Human Capital Spillovers and the Geography of Intergenerational Mobility

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Geographic Variation in Intergenerational Persistence.

- Intergenerational persistence varies across countries and regions.
- The usual story is persistence of worker characteristics
- Wages and earnings also depend on the distribution of job characteristics.
- Geographic variation of industrial composition will affect the wage distribution and possibly intergenerational persistence.
- **We focus on variation in skill complementarity, i.e. human capital spillovers.**

We do three things:

(1) We use a simple two-period example to illustrate the mechanism by which variation in human capital spillovers generates variation in intergenerational persistence.

(2) We provide descriptive evidence on the relationship between intergenerational persistence and skill complementarity.

(3) We develop a quantitative model that can be used to explore the importance of spillovers for variation in mobility.

Two-Generation Analytical Example.

- Two generations only. First period: both generations alive (adults and children)
- parent value function depends on own consumption and on child's value function

$$V_p(h_p) = \max_{c_p, h_c} \{u(c_p) + \beta \cdot V_c(h_c) \mid c_p + h_c = w(h_p))\}$$

- Second period: only younger cohort is alive

$$V_c(h_c) = \max_{c_c} \{u(c_c) \mid c_c = w(h_c))\}$$

  - Parent's human capital, h_p, is an endowment.
  - the child's human capital, h_c, is purchased by their parent.

Two-Generation Analytical Example: Production.

- We want to flexibly allow for spillovers in production. An extremely simple two-worker example would be $y = (h_1^\lambda + h_2^\lambda)^{\frac{1}{\lambda}}$.
- High-skilled workers gain by working together. High-skilled and low-skilled influence each other's productivity.
- With a continuum of workers:

$$y = \left(\int_{i \in I} h_i^\lambda \, di \right)^{\frac{1}{\lambda}}.$$

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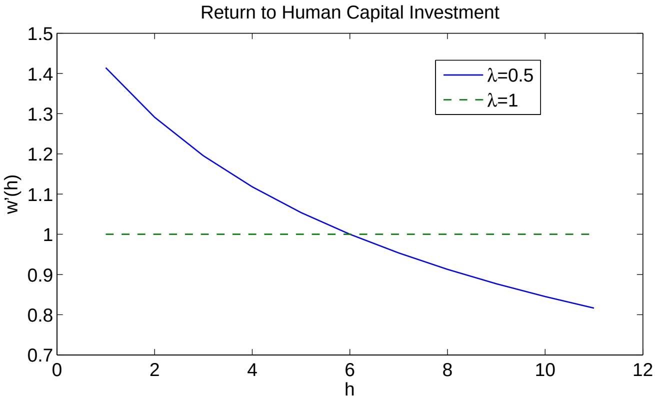
$$y = \left(\int_{i \in I} h_i^\lambda di\right)^{\frac{1}{\lambda}}.$$

- We assume a set H of possible human capital attainments, with density $q(h)$ at each level h:

$$y = \left(\int_{h \in H} q(h) h^\lambda dh\right)^{\frac{1}{\lambda}}.$$

The marginal return to human capital investments is the derivative of earnings w.r.t. h:

$$w'(h) = y^{1-\lambda} h^{\lambda-1}.$$



Intergenerational Earnings Elasticity

- The f.o.n.c. under log-utility $\Longrightarrow$ child's earnings when adult.

$$w(h_c^*) = \left(\frac{\beta\lambda}{1+\beta\lambda}\right)^{\lambda} \cdot y_c^{1-\lambda} \cdot w(h_p)^{\lambda}$$

– **Results**
  - ✓ elasticity of child's earnings w.r.t. to parent's depends on λ
  - ✓ Arguments for education subsidies in presence of HC spill-over apply. Larger spill-overs $\Rightarrow$ larger education subsidies.

link: constrained SPP example

Measuring Skill Complementarity

- Use industry-specific O*Net measures.
  - "depending on oneself to get things done."
  - "How responsible are you for work outcomes and results of other workers"
  - "Are you a member of a team?"
- Use them individually or extract common factor. Results are robust.

