Higher Education in a Heterogeneous Agent Economy: Revisiting Transatlantic Differences

Orhan Torul

orhan.torul@boun.edu.tr

Department of Economics, Boğaziçi University

Higher Education

- Higher education is central to a modern economy through human capital channel
- Countries of comparable development levels vary substantially in terms of public versus private higher education choice

▸ Education Expenditure by Country

- U.S. on the private, Scandinavian countries on the public end of the *de facto* spectrum

U.S. & Nordic Education Comparison

Table: Comparison of Scandinavian and U.S. Tertiary Education

	Higher Edu. Exp. per Student	Public Exp. on Higher Edu./GDP	Private Exp. on Higher Edu./GDP	Public/ Total Exp. on Higher Edu.	Ratio of Students in Public Edu.
Denmark	$16,466	1.6%	0.1%	96.50%	98%
Finland	$13,566	1.6%	0.1%	96.07%	87%
Iceland	$6,721	1.1%	0.1%	91.01%	80%
Norway	$17,754	1.2%	0.0%	95.83%	88%
Sweden	$18,361	1.4%	0.2%	89.73%	93%
Nordic Average	**$14,451**	**1.4%**	**0.1%**	**93.90%**	**89%**
USA	**$27,010**	**1.0%**	**2.1%**	**32.27%**	**67%**

Source: Education at a Glance 2010, OECD.

▸ Tuition Fees by Country ▸ Comparison of Tuition Fees ▸ Evidence on Educational Inequality

Comparison of Tax Rates

Table: Average Tax Revenues

Total Tax Revenue as Percentage of GDP

	2005	2006	2007	2008	Average
Nordic Average	45.65%	45.45%	44.76%	43.40%	**44.79%**
USA	27.10%	27.85%	27.86%	26.06%	**27.22%**

Total Tax Revenue from Incomes and Profits as Percentage of GDP

	2005	2006	2007	2008	Average
Nordic Average	21.22%	21.20%	20.83%	20.45%	**20.92%**
USA	12.65%	13.45%	13.61%	11.77%	**12.87%**

Source: OECD Tax Database, 2010.

Main Questions

- Can tax rates alone explain the structural discrepancies in higher education systems between the U.S. and the Scandinavian countries?
- What are the macroeconomic implications of the contrary educational compositions?
- How do aggregate and individual welfare vary under different tax rates and educational structures?
- What normative policy recommendations can be inferred from the model?

Literature

Education Literature:

- Bénabou (2000, AER; 2002, ECTA), Soares (2003, JPubE; 2006, JPopE)

Redistributive Policy Literature:

- Economic Explanations
  - Bénabou and Ok (2001, QJE), Alesina and Glaeser (2004, *Oxford Press*), Hassler *et al* (2003, AER)
- Political Explanations
  - Alesina *et al* (2005, Brookings), Alesina and Glaeser (2004, *Oxford Press*)
- Behavioral Explanations
  - Alesina and Angeletos (2005, AER), Bénabou and Tirole (2006, QJE)

Contributions and Results

- First paper to model public and private education explicitly in agents' choice set in a heterogeneous-agent economy with uninsurable idiosyncratic shocks
- Earliest study to deliver structural differences in higher education by relating to welfare measures using a general equilibrium model
  - Lower U.S. tax rate to explain lower U.S. public education, and higher total education expenditure levels, lower public school attendance ratio and more unequal educational attainment
  - Majority of individuals roughly indifferent between calibrated high and low tax regimes

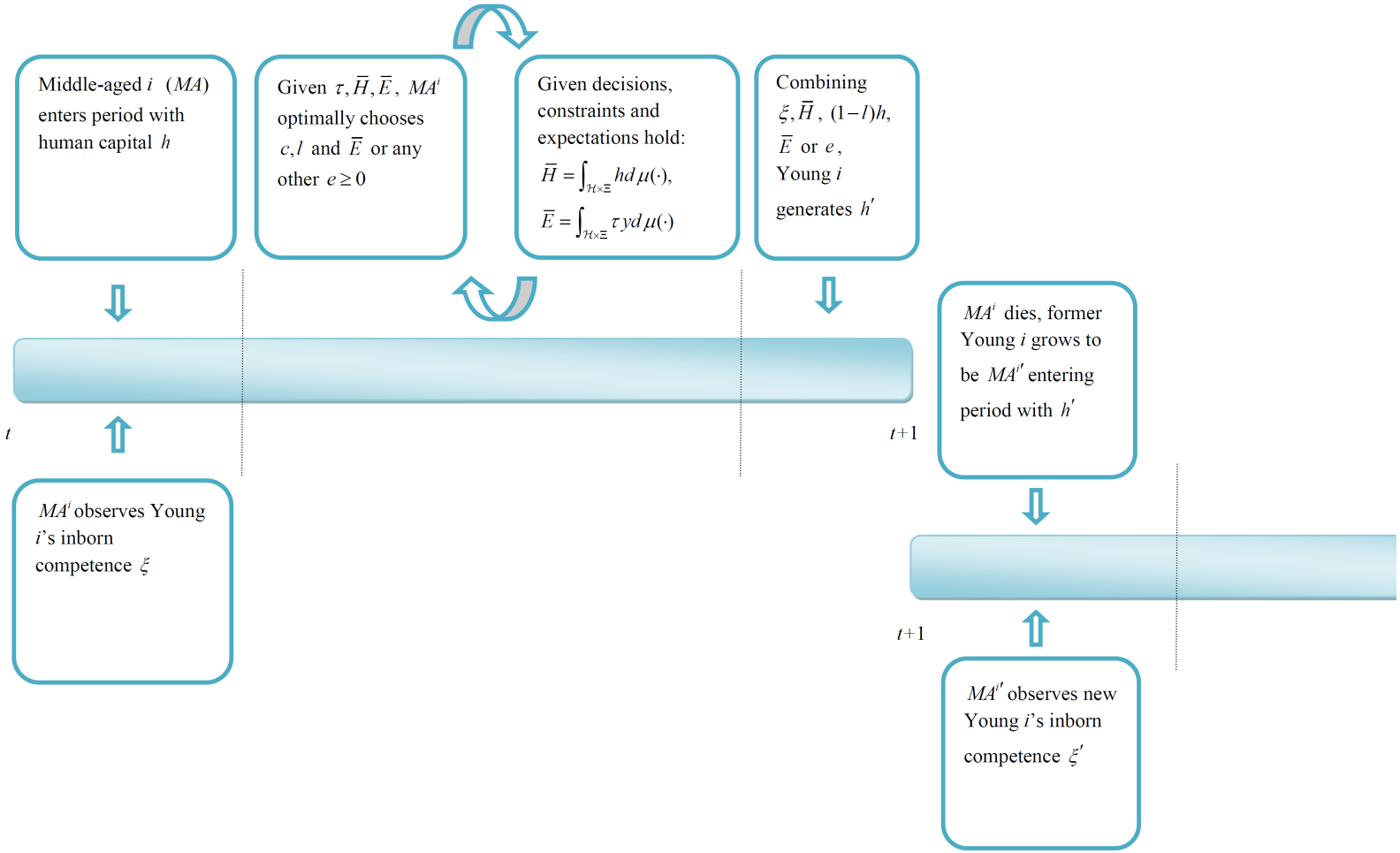
Contributions and Results

- Generates the U-shaped behavior of per-capita output over public education expenditure ratio as in data
  - Increase in the distortionary tax rate discourages private education and encourages public education attendance
  - Decrease in private education offsets increase in public education attainment unless public education is chosen by a large fraction of population
- Normatively, high reliance on public *or* private education ideal, but not the hybrid case

Model Description

- Heterogeneous-agent OLG model with two cohorts: Middle-aged & Young
- Only idiosyncratic, and no aggregate shocks
- Middle-aged decide how much to work, consume, and bequest private education if any (or choose public education) to young
- Young generate human capital to be used when middle-aged via in-born competence, education, aggregate and parental human capital

Timeline of the Model



Recursive Competitive Equilibrium

The recursive competitive equilibrium under constant exogenous taxes is a set of value functions, decision rules, allocations and stationary distribution, such that

1. Given $\overline{H}$, $\overline{E}$, and τ, $\tilde{c}(h,\xi;\overline{H},\overline{E},\tau)$, $\tilde{l}(h,\xi;\overline{H},\overline{E},\tau)$ and $\tilde{e}(h,\xi;\overline{H},\overline{E},\tau)$ are optimal decision rules to household agent i's problem, $\tilde{h}(h,\xi;\overline{H},\overline{E},\tau)$ is the implied human capital rule by optimal education decision, $V(h,\xi;\overline{H},\overline{E},\tau)$ is the resultant value function, and inborn cognitive capability follows its exogenous log-normal law of motion:

$$V(h,\xi;\overline{H},\overline{E},\tau) = \max_{\{c,l,e\}} \left\{ u(c) + v(1-l) + \rho \sum_{\xi'} \pi(\xi',\xi) V(h',\xi';\overline{H},\overline{E},\tau) \right\} \tag{1}$$

subject to

$$c = (1-\tau)\Theta l^{(1-\lambda)} h^{\lambda} - e \tag{2}$$

$$e \geq 0 \tag{3}$$

$$h' = \begin{cases} \xi(\overline{E})^{\varepsilon}((1-l)h))^{(1-\varepsilon)\gamma}\overline{H}^{(1-\varepsilon)(1-\gamma)} & e = 0 \\ \xi(e+\nu\overline{E})^{\varepsilon}((1-l)h)^{(1-\varepsilon)\gamma}\overline{H}^{(1-\varepsilon)(1-\gamma)} & e > 0 \end{cases} \tag{4}$$

$$\log(\xi) \sim N(\mu_{\xi}, \sigma_{\xi}^2) \tag{5}$$

Recursive Competitive Equilibrium

2. The time-invariant stationary distribution satisfies:

$$\mu(h', \xi'; \overline{H}, \overline{E}, \tau) = \sum_{\xi'} \int_{\mathcal{H} \times \Xi} \chi_{\{\tilde{h}(h,\xi;\overline{H},\overline{E},\tau)=h'\}} \pi(\xi', \xi) d\mu(h, \xi; \overline{H}, \overline{E}, \tau) \quad (6)$$

3. All aggregate variables stay constant at all periods:

$$H_t = H_{t+1} = \ldots = \overline{H}, Y_t = Y_{t+1} = \ldots \overline{Y}, \ldots \quad (7)$$

4. Aggregate resource constraint holds:

$$\overline{Y} = \overline{C} + \overline{E} + \int_{\mathcal{H} \times \Xi} e d\mu(h, \xi; \overline{H}, \overline{E}, \tau) \quad (8)$$

