Public and Private Expenditures on Human Capital Accumulation in India

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Introduction

- How does public education spending influence economic growth?
  - Human capital is often referred to as the "engine of growth" (Lucas, 1988)
  - Public education funding determines human capital accumulation, therefore exploring this nexus is crucial (see Glomm and Ravikumar (1998), Kaganovich and Zilcha (1999), and Blankenau and Simpson (2004)).
- How does public education spending influence income distribution?
  - Public education is one of the "greatest equalizers of the condition of men" (Horace Mann)
  - See Loury (1981), Durlauf (1996), Fernandes and Rogerson (1998), and Glomm and Kaganovich (2003))

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  - Bénabou (1996), in addition to parental human capital and time, considers public education in the production of future human capital
  - Lucas (1988) considers only a private input in human capital accumulation
  - All inputs in Glomm and Ravikumar (1998), Kaganovich and Zilcha (1999), and Blankenau and Simpson (2004) have unitary elasticity
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Our paper

- Our paper builds on the above literature in three main respects.
  1. We allow for imperfect substitutability of public and private education in a child's human capital accumulation (see Tooley and Dixon (2007) and Glomm and Kaganovich (2003, 2008))
  2. We allow for complementarity between child's ability and parental human capital in human capital accumulation (this is operative only if parental human capital exceeds a minimum exogenous threshold to intellectually contribute to the child's learning (see Cunha et al. (2010)))
  3. We also allow for non-homothetic preferences
- We also assume that public education spending by the state is financed by a variety of taxes (income tax, a tax on consumption, and a centre-state transfer)
- We then calibrate the model to a representative state (the state with the median level of public education expenditures/NSDP in 1985) in India

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Main Results

- Economic growth is higher due to higher public education spending.
- However, how higher public education is financed has a bearing on the growth-inequality trade-off
  - If higher public education is financed by a higher consumption tax or a centre-state federal transfer instead of a higher labor income tax, this causes growth to go up by more but inequality to go down by less
  - If higher public education is financed by a higher labor income tax – keeping consumption tax and centre-state federal transfer fixed – this causes growth to go up by less and inequality to go down by more
- Therefore, there is a growth-inequality trade-off
- Computationally, we show that relatively large changes in funding levels in education have relatively minor impacts on growth of aggregate human capital, and the evolution of income inequality.

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Description of the Model

- The economy consists of n OLG families who live for two periods
- Effectively, parents have one decision – to derive utility out of out of consumption $(c_t > \underline{c})$ and out of child's human capital accumulation (h_{t+1}) such that

$$u\left(c_t, h_{t+1}\right) = \phi \ln\left(c_t - \underline{c}\right) + \ln\left(h_{t+1}\right)$$

where,

$$h_{t+1} = \begin{cases} B\left(E_t^{\rho} + \theta e_t^{\rho}\right)^{\frac{\alpha}{\rho}} \left(a_t h_t\right)^{\delta}, & h_t \geqslant \overline{h}_t \\ B\left(E_t^{\rho} + \theta e_t^{\rho}\right)^{\frac{\alpha}{\rho}} \left(a_t\right)^{\delta}, & h_t < \overline{h}_t \end{cases} \tag{1}$$

and,

$$\left(1 + \tau_c\right) c_t + e_t = \left(1 - \tau_L\right) w_t h_t. \tag{2}$$

- E_t is (per-capita) public spending on education, e_t is private spending on education, a_t is the child's ability, h_t is the parent's stock of human capital.
- Note $\rho \in (0, 1)$: If $0 < \rho < 1$, these two inputs are substitutes.
- In the calibration, we will let $\overline{h}_t = F_{ht}^{-1}(\psi)$.

GBC: State and the Federal Government

- The state government faces the following GBC

$$\begin{aligned} n_t E_t &= \tau_c C_t + T_t. \\ E_t &= \frac{\tau_c C_t + T_t}{n_t}. \end{aligned}$$

  where C_t is the state's aggregate consumption, and T_t is the centre-state transfer.
- The following is the federal government's budget constraint

$$T_t = \Delta \tau_L w_t H_t.$$

  where Δ, τ_L, and τ_c are exogenous.
- Note that the state is a net receiver of federal funds if

$$\Delta > 1$$

  and a net contributor if

$$\Delta < 1$$

Solving the model

- The household solves the following

$$\max_{c_t, e_t} u\left(c_t, h_{t+1}\right) = \phi \ln\left(c_t - \underline{c}\right) + \ln\left(h_{t+1}\right)$$

  subject to (1) and (2)

- From (2)

$$c_t - \underline{c} = \frac{\overline{e}_t - e_t}{1 + \tau_c}$$

where $\overline{e}_t$ is the maximum private expenditure possible for the household on e_t such that

$$\overline{e}_t = (1 - \tau_L) w_t h_t - (1 + \tau_c)\, \underline{c}. \tag{3}$$

- The FOC $\{e_t\}$ yields an interior solution e_t^* such that,

$$(\phi + \alpha)\, \theta \left(e_t^*\right)^{\rho} = \alpha \theta \overline{e}_t \left(e_t^*\right)^{\rho - 1} - \phi E_t^{\rho}, \tag{4}$$

Solving the model

- From (4) and (3), two conditions emerge for $e_t^* > 0$.
  - First, from $\overline{e}_t \geqslant 0$, there exists a cutoff level of h_t below which $e_t = 0$

$$h_t \geqslant \underbrace{\frac{(1+\tau_c)\,\underline{c}}{(1-\tau_L)w_t}}_{\text{Subsistence Threshold}} = \widehat{h}_t \tag{5}$$

  - Second since E_t and e_t are imperfect substitutes, E_t and therefore the tax instruments $\{\tau_c, \tau_L\}$ cannot be too high.
- Comparative statics: From (4) $\frac{\partial e_t^*}{\partial E_t} < 0$, $\frac{\partial e_t^*}{\partial h_t} > 0$, $\frac{\partial e_t^*}{\partial \tau_L} < 0$, and $\frac{\partial e_t^*}{\partial \tau_c} < 0$

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Equilibrium Dynamics

- Dynamics of the model pinned down by:

$$\begin{aligned} \widehat{h}_t &> \overline{h}_t \\ \overline{h}_t &< \widehat{h}_t \\ \widehat{h}_t &= \overline{h}_t \end{aligned}$$

- We therefore get

$$h_{t+1} = \begin{cases} B\left(E_t^{\rho} + \theta\left(e_t^*\right)^{\rho}\right)^{\frac{\alpha}{\rho}}\left(a_t h_t\right)^{\delta}, & h_t > \overline{h}_t \text{ and } h_t > \widehat{h}_t \\ B\left(E_t\right)^{\alpha}\left(a_t h_t\right)^{\delta}, & h_t > \overline{h}_t \text{ and } h_t < \widehat{h}_t \\ B\left(E_t\right)^{\alpha}\left(a_t\right)^{\delta} & \text{otherwise} \end{cases} \tag{6}$$

Special case

- When $\rho = 1$, we get

$$e_t^* = \begin{cases} \frac{\alpha\theta\overline{e}_t - \phi E_t}{(\phi+\alpha)\theta}, & \overline{e}_t > \frac{\phi E_t}{\alpha\theta} \\ 0, & \text{otherwise} \end{cases} \tag{7}$$

and

$$h_{t+1} = \begin{cases} B\left[\left(\frac{\alpha}{\phi+\alpha}\right)\left(E_t + \theta\overline{e}_t\right)\right]^{\alpha}\left(a_t h_t\right)^{\delta}, & h_t > \overline{h}_t \text{ and } h_t > \widehat{h}_t \\ B\left(E_t\right)^{\alpha}\left(a_t h_t\right)^{\delta}, & h_t > \overline{h}_t \text{ and } h_t < \widehat{h}_t \\ B\left(E_t\right)^{\alpha}\left(a_t\right)^{\delta}, & \text{otherwise} \end{cases} \tag{8}$$

