditures i^g proxy for both pre-tertiary and tertiary education spending because the model because the model does not have a dynamic dimension.

Throughout I focus on a marginal reform of T^k, T^p and i^g, assuming that in the baseline $T^k = T^p = i^g = 0$ (and, thus, also $\tau^k = \tau^p = 0$).

For later use, observe that under $T^k = T^p = i^g = \tau^p = \tau^k = 0$ (i.e. setting all policy parameters to zero) optimal i can be obtained in closed form:

$$i = \frac{\nu \varrho y}{1 + \nu \varrho}. \tag{4}$$

Note that under this restriction on policy parameters for any $\nu > 0$ optimal i is given by an interior solution. And since a marginal reform implies a variation around this solution, the corner solution $i = 0$ never becomes relevant unless ν is very small.

3.3 Child Human Capital and Public Policies

Definition 1. T and i^g are defined as *policy substitutes* concerning their effect on human capital accumulation if $\frac{\partial h}{\partial T}$ and $\frac{\partial h}{\partial i^g}$ have the same sign.

Definition 2. T and i^g are defined as *policy complements* concerning their effect on human capital accumulation if $\frac{\partial h}{\partial T}$ and $\frac{\partial h}{\partial i^g}$ have opposite signs.

No Government Budget Balancing Using the implicit function theorem (see Appendix A for details) and given the properties of the human capital production function, the following holds:

$$\frac{\partial h}{\partial T^p} > 0, \ \frac{\partial h}{\partial T^k} < 0, \ \frac{\partial h}{\partial i^g} > 0. \tag{5}$$

We are interested in the effect of a joint marginal reform of T^p and T^k on child human capital h:

$$\frac{\partial h}{\partial T} = \frac{\partial h}{\partial T^p} + \frac{\partial h}{\partial T^k}. \tag{6}$$

First I analyze a marginal reform of T without rebalancing the government budget.

Proposition 1. *Consider a marginal reform of T. There exists a unique child ability threshold $\bar{A}$ such that*

- *for children with $A \geq \bar{A}$ public transfers T positively affect parental human capital investments and, thus, child human capital (i.e. $\frac{\partial h}{\partial T} \geq 0$). Therefore, government transfers and pubic education spending i^g are* **policy substitutes**

- *for children with $A < \bar{A}$ public transfers T negatively affect parental human capital investments and, thus, child human capital (i.e. $\frac{\partial h}{\partial T} < 0$). Therefore, public transfers and pubic education spending i^g are* **policy complements**

where

$$\bar{A} = \frac{1}{(\nu\varrho)^{\varrho}(1+\nu\varrho)^{1-\varrho}} \frac{y^{1-\varrho}}{w^k}. \tag{7}$$

The ability threshold $\bar{A}$ is

1. *Increasing in parental income y*
2. *Decreasing in the degree of parental altruism ν*
3. *Decreasing in the aggregate child wage level w^k.*

Proof 1. *See Appendix A.*

Thus, a marginal reform of T, not accompanied by the government budget rebalancing, positively affects human capital of children with a high enough ability. Whether the child ability is below or above the threshold $\bar{A}$ determines whether parents invest additional resources into the child human capital or rather increase own consumption. The probability of the ability threshold being reached is higher if the aggregate wage level for the child generation is high as well as if the parental generation has low incomes and features a high degree of altruism.

It can be seen directly from the parental maximization problem stated in eq. (3) that the returns to parental investment i are increasing in the child wage level w^k and the strength of parental altruism ν. Therefore, the higher w^k and ν are, the lower is the child ability threshold $\bar{A}$. At the same time, human capital investment decisions of low-income parents are ceteris paribus more responsive to changes in the amount of taxes that have to be paid, i.e. the strength of the *current generation* effect is decreasing in parental income.

Balanced Government Budget As a next step, assume that the government budget is balanced on a per generation basis.

For the parental generation the government budget can be written as

$$T^p + i^g = \tau^p \int (y) d\Phi_y$$

where Φ_y denotes the parental income distribution.

Therefore, under a balanced government budget, the effect of T^p on the child human capital h is given by (superscript bal refers to *bal*anced government budget)

$$\left(\frac{\partial h}{\partial T^p}\right)^{bal} = \frac{\partial h}{\partial T^p} + \frac{\partial h}{\partial \tau^p}\frac{\partial \tau^p}{\partial T^p}.$$

For the child generation the government budget is

$$T^k = \tau^k w^k \int\int A(i(y,A) + i^g)^{\varrho} d\Phi_A d\Phi_y$$

where Φ_A denotes the child ability distribution.

Under a balanced government budget the effect of a marginal reform of T^k on child human capital h is given by

$$\left(\frac{\partial h}{\partial T^k}\right)^{bal} = \frac{\partial h}{\partial T^k} + \frac{\partial h}{\partial \tau^k}\frac{\partial \tau^k}{\partial T^k}.$$

Observe that as before the following holds (see Appendix A for details):

$$\left(\frac{\partial h}{\partial T^p}\right)^{bal} > 0, \ \left(\frac{\partial h}{\partial T^k}\right)^{bal} < 0, \ \left(\frac{\partial h}{\partial i^g}\right)^{bal} > 0. \tag{8}$$

Finally, the net effect of a joint reform of T^p and T^k on the child human capital h is given by:

$$\left(\frac{\partial h}{\partial T}\right)^{bal} = \left(\frac{\partial h}{\partial T^p}\right)^{bal} + \left(\frac{\partial h}{\partial T^k}\right)^{bal}.$$

Proposition 2. *Consider a marginal reform of T under a balanced government budget. There exists a unique child ability threshold $\bar{A}$ such that*

- *for children with $A \geq \bar{A}$ public transfers T positively affect parental human capital investments and, thus, child human capital (i.e. $\left(\frac{\partial h}{\partial T}\right)^{bal} \geq 0$). Therefore, government transfers and pubic education spending i^g are* **policy substitutes**.
- *for children with $A < \bar{A}$ public transfers T negatively affect parental human capital investments and, thus, child human capital (i.e. $\left(\frac{\partial h}{\partial T}\right)^{bal} < 0$). Thus, government transfers and pubic education spending i^g are* **policy complements**.

where

$$\bar{A} = \frac{1}{(\nu\varrho)^{\varrho}(1+\nu\varrho)^{1-\varrho}} \frac{y^{1-\varrho}}{w^k} \frac{1}{\left(1 - \frac{y}{\int (y) d\Phi_y} - \frac{2y(1+\nu\varrho)^{\varrho}}{w^k (\nu\varrho)^{\varrho} \int\int A y^{\varrho} d\Phi_A d\Phi_y}\right)}. \tag{9}$$

The dependence of the ability threshold $\bar{A}$ on parental income y, parental altruism ν and aggregate child wage w^k as stated in **Proposition 1** *holds. However, the elasticity of the ability threshold $\bar{A}$ with respect to y, ν and w^k is higher than without the government budget being balanced.*

Proof 2 *See Appendix A.*

Thus, also when a marginal reform of public transfers T is financed by adjusting the linear labor income tax τ it is still the case that its effect on the child human capital is positive for high ability children. However, the restrictions on parental income and parental altruism for the ability threshold to be reached become stricter as compared to the case when τ is not adjusted. In addition, the ability threshold is now more sensitive to the aggregate wage level w^k of the child generation. The intuition for the latter result is that under a balanced government budget a higher w^k increases the return to child human capital not only directly but also indirectly via a smaller required increase in τ^k.

4 Quantitative Model

4.1 Overview

The model is a general equilibrium overlapping generations framework with intergenerational links. Parents are altruistic towards their children and can invest their time and monetary resources into the human capital of their children while the latter are in the household as well as transfer wealth to them directly when they leave the household. Innate ability (initial human capital) of children is correlated with parental education. Thus, the model captures both nature and nurture dimensions of intergenerational transmission of skills.

4.2 Individual State Variables

At the beginning of economic life young households are heterogeneous along the following two dimensions: acquired human capital and initial assets. After the education decision is taken, also education level becomes a state variable. After education is completed human capital h seizes to be a state variable and is stochastically mapped into a fixed productivity component

$\gamma(s)$. When children are born into the household their human capital is also a state variable for parents. Additionally, since labor income is subject to idiosyncratic productivity shocks the transitory and persistent shock realizations - ϵ and η, respectively - also enter the state space. Table 5 summarizes the individual state variables and defines the range of values they can take.

Table 5: State Variables

State Var.	Values	Interpretation
j	$j \in \{0, 1, \ldots, J\}$	Model Age
a	$a \geq -\underline{a}(j, s)$	Assets
h	$h > 0$	Human Capital (during education phase)
$\gamma(s, h)$	$\gamma(s, h) \in \{\gamma^l(s), \gamma^h(s)\}$	Fixed Productivity Component (after labor market entry)
s	$s \in \{hi, sco, co\}$	Education
$\hat{h}$	$\hat{h} > 0$	Child Human Capital
η	$\eta \in \{\eta_l, \eta_h\}$	Persistent Productivity Shock
ϵ	$\epsilon \in \{\epsilon_l, \epsilon_h\}$	Transitory Productivity Shock

Notes: List of state variables of the economic model.