5. Government runs a balanced budget:

$$\overline{E} = \int_{\mathcal{H} \times \Xi} \tau(\Theta l^{(1-\lambda)} h^{\lambda}) d\mu(h, \xi; \overline{H}, \overline{E}, \tau) \quad (9)$$

6. Markets clear, definitions and expectations hold:

$$\overline{H} = \int_{\mathcal{H} \times \Xi} h d\mu(h, \xi; \overline{H}, \overline{E}, \tau), \overline{Y} = \int_{\mathcal{H} \times \Xi} y d\mu(h, \xi; \overline{H}, \overline{E}, \tau), \ldots \quad (10)$$

Calibration

Table: Benchmark Parameter Values

λ	0.625	Bénabou (2000, AER)
γ	0.200	Zhang (2005, JEDC)
ρ	0.800	Zhang (2005, JEDC)
ε	0.300	Bénabou (2000, AER) & Zhang (2005, JEDC)
μ_ξ	0.000	Bénabou (2000, AER)
σ_ξ	1.000	Bénabou (2000, AER)
$\bar{l}$	0.330	RBC Literature
ν	0.500	Neutral Stance from Two Polar Cases
Θ	5.000	Calibrated to Match $\overline{Y}^{Nor}/\overline{Y}^{US} = 87\%$
τ^{US}	4.784%	Calibrated to Match $\overline{E}/\overline{\mathcal{E}} = 32.27\%$ for the U.S.
τ^{Nor}	11.774%	Calibrated to Match $\overline{E}/\overline{\mathcal{E}} = 93.90\%$ for the Nordic Average

Decision Rules

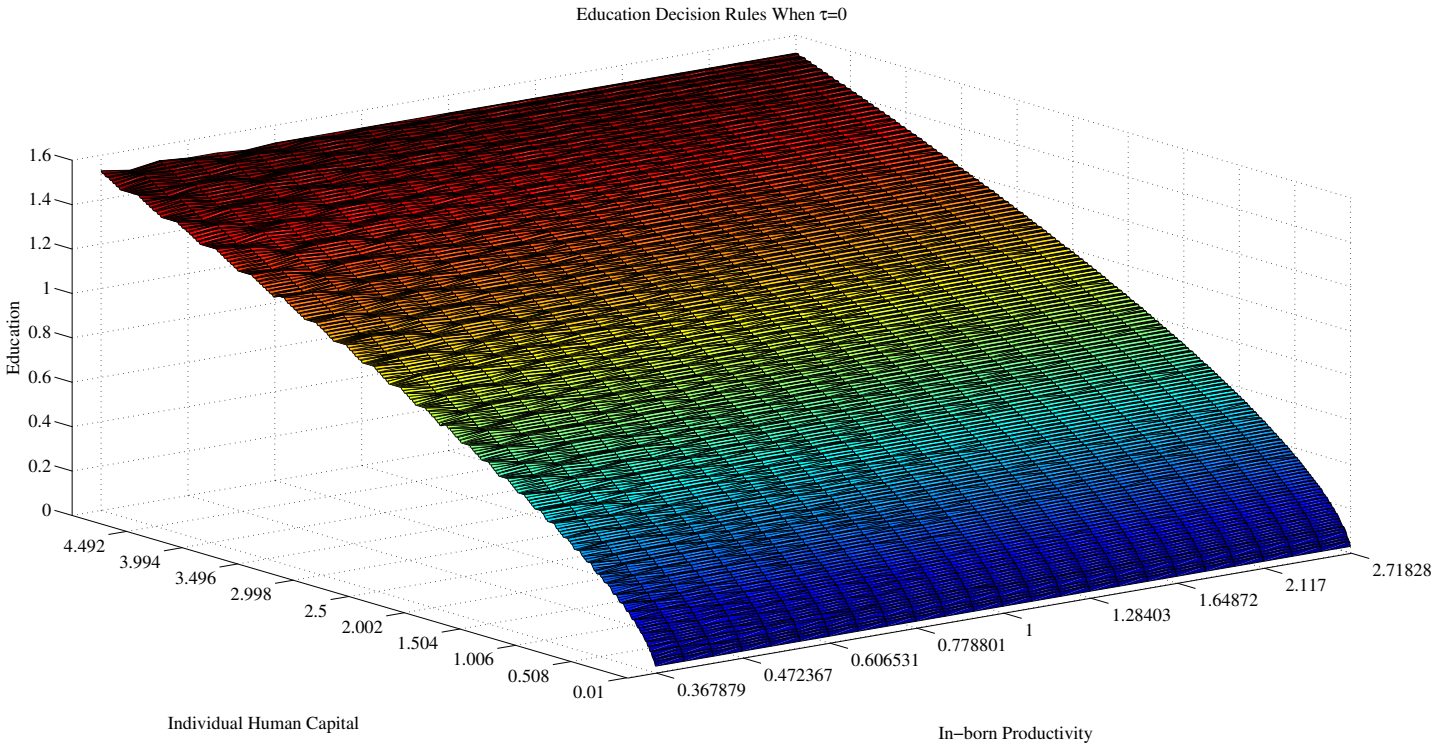


Figure: Education Decision Rules at State Pairs when $\tau = 0.000$

Decision Rules

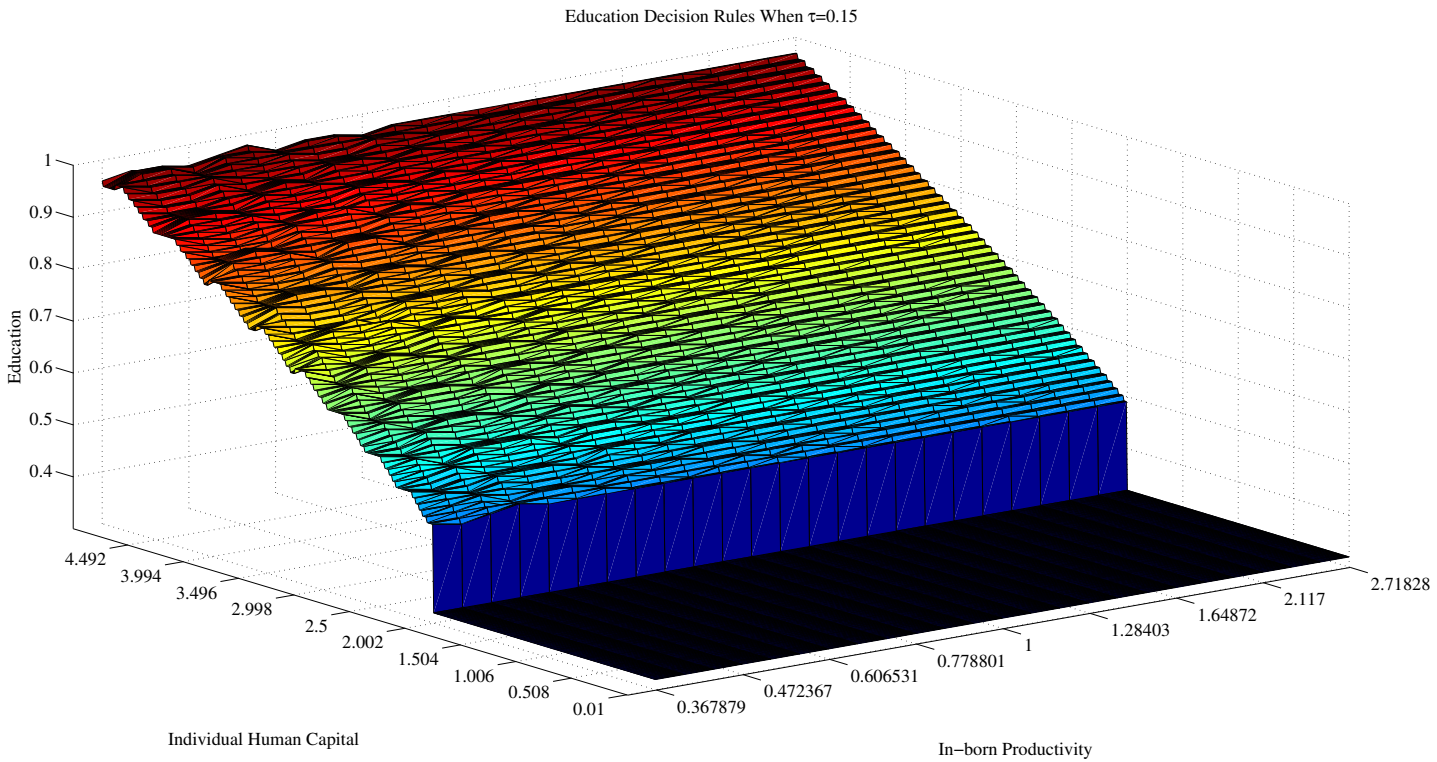


Figure: Education Decision Rules at State Pairs when $\tau = 0.150$

Benchmark Results

Table: Steady-State Results of the Benchmark Model

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{C}/\overline{Y}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.672	2.419	2.010	0.831	0.410	0.000	0.00%	0.00%
2.50%	0.630	2.324	1.941	0.835	0.383	0.058	15.17%	0.00%
4.78%	0.441	1.851	1.577	0.852	0.275	0.089	32.27%	28.34%
5.00%	0.427	1.814	1.548	0.853	0.266	0.091	34.12%	31.34%
7.50%	0.354	1.615	1.398	0.866	0.216	0.121	55.99%	59.22%
10.00%	0.353	1.618	1.408	0.871	0.209	0.162	77.25%	78.99%
11.78%	0.343	1.593	1.393	0.875	0.200	0.188	93.90%	94.63%
12.50%	0.353	1.625	1.419	0.873	0.207	0.203	98.34%	98.64%
15.00%	0.544	2.131	1.812	0.850	0.320	0.320	100.00%	100.00%

▸ Distributional Properties of the Benchmark Model

Why the U-Shape?