Calibration Strategy

- Data period - 1985 to 2005.
- Pick the state with the median public education spending share as a fraction of NSDP for 15 Indian states (Tamil Nadu)
- Choose parameters such that the simulated model's moments match observed moments in the data for this state..
- There are seven moments that need to be matched.
  - Growth rate from 1985-2005
  - Public Edu. Expenditure / NSDP in 1985 and 2005
  - Private Edu. Expenditure /NSDP in 1985 and 2005
  - Gini Coefficient in 1985 and 2005
- Run counter-factual experiments

Calibration - Tax Experiments

- For the tax experiments, we calibrate the model to match the median public education spending share as a fraction of GDP for 15 Indian states (3.2%)
- We then range the education spending fraction in our experiments from 2.57% (second lowest) to 4.24% (second highest)
- No clear data on private expenditure on education

$$\text{private expenditure share} = \left(\frac{r}{1-r}\right) \times \text{ public expenditure share}$$

where r = share of enrollment of students in private school.

Calibration

- Gini coefficients used to pin down the variance of the distribution of h such that $h \geqslant 1$ and has a mean normalized to 10
- Given that all the tax collected goes towards public education spending, we assume $\tau_c = 0.02$
- $\Delta = 1$ and $\tau_L = 0.015$ so as to match the public expenditure ratio of 0.0342 which is true during the concerned period
- $\delta = 0.8$ and $\alpha = 0.2$ to match the Gini coefficient of our data sample and to maintain CRS
- $\phi = 8$ and $\theta = 1.5$ to match the private expenditure shares in data
- Consumption Gini coefficient fixed at $\frac{1}{3}$
- We simulate the model for 500 families

Parameters - Summary Table

Parameter	Value	Parameter	Value	Parameter	Value
$\text{mean}(h_0)$	10	α	0.20	ϕ	8
$\text{var}(h_0)$	36.70	δ	0.80	θ	1.5
$\underline{c}$	4	$\text{mean}(a)$	1	ψ	0.05
τ_c	0.02	$\text{var}(a)$	0.05	w	1
Δ	1	B	5.5	ρ	0.50
τ_l	0.015				

Calibration Results

	Data	Model
Annualized Growth Rate	0.0646	0.0570
Gini Coefficient, 1985	0.3200	0.3200
Gini Coefficient, 2005	0.3200	0.3416
Public Expenditure Share (nE/Y), 1985	0.0330	0.0342
Public Expenditure Share (nE/Y), 2005	0.0350	0.0341
Private Expenditure Share $(1/Y\sum e)$, 1985	0.0037	0.0049
Private Expenditure Share $(1/Y\sum e)$, 2005	0.0085	0.0096

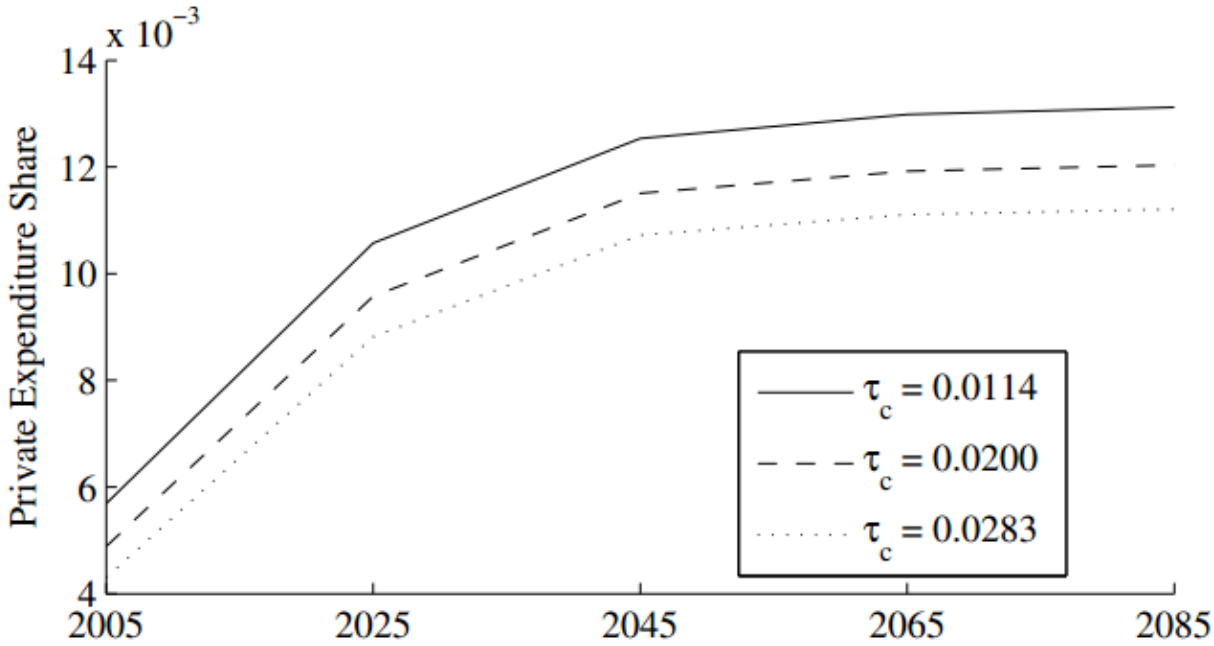
- Above table shows the observed and simulated moments.
- The cutoff human capital level, $\overline{h} = F_{h_t}^{-1}(\psi)$, where F_{H_t} is the human capital cumulative distribution at t. For example, when $\psi = x$, $x\%$ of parent's *do not* augment their child's ability.
- Assume $\psi = 0.05$ and the efficiency wage w is normalized to unity

Experiment 1: Changing the consumption tax to finance higher E

- We change τ_c so as to change public expenditure spending from 3.42% to 2.57% and 4.24%
- Increasing E_t by increasing τ_c causes contrasting income and substitution effects which work in opposite directions. A higher E_t also crowds out e_t^* which is higher for higher ρ.
  - $\tau_c \uparrow \Longrightarrow e_t \downarrow$ (income effect)
  - $\tau_c \uparrow \Longrightarrow c_t \downarrow \Longrightarrow e_t \uparrow$ (substitution effect)
  - $\tau_c \uparrow \Longrightarrow E_t \uparrow \Longrightarrow e_t \downarrow$ (direct effect)
  - Net effect $\Longrightarrow e_t \downarrow$
- As $\rho \downarrow$, may even get crowding in (because E and e are more (less) complimentary (substitutable))