Country-specific skill complementarity measures:

step 1 → Compute O*Net complementarity index for each industry.

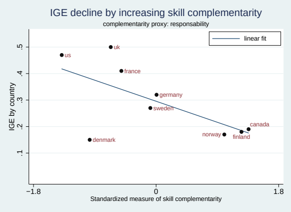
step 2 → Average industry scores using OECD industry size data as weights.

- Key assumption, which affects interpretation, is that skill complementarity within industries is similar across countries (indirectly testable).

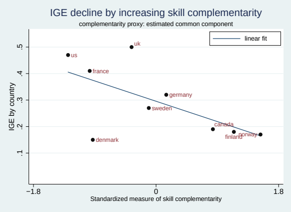
link: wage dispersion by industry

Note: at ISIC3 level, there are 31 industries. Weights are average shares between 2001 and 2005.

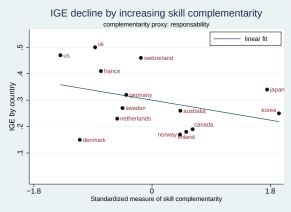
Figure: IGE vs Complementarity Index: ONET Measures.



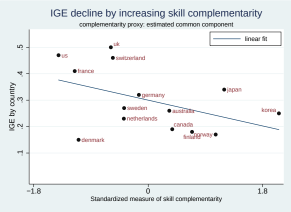
(a) Core Sample



(b) Core Sample



(c) Extended Sample



(d) Extended Sample

link: US commuting zone graphs

Richer Model: Assess Quantitative Importance.

- We develop a more elaborate OLG equilibrium model, including heritable traits, earnings risk, etc.
- The production side is designed to accommodate our industry level complementarity proxy data.

Household's Problem.

✓ Two period life: first as child, second as parent. Parental decision problem

- Parent and child overlap for one period. Parent has full information about child's inherited traits θ'
- Altruism weight on child's wellbeing (β)
- Progressive tax policy: proportional wage tax τ plus lump-sum transfer T

$$
\begin{aligned}
V(a, h, \theta', z) &= \max_{c,m} \left\{ \frac{c^{1-\sigma}}{1-\sigma} + \beta \cdot \mathbb{E}\left[V(a', h', \theta'', z') | \theta' \right] \right\} \\
s.t. & \\
c + m + a' &= z \cdot W(h) \cdot (1-\tau) + T + a(1+r) \\
h' &= \theta' (m+s)^{\psi} \\
\ln(\theta') &\sim N\left\{ \rho \ln(\theta), \sigma_{\eta}^2 \right\} \\
\ln(z') &\sim N\left\{ \mu_z, \sigma_z^2 \right\}
\end{aligned}
$$

- $\sigma = 2$, $\beta = 0.5$, $\sigma_z^2 = 0.4 * \sigma_y^2$.

Production.

- The production side consists of N sectors

$$y_n = k_n^{\alpha_n} \ell_n^{1-\alpha_n}$$

- Output of the final consumption good is aggregate of all sectoral output:

$$Y = \prod_{n=1}^{N} y_n^{\gamma_n}$$

- The goal is to do counterfactual experiments in which we vary $\{\gamma_n\}$ according to OECD output shares data.

Sorting.

- additional complexity: stable matching must account for fact that each worker's productivity depends on that of co-workers, and differently so in different industries
  - ✓ 'no-substitutability' assumption does not hold (Roth and Sotomayor, 1992)

- problem tractable under assumption of finite number of skills which change in discrete steps
  - ⇒ equilibrium allocation is solution to standard Kuhn-Tucker program
  - – solution of this constrained maximization problem describes sorting prevailing in equilibrium

Demand for Skills: Kuhn-Tucker Program.