4.3 Demographics, Timing and Economic Decisions

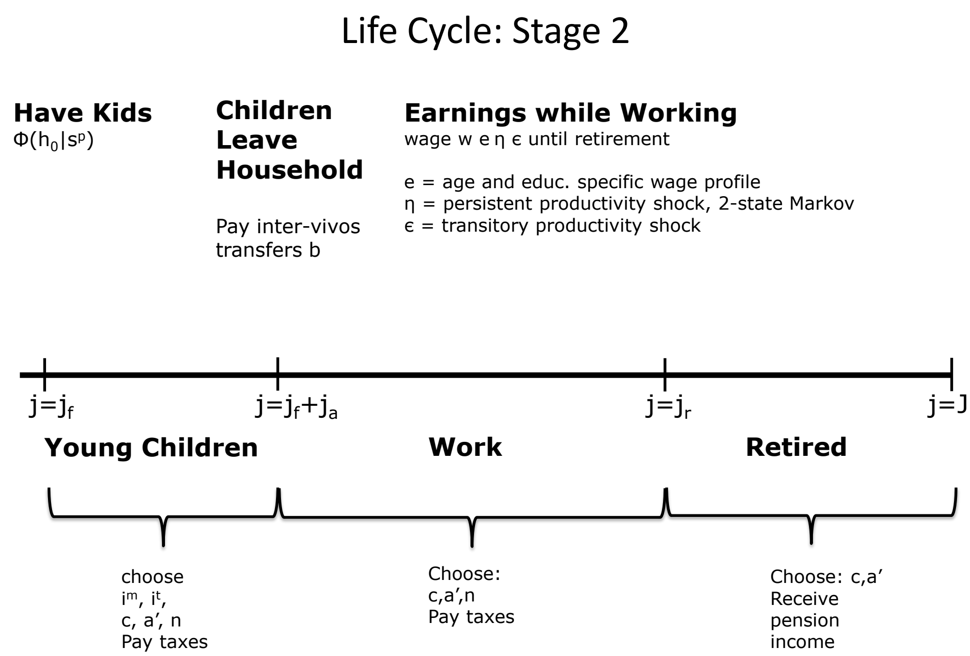
Time is discrete, indexed by t and goes forever. One model period is equal to four years. In every period t the economy is populated by J overlapping generations indexed by j. Individuals survive from age j to age $j+1$ with probability ϕ_{j+1}. Before retirement survival is certain while from the retirement age j_r onwards survival risk becomes relevant.

Children stay in the parental household until biological age 18 (model age j_a), i.e. for four model periods. The first two years of child lifecycle are ignored and thus children are "born" at biological age 2. At this age parents draw an initial child human capital level from a distribution that depends on their education level[5]. While children are in the household parents invest their time and monetary resources into the child human capital. These parental investments are referred to as private human capital investments. When children leave the parental household parents give them (non-negative) inter-vivos transfers b which can be used for consumption financing and/or for covering college expenses. The lifecycle of households starting from the point in time when children are born is summarized in the upper panel of Figure 1.

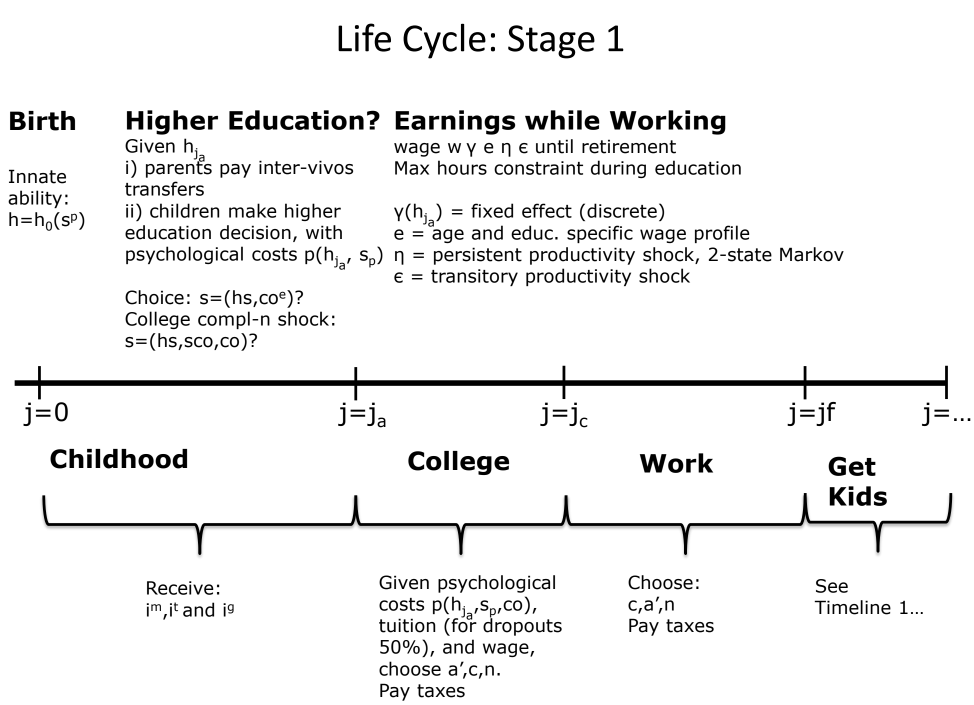
At age j_a the college education decision takes place. Those children who choose college spend one model period for education, the other group starts working directly at age j_a. Dropping out of college takes place stochastically with the dropout shock being realized directly before the

[5] Bolt et al. (2018) also assume that the initial child human capital depends only on parental education.

Figure 1: Two Stages of Household Life-Cycle: Before and After Children are Born



(a) Lifecycle Description Stage 2: After Children are Born



(b) Lifecycle Description Stage 1: Before Children are Born college education starts[6]. College dropouts are assumed to have to pay two times smaller tuition costs than college graduates.

At age j_a all education groups draw a fixed productivity component which has only two realizations - high and low. The probability of drawing a high realization of the fixed effect is an increasing function of acquired human capital. College students (both those who will graduate and those who will drop out) are assumed to work at non-college wages[7].

After education is completed all households enter the labor market. When the labor market entry happens acquired human capital seizes to be a state variable for all education groups. College graduates and college dropouts redraw their fixed productivity component based on the newly obtained higher education level. The lifecycle of households starting from the beginning of their economic life up to the point in time when they become parents is summarized in the lower panel of Figure 1.

During the working life households endogenously choose hours worked subject to a time endowment constraint. Retirement takes place exogenously at the model age j_r. The maximum possible lifespan is J.

4.4 Human Capital

Human Capital Accumulation during Childhood. In every period during childhood human capital accumulation takes places according to the following production function:

$$h' = g\left(j, h, i^m, i^t, i^g\right), \tag{10}$$

where i^t and i^m denote parental time and monetary investment while i^g denotes public investment.

4.5 Higher Education Decision

After leaving the parental household the first economic decision of children is a discrete choice whether to attend college or not.

During the college phase students can work at non-college wages. Students have to pay tuition fees, but are also allowed to borrow.

At the beginning of the college period the college completion shock is realized which determines the household wages for the rest of the lifcycle, as well as the cost of education and

[6] Given the four year frequency of the model this is the most parsimonious way of modeling college dropout risk.

[7] This means that both the aggregate wage level as well as the fixed productivity component are the same as for non-college workers.

borrowing conditions (college dropouts pay smaller tuition costs and face a tighter borrowing limit than college graduates).

4.6 Labor Productivity

The wage of a household at age j with education level s and with a fixed productivity component realization $\gamma(s)$ is given by:

$$w(s,h,j) = w_s \cdot \gamma(s) \cdot \epsilon(s,j) \cdot \eta \cdot \varepsilon \tag{11}$$

where w_s is the aggregate wage component, $\gamma(s)$ is a fixed household productivity component, $\epsilon(s,j)$ is a deterministic education-specific productivity profile, and η and ε denote persistent and transitory productivity shocks.

4.7 Decision Problems

Below household decision problems are stated using a recursive formulation.

4.7.1 The Education Choice

At age j_a, given their initial asset position a, the stock of acquired human capital h as well the education level of their parents s_p young households make a higher education choice $s \in \{hs, co^e\}$ where hs denotes high school and co^e denotes college enrollment. Children who decide not to enroll in college and choose $s = hs$, enter directly the labor market and their labor productivity is determined by the realizations of the fixed effect $\gamma(s = hs)$, the stochastic persistent income shock η and the stochastic transitory income shock ε.

Children who decide to enroll in college become college graduates or college dropouts with a probability $\pi^c(h)$ and $1 - \pi^c(h)$, respectively. The college completion probability $\pi^c(h)$ depends on the level of acquired human capital h.

During the college period all households work at high school wages and their permanent productivity level $\gamma(s = hs)$ is also determined in the same way as for high school graduates. Also, during the college period students can work only part time. Additionally, college students experience utility (or psychological) costs that depend on their acquired human capital h and on the education of their parents s_p.