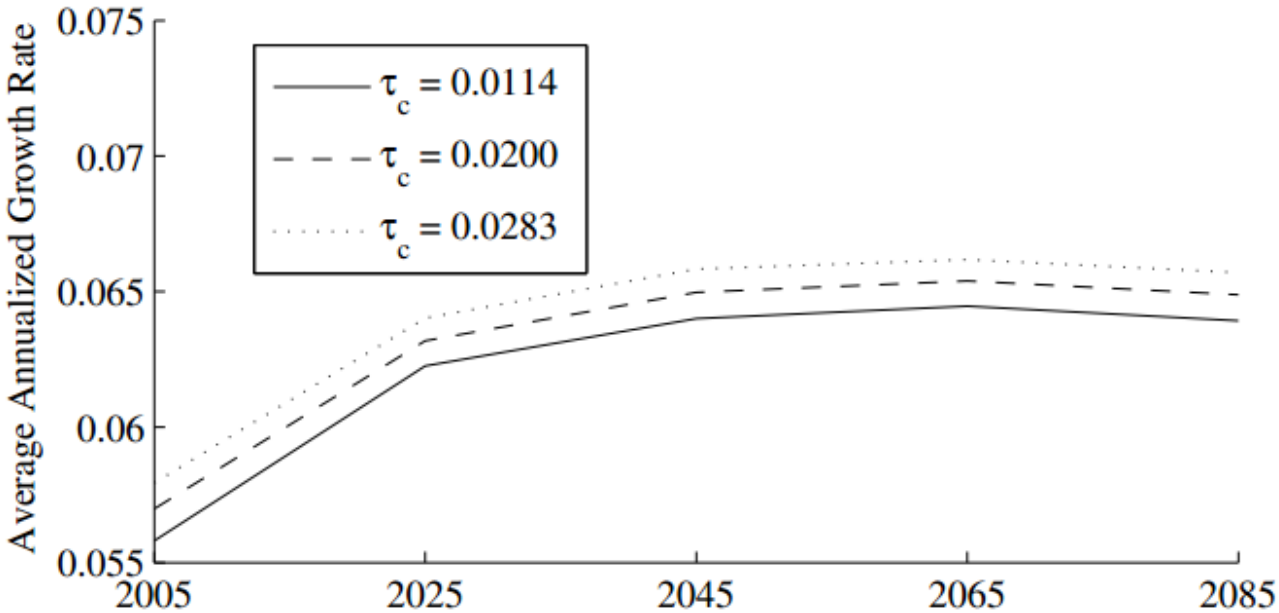
Experiment 1: Calibrated effect on e

Net effects on e_t: $\tau_c \uparrow \Longrightarrow E_t \uparrow$ and $e_t^* \downarrow$, although $e_t^* \downarrow$ not by a lot.
Doubling τ_c increases E_t but lowers e_t^* by not more than 2%



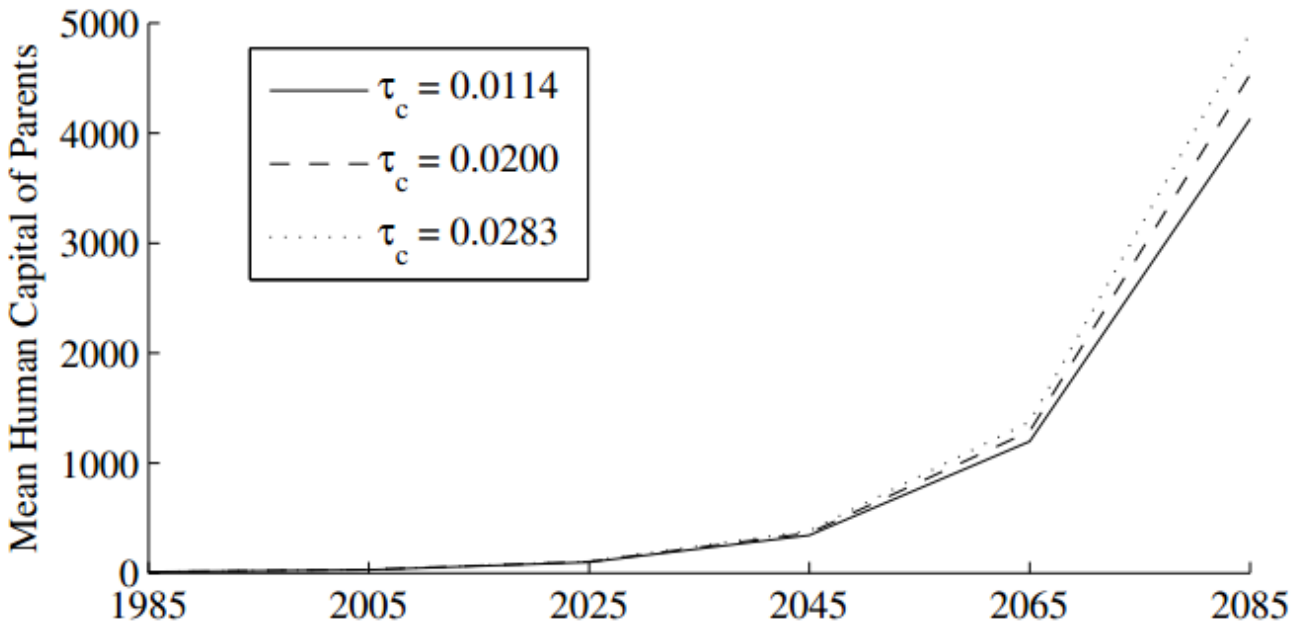
Experiment 1: Calibrated effect on human capital growth

Net effects on human capital growth $\left(\frac{h_{t+1}}{h_t}\right)$: Doubling τ_c increases human capital growth rate but by less than 3%, although more perceptible over time



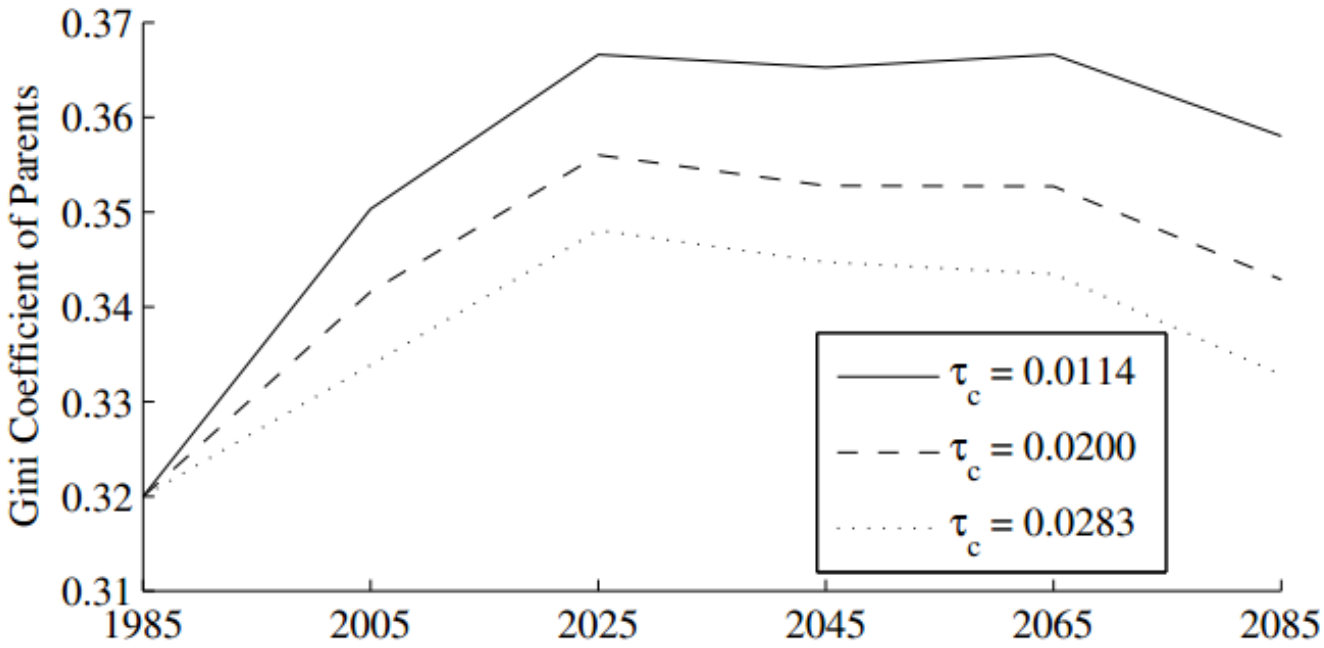
Experiment 1: Calibrated effect on the level of human capital

Net effects on level of human capital: The average family becomes wealthier by 1.1% in 20 years, by 3.49% in 40 years, by 5.16% in 60 years, by 6.74% in 80 years, and by 8.39% in 100 years.