Four competing factors:

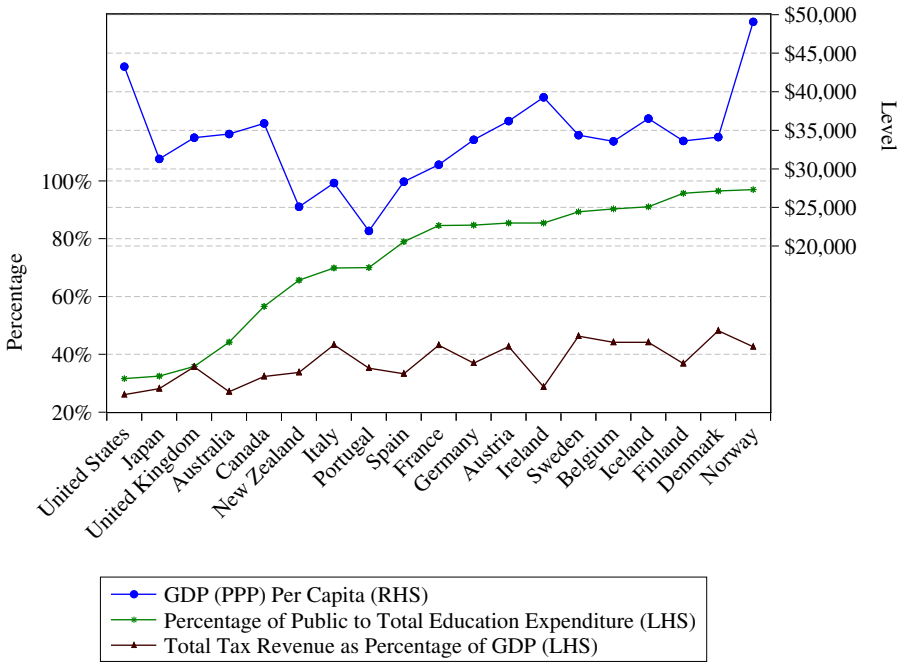
- Lower disposable income $\rightarrow$ lower private education in the intensive margin $(-)$
  - $\frac{\partial e}{\partial \tau} = -\frac{\lambda\rho\varepsilon\Theta h^{\lambda}\bar{l}^{1-\lambda}}{1-\rho(1-\varepsilon)\gamma} < 0$ when $\nu = 0$
- "Disincentivizing extensive margin effect" of public education $\rightarrow$ lower private education and total education $(-)$
- Lower return on education $\rightarrow$ lower private and total education $(-)$
- Public education benefit to the poor $\rightarrow$ higher aggregate education $(+)$

Model Fit for U.S. and Scandinavia

Table: Comparison of Model for the U.S. and Nordic Average with Data

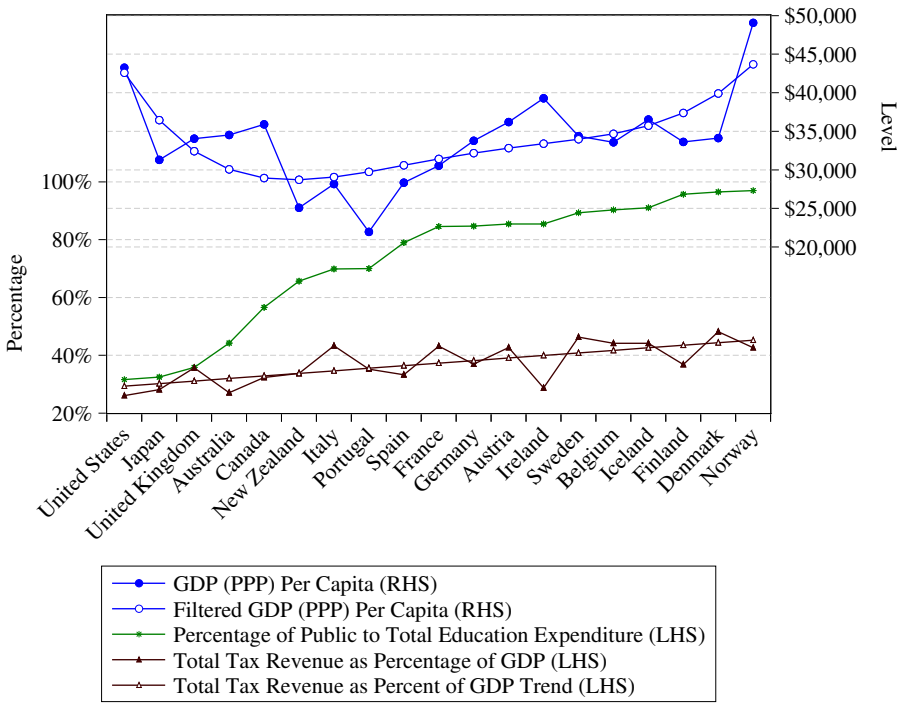
	Country	$\overline{E}/\overline{\mathcal{E}}$	$\overline{Y}/\overline{Y}^{US}$	$\overline{\tau}$	$\overline{E}/\overline{E}^{US}$	$\overline{\mathcal{E}}/\overline{Y}$	$Pop._{\overline{E}}$	$GINI_{\overline{\mathcal{E}}}$
Model	U.S.	32.27%	100%	4.78%	100%	14.83%	28%	0.33
	Nordic	93.90%	87%	11.78%	211%	12.54%	95%	0.06
	Average							
Data	U.S.	32.27%	100%	12.87%	100%	3.10%	67%	N/A (+)
	Nordic	93.90%	87%	20.92%	155%	1.60%	89%	N/A (−)
	Average							

Tax, Output and Public Education Share by Country



Source: OECD Tax Revenue Database, 2008.

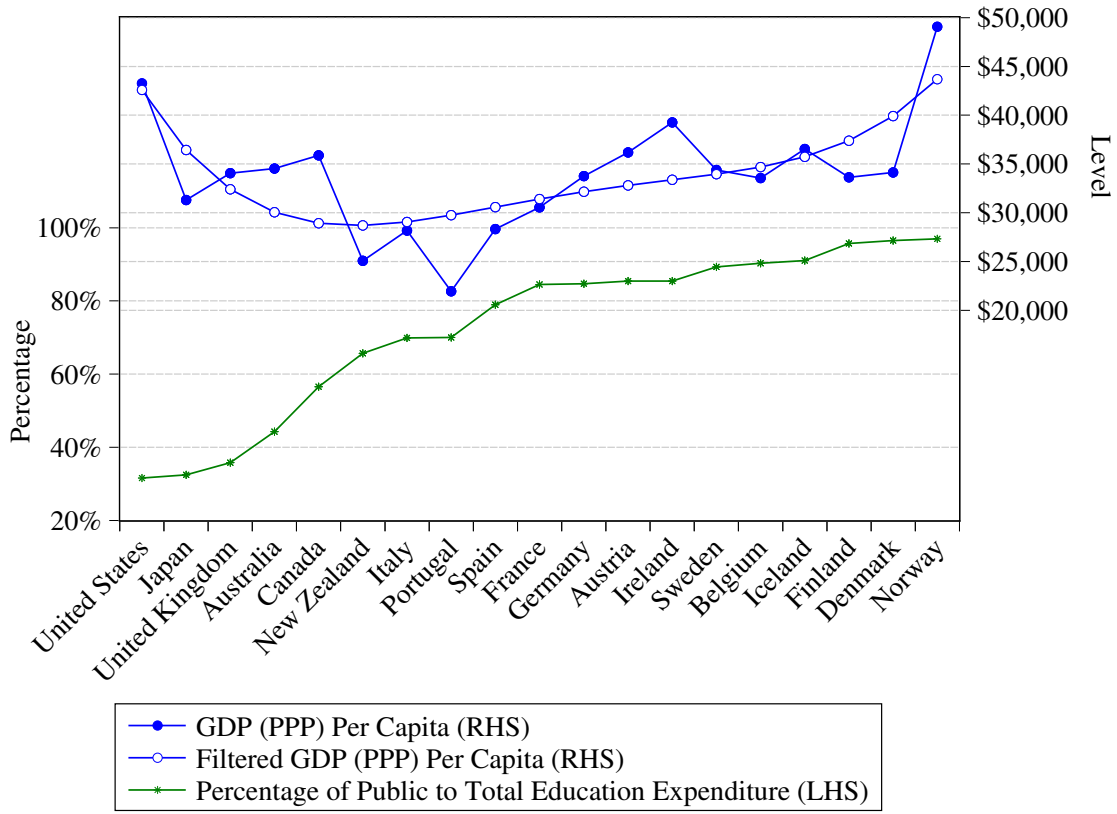
Tax, Output and Public Education Share by Country



Source: OECD Tax Revenue Database, 2008.

$$\frac{\overline{E_i}}{\mathcal{E}_i} = -0.149 + 2.354\tau_i \quad p = 0.0011$$

Model Match by Country



Source: OECD Tax Revenue Database, 2008.

Comparative Statics

Table: Comparative Statics

Change	Level	U-Shape
High Complementarity	+	Steeper right arm
High Intergenerational Transmission	−	Only left arm
High Return on Education	+	Slightly flatter
High Share of Human Capital	+	Slightly steeper
No Idiosyncratic Shocks	−	Steeper
High Persistence of Shocks	−	Flatter
High Altruism	+	Steeper
Low Fixed Labor	−	Roughly same