The post-education decision skill state is determined as follows

$$s = \begin{cases} hs & \text{if } V(j_a, s = hs; a, h) \geq V(j_a, s = co^e; s_p, a, h) \\ co^e & \text{if } V(j_a, s = co^e; s_p, a, h) \geq V(j_a, s = hs, s_p; a, h), \end{cases} \tag{12}$$

where $V(j_a, s = co^e; s_p, a, h)$ is the pre-dropout/graduation value function given by:

$$V(j_a, s = co^e; s_p, a, h) = \pi^c(h) \cdot V(j_a, s = co; s_p, a, h) + (1 - \pi^c(h)) \cdot V(j_a, s = sco; s_p, a, h). \tag{13}$$

Therefore, the pre-education choice value function can be written as

$$V(j_a, s_p; a, h) = \max_{s \in \{hs, co^e\}} \left\{ V(j_a, s = hs; a, h), V(j_a, s = co^e, s_p; a, h) \right\}. \tag{14}$$

In the computational implementation, to achieve faster convergence of the model solution I apply Extreme Value Type I (Gumbel) i.i.d. taste shocks to smooth the decision problem stated in eq. (14).

4.7.2 Working Life

Before children are born into the household and after they leave the parental household parents solve a standard consumption-savings problem with endogenous labor supply. Thus, the decision problem can be written as

$$V(j, s, \gamma, \eta, \varepsilon, a) = \max_{c, a', \ell} \left\{ u(c) - v(\ell) + \beta \sum_{\eta'} \pi(\eta'|\eta) \sum_{\varepsilon'} \psi(\varepsilon') V(j+1, s, \gamma, \eta', \varepsilon', a') \right\}$$

subject to

$$\begin{aligned} a' + c(1 + \tau^c) &= a(1 + r(1 - \tau^k)) + y(1 - \tau^p) - T(y(1 - \tau^p)) \\ y &= w\epsilon(s, j)\eta\varepsilon n(\ell) \\ a' &\geq -\underline{\mathsf{a}}(s, j) \\ \ell &\leq \Gamma. \end{aligned}$$

where the function $n(\ell)$ defines a mapping of supplied hour worked ℓ into effective hours worked, and $\underline{\mathsf{a}}(s, j)$ is an age- and education-specific borrowing limit. Γ denotes the per period time endowoment.

4.7.3 Parenthood

Children are born into the household at model age j_f. Initial human capital of children h_0 depends on the education level of parents s^p. Since the dependence on parental education is deterministic, in the model period $j_f - 1$ no expectation over the child innate human capital has to be formed. While children are in the household parents optimally choose monetary and time investments into the child human capital as well as continue choosing hours worked and making a consumption-savings decision. Thus, the decision problem during this stage of the lifecycle can be written as

$$V(j,s,\gamma,\eta,\varepsilon;a,h) = \max_{c,i^m,i^t,a',h',\ell} \Big\{ u\left(c\right) - v(\ell) - v^t(\xi \cdot i^t) \\ + \beta \sum_{\eta'} \pi(\eta'|\eta) \sum_{\varepsilon'} \psi(\varepsilon') V(j,s,\gamma,\eta',\varepsilon';a',h') \Big\}$$

subject to

$$\begin{aligned} a' + c(1+\tau^c) + \xi \cdot i^m &= a(1+r(1-\tau^k)) + y(1-\tau^p) - T(y(1-0.5\tau^p)) \\ y &= w\epsilon(s,j)\eta\varepsilon n(\ell) \\ a' &\geq -\underline{a}(j,s) \\ \ell + \xi \cdot i^t &\leq \Gamma \\ h' &= g(j,h,i(i^m,i^t,i^g)). \end{aligned}$$

4.7.4 Children leave the Household

At parental age $j_f + j_a$ children leave the household of parents and form own adult households. In this period a one time inter-vivos transfer decision b is made. These transfers become assets of children within the same model period, and thus also generate utility for their parents. The dynamic program then reads as

$$V(j_a+j_f,s,\gamma,\eta,\epsilon;a,h) = \max_{c,b,a',\ell} \{ u\left(c\right) - v\left(\ell\right) \\ + \beta \sum_{\eta'} \pi(\eta'|\eta) \sum_{\varepsilon'} \pi(\varepsilon') V(j_a+j_f+1,s,\gamma,\eta',\varepsilon';a') + \nu V\left(j_a, s_p; \frac{b}{1+r(1-\tau^k)}, h\right) \Bigg\},$$

where $V\left(j_a, s_p; \frac{b}{1+r(1-\tau^k)}, h\right)$ denotes the pre-education decision value function of children. Maximization is subject to

$$\begin{aligned} a' + c(1+\tau^c) + \xi \cdot b &= a(1+r(1-\tau^k)) + y(1-\tau^p) - T(y(1-\tau^p)) \\ y &= w\epsilon(s,j)\eta\varepsilon n(\ell) \\ a' &\geq -\underline{\mathsf{a}}(s,j) \\ \ell &\leq \Gamma. \end{aligned}$$

After children have left the household, parental households continue solving a consumption-savings problem and choose hours worked until they reach retirement:

$$V(j,s,\gamma,\eta,\varepsilon,a) = \max_{c,a',\ell} \left\{ u(c) - v(\ell) + \beta \sum_{\eta'} \pi(\eta'|\eta) \sum_{\varepsilon'} \psi(\varepsilon') V(j+1,s,\gamma,\eta',\varepsilon',a') \right\}$$

subject to

$$\begin{aligned} a' + c(1+\tau^c) &= a(1+r(1-\tau^k)) + y(1-\tau^p) - T(y(1-\tau^p)) \\ y &= w\gamma\epsilon(s,j)\eta\varepsilon n(\ell) \\ a' &\geq -\underline{\mathsf{a}}(s,j) \\ \ell &\leq \Gamma. \end{aligned}$$

4.7.5 Retirement

During retirement, i.e. after reaching the model age j_r, households solve a standard consumption-saving problem given by:

$$V(j,s,\gamma,\eta;a) = \max_{c,a'} \{u(c) + \beta\phi(j)V(j+1,s,\gamma,\eta;a')\}$$

subject to

$$\begin{aligned} a' + c(1+\tau^c) &= a(1+r(1-\tau^k)) + y - T(y) \\ y &= pen(s,\gamma,\eta_{j_r-1}) \\ a' &\geq 0 \\ \eta &= \eta(j_r-1), \end{aligned}$$

where $pen(s,\gamma,\eta(j_r-1))$ is retirement income which depends on education-specific wages $w(s)$, persistent shock realization in the last working period before retirement $\eta(j_r-1$, skill level s and the fixed productivity component γ. This allows to capture the actual degree of progressivity embedded in the US social security system.

4.8 Production

The final output is produced according to a standard Cobb-Douglas production function:

$$Y_t = F(K_t, L_t) = AK_t^{\alpha} L_t^{1-\alpha} \tag{15}$$

where A is the total factor productivity, and α determines the elasticity of output with respect to capital.

Assume that non-college labor (i.e. high school graduates and college dropouts) and college labor (college graduates) are imperfectly substitutable in production. Within the non-college workers group labor inputs of high school graduates and college dropout workers are perfectly substitutable.

Thus, total efficiency units at time t are given by:

$$L_t = ([L_{t,hs} + L_{t,scl}]^{\rho} + L_{t,co}^{\rho})^{\frac{1}{\rho}} \tag{16}$$

where $\frac{1}{1-\rho}$ is the elasticity of substitution between college and non-college labor.

4.9 Government

The government administers a progressive labor income tax code and pays transfers to households as well as collects linear taxes on consumption and capital income. For tractability I abstract from the fact that according to legislation transfers paid in the scope of existing social assistance programs are conditioned on income, assets and family composition and instead approximate all transfer programs by a lump-sum component. This simplification is also done, for example, in Boar and Midrigan (2020) as well as Daruich and Fernández (2020)[8].

Let T^{LS} denote the aggregate lump-sum transfer payments while T refers to the aggregate income-dependent tax (and transfer) payments.

Regarding the education financing policies, the government spends $i^g \alpha_j$ per child on primary and secondary school education with the aggregate spending being denoted by E. In addition, it also subsidizes tertiary education at a subsidy rate ϱ, with the aggregate amount of subsidy

[8] While a distinction between progressivity of marginal tax rates and progressivity of average tax rates is crucial for the research question of the current paper, institutional details of public transfers design are less central.

being denoted by E^{CL}. Thus, there are two policy parameters governing the generosity of the education system, i^g and ϱ[9].

The government budget constraint is therefore given by:

$$\underbrace{T_t^{LS}}_{\text{transfer payments}} + \underbrace{E_t + E_t^{CL}}_{\text{education spending}} + G_t = T_t + \tau_{c,t} C_t + \tau_{k,t} r_t K_t \tag{17}$$

where G_t denotes government consumption (net of education spending).

Finally, the government also runs a pay-as-you-go social security system.

4.10 Social Welfare

I use a Utilitarian welfare function as a baseline welfare criterion. The social welfare function is defined as follows

$$SWF(\mathcal{T}) = \sum_j N_j \int V(j, \cdot) d\Phi_j, \tag{18}$$

where $V_1(\cdot)$ is the value function of households of age j given the tax system $(\mathcal{T})$ and Φ_j is the respective cross-sectional distribution given the policy $(\mathcal{T})$. To simplify notation I omit time subscript t which becomes relevant in the transition analysis.