Experiment 1: Calibrated effect on inequality

A higher τ_c causes inequality to fall over time, but by very little



This is because $\tau_c \uparrow \Longrightarrow$ after tax income $\downarrow$. But preferences are non-homothetic $\Longrightarrow e \downarrow$ (proportionately) more for richer households than poorer households $\Longrightarrow$ downward pressure on inequality.

Experiment 2: Changing the labor income tax to finance a higher E

- Now there are no substitution effects, only an income effect.
  - $\tau_L \uparrow \Longrightarrow e \downarrow$ (income effect)
  - $\tau_L \uparrow \Longrightarrow E_t \uparrow \Longrightarrow e_t \downarrow$ (Direct Effect)
  - Net effect on $e_t \downarrow$ higher
  - This is because of no compensating substitution effect
- We change τ_L so as to change public expenditure spending from 3.42% to 2.57% and 4.24%
- Numerical effects: in comparison to a $\tau_c \uparrow$,
  - $\tau_L \uparrow \Longrightarrow e \downarrow$ by more but the difference is only about 1.5% to 2%(very small)
  - Growth: $\tau_L \uparrow \Longrightarrow e \downarrow$ by more $\Longrightarrow h$ increases by less (although not very significantly) over a span of 100 years $\Longrightarrow$ growth $\uparrow$ by less compared to previous case.
  - Inequality: $\tau_L \uparrow \Longrightarrow$ inequality $\downarrow$ by more. This is because, for the wealthy, $e \downarrow$ by a lot more because they have a higher marginal product of e compared to the poor $\Longrightarrow$ gaps get bridged

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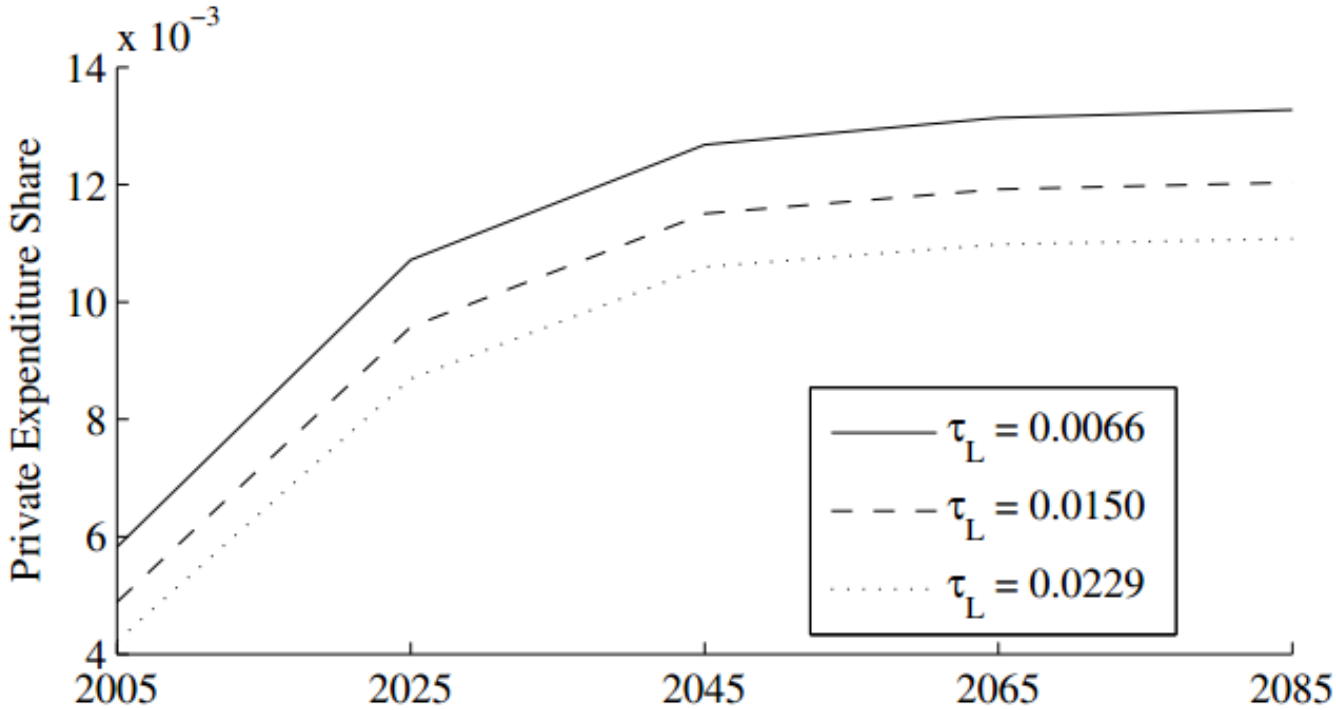

Experiment 3: Changing the centre-state transfer

- A pure windfall for the state ($\Delta \uparrow$)– a change in the centre-state transfer does not generate the same substitution effect as under the consumption tax
- Pure wealth effect because of the windfall: $e_t \uparrow \Longrightarrow \frac{h_{t+1}}{h_t} \uparrow$.
- Numerically however, it does little to boost private education nor does it substantially increase human capital accumulation (compared to a consumption tax)
- This is because the outlet for net transfer is higher consumption.

Experiment 3: Growth versus Inequality

- Effects: In comparison to a $\tau_c \uparrow$ or a $\tau_L \uparrow$
  - Most of the change goes towards private consumption; $e \uparrow$ very marginal
  - Growth: since $\Delta \uparrow$ mainly means freeing of up of resources, the initial increase (60 years) in h is slightly higher than due to a $\tau_c \uparrow$. However, this initial difference does not last for long. As a result, growth effects are also not significant
  - Inequality: since, the effect on e is very small, the effect on lowering inequality is again not significantly different compared to a $\tau_c \uparrow$. This could have potentially been a stronger force had the transfers been directed specifically towards poor households.