▸ Alternative Spillover Rates ▸ Results with Endogenous Labor

Stationary Distribution for the U.S. Economy

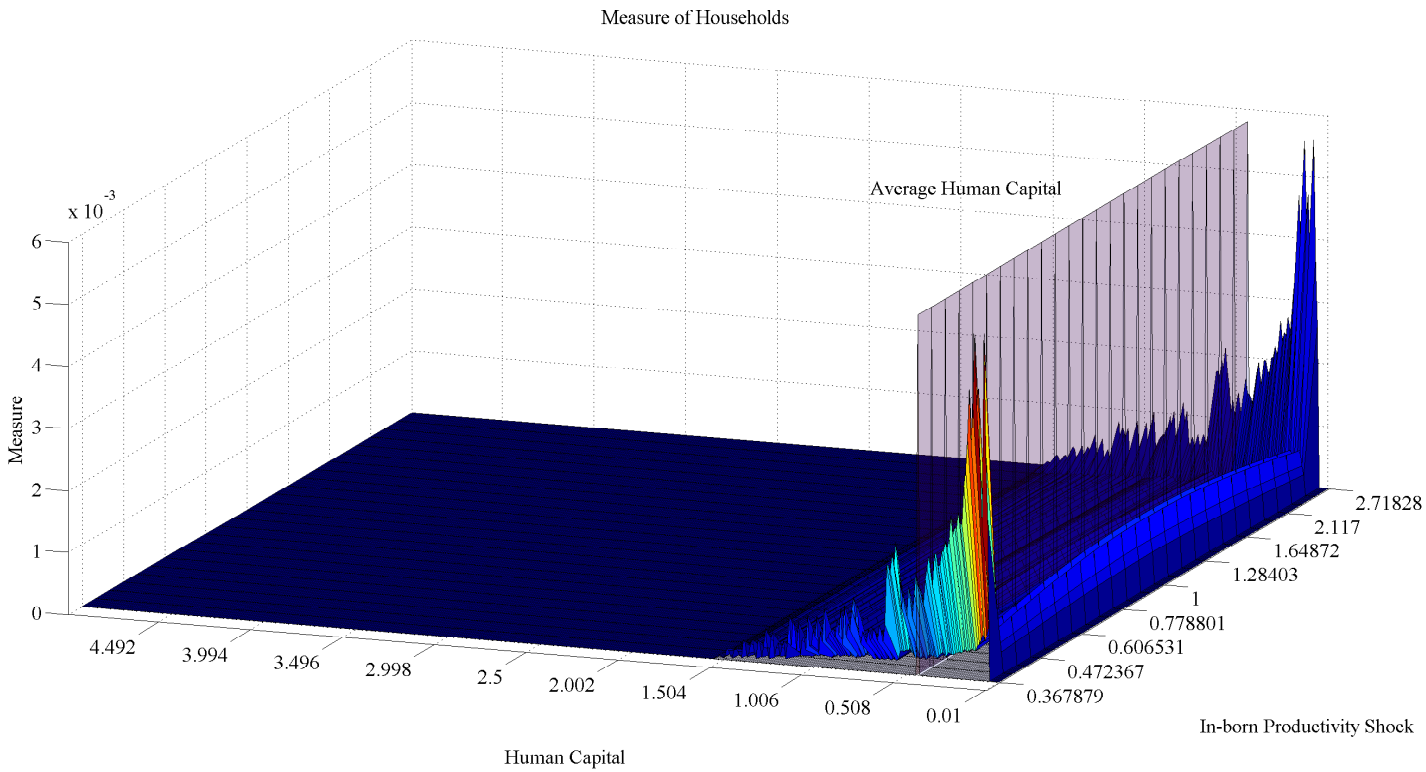


Figure: Stationary Distribution for the U.S. Economy

Stationary Distribution for the Nordic Economy

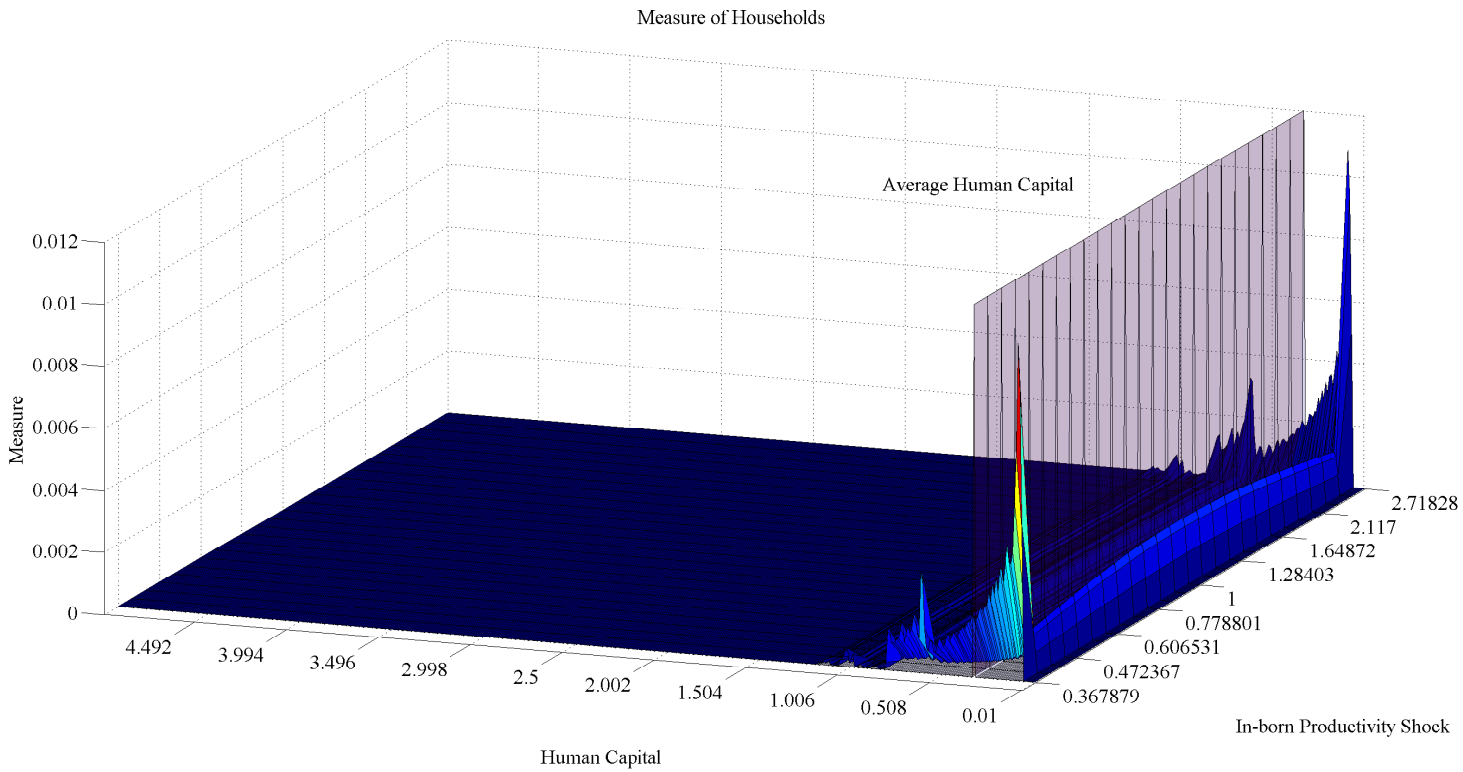


Figure: Stationary Distribution for the Nordic Economy

Consumption Equivalent Gains

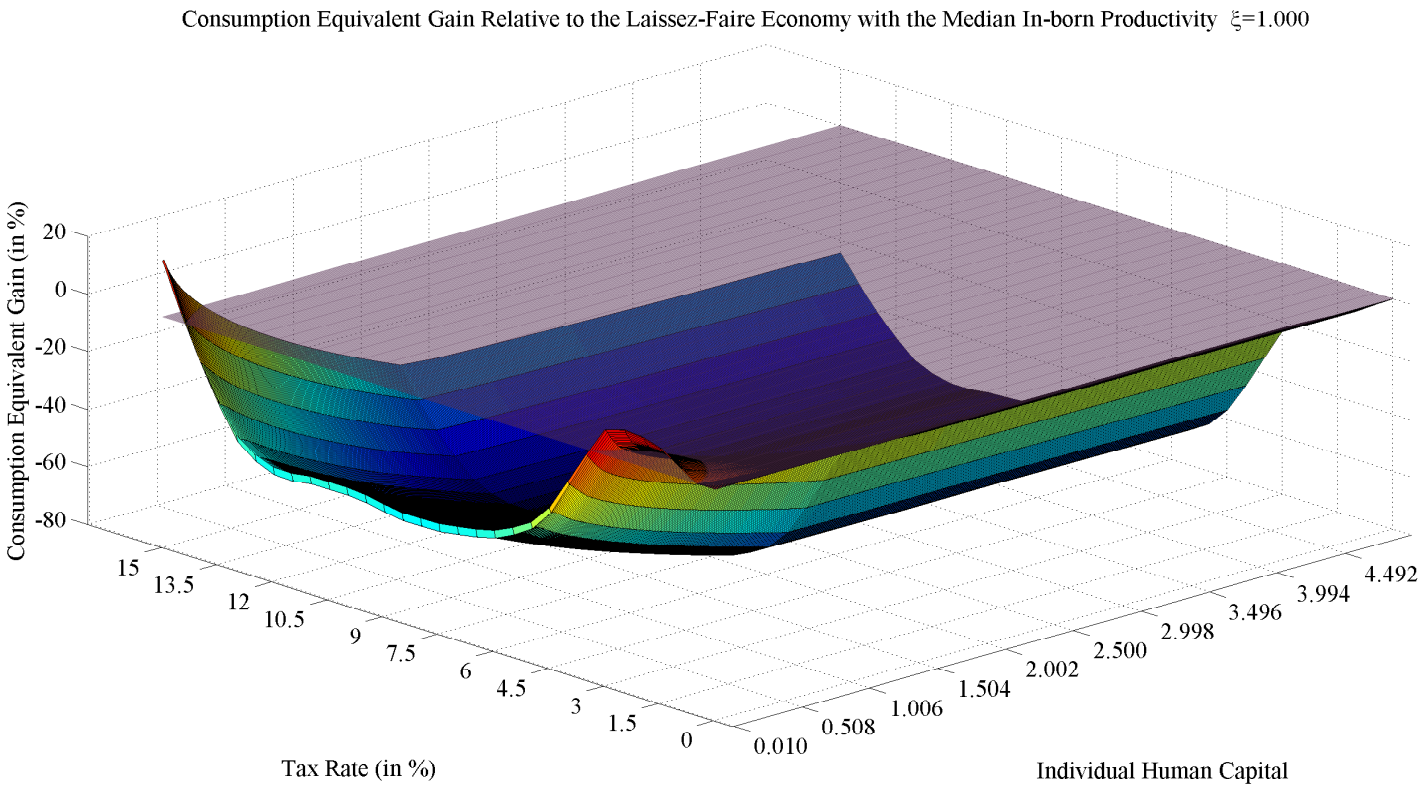


Figure: Consumption Equivalent Welfare Gains with Median Productivity

Consumption Equivalent Gains

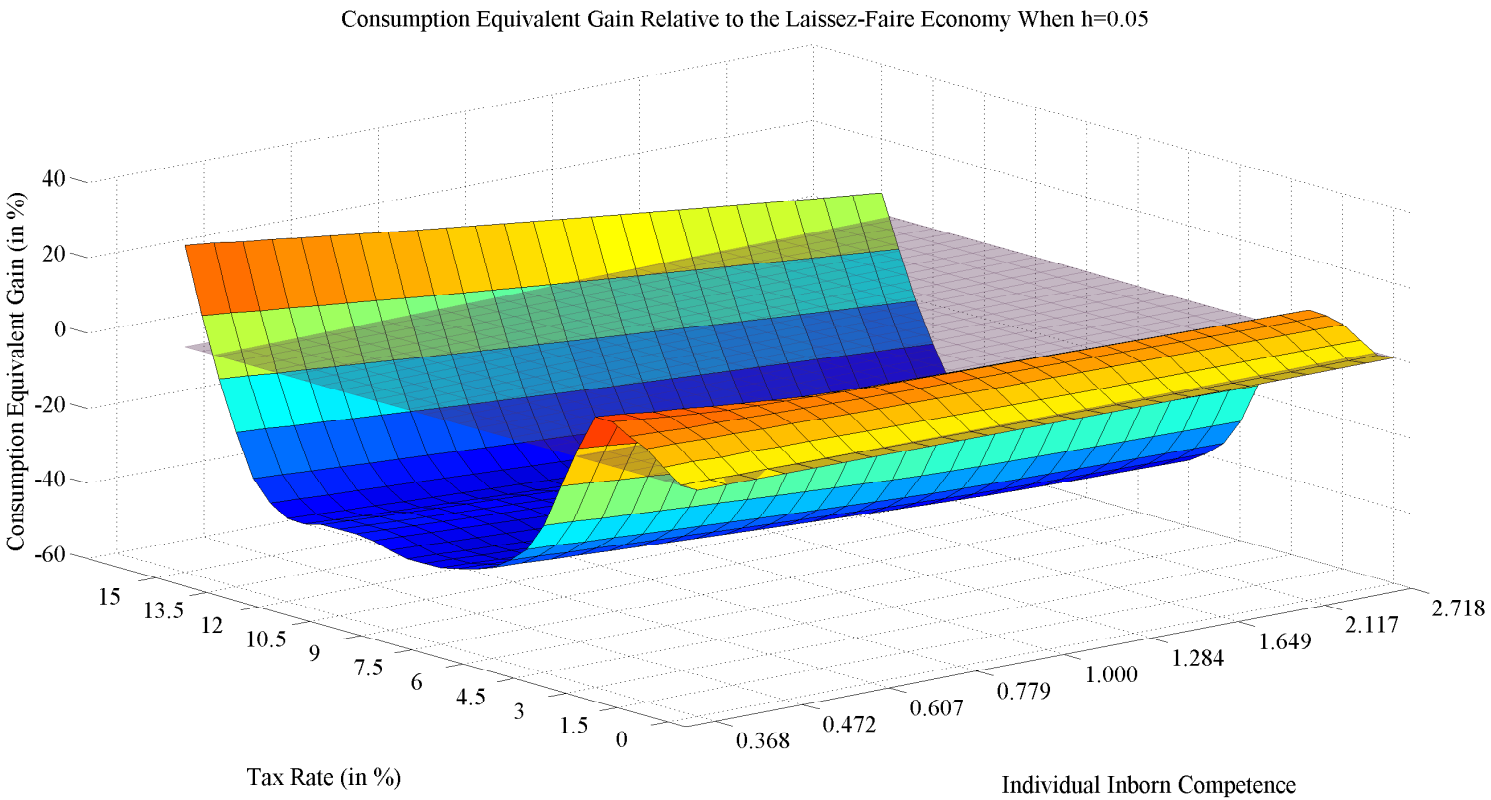


Figure: Consumption Equivalent Welfare Gains When $h = 0.05$

Consumption Equivalent Gains

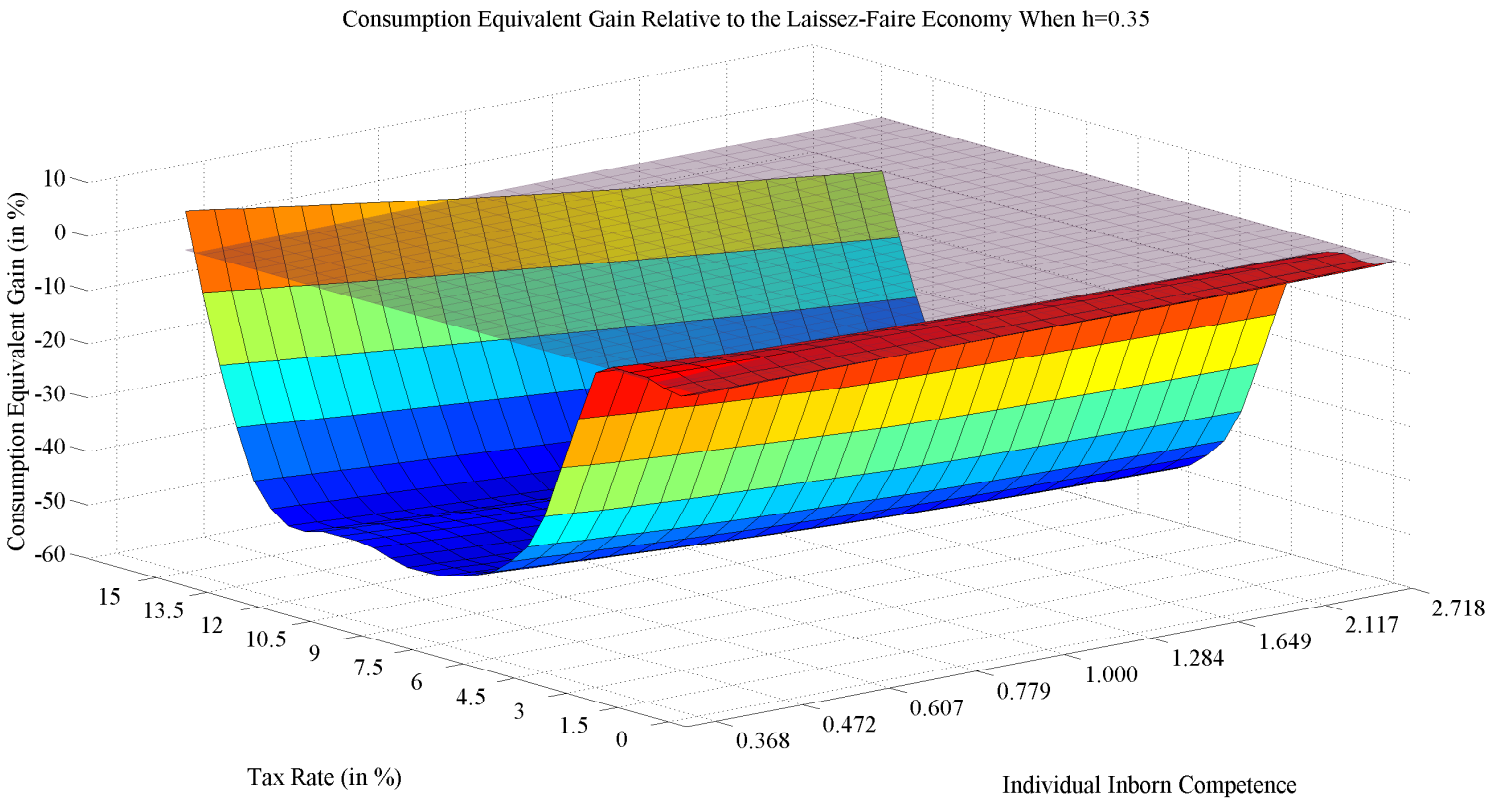


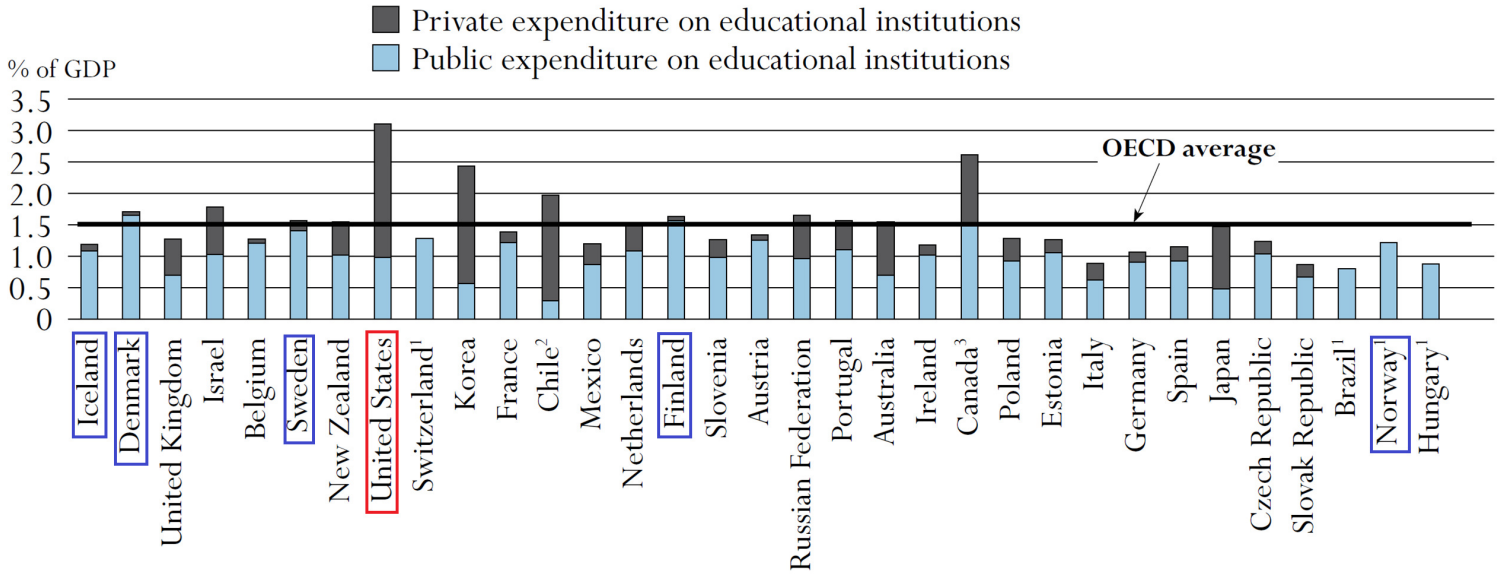
Figure: Consumption Equivalent Welfare Gains When $h = 0.35$

Conclusions

- A given tax rate difference of 7% alone can deliver structural differences on several accounts, without having to rely on differences in preferences, variations in deep structural parameters or other unorthodox elements.
- The proposed model generates a U-shape for macro variables over public education expenditure ratio and tax rate as in data, which enables majority of agents to have comparable life-time utility in both high and low tax rate regimes.
- Normatively, heavy reliance on either public or private education is preferable, but not taking the "middle road."

Composition of Higher Education Expenditure

Expenditure on Tertiary education as a percentage of GDP (2007)



1. Public expenditure only (for Switzerland, in tertiary education only).
2. Year of reference 2008.
3. Year of reference 2006.

Countries are ranked in descending order of expenditure from both public and private sources on educational institutions in primary, secondary and post-secondary non-tertiary education.

Source: OECD. Table B2.4. See Annex 3 for notes *(www.oecd.org/edu/eag2010)*.