Observe that the overall change in welfare is determined jointly by a change in the household value function $V(j, \cdot)$ and the change in the cross-sectional distribution Φ_j.

5 Calibration

In this section I introduce functional form specifications and explain how model parameters are calibrated. There are two subsets of parameters: those exogenously calibrated outside of the model and those endogenously calibrated within the model.

The calibration is based on an average household in the data where average is taken across all demographic characteristics including the marital status.

5.1 Age Brackets

One model period is equal to four years. The first two years of child lifecycle are discarded and thus children are "born" at biological age 2, which is model age $j = 0$. Parental age when

[9]It would also be interesting to model the degree of progressivity embedded in educational spending but at the current stage I abstract from it.

Table 6: First Stage Calibration Parameters

Parameter	Interpretation	Value	Source (data/lit)
	Population		
$j=0$	Age at economic birth (age 2)	0	
j_a	Age at beginning of econ life (age 18)	4	
j_c	Age at finishing CL (age 24)	5	
j_f	Fertility Age (age 32)	7	
j_r	Retirement Age (age 66)	16	
J	Max. Lifetime (age bin 98-101)	24	
ξ	Fertility rate	2.03	PSID 2011-2017
$\{\phi_j\}$	Survival Probabilities	see main text	Life Tables SSA
	Preferences		
θ	Relative risk aversion parameter	1	
φ	Curvature of labor disutility	0.6	
	Labor Productivity		
$\{\epsilon(j,s\}$	Age Profile	see main text	PSID 1968-2012
$[\varepsilon_l, \varepsilon_h]$	Realizations of Transitory Shock	$[0.881, 1.119]$	PSID 1968-2012
$[\eta_l, \eta_h]$	States of Markov process	$[0.8226, 1.1774]$	PSID 1968-2012
π_{hl}	Transition probability of Markov process	0.0431	PSID 1968-2012
	Ability/Human Capital and Education		
ι	College tuition costs (annual, net of grans and subsidies)	14756$	Krueger and Ludwig (2016)
$\underline{a}(j \in [j_h, j_c-1], co, ch)$	College borrowing limit	45000$	Krueger and Ludwig (2016)
σ^h	Elast of subst b/w human capital and CES inv. aggr.	1	Cunha et al. (2010)
σ^g	Elast of subst b/w public inv. and CES aggr. of private inv.	2.43	Kotera and Seshadri (2017)
σ^m	Elast of subst b/w monetary and time inv.	1	Lee and Seshadri (2019)
κ_3^m	CES share parameter of monetary and time inv. (age bin 10-14)	0.5	normalization
$\kappa_j^g = \bar{\kappa}^g, j>0$	Share of government input for ages 6 and older	0.676	Kotera and Seshadri (2017)
$\Phi(h(j=0)\|s_p)$	Innate ability dist-n of children by parental education	see main text	PSID CDS I
$\underline{h}_0$	Normalization parameter of initial dist-n of initial ability	0.1248	PSID CDS I-III
	Baseline Government policy		
ξ	Public CL education subsidy	38.8%	Krueger and Ludwig (2016)
i_j^g	Public early education spending by age	$\approx$ 5000$	UNESCO (1999-2005)
τ_c	Consumption Tax Rate	5.0%	legislation
$\tilde{\tau}_k$	Capital Income Tax Rate	20%	legislation
τ^p	Soc Sec Payroll Tax	12.4%	legislation
G/Y	Government consumption to GDP	13.8%	current value

Notes: First stage parameters calibrated exogenously by reference to other studies and data.

Table 7: Second Stage Calibration Parameters

Parameter	Interpretation	Value
	Preferences	
β	Time discount rate (target: capital output ratio)	0.9735
ν	Altruism parameter (target: average IVT transfer per child)	0.5058
	Human Capital and Education	
κ	Utility weight on time inv. (target: average time inv.)	0.3032
κ_j^h	Share of human capital (target: average monetary inv. & slope of time inv.)	cf. Figure 2
κ_j^m	Share of monetary input (target: slope of money inv.)	cf. Figure 2
κ_0^g	Share of government input for age bin 4-6 (target: average time inv. age bin 2-6)	0.4437
$\bar{A}$	Investment scale parameter (target: average HK at age j_a)	1.1989
$\tilde{\varrho}(s^p < co) = \tilde{\varrho}(s^p = hs)$	utility costs $s = co, s^p < co$ (target: fraction of group $s = co$)	-0.4301
$\tilde{\varrho}(s^p = co)$	utility costs $s = co, s^p = co$ (target: conditional fraction of group $s = co$)	-0.4929
	Government policy	
λ	Level parameter of HSV tax function (balance gvt budget)	0.9968
ρ^p	Pension replacement rate (balance socsec budget)	0.1893

Notes: Second stage parameters calibrated endogenously by targeting selected data moments.

children are "born" is denoted by j_f which is equal to 7 and corresponds to biological age 30. Children stay in the parental household for four model periods and at biological age 18 (model age $j_a = 4$) child households start their independent economic life. Young households who decide to pursue college education spend one model period for education and thereafter at model age j_c which is equal to 5 and corresponds to biological age 22 enter the labor market.

At the point in time when children leave the parental household parental age is denoted $j_t = j_a + j_f$ which is equal to 11 and corresponds to biological age 46. Retirement is exogenous and takes places at model age $j_r = 16$ (biological age 66). The maximum lifespan is denoted by $J = 24$ (biological age 99).

5.2 Demographics

The number of children is assumed to be the same for all education groups and is computed based on the four recent waves of PSID: 2011, 2013, 2015 and 2017. The average number of children in households where households heads are in the age range 25-35 is equal to 2.03. Thus, in the model I set $\xi = 2.03$.

5.3 Prices

The baseline model is cast in a general equilibrium framework and, therefore, wages and interest rate are determined endogenously such that first order conditions of the firm's problem are satisfied.

5.4 Preferences

The per period utility function takes the following functional form

$$u(c,n) = \frac{c^{1-\theta}}{1-\theta} - \phi\frac{\ell^{1+\frac{1}{\psi}}}{1+\frac{1}{\psi}} \tag{19}$$

where $\theta = 1$ (i.e. assume logarithmic utility) which makes the above utility function also balanced growth path consistent. Parameter ψ governs directly the Frisch elasticity of labor supply and is set to 0.6 following Kindermann and Krueger (2014)[10]. In turn, parameter ϕ is calibrated endogenously to match average hours worked of $1/3$ of their time endowment.

During parenthood also time spent with children affects parental utility. Particularly, I assume that the disutility from time with children enters the utility function in an additively separable manner[11]:

$$u(c,n) = \frac{c^{1-\theta}}{1-\theta} - \phi\frac{\ell^{1+\frac{1}{\psi}}}{1+\frac{1}{\psi}} - \kappa\frac{\xi \cdot i^{t^{1+\frac{1}{\psi}}}}{1+\frac{1}{\psi}} \tag{20}$$

where κ is calibrated to match average time investment into children (per week per child).

As stated in the dynamic programs description I explicitly model a time endowment constraint assuming that $\ell + i^t$ cannot exceed the maximum time endowment Γ which is w.l.o.g. normalized to one[12]. For college students the assumption is that the maximum possible hours worked equal 50% of full-time[13].

During the college stage students also experience psychological costs determined by the following cost function

$$p(s, s_p; h) = \varrho(s_p) + \frac{1}{h}$$

where $\varrho(s_p)$ is a calibration parameter which depends on parental education. Particularly, $\varrho(s_p < co)$ is calibrated to match the average college share while $\varrho(s_p = co)$ is calibrated to match the college share conditional on parents being college graduates themselves.

[10]As Kindermann and Krueger (2014) point out this value is based on average estimates for both men and women.

[11]Empirically there appears to be only weak correlation between hours worked and time with children. Also, Bastian and Lochner (2020) point out that mothers increase their time with children not at the cost of hours worked but rather via reallocating their leisure time.

[12]This is similar to e.g. Holter et al. (2019)

[13]Tbc reference that only 50% of students work and not more than 2 days a week

5.5 Human Capital Accumulation

5.5.1 Initial Child Human Capital

Innate human capital (at biological age 2) is drawn from a distribution the mean of which depends on parental education. For given parental education the initial human capital distribution is defined exogenously based on child test score data from the Child Development Supplement (CDS) to PSID. Particularly, both the mean of the initial human capital and its dependence on parental education are defined based on child test score data.

5.5.2 Human Capital Production Function

At birth at model age $j = 0$, the innate ability (initial human capital) $h = h_0$ of children is determined conditional on parental education level s_p. The dependence of initial human capital on parental education is exogenously given and disciplined by child Letter Word test score data for children of ages 3-5 in the Child Development Supplement (CDS) to PSID. Table 8 summarizes average initial child test scores by parental education - column 2 shows absolute levels and column 3 shows them expressed as a fraction of average test scores for the age group under consideration.

Table 8: Initial Ability by Parental Education

Educ of HH Head	Avg. Score	Fraction of $\bar{h}_0$
(HS- & HS)	38.14	0.9175
CL-	40.20	0.9670
(CL & CL+)	45.15	1.0861

Notes: Estimated initial ability of children as measured by the letter word test in the Child Development Supplement Surveys 1-3 (years 1997, 2002, 2007) of the PSID.