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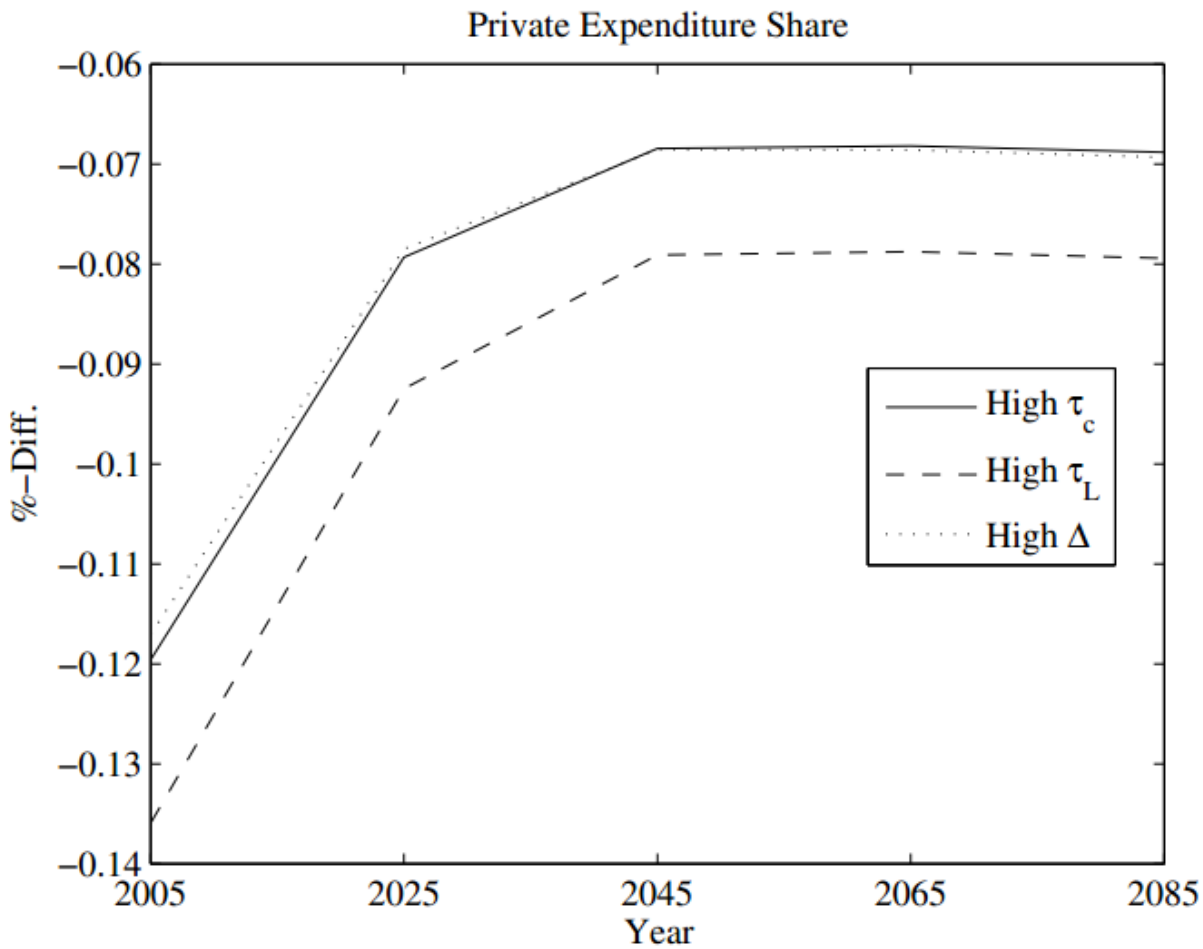
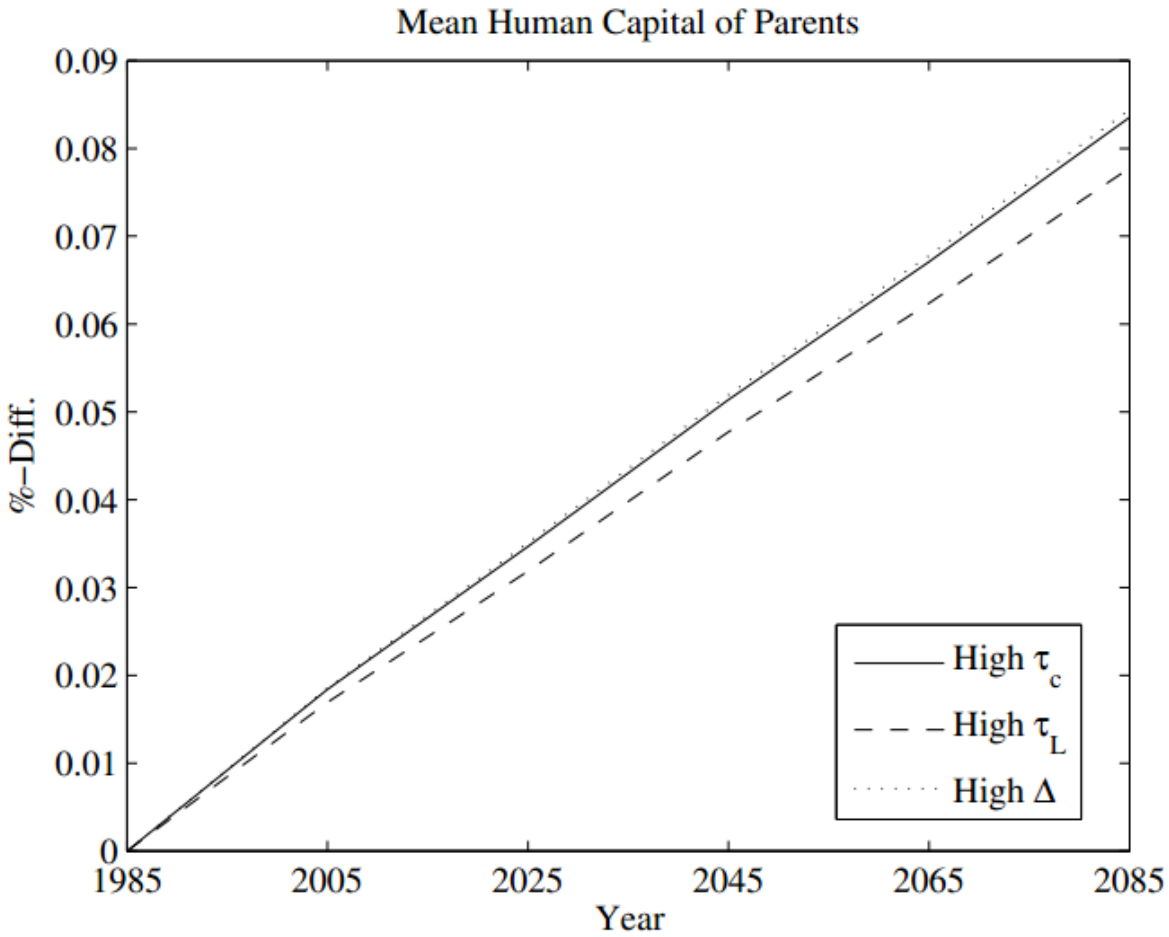
Experiment 3: Comparative effect on e