▸ Higher Education

Public School Tuition Fees by Country

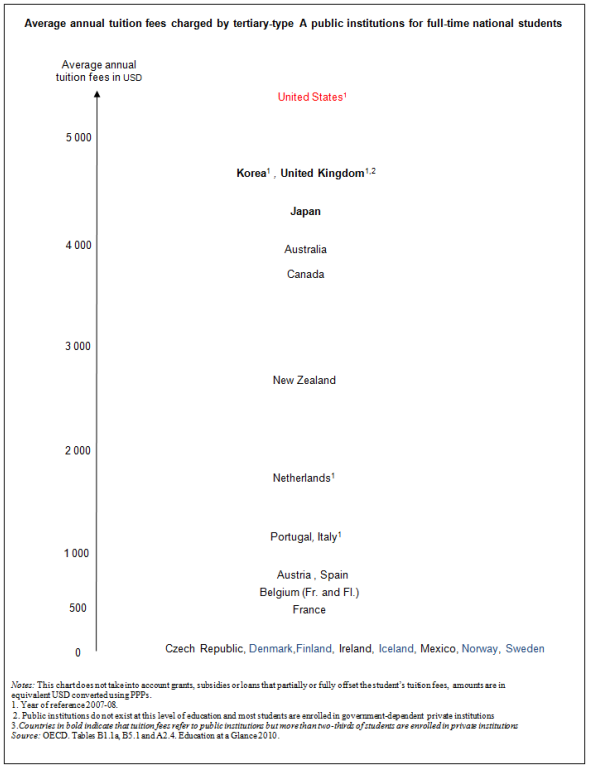


Figure: Average Public Tertiary Tuition Fees Across Countries

▸ Comparison of Education Systems ▸ Comparison of Tuition Fees

U.S. & Nordic Tuition Costs

Table: Comparison of Scandinavian and U.S. Tertiary Education Costs

	Average Public Institute Tuition	Average Private Institute Tuition	Average Tuition (Net of Subsidies)	Average Tuition/ Per-capita Income	Net Entry Rate in Higher Education
Denmark	$0	N/A	-$217	-0.59%	57%
Finland	$0	$0	-$300	-0.87%	71%
Iceland	$0	$4,253	$851	2.26%	73%
Norway	$0	$5,427	$150	0.27%	70%
Sweden	$0	$0	-$239	-0.63%	73%
Nordic Average	$0	$2,420	**$49**	**0.09%**	**69%**
USA	$5,493	$21,979	**$10,412**	**22.42%**	**65%**

Source: Education at a Glance 2010, OECD, and World Development Indicators database, 2010.

▸ Comparison of Education Systems ▸ Tuition Fees by Country

Dispersion on Educational Attainment

Table: Descriptive Statistics from International Adult Literacy Survey

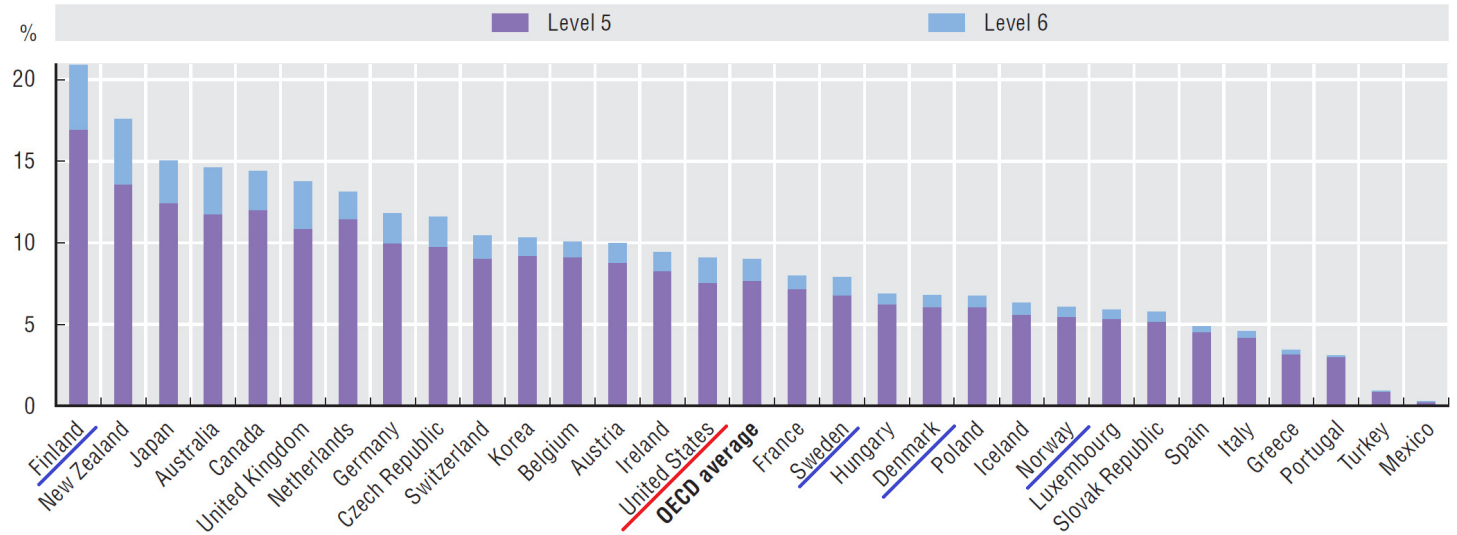
	Mean	Std. Dev.	Differential	
			50-10 Percentile	90-50 Percentile
Denmark	296.44	38.00	51.44	38.92
Finland	296.75	40.19	54.14	45.82
Norway	300.09	38.62	57.96	40.00
Sweden	311.60	46.37	57.63	52.03
Nordic Average	**301.22**	**40.80**	**55.29**	**44.19**
United States	**288.97**	**61.43**	**80.67**	**59.98**

Source: Blau and Kahn (2005, RES)

- "...the very best schools in the U.S. are extraordinary ... but the big concern in the U.S. is the *diversity* of quality of institutions."

Barry McGaw, (Director of Education for the OECD) on "Education at a Glance 2009: OECD Indicators" ▸ PISA Scores ▸ Educational Comparison

PISA Scores



Source: OECD (2009), *Education at a Glance 2009*, Chart A4.1, available at *http://dx.doi.org/10.1787/664076271473*.

Figure: PISA Level 5 and 6 Scores by Country

▸ Comparison of Educational Performance ▸ Educational Comparison

Distributional Properties

Table: Distributional Properties of the Benchmark Model

τ	$GINI_h$	$GINI_y$	$GINI_c$	$GINI_e$
0.00%	0.400	0.265	0.266	0.264
2.50%	0.400	0.266	0.262	0.263
4.78%	0.414	0.276	0.251	0.330
5.00%	0.414	0.276	0.249	0.332
7.50%	0.410	0.272	0.239	0.298
10.00%	0.400	0.264	0.239	0.194
11.78%	0.389	0.258	0.249	0.063
12.50%	0.382	0.253	0.251	0.017
15.00%	0.379	0.252	0.252	0.000