At ages $j_0, \ldots, j_a - 1$, children then receive parents' human capital investments through money and time $i^m(j), i^t(j)$ and governmental input i^g, respectively. Human capital is accumulated according to a multi-layer human capital production function with imperfectly substitutable inputs

$$h'(j) = \left(\kappa_j^h h^{1-\frac{1}{\sigma^h}} + (1-\kappa_j^h) i(j)^{1-\frac{1}{\sigma^h}}\right)^{\frac{1}{1-\frac{1}{\sigma^h}}} \tag{21a}$$

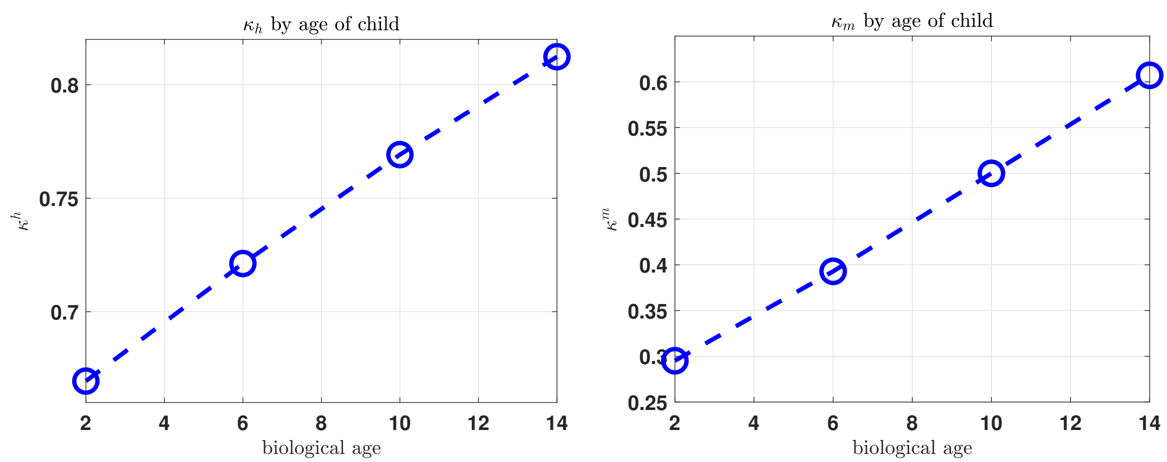
$$i(j) = \bar{A}\left(\kappa_j^g \left(\frac{i^g}{\bar{i}^g}\right)^{1-\frac{1}{\sigma^g}} + (1-\kappa_j^g)\left(\frac{i^p(j)}{\bar{i}^p}\right)^{1-\frac{1}{\sigma^g}}\right)^{\frac{1}{1-\frac{1}{\sigma^g}}} \tag{21b}$$

$$i^p(j) = \left(\kappa_j^m \left(\frac{i^m(j)}{\bar{i}^{m,d}}\right)^{1-\frac{1}{\sigma^m}} + (1-\kappa_j^m)\left(\frac{i^t(j)}{\bar{i}^{t,d}}\right)^{1-\frac{1}{\sigma^m}}\right)^{\frac{1}{1-\frac{1}{\sigma^m}}}. \tag{21c}$$

The production function features partially age dependent parameters for calibration purposes - to reflect relative differences in importance of different inputs at different stages of childhood. All inputs are divided by their respective unconditional means through which I achieve unit independence (see Cantore and Levine (2012)).

In the outermost (first) nest human capital at age j is combined with aggregate investment at age j. The substitution elasticity σ^h is fixed exogenously at 1 for all ages (implying a Cobb-Douglas specification) while the age-specific weight parameter $\kappa^j(j)$ is calibrated to match the age profile of (per child) parental time investment. Panel (a) of Figure 2 shows the resulting age profile.

Figure 2: Age Dependent Parameters κ_j^h, κ_j^m over Child Age



(a) Weight κ_j^h

(b) Weight κ_j^m

Notes: Age-specific weight parameters κ_j^h and κ_j^m calibrated endogenously to match time and money investment profiles.

In the inner (second) nest public and private inputs are combined with the substitution elasticity being denoted by σ^g and the age-specific weight parameter $\kappa^g(j)$. The substitution elasticity is set exogenously to 2.43 using the estimate provided in Kotera and Seshadri (2017). The weight parameter is also fixed exogenously for all ages apart from the kindergarten age, i.e. age bin 2-6. Thus, for school aged children the parameter κ^g is set to 0.676 while for the age bin 2-6 it is calibrated endogenously to match average parental time investment at that age. The resulting $\kappa^g(j_0)$ is equal to 0.558. $\bar{A}$ is a computational normalization parameter which is chosen such that average acquired human capital at age 18 is equal to 1 which gives $\bar{A} = 1.20$.

Finally, in the innermost (third) nest parental time and money inputs are combined with the substitution elasticity being denoted by σ^m and the age-dependent weight parameter $\kappa^m(j)$. The substitution elasticity σ^m is fixed exogenously at the value of 1 using the estimate provided in Lee and Seshadri (2019) while the weight parameter $\kappa^m(j)$ is calibrated endogenously to match the age profile of the parental monetary input. Panel (b) of Figure 2 shows the resulting age profile.

5.6 College Dropout

The probability of finishing college takes the following functional form:

$$\pi^c(h) = 1 - \exp(-\lambda^c h) \tag{22}$$

where λ^c is a parameter calibrated endogenously to match the average share of college dropouts in PSID data[14]. Thus, the probability of finishing college is increasing in acquired human capital.

5.7 Labor Productivity

5.7.1 Productivity Process

To estimate the labor productivity process I use PSID 1967-2013. Particularly, for each education level[15] I regress log household wages on a cubic in age of the household head, time dummies, family size and individual fixed effects. The age wage profile $\epsilon(s, j)$ is obtained by predicting the age polynomial.

As a second step, to obtain estimates of the stochastic productivity component I compute log wage residuals and estimate moments of the wage process by the Generalized Method of Moments (GMM) assuming a standard specification with a persistent and a transitory components:

$$\ln(\mathrm{y}_t) = \ln(\mathrm{z_t}) + \ln(\varepsilon_t)$$
$$\ln(\mathrm{z_t}) = \rho \ln(\mathrm{z_{t-1}}) + \ln(\nu_t)$$

where $\varepsilon_t \sim_{i.i.d} \mathcal{D}_\varepsilon(0, \sigma^2_\varepsilon)$, $\nu_t \sim_{i.i.d} \mathcal{D}_\nu(0, \sigma^2_\nu)$ for density functions $\mathcal{D}$.

5.7.2 Acquired Human Capital and Wages

The mapping of human capital into a fixed productivity component is probabilistic. The fixed effect $\gamma(s)$ can take two values - high and low ($\gamma^h(s)$ and $\gamma^l(s)$, respectively) - for each education group. The probability of drawing a high realization $\gamma^h(s)$ is given by

$$\pi^h(s, h) = \min\left\{1, \frac{h}{\bar{h}}\right\} \tag{23}$$

[14] Education shares are based on the four recent waves of PSID: 2011, 2013, 2015 and 2017.

[15] Education level of the household is determined by the education level of the household head.

where h is the child acquired human capital (at age 18) and $\bar{h}$ is a scaling parameter fixed exogenously for all education groups. $\gamma^h(s)$ and $\gamma^l(s)$ are calibrated endogenously to ensure that for each education group average $\gamma(s)$ is equal to one[16], i.e.

$$\int \left(\pi^h(s,h)\gamma^h(s) + \left(1 - \pi^h(s,h)\right)\gamma^l(s)\right)\Phi(dh,s) = 1.$$

.

The education-specific spreads between $\gamma^h(s)$ and $\gamma^l(s)$ are calibrated to match education-specific ability gradients of wages estimated using NLSY79 data. Particularly, estimates of ability gradients $\hat{\rho}(s)$ are obtained by running the following regressions:

$$\ln\left(\omega(s)\right) = \rho(s) \cdot \frac{e}{\bar{e}} + \upsilon(s),$$

where $\omega(s)$ denotes age-free education-specific wages and e measures test scores of the Armed Forces Qualification Test (AFQT) which are normalized by their mean $\bar{e}$. Finally, $\upsilon(s)$ is an education group specific error term.

Table 9 shows the resulting estimates $\hat{\rho}(s)$. The estimated ability (human capital) gradient is strictly increasing in education reflecting a pronounced complementarity between ability (human capital) and education.

Table 9: Ability Gradient by Education Level

Education Level	Ability Gradient
(HS- & HS)	0.4248 (0.0481)
(CL-)	0.5786 (0.0245)
(CL & CL+)	0.7298 (0.0670)

Notes: Estimated ability gradient $\hat{\rho}(s)$, using NLSY79 as provided in replication files for Abbott et al. (2019). Standard errors in parentheses.

[16] This ensures that skill premia are matched.