$e_t^* \downarrow$ by more due to an increase in τ_L



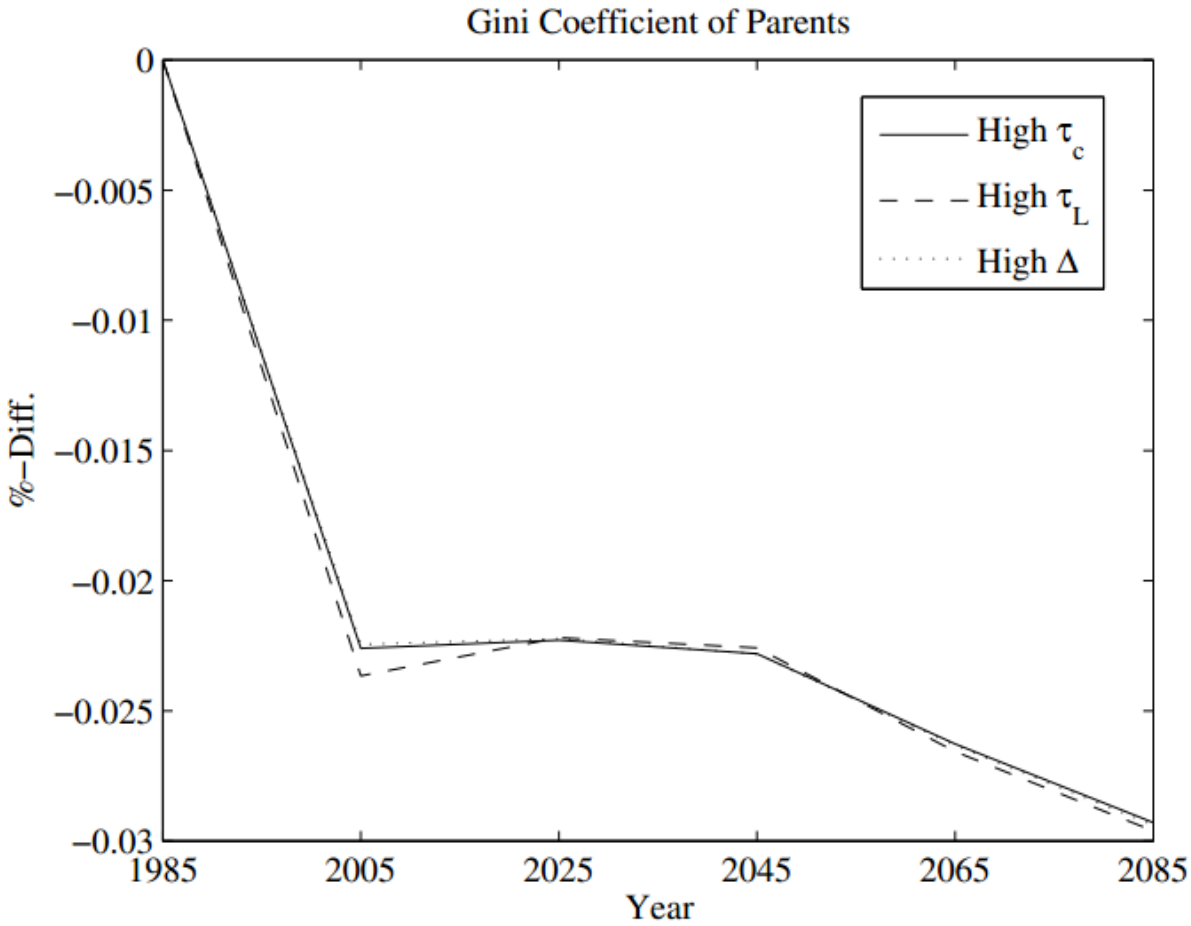
Experiment 3: Comparative effect on the level of human capital

Average human capital ↑ by a little more than due to an increase in τ_c



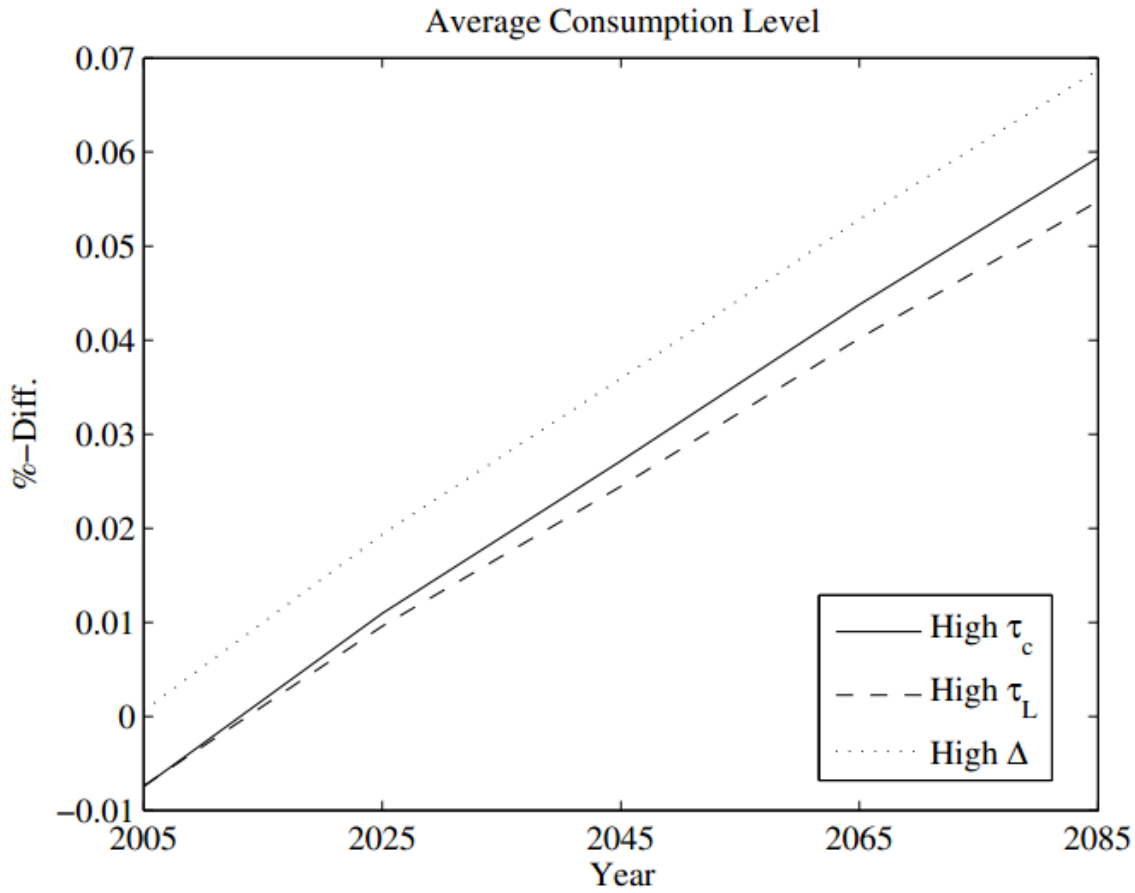
Experiment 3: Comparative effect on the Gini coefficient

Not significantly different



Experiment 3: Comparative effect on the average consumption level

$\tau_c \uparrow$ lowers consumption in the short run, but increases over time - by stimulating growth in human capital accumulation. Transfers increases consumption by most.



Sensitivity Analysis – Private education spending shares

		1985	2005	2025	2045	2065
$\rho = 0.01$	τ_c	-0.0058	-0.0022	-0.0113	-0.0137	-0.0121
	τ_l	-0.0139	-0.0098	-0.0439	-0.0736	-0.1016
	Δ	-0.0008	-0.0034	-0.0447	-0.0761	-0.1035
$\rho = 0.10$	τ_c	-0.0160	-0.0085	-0.0085	-0.0086	-0.0087
	τ_l	-0.0258	-0.0169	-0.0168	-0.0169	-0.0170
	Δ	-0.0120	-0.0082	-0.0086	-0.0087	-0.0087
$\rho = 0.25$	τ_c	-0.0524	-0.0252	-0.0249	-0.0252	-0.0254
	τ_l	-0.0647	-0.0345	-0.0339	-0.0342	-0.0344
	Δ	-0.0492	-0.0245	-0.0249	-0.0253	-0.0256
$\rho = 0.50$	τ_c	-0.1198	-0.0796	-0.0687	-0.0685	-0.0691
	τ_l	-0.1362	-0.0928	-0.0794	-0.0791	-0.0797
	Δ	-0.1173	-0.0787	-0.0688	-0.0689	-0.0696
$\rho = 0.75$	τ_c	-0.2255	-0.1966	-0.1720	-0.1601	-0.1577
	τ_l	-0.2396	-0.2116	-0.1864	-0.1742	-0.1716
	Δ	-0.2231	-0.1959	-0.1728	-0.1608	-0.1586
$\rho = 1.00$	τ_c	-0.3095	-0.3565	-0.3679	-0.3840	-0.3861
	τ_l	-0.3263	-0.3748	-0.3873	-0.4031	-0.4056
	Δ	-0.3054	-0.3549	-0.3674	-0.3839	-0.3863