▸ Benchmark Results

▸ $Lorenz_h$ ▸ $Lorenz_y$ ▸ $Lorenz_c$ ▸ $Lorenz_e$

Lorenz Curve for Human Capital

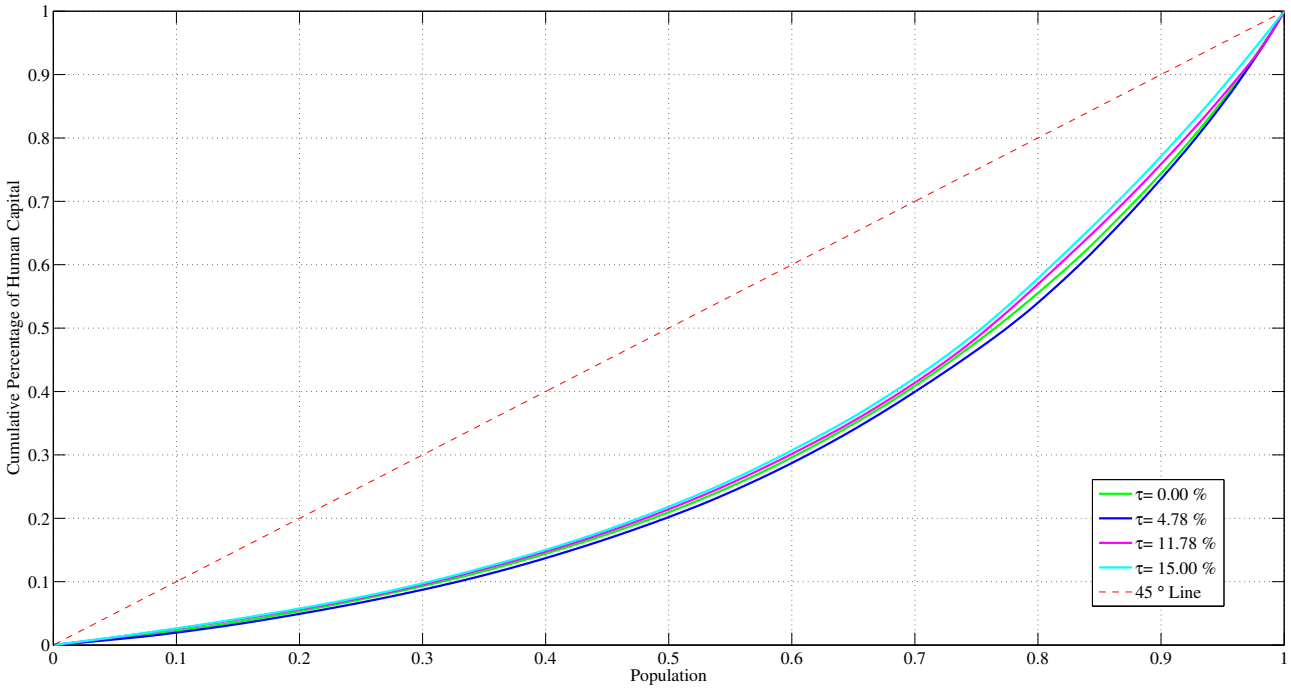


Figure: Lorenz Curve for Human Capital

▸ Distributional Properties ▸ $Lorenz_y$ ▸ $Lorenz_c$ ▸ $Lorenz_e$

Lorenz Curve for Output

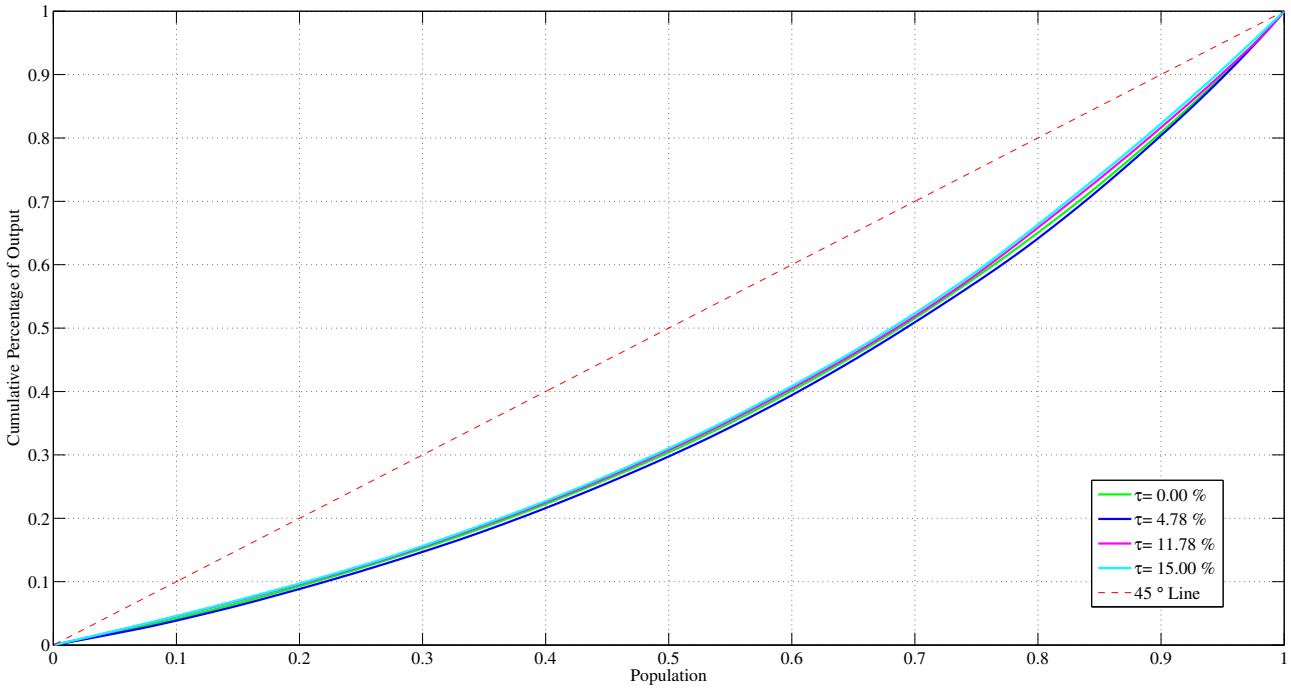


Figure: Lorenz Curve for Output

▸ Distributional Properties ▸ $Lorenz_h$ ▸ $Lorenz_c$ ▸ $Lorenz_e$

Lorenz Curve for Consumption

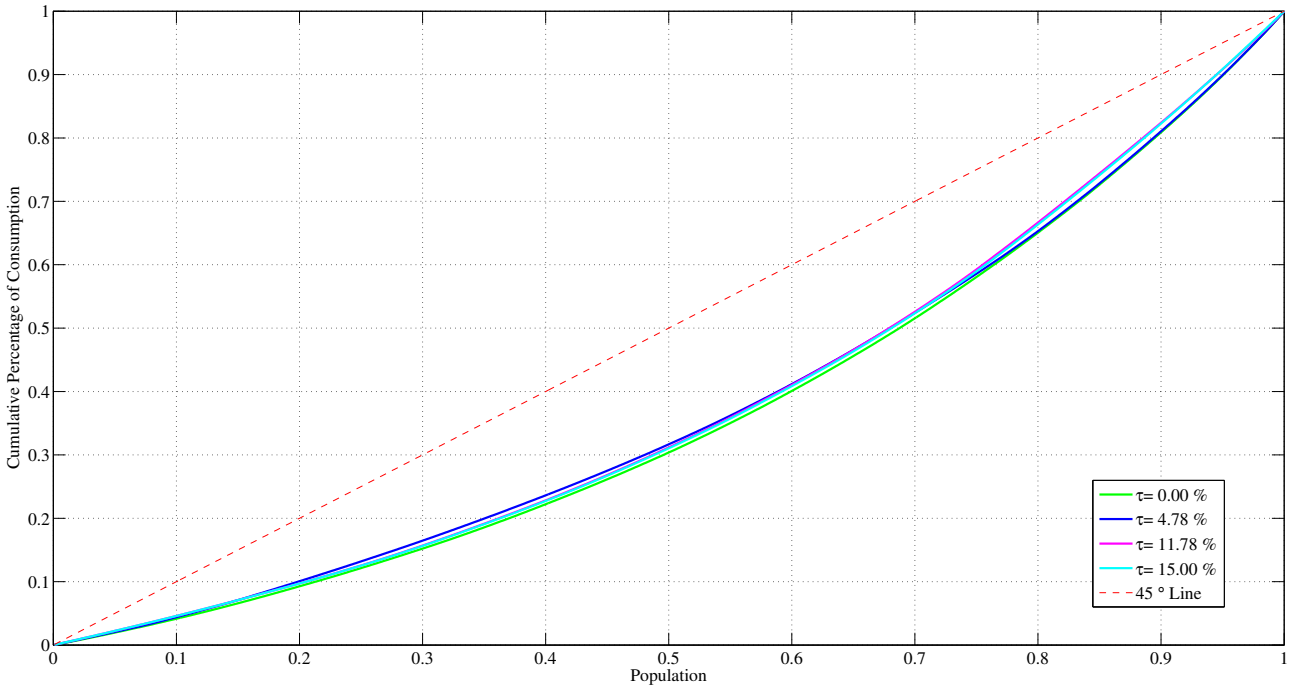


Figure: Lorenz Curve for Consumption

▸ Distributional Properties ▸ $Lorenz_h$ ▸ $Lorenz_y$ ▸ $Lorenz_e$

Lorenz Curve for Education

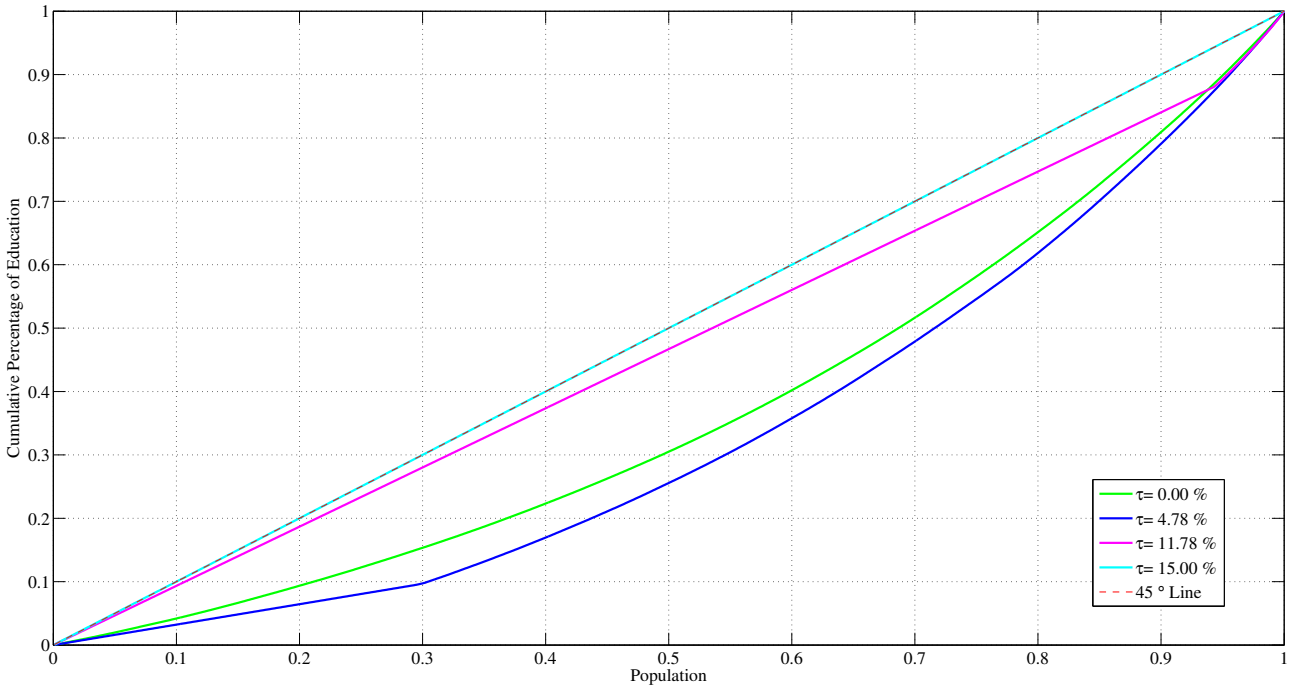


Figure: Lorenz Curve for Education

▸ Distributional Properties ▸ $Lorenz_h$ ▸ $Lorenz_y$ ▸ $Lorenz_c$

Alternative Spillover Rates of Public Education

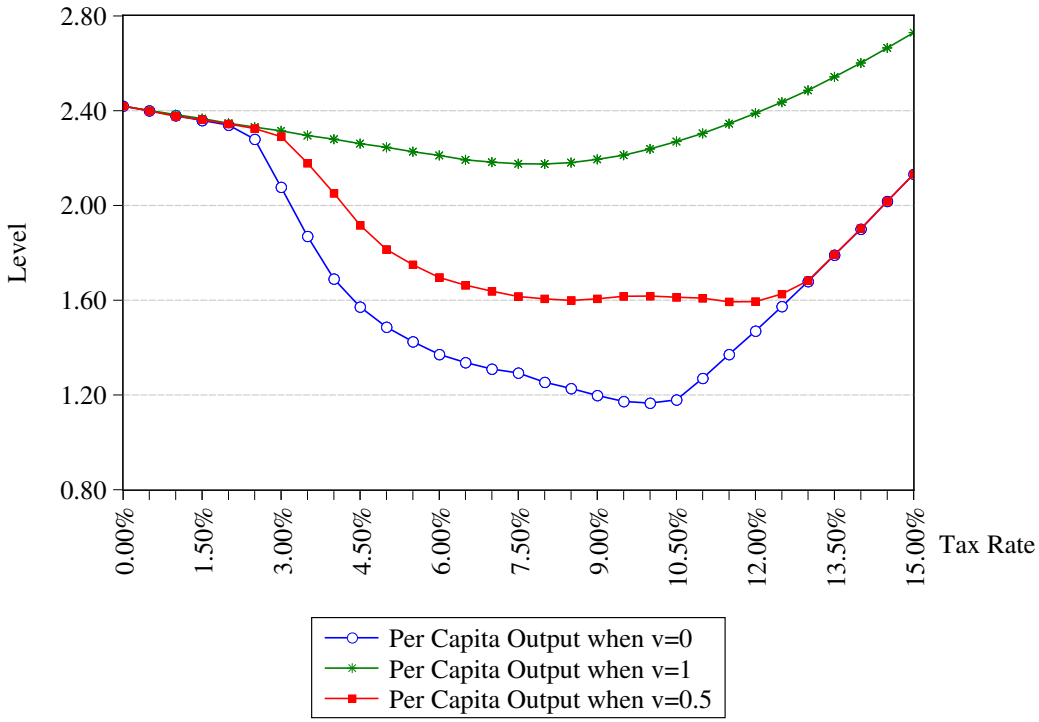
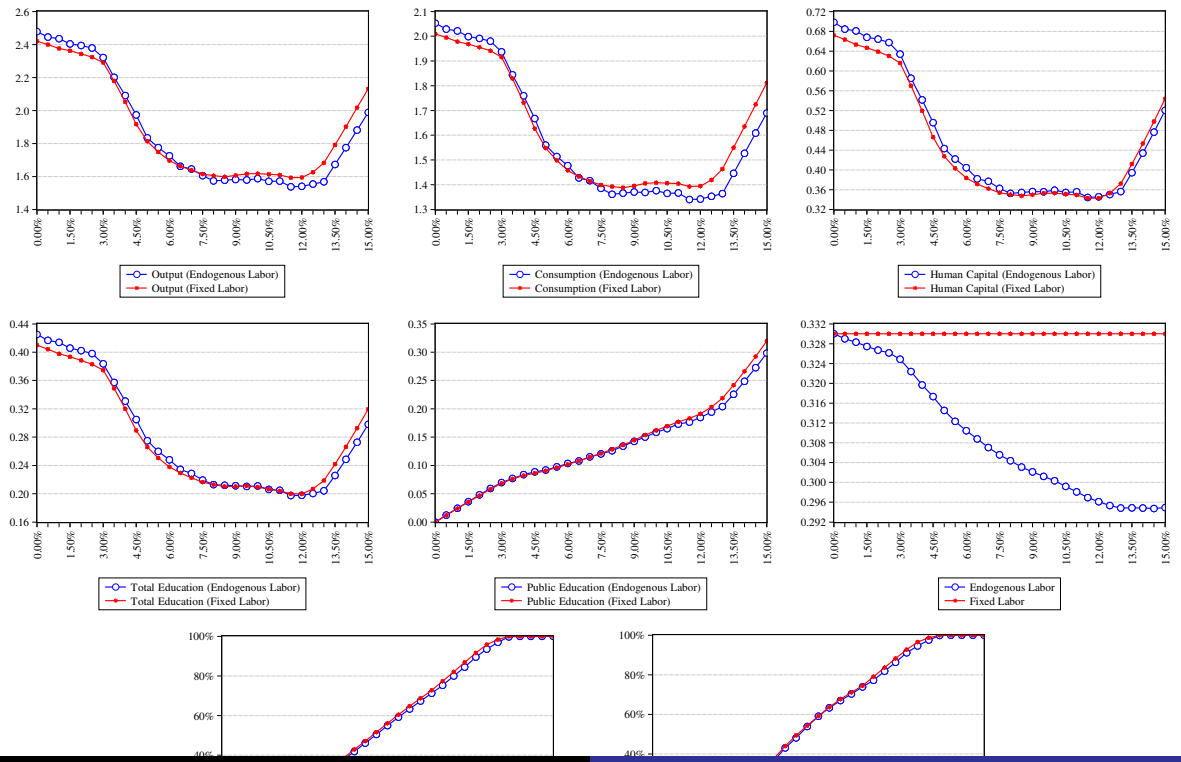


Figure: Comparison of Average Output with Different Spillover Rates

▸ Comparative Statics

Results with Endogenous Labor

- $u(c) + v(1 - l) = \log(c) - \phi \frac{l^{1+\omega}}{1+\omega}(l)$
- $\omega = 0.5 \rightarrow$ Frisch elasticity of labor supply $= 2$
- $\phi = 2.138 \rightarrow \overline{L} = 0.33$ when $\tau = 0$



Sensitivity Analysis

Table: High Complementarity ($\gamma = 0$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.971	3.060	2.600	0.460	0.000	0.00%	0.00%
4.78%	0.584	2.219	1.934	0.285	0.106	37.21%	35.55%
11.78%	0.614	2.303	2.032	0.271	0.271	100.00%	100.00%
15.00%	1.172	3.449	2.931	0.517	0.517	100.00%	100.00%

Table: Benchmark Model ($\gamma = 0.20$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.672	2.419	2.010	0.410	0.000	0.00%	0.00%
4.78%	0.441	1.851	1.577	0.275	0.089	32.27%	28.34%
11.78%	0.343	1.593	1.393	0.200	0.188	93.90%	94.65%
15.00%	0.544	2.131	1.812	0.320	0.320	100.00%	100.00%

▸ Comparative Statics

Sensitivity Analysis

Table: High Intergenerational Transmission ($\gamma = 1$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.431	1.646	1.111	0.535	0.000	0.00%	0.00%
4.78%	0.381	1.505	1.047	0.458	0.072	15.72%	16.47%
11.78%	0.258	1.156	0.844	0.312	0.136	43.61%	59.58%
15.00%	0.226	1.072	0.791	0.281	0.161	57.24%	72.35%

Table: Benchmark Model($\gamma = 0.20$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.672	2.419	2.010	0.410	0.000	0.00%	0.00%
4.78%	0.441	1.851	1.577	0.275	0.089	32.27%	28.34%
11.78%	0.343	1.593	1.393	0.200	0.188	93.90%	94.65%
15.00%	0.544	2.131	1.812	0.320	0.320	100.00%	100.00%

▸ Comparative Statics

Sensitivity Analysis

Table: High Return on Education ($\varepsilon = 0.33$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.770	2.632	2.145	0.488	0.000	0.00%	0.00%
4.78%	0.544	2.107	1.759	0.349	0.101	28.90%	21.55%
11.78%	0.386	1.712	1.478	0.234	0.202	86.07%	87.65%
15.00%	0.495	2.011	1.709	0.302	0.302	100.00%	100.00%

Table: Benchmark Model ($\varepsilon = 0.30$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.672	2.419	2.010	0.410	0.000	0.00%	0.00%
4.78%	0.441	1.851	1.577	0.275	0.089	32.27%	28.34%
11.78%	0.343	1.593	1.393	0.200	0.188	93.90%	94.65%
15.00%	0.544	2.131	1.812	0.320	0.320	100.00%	100.00%

▸ Comparative Statics

Sensitivity Analysis