5.7.3 Marginal Premium and Complementarity between Human capital and Education

Using the functional form in eq. 23 observe that the average college wage premium is proportional to the following ratio:

$$\bar{wp} = \frac{\gamma^l(s=cl) + [\gamma^h(s=cl) - \gamma^l(s=cl)] \cdot \bar{h}(s=cl)}{\gamma^l(s<cl) + [\gamma_h(s<cl) - \gamma_l(s<cl)] \cdot \bar{h}(s<cl)}$$
$$\bar{wp} = \frac{\gamma^l(s=cl) + \Delta(s=cl) \cdot \bar{h}(s=cl)}{\gamma^l(s<cl) + \Delta(s<cl) \cdot \bar{h}(s<cl)}, \tag{24}$$

where $\Delta(s)$ denotes education specific spreads between low and high $\gamma(s)$ realization, and $\bar{h}(s<cl)$ and $\bar{h}(s=cl)$ denote average acquired human capital of non-college and college educated households, respectively.

Denote by h^* the average human capital level of marginal households - i.e. those households for whom the probability of choosing college is non-zero but smaller than one. For these types the college wage premium can be written as

$$\bar{wp}(h^*) = \frac{\gamma^l(s=cl) + \Delta(s=cl) \cdot h^*}{\gamma^l(s<cl) + \Delta(s<cl) \cdot h^*}. \tag{25}$$

Based on a comparison of eq. (24) and eq. (25) observe that the condition that the marginal premium is smaller than the average one, i.e. $\bar{wp}(h^*) < \bar{wp}$, always holds whenever $h(s<cl) < h^* < h(s=cl)$, i.e. as long as the threshold property of the discrete college decision is preserved (technically, due to the presence of Gumbel shocks as a smoothing device this is equivalent to saying that the college choice probability should be monotonically increasing in human capital).

The ratio between the marginal and the average premium $\frac{\bar{wp}(h^*)}{\bar{wp}}$ is increasing in the ratio of education specific spreads $\frac{\Delta(s=cl)}{\Delta(s<cl)}$. Also observe that the complementarity between human capital and education mentioned above requires that $\frac{\Delta(s=cl)}{\Delta(s<cl)} > 1$. Qualitatively the two properties - first, marginal premium is smaller than the average premium; second, complementarity between ability and education - are consistent with each other.

However, quantitatively only one of the two can be exactly matched (because both are driven by the ratio of education specific spreads). My current strategy is to calibrate explicitly the complementarity between ability and education based on NLSY79 data and leave the marginal college premium as a non-targeted moment.

5.7.4 Hours Worked and Efficiency Units

The mapping from hours worked to labor services is assumed to be non-linear, as in French (2005), Rogerson and Wallenius (2009) and Erosa et al. (2016). Particularly, n hours of work translate into n^θ efficiency units (with $\theta > 1$). Following Aaronson and French (2004) and Erosa et al. (2016) I set exogenously $\theta = 1.4$.

5.8 College Costs and Borrowing Constraints

As in Krueger and Ludwig (2016) the net tuition cost ι (tuition, fees, room and board net of grants and education subsidies) for one year of college in constant 2005 dollars is 13,213\$. In 2008 dollars, the maximum amount of publicly provided students loans per year is given by $11,250\$$, which is the borrowing limit for college students in the model. For college dropouts I assume that the borrowing limit is 50% of the borrowing limit for college graduates. For all ages after the college period (i.e. for all $j > j_a$) I let

$$\underline{\mathsf{a}}(j, s > hs) = \underline{\mathsf{a}}(j-1, s > hs)(1+r) - rp$$

and compute rp such that the terminal condition $\underline{\mathsf{a}}(j_r, s) = 0$ is met.

5.9 Government

The government has to balance the budget of the general tax and transfer system as well as the budget of the pension system. The revenue side of the general tax and transfer system consists of taxes on consumption, capital and labor income. The consumption tax rate is set to 5% (see Mendoza et al. (1994)) while the capital income tax rate is fixed at 20% as implied by the current statutory tax rates.

The labor income tax schedule is approximated using a two-parameter tax function as in Heathcote et al. (2017) which is additionally augmented with an intercept. The intercept approximates existing transfer programs and allows to better capture the actual degree of progressivity embedded into the US tax and transfer system. Thus, the resulting tax and transfer function writes as:

$$T(y) = -\omega + y - (1-\tau)y^{1-\xi} \tag{26}$$

where τ is the level parameter, ξ is the progressivity parameter[17] and ω is the additional lump-sum component. Such a specification is also used in Boar and Midrigan (2020) as well as Daruich and

[17] ξ determines the slope of marginal tax schedule, i.e. the progressivity of marginal tax rates.

Fernández (2020). To parameterize this tax function I rely on estimates provided in Boar and Midrigan (2020) and set ξ equal to 0.049 and ω to 0.167 of the mean household income.[18] Finally, the level parameter τ is calibrated endogenously to match the ratio of exogenous government spending (net of spending on education) to GDP of 13.8%.

Regarding the education financing policies, the government spends $i^g\alpha_j$ per child on primary and secondary school education where both the level parameter i^g and the age profile α_j are set exogenously based on OECD data.

Finally, as for the the pension system, the payroll tax τ^p is set to the current legislative level of 12.4% and the actual progressivity of the pension system is taken into account.

5.9.1 Progressivity of the Tax and Transfer System

According to the tax function defined in eq. 26 there are two parameters that determine overall progressivity of the tax and transfer system: ξ and ω. The former determines progressivity of marginal tax rates while the latter drives progressivity of average tax rates. In addition, also the tax level determined by the parameter τ affects overall progressivity of the tax and transfer system.

One commonly used definition of progressivity that allows use of a one-dimensional measure relies on the ratio of marginal to average tax rates being larger than one[19]. Therefore, a tax system is labelled is progressive if the ratio of marginal to average tax rates is larger than 1 for all income levels and as regressive if this ratio is smaller than 1. A proportional tax scheme implies that an average tax rate is always equal to a marginal tax rate.

Additionally, I also employ Suits index as a second measure of progressivity that has been widely used in the empirical public literature following Suits (1977) [20]. Technically, the Suits index is a Gini coefficient of tax contributions by income level and can vary from -1 (fully regressive system) to $+1$ (fully progressive system).

5.10 Model Validation

Before proceeding to policy experiments I discuss several non-targeted moments as well as selected model implied elasticities.

While age profiles of parental human capital investments are largely explicitly targeted in the calibration the gradients of parental investments by parental education are not calibrated and are an endogenous outcome of the model. Figure 3 shows time and money investments by parental

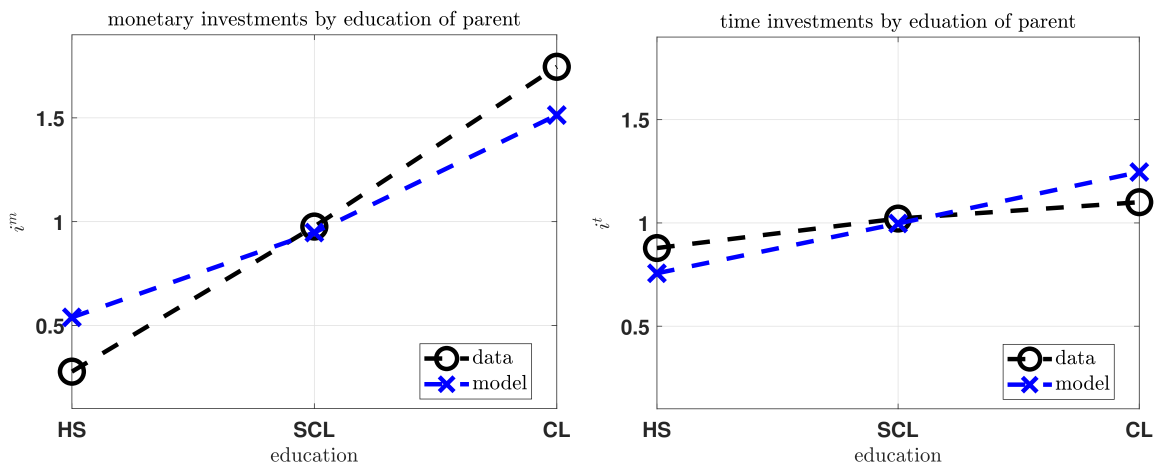
[18] This is approximately \$14,000.

[19] Heathcote et al. (2017) also use this definition of tax progressivity.

[20] It has also recently been used in the quantitative macroeconomic literature, see e.g. Jung and Tran (2017).

education level. The model matches well the positive slope of both types of investment in parental education. More educated parents invest more both in terms of time and money into the human capital of their children because income and accumulated wealth of the household are increasing in the household education.

Figure 3: Money and Time Investments by Education of Parents



(a) Money Investments

(b) Time Investments

Notes: Average money and time investments by parents' education in the data (black circles) and model (blue crosses).

Next, given the special focus of the paper on the effects of public policies on educational attainment I compute a model implied elasticity of college enrollment decision with respect to an increase in tertiary education subsidies. Deming and Dynarski (2009) summarize existing empirical evidence on the responsiveness of the college enrollment margin to increases in the generosity of college subsidies. According to their estimates, a $\$1,000$ increase in college subsidies results into an increase in college enrollment in the range of 3-6 pp. To obtain a model equivalent of this number I consider an increase in tertiary education subsidies in the model also by $\$1,000$ in a parital equilibrium setting, i.e. holding the interest rate and wages at the initial steady state level. The model implied increase in college enrollment is 3.5% which is within the range implied by the empirical estimates.