Sensitivity Analysis – Average human capital

		1985	2005	2025	2045	2065	2085
$\rho = 0.01$	τ_c	0.0000	0.0156	0.0152	0.0139	0.0124	0.0111
	τ_l	0.0000	0.0139	0.0474	0.0795	0.1134	0.1493
	Δ	0.0000	0.0166	0.0507	0.0824	0.1157	0.1513
$\rho = 0.10$	τ_c	0.0000	0.0117	0.0276	0.0444	0.0611	0.0791
	τ_l	0.0000	0.0083	0.0229	0.0385	0.0545	0.0714
	Δ	0.0000	0.0123	0.0283	0.0451	0.0620	0.0802
$\rho = 0.25$	τ_c	0.0000	0.0111	0.0263	0.0435	0.0599	0.0776
	τ_l	0.0000	0.0085	0.0229	0.0389	0.0542	0.0710
	Δ	0.0000	0.0114	0.0268	0.0441	0.0606	0.0784
$\rho = 0.50$	τ_c	0.0000	0.0185	0.0349	0.0516	0.0674	0.0839
	τ_l	0.0000	0.0170	0.0321	0.0480	0.0627	0.0782
	Δ	0.0000	0.0187	0.0353	0.0522	0.0681	0.0848
$\rho = 0.75$	τ_c	0.0000	0.0220	0.0375	0.0525	0.0678	0.0833
	τ_l	0.0000	0.0213	0.0359	0.0498	0.0641	0.0786
	Δ	0.0000	0.0222	0.0379	0.0529	0.0684	0.0840
$\rho = 1.00$	τ_c	0.0000	0.0273	0.0497	0.0694	0.0876	0.1062
	τ_l	0.0000	0.0268	0.0486	0.0674	0.0848	0.1026
	Δ	0.0000	0.0274	0.0499	0.0697	0.0879	0.1066

Sensitivity Analysis – Gini coefficient of parents

		1985	2005	2025	2045	2065	2085
$\rho = 0.01$	τ_c	0.0000	0.0014	0.0009	0.0008	0.0007	0.0006
	τ_l	0.0000	0.0034	0.0037	0.0043	0.0043	0.0049
	Δ	0.0000	-0.0001	-0.0005	-0.0004	-0.0003	-0.0002
$\rho = 0.10$	τ_c	0.0000	0.0064	0.0057	0.0043	0.0033	0.0018
	τ_l	0.0000	0.0104	0.0099	0.0083	0.0068	0.0052
	Δ	0.0000	0.0062	0.0056	0.0041	0.0032	0.0017
$\rho = 0.25$	τ_c	0.0000	-0.0024	-0.0056	-0.0073	-0.0097	-0.0106
	τ_l	0.0000	-0.0017	-0.0049	-0.0069	-0.0097	-0.0105
	Δ	0.0000	-0.0023	-0.0056	-0.0073	-0.0097	-0.0107
$\rho = 0.50$	τ_c	0.0000	-0.0227	-0.0224	-0.0229	-0.0264	-0.0294
	τ_l	0.0000	-0.0237	-0.0223	-0.0227	-0.0267	-0.0298
	Δ	0.0000	-0.0225	-0.0223	-0.0229	-0.0265	-0.0295
$\rho = 0.75$	τ_c	0.0000	-0.0245	-0.0364	-0.0391	-0.0412	-0.0473
	τ_l	0.0000	-0.0256	-0.0379	-0.0408	-0.0429	-0.0491
	Δ	0.0000	-0.0244	-0.0364	-0.0389	-0.0412	-0.0473
$\rho = 1.00$	τ_c	0.0000	-0.0246	-0.0484	-0.0695	-0.0840	-0.0992
	τ_l	0.0000	-0.0255	-0.0502	-0.0723	-0.0874	-0.1031
	Δ	0.0000	-0.0244	-0.0481	-0.0693	-0.0839	-0.0991

Sensitivity Analysis – Average consumption

		1985	2005	2025	2045	2065
$\rho = 0.01$	τ_c	-0.0081	0.0073	0.0070	0.0056	0.0041
	τ_l	-0.0080	0.0057	0.0389	0.0707	0.1044
	Δ	0.0000	0.0167	0.0507	0.0824	0.1157
$\rho = 0.10$	τ_c	-0.0080	0.0036	0.0194	0.0360	0.0526
	τ_l	-0.0079	0.0003	0.0148	0.0302	0.0461
	Δ	0.0001	0.0124	0.0284	0.0453	0.0622
$\rho = 0.25$	τ_c	-0.0078	0.0032	0.0184	0.0354	0.0516
	τ_l	-0.0077	0.0007	0.0150	0.0309	0.0461
	Δ	0.0003	0.0117	0.0272	0.0445	0.0610
$\rho = 0.50$	τ_c	-0.0075	0.0110	0.0273	0.0440	0.0597
	τ_l	-0.0074	0.0097	0.0246	0.0404	0.0551
	Δ	0.0006	0.0195	0.0361	0.0531	0.0691
$\rho = 0.75$	τ_c	-0.0072	0.0152	0.0307	0.0456	0.0608
	τ_l	-0.0071	0.0146	0.0292	0.0431	0.0573
	Δ	0.0009	0.0236	0.0395	0.0546	0.0701
$\rho = 1.00$	τ_c	-0.0071	0.0206	0.0433	0.0630	0.0813
	τ_l	-0.0071	0.0202	0.0423	0.0612	0.0786
	Δ	0.0010	0.0290	0.0520	0.0720	0.0904

Parental human capital effectivity – Private education spending share

		1985	2005	2025	2045	2065
$\psi = 0.00$	τ_c	-0.1198	-0.0786	-0.0698	-0.0697	-0.0704
	τ_l	-0.1362	-0.0926	-0.0804	-0.0803	-0.0811
	Δ	-0.1173	-0.0778	-0.0699	-0.0701	-0.0709
$\psi = 0.10$	τ_c	-0.1198	-0.0781	-0.0671	-0.0672	-0.0677
	τ_l	-0.1362	-0.0904	-0.0781	-0.0778	-0.0783
	Δ	-0.1173	-0.0772	-0.0675	-0.0676	-0.0682
$\psi = 0.20$	τ_c	-0.1198	-0.0746	-0.0645	-0.0642	-0.0646
	τ_l	-0.1362	-0.0869	-0.0751	-0.0747	-0.0752
	Δ	-0.1173	-0.0738	-0.0646	-0.0646	-0.0651
$\psi = 0.40$	τ_c	-0.1198	-0.0640	-0.0583	-0.0572	-0.0571
	τ_l	-0.1362	-0.0747	-0.0688	-0.0676	-0.0674
	Δ	-0.1173	-0.0633	-0.0585	-0.0576	-0.0576

Parental human capital effectivity – Average human capital

		1985	2005	2025	2045	2065	2085
$\psi = 0.00$	τ_c	0.0000	0.0187	0.0360	0.0532	0.0694	0.0864
	τ_l	0.0000	0.0172	0.0330	0.0494	0.0644	0.0805
	Δ	0.0000	0.0189	0.0364	0.0538	0.0701	0.0872
$\psi = 0.10$	τ_c	0.0000	0.0182	0.0341	0.0504	0.0658	0.0819
	τ_l	0.0000	0.0167	0.0315	0.0469	0.0612	0.0764
	Δ	0.0000	0.0184	0.0345	0.0510	0.0665	0.0828
$\psi = 0.20$	τ_c	0.0000	0.0174	0.0321	0.0476	0.0621	0.0776
	τ_l	0.0000	0.0158	0.0293	0.0439	0.0573	0.0717
	Δ	0.0000	0.0176	0.0325	0.0482	0.0629	0.0784
$\psi = 0.40$	τ_c	0.0000	0.0146	0.0276	0.0413	0.0537	0.0672
	τ_l	0.0000	0.0128	0.0249	0.0376	0.0488	0.0613
	Δ	0.0000	0.0148	0.0281	0.0419	0.0545	0.0681