Table: High Share of Human Capital in Production ($\lambda = 0.6875$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	1.017	3.378	2.749	0.629	0.000	0.00%	0.00%
4.78%	0.643	2.453	2.049	0.405	0.117	29.00%	25.98%
11.78%	0.511	2.108	1.807	0.301	0.248	82.34%	84.30%
15.00%	0.607	2.384	2.027	0.357	0.357	100.00%	100.00%

Table: Benchmark Model($\lambda = 0.625$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.672	2.419	2.010	0.410	0.000	0.00%	0.00%
4.78%	0.441	1.851	1.577	0.275	0.089	32.27%	28.34%
11.78%	0.343	1.593	1.393	0.200	0.188	93.90%	94.65%
15.00%	0.544	2.131	1.812	0.320	0.320	100.00%	100.00%

▸ Comparative Statics

Sensitivity Analysis

Table: No Idiosyncratic Shocks ($\sigma_\xi = 0$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.140	0.967	0.797	0.170	0.000	0.00%	0.00%
4.78%	0.112	0.838	0.703	0.135	0.040	29.62%	0.00%
11.78%	0.046	0.480	0.424	0.056	0.056	100.00%	100.00%
15.00%	0.094	0.752	0.639	0.113	0.113	100.00%	100.00%

Table: Benchmark Model ($\sigma_\xi = 1$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.672	2.419	2.010	0.410	0.000	0.00%	0.00%
4.78%	0.441	1.851	1.577	0.275	0.089	32.27%	28.34%
11.78%	0.343	1.593	1.393	0.200	0.188	93.90%	94.65%
15.00%	0.544	2.131	1.812	0.320	0.320	100.00%	100.00%

▸ Comparative Statics

Sensitivity Analysis

Table: High Persistence of Shocks ($\kappa = 0.40, \sigma_\xi = 1.19$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.078	0.605	0.500	0.106	0.000	0.00%	0.00%
4.78%	0.063	0.531	0.450	0.080	0.025	31.68%	31.08%
11.78%	0.051	0.463	0.395	0.068	0.054	80.34%	83.88%
15.00%	0.068	0.558	0.469	0.089	0.084	94.04%	94.60%

Table: Benchmark Model ($\kappa = 0, \sigma_\xi = 1$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.672	2.419	2.010	0.410	0.000	0.00%	0.00%
4.78%	0.441	1.851	1.577	0.275	0.089	32.27%	28.34%
11.78%	0.343	1.593	1.393	0.200	0.188	93.90%	94.65%
15.00%	0.544	2.131	1.812	0.320	0.320	100.00%	100.00%

▸ Comparative Statics

Sensitivity Analysis

Table: High Altruism ($\rho = 0.88$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.892	2.888	2.343	0.545	0.000	0.00%	0.00%
4.78%	0.636	2.327	1.934	0.394	0.111	28.28%	19.84%
11.78%	0.445	1.871	1.610	0.261	0.220	84.48%	85.96%
15.00%	0.547	2.140	1.819	0.321	0.321	100.00%	100.00%

Table: Benchmark Model ($\rho = 0.80$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.672	2.419	2.010	0.410	0.000	0.00%	0.00%
4.78%	0.441	1.851	1.577	0.275	0.089	32.27%	28.34%
11.78%	0.343	1.593	1.393	0.200	0.188	93.90%	94.65%
15.00%	0.544	2.131	1.812	0.320	0.320	100.00%	100.00%

▸ Comparative Statics

Sensitivity Analysis

Table: Low Labor ($\bar{l} = 0.297$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.645	2.266	1.882	0.384	0.000	0.00%	0.00%
4.78%	0.426	1.741	1.483	0.258	0.083	32.22%	27.80%
11.78%	0.330	1.495	1.308	0.187	0.176	93.99%	94.95%
15.00%	0.523	2.001	1.700	0.300	0.300	100.00%	100.00%

Table: Benchmark Model ($\bar{l} = 0.33$)

τ	$\overline{H}$	$\overline{Y}$	$\overline{C}$	$\overline{\mathcal{E}}$	$\overline{E}$	$\overline{E}/\overline{\mathcal{E}}$	$Pop._{\overline{E}}$
0.00%	0.672	2.419	2.010	0.410	0.000	0.00%	0.00%
4.78%	0.441	1.851	1.577	0.275	0.089	32.27%	28.34%
11.78%	0.343	1.593	1.393	0.200	0.188	93.90%	94.65%
15.00%	0.544	2.131	1.812	0.320	0.320	100.00%	100.00%

▸ Comparative Statics