6 Simple Reforms

The analysis in this section is restricted to a steady state comparison and focuses on several stylized policy reforms that change the progressivity of the tax and transfer system. The purpose of this section is threefold. First, I want to determine the sign of the aggregate effect of higher progressivity (achieved either via public transfer expansions or via changing the marginal tax rates schedule) on child human capital accumulation and educational attainment and how this effect is relevant for the welfare implications of such a reform. Second, I want to understand whether it matters if progressivity is increased via adjusting average or marginal tax rates. Third, I discuss whether it plays a role for the aggregate effect and the welfare implications if public transfer expansions are financed with labor income taxes or with consumption taxes.

I consider the following three stylized reforms. The first reform is defined as a lump-sum transfer expansion of ca. $1,000 per household annually financed with a labor income tax increase. The second reform implies that the same transfer expansion as in the first reform is financed with consumption taxes instead. Finally, I also consider an alternative way of increasing the overall progressivity of the tax and transfer system which is via increasing the progressivity of marginal tax rates. Technically, this reform is implemented by picking a larger value of the progressivity parameter ξ. The government budget is rebalanced via adjusting the average labor income tax rate and the value of ξ is chosen such that the overall progressivity of the tax and transfer system is the same as implied by the first reform[21].

The first two reforms can be seen as a stylized anti-poverty policy that has the goal to reduce inequality and the share of households with the after-tax income below the poverty line. Poverty line is defined as half of the medium household income, based on the OECD definition. Additionally, the lump-sum transfer expansion financed with labor income taxes is most closely comparable to the discussion of marginal reforms in Section 3.

6.1 "Small" Public Transfer Expansion

6.1.1 Transfer Expansion financed with Labor Income Taxes

The first three columns of Table 10 show macroeconomic aggregates, parental human capital investments as well as fiscal variables in the baseline and the reform scenario - with and without rebalancing the government budget, respectively.

Holding other policy instruments fixed and introducing a lump-sum transfer T of $1,000 annually to all adult households - including students - results in a welfare gain of 4.01% of permanent consumption if the government budget is not rebalanced. However, the reform leads to a small fiscal deficit and as a consequence the average labor income tax has to be increased. Therefore, to achieve the same level of government spending as in the baseline the level parameter of the tax function has to be increased from 0.274 to 0.301. As a result, the welfare gain turns into a welfare loss once the required labor income tax adjustment is taken into account. Thus, under a balanced government budget consumption equivalent variation equals -2.26%.

[21] The overall change in progressivity is measured by the Suits index.

Table 10: Aggregate Outcomes: "Small" Transfer Reform

	baseline level	no bal budget (% change)	τ (% change)	τ^c (% change)
share $s = hs$	45.12%	1.59%	13.00%	3.07%
share $s = sco$	15.10%	-1.92%	-10.75%	-3.27%
share $s = co$	39.78%	-1.01%	-10.67%	-2.26%
av HK	1.00	0.77%	-2.24%	0.56%
av money inv	$1,320	0.53%	-13.28%	0.02%
av time inv	27.66	1.05%	-3.77%	0.53%
av ivt	$34,511	-0.65%	-14.49%	-0.88%
av hours	0.300	-1.13%	-2.27%	-0.20%
tax fun. param. τ	0.274	0.00%	10.47%	0.00%
Suits index	0.351	11.34%	4.98%	2.25%
CEV	0.00%	4.01%	-2.26%	2.20%

Notes: Columns two, three and four show percent change of aggregate outcomes following a "small" transfer T expansion relative to the baseline - without and with rebalancing the government budget, respectively. The government budget is rebalanced either via adjusting the average labor income tax (column 3) or the consumption tax rate (column 4). Parental human capital investments in terms of money are reported on a per child and per year basis while time investments are reported on a per child and per week basis.

Table 11: Inequality Statistics and Heterogeneity: "Small" Transfer Reform

	baseline	no bal budget (% change)	τ adj (% change)	τ^c adj (% change)
Var(log earn), age bin 38-42	0.363	0.42%	-0.16%	0.03%
Frac poor, age bin 38-42	6.75%	-4.01%	4.00%	-3.87%
$\Phi(s = co, j = j_a \mid s^p = hs)$	29.71%	0.61%	-11.86%	-2.10%
$\Phi(s = co, j = j_a \mid s^p = co)$	51.42%	-1.32%	-4.64%	-1.02%
$i^m(s = hs)$	$750	4.46%	-12.12%	2.46%
$i^m(s = co)$	$1,822	-0.10%	-7.35%	0.96%

Notes: Columns two, three and four show percent change of several inequality related statistics following a "small" transfer T expansion relative to the baseline - without and with rebalancing the government budget, respectively. The government budget is rebalanced either via adjusting the average labor income tax (column 3) or the consumption tax rate (column 4).

As can be seen from the table the average human capital stock increases if the government budget is not rebalanced but it slightly falls once the required labor income tax increase is implemented. This means that in the former case the positive income effect on recipient parental households (*current generation* effect) outweighs the distortive *future generation* effect. However, the average educational attainment deteriorates in both cases - the college share falls by ca. 1% without government budget rebalancing and by almost 11% once the government budget rebalancing is achieved. The change in education shares is primarily explained by the inter-vivos transfers responses which are negative both with and without government budget rebalancing.

In the former case the average inter-vivos transfers fall by less than 1% (column 2) while in the latter case the drop of parental transfers amounts to more than 14% (column 3).

Table 11 reports several inequality related statistics - the variance of log earnings for the age bin 38-42, the fraction of households below the poverty line for the age bin 38-42 as well as shares of children finishing college conditional on parents being high school graduates or college graduates, respectively. Additionally, the table also reports parental monetary investment responses by the education level of parents. Based on responses of the conditional college shares I draw conclusions on the implied change of the intergenerational persistence in education. Particularly, if the share of college graduates with $s^p = hs$ drops by more than the share of college graduates with $s^p = co$, this implies that the intergenerational persistence in education becomes higher and vice versa.

First observation is that the cross-sectional earnings inequality changes only slightly in both scenarios - with and without the government budget rebalancing, respectively. Second, intergenerational persistence in education is reduced in the scenario without government budget rebalancing - $\Phi(s = co, j = j_a|s^p = hs)$ increases by almost 1% while $\Phi(s = co, j = j_a|s^p = co)$ falls by more than 1%. However, intergenerational educational persistence goes up once the labor income tax increase is taken into account - $\Phi(s = co, j = j_a|s^p = hs)$ falls by almost 12% while $\Phi(s = co, j = j_a|s^p = co)$ is reduced by only ca. 5%. Similar patterns are observed for the parental human capital investment decisions[22].

The intuition for the intergenerational persistence responses is as follows. Without the government budget rebalancing the *current generation* effect dominates for households whose parents have the lowest education degree while for households whose parents have a college degree the *future generation* effect is decisive. In other words, educational attainment of children from most disadvantaged backgrounds is improved while it deteriorates for children from most privileged backgrounds. However, once the labor income tax is increased all parents reduce their investments into child human capital with low-education parents reacting stronger. Therefore, while it is true that on average the relative weight of private human capital inputs is reduced this response is strongest for parents with lower education levels. This explains the larger drop in the conditional college share for this population group.

Finally, regarding the fraction of households below the poverty line the following has to be noted - without the government budget rebalancing the fraction of "poor" falls by ca. 4% while with the government budget being rebalanced it increases by almost 4%. Given that the poverty line is defined based on the baseline medium income and given that the average educational attainment deteriorates once labor income tax is adjusted, the fraction of households with the

[22] For brevity the table reports only the monetary investment responses by parental background. The same patterns hold also for the time investment responses.

after-tax income below the poverty line goes up[23]. This is in contrast to the scenario with the labor income tax being held constant when the educational attainment deterioration is much less pronounced.

6.1.2 Transfer Expansion financed with Consumption Taxes

The last columns of Table 10 and Table 11, respectively, report model outcomes discussed above for the scenario when the $\$1,000$ transfer expansion is financed via increasing the consumption tax rate. In this scenario the average effect of a more generous transfer on the human capital stock is slightly positive due to the fact that a higher τ^c distorts parental human capital investments as well as hours worked substantially less than a higher labor income tax τ. However, the share of college graduates still falls, but significantly less so than in the case of labor income tax financing (-2.26% versus -10.67%).

Importantly, the fraction of households below the poverty line is reduced by almost 4%, and the reform results in a welfare gain with the consumption equivalent variation being equal to 2.20%.

6.2 "Higher Marginal Tax Rates Progressivity" Reform

From the transfer expansion reform considered above it follows that more generous transfer payments are a costly policy and require non-negligible labor income tax adjustments which induce an average welfare loss. However, if the reform is financed via increasing the consumption tax rate the distortive effect on parental human capital investment decisions becomes much weaker which is crucial for the sign of the welfare effect.

As a next step I explore the implications of increasing progressivity of the tax and transfer system by increasing the steepness of the marginal tax rates schedule. To make this reform comparable to the "small" transfer expansion discussed above I consider an increase in the tax function progressivity parameter ξ such that the overall change in the progressivity of the system as measured by the Suits index is approximately the same across the two reforms.