Parental human capital effectivity – Gini coefficient of parents

		1985	2005	2025	2045	2065	2085
$\psi = 0.00$	τ_c	0.0000	-0.0239	-0.0263	-0.0277	-0.0318	-0.0356
	τ_l	0.0000	-0.0250	-0.0260	-0.0274	-0.0321	-0.0359
	Δ	0.0000	-0.0237	-0.0263	-0.0277	-0.0319	-0.0357
$\psi = 0.10$	τ_c	0.0000	-0.0211	-0.0194	-0.0193	-0.0221	-0.0244
	τ_l	0.0000	-0.0220	-0.0195	-0.0191	-0.0223	-0.0245
	Δ	0.0000	-0.0209	-0.0193	-0.0192	-0.0220	-0.0244
$\psi = 0.20$	τ_c	0.0000	-0.0175	-0.0136	-0.0128	-0.0151	-0.0166
	τ_l	0.0000	-0.0182	-0.0135	-0.0125	-0.0151	-0.0165
	Δ	0.0000	-0.0173	-0.0136	-0.0128	-0.0152	-0.0166
$\psi = 0.40$	τ_c	0.0000	-0.0112	-0.0070	-0.0055	-0.0065	-0.0073
	τ_l	0.0000	-0.0115	-0.0071	-0.0054	-0.0065	-0.0072
	Δ	0.0000	-0.0111	-0.0070	-0.0055	-0.0065	-0.0073

Composite ability share – Private education spending

		1985	2005	2025	2045	2065
$\delta = 0.80$	τ_c	-0.1198	-0.0796	-0.0687	-0.0685	-0.0691
	τ_l	-0.1362	-0.0928	-0.0794	-0.0791	-0.0797
	Δ	-0.1173	-0.0787	-0.0688	-0.0689	-0.0696
$\delta = 0.85$	τ_c	-0.1327	-0.0962	-0.0779	-0.0765	-0.0767
	τ_l	-0.1611	-0.1140	-0.0889	-0.0876	-0.0876
	Δ	-0.1305	-0.0955	-0.0780	-0.0769	-0.0771
$\delta = 0.90$	τ_c	-0.2691	-0.1427	-0.0926	-0.0888	-0.0885
	τ_l	-0.2771	-0.1568	-0.1045	-0.0998	-0.0996
	Δ	-0.2677	-0.1421	-0.0927	-0.0891	-0.0889

Composite ability share – Average human capital

		1985	2005	2025	2045	2065	2085
$\delta = 0.80$	τ_c	0.0000	0.0185	0.0349	0.0516	0.0674	0.0839
	τ_l	0.0000	0.0170	0.0321	0.0480	0.0627	0.0782
	Δ	0.0000	0.0187	0.0353	0.0522	0.0681	0.0848
$\delta = 0.85$	τ_c	0.0000	0.0185	0.0318	0.0451	0.0588	0.0724
	τ_l	0.0000	0.0167	0.0284	0.0406	0.0538	0.0669
	Δ	0.0000	0.0186	0.0321	0.0455	0.0592	0.0729
$\delta = 0.90$	τ_c	0.0000	0.0133	0.0223	0.0325	0.0428	0.0535
	τ_l	0.0000	0.0133	0.0217	0.0314	0.0413	0.0516
	Δ	0.0000	0.0134	0.0223	0.0327	0.0430	0.0537

Composite ability share – Gini coefficient of parents

		1985	2005	2025	2045	2065	2085
$\delta = 0.80$	τ_c	0.0000	-0.0227	-0.0224	-0.0229	-0.0264	-0.0294
	τ_l	0.0000	-0.0237	-0.0223	-0.0227	-0.0267	-0.0298
	Δ	0.0000	-0.0225	-0.0223	-0.0229	-0.0265	-0.0295
$\delta = 0.85$	τ_c	0.0000	-0.0172	-0.0174	-0.0183	-0.0189	-0.0219
	τ_l	0.0000	-0.0194	-0.0186	-0.0204	-0.0204	-0.0227
	Δ	0.0000	-0.0171	-0.0174	-0.0183	-0.0190	-0.0219
$\delta = 0.90$	τ_c	0.0000	-0.0127	-0.0155	-0.0152	-0.0154	-0.0161
	τ_l	0.0000	-0.0128	-0.0158	-0.0155	-0.0158	-0.0165
	Δ	0.0000	-0.0127	-0.0154	-0.0153	-0.0155	-0.0161

Composite ability share – Average consumption

		1985	2005	2025	2045	2065
$\delta = 0.80$	τ_c	-0.0075	0.0110	0.0273	0.0440	0.0597
	τ_l	-0.0074	0.0097	0.0246	0.0404	0.0551
	Δ	0.0006	0.0195	0.0361	0.0531	0.0691
$\delta = 0.85$	τ_c	-0.0077	0.0109	0.0241	0.0373	0.0509
	τ_l	-0.0076	0.0092	0.0208	0.0329	0.0460
	Δ	0.0004	0.0192	0.0327	0.0461	0.0599
$\delta = 0.90$	τ_c	-0.0078	0.0056	0.0144	0.0246	0.0348
	τ_l	-0.0078	0.0056	0.0139	0.0236	0.0333
	Δ	0.0003	0.0138	0.0228	0.0331	0.0434

In a nutshell – sensitivity analysis of changing elasticity of substitution

- $\rho \uparrow \Longrightarrow$ elasticity of substitution between private and public spending on education is higher $\Longrightarrow$ more crowding out of e due to an increase in taxes $\Longrightarrow$ $e \downarrow$ by more
  - Growth: $e \downarrow$ by more is mitigated by $E \uparrow$ by more, hence, increases in growth due to $E \uparrow$ are also large. This is because e and E are also less complementary. Growth gains due to $\Delta \uparrow > \tau_c \uparrow > \tau_L \uparrow$.
  - Inequality: $\rho \uparrow \Longrightarrow$ inequality reduces by more because of $E \uparrow$. This is because, crowding out of E to lower e affects rich households relatively more
- Therefore $\rho \uparrow \Longrightarrow$ public spending matter more!

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In a nutshell – sensitivity analysis of changing the parental human capital cutoff

- $\psi \uparrow \Longrightarrow$ fewer parents can augment their child's human capital accumulation $\Longrightarrow$ the effect of $E \uparrow$ on growth is lesser
- $\psi \uparrow \Longrightarrow$ upward pressure on inequality, but the crowding out effect of $E \uparrow$ causes inequality to actually fall although by less for higher ψ
- Therefore $\psi \uparrow \Longrightarrow$ public spending matter less!

Conclusion

- Raising public spending on education increases economic growth by raising taxes or transfers. As substitutability between public and private education spending increases,
  - higher public spending first yields smaller economic growth gains, before gains increase
  - inequality is reduced
- Higher public spending yields smaller growth gains and inequality reductions as the parental human capital cut-off is increased
- Relatively large changes in funding levels for education have relatively minor impacts both on growth and on evolution of income inequality
- Policy implications – public funding on education has only minor effects on growth and lowering inequality. This is especially true when fewer parents intellectually contribute to a child's human capital accumulation.

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Thank you!