As Table 12 shows, holding other policy instruments fixed and increasing the progressivity parameter ξ from 0.049 in the baseline to 0.068 results in a welfare loss of -0.83% of permanent consumption if the government budget is not rebalanced (column 2). Furthermore, once the required labor income tax increase is taken into account the implied welfare loss increases to -6.01% of permanent consumption. The result that increasing progressivity of marginal tax

[23] In other words, the positive response of the fraction of "poor" in column 3 is explained by a reduction of pre-tax income.

rates relative to the status quo leads to welfare losses is consistent with the finding in Heathcote et al. (2017).

Based on a comparison of the responses of education shares, average human capital stock and parental human capital investments shown in Table 12 to those shown in Table 10 it follows that a higher progressivity of marginal tax rates distorts average human capital accumulation and educational attainment stronger than a higher progressivity of average tax rates (achieved via more generous transfers).

Table 12: Aggregate Outcomes: Marginal Progressivity Reform

	baseline level	no bal budget (% change)	τ adj (% change)	τ^c adj (% change)
share $s = hs$	45.12%	16.71%	28.05%	16.54%
share $s = sco$	15.10%	-14.54%	-23.21%	-14.23%
share $s = co$	39.78%	-13.73%	-23.01%	-13.35%
av hk	1.00	-2.35%	-5.24%	-2.28%
av money inv	$1,320	-13.42%	-43.86%	-12.53%
av time inv	27.66	-4.20%	-8.96%	-4.11%
av ivt	$34,511	-15.23%	-25.43%	-17.40%
av hours	0.300	-2.05%	-3.06%	-1.38%
tax fun. param. τ	0.274	0.00%	8.94%	0.00%
Suits index	0.351	9.58%	5.05%	8.88%
cev	0.00%	-0.83%	-6.01%	-1.95%

Notes: Columns two and three show percent change of aggregate outcomes following an increase in the progressivity parameter ξ relative to the baseline - without and with rebalancing the government budget, respectively. The government budget is rebalanced either via adjusting the average labor income tax (column 3) or the consumption tax rate (column 4). Parental human capital investments in terms of money are reported on a per child and per year basis while time investments are reported on a per child and per week basis.

Table 13: Inequality Statistics and Heterogeneity: Marginal Progressivity Reform

	baseline	no bal budget (% change)	τ (% change)	τ^c (% change)
Var(log earn), age bin 38-42	0.363	-3.63%	-5.37%	-4.15%
Frac poor, age bin 38-42	6.75%	3.58%	11.84%	3.26%
$\Phi(s = co, j = j_a \| s^p = hs)$	29.71%	-19.20%	-30.70%	-18.49%
$\Phi(s = co, j = j_a \| s^p = co)$	51.42%	-3.39%	-5.30%	-3.35%
$i^m(s = hs)$	$750	-13.77%	-27.80%	-12.96%
$i^m(s = co)$	$1,822	-4.72%	-10.37%	-3.71%

Notes: Columns two and three show percent change of several inequality related statistics following an increase in the progressivity parameter ξ relative to the baseline - without and with rebalancing the government budget, respectively. The government budget is rebalanced either via adjusting the average labor income tax (column 3) or the consumption tax rate (column 4).

Analogous to Table 11, now Table 13 shows the variance of log earnings, fraction of households below the poverty line, conditional college shares as well as parental human capital investments by the education level of parents for the reform of marginal progressivity. First, cross-sectional inequality is now reduced more substantially than in the case of a lump-sum transfer expansion. Second, given the stronger deterioration of average human capital stock and educational attainment the share of households below the poverty line also becomes substantially larger.

Next, regarding the response of intergenerational persistence in education the main takeaway is that in both cases (with and without the labor income tax adjustment) intergenerational persistence goes up. This happens largely due to a strong endogenous drop in human capital investments of low educated parents but also due to the fact that the average college wage premium for children of low income parents is smaller than for their counterparts from more affluent family backgrounds[24].

6.2.1 Marginal Progressivity Reform financed with Consumption Taxes

The last columns of Table 12 and Table 13, respectively, report model outcomes discussed above for the scenario when the increase of the progressivity of the marginal tax rates schedule is financed with consumption taxes. Similarly to the public transfer expansion reforms discussed above, in this scenario the negative effect of higher progressivity on the average human capital accumulation and educational attainment as well as hours worked is weaker than in the scenario when labor income taxes are used to balance the government budget (column 3). Particularly, the average human capital stock falls now by ca. 2% versus ca. 5% in the case of labor income tax financing. Similarly, the share of college graduates is reduced now by only ca. 13% while it drops by ca. 23% when the governmemnt relies on labor income taxes to raise additional revenues.

Regarding the inequality related statistics, cross-sectional earnings inequality is reduced now by less than in the scenario with labor income tax financing. Also, the fraction of households below the poverty line increases by substantially less (ca. 3%) than it is the case when labor income taxes are used to balance the government budget (ca. 12%).

Despite of the smaller negative effect on average human capital accumulation, educational attainment and hours worked, an increase of the progressivity of marginal tax rates when financed with consumption taxes still results in an average welfare loss of almost 2% of permanent consumption. Therefore, also under the consumption tax financing a higher marginal tax progressivity reform unambigiously results in welfare losses.

[24]This is the case due to the explicitly modelled complementarity between human capital and education.

7 Conclusion

In this paper I analyze the role of human capital accumulation during childhood and endogenous parental human capital investment decisions for aggregate, distributional and welfare implications of a set of stylized tax and transfer reforms. I focus on the reforms that increase the degree of progressivity of the overall tax and transfer system either via public transfer expansions or via increasing the progressivity of the marginal tax rates schedule.

For this purpose I first investigate marginal transfer expansions in a simple static model and analyze the major trade-off that is central for the sign of the aggregate effect of tax progressivity on human capital accumulation during childhood. Particularly, I show that, on the one hand, higher progressivity has a positive budgetary effect on parental households who are net transfer recipients but, on the other hand, it negatively distorts the incentives of parents to invest into child human capital since the returns to those investments become lower.

As a second step, I develop an overlapping generation with intergenerational links that includes endogenous human capital investment decisions of parents into their children both in terms of time and money as well as a discrete higher education choice of children when they turn adults. The model is calibrated to capture the degree of tax and transfer progressivity embedded into the current US system. Using the model as a quantitative laboratory I first introduce an annual $\$1,000$ lump-sum transfer expansion and show that it negatively affects the aggregate human capital stock as well as educational attainment if financed with higher labor income taxes. However, if the consumption tax is used to balance the government budget the negative effect on educational attainment becomes much smaller with the average human capital stock even increasing slightly. As a result, such a reform induces an average welfare gain.

Finally, I consider an alternative way of increasing the overall progressivity of the tax and transfer system. Particularly, I implement it via increasing the progressivity of the marginal tax rates schedule such that the implied increase in the overall tax and transfer progressivity is the same as it is in the case of a $\$1,000$ lump-sum transfer expansion financed with a labor income tax increase. This experiment shows that higher progressivity of marginal tax rates leads to a stronger deterioration of the human capital stock and educational attainment than a lump-sum transfer expansion and results in average welfare losses. Furthermore, also when consumption taxes are used to achieve budget neutrality of such a reform, the sign of the average welfare effect is still negative.

Summing up, I show that in a model with endogenous parental human capital investment decisions into their children and an endogenous higher education decision of young households increasing the progressivity of average tax rates (via public transfer expansions) results in welfare losses when labor income taxes are used to rebalance the government budget while it leads to welfare gains under the consumption tax financing. In contrast, increasing the progressivity of marginal tax rates always results in welfare losses, independent of the fiscal instrument the government uses to raise additional revenues.

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A Simple Model

Using implicit function theorem obtain:

$$\frac{\partial i}{\partial Tr^p} = \frac{\nu\varrho}{i^{\varrho-1}\Big[i\varrho(1+\nu)+(1-\varrho)\big(\nu\varrho(y-i)\big)\Big]} > 0 \tag{27}$$

$$\frac{\partial i}{\partial Tr^k} = \frac{-1}{w^k A(i)^{\varrho-2}\Big[i\varrho(1+\nu)+(1-\varrho)\big(\nu\varrho(y-i)\big)\Big]} < 0 \tag{28}$$

$$\frac{\partial i}{\partial \tau^p} = -\frac{\partial i}{\partial Tr^p} y < 0 \tag{29}$$

$$\frac{\partial i}{\partial \tau^k} = -\frac{w^k A i^{\varrho-1}\Big[i+\nu\varrho(y-i)\Big]}{w^k A i^{\varrho-2}\Big[i\varrho(1+\nu)+(1-\varrho)\big(\nu\varrho(y-i)\big)\Big]} < 0 \tag{30}$$

$$\frac{\partial i}{\partial i^g} = -\frac{i+(\varrho-1)\Big[i-\nu\varrho(y-i)\Big]}{i\varrho(1+\nu)+(1-\varrho)\big(\nu\varrho(y-i)\big)} < 0 \text{ (and also, observe that } \frac{\partial i}{\partial i^g} > -1\text{).} \tag{31}$$