- Our specification of human capital input with strategic complementarity is:

$$\ell_n = \left(\int_{I_n} z(i) \cdot h(i)^{\lambda_n} di \right)^{\frac{1}{\lambda_n}}$$

- An equivalent expression with a different integrand is:

$$\ell_n = \left[\int_H \left(\int_Z z dF(z) \right) q_n(h) \cdot h^{\lambda_n} dh \right]^{\frac{1}{\lambda_n}}$$

- Let H be a finite set of possible skill attainments, and $q_n(h)$ be the measure of workers with skill h in industry n.
- With finite and discrete set of skill levels the problem can be conceptualized as one in which a representative firm chooses $\{q_n(h)\}$ to maximize profit, taking $\{w(h, n)\}$ as given.

Demand for Skills: Kuhn-Tucker Program.

- aggregate technology as operated by a representative firm ⇒ profit maximization implies **complementary slackness conditions** for HC input

$$q_n(h) \cdot \left[\frac{\partial Y}{\partial q_n(h)} - w(h, n) \right] = 0$$

✓ workers with skill '*h*' paid their marginal product within an industry

✓ wage for skill-*h* workers,

$$w(h, n) = \gamma_n \cdot \frac{1 - \alpha_n}{\lambda_n} \cdot Y \cdot \left(\frac{h}{\ell_n} \right)^{\lambda_n}$$

✓ Workers with skill level h choose the industry with the highest $w(h, n)$.

▸ Equilibrium definition

A Sorting Result.

Industries characterized by relatively higher skill substitutability employ workers with relatively higher human capital.

Proposition: Suppose workers i and j have skill levels h_i and h_j, where $h_i > h_j$. If worker i is in industry 1 and worker j is in industry 2, then $\lambda_1 \geq \lambda_2$.

A Sorting Result.

Industries characterized by relatively higher skill substitutability employ workers with relatively higher human capital. Formally:

Proposition: Suppose workers i and j have skill levels h_i and h_j, where $h_i > h_j$. If worker i is in industry 1 and worker j is in industry 2, then $\lambda_1 \geq \lambda_2$.

In equilibrium workers choose industries where their wage will be the highest. Then $w(i,1) \geq w(i,2)$, and $w(j,1) \leq w(j,2)$. Therefore,

$$\frac{w(i,1)}{w(j,1)} \geq \frac{w(i,2)}{w(j,2)}.$$

Using the wage equations (labor demand) this implies

$$\left(\frac{h_i}{h_j}\right)^{\lambda_1} \geq \left(\frac{h_i}{h_j}\right)^{\lambda_2}.$$

Identification of λ_n parameters

- We use our O*Net measure as an indicator if variation in λ_n by specifying the relationship.

$$\lambda_n = a_0 + a_1 \cdot \text{O*Net}_n$$

- To identify a_0 and a_1 we use a theoretical relationship between the variance of log earnings and O*Net:

$$Var_n(\ln(y)) = Var(\ln(z)) + \lambda_n^2 Var_n(\ln(h))$$

Var of Earnings

- a_0 affects $Var_n(\ln(y))$ of every industry, and therefore $Var(\ln(y))$.
- a_1 affects the correlation between $Var_n(\ln(y))$ and O*Net_n:

$$Var_n(\ln(y)) = \hat{b}_0 + \hat{b}_1 \cdot \text{O*Net}$$

Implementation

– Indirect inference through *auxiliary* correlation restriction:

$$cov\left(Var_n(\ln(y)), \mathrm{ONet}_n\right) = \hat{b}_1$$

(1) First estimate targets for aggregate variance $Var(\ln(y))$ and $\hat{b}_1$

- For aggregate variance, $Var(\ln(y))$, we consider lifetime earnings and target 0.42 (see e.g. Bowlus and Robin, 2012).
- For $\hat{b}_1$ we use an estimate based on merged ONET-CPS data. $\hat{b}_1 = 0.56$

(2) Simulate model given initial guesses for a_0 and a_1, then compute the model counterparts of $Var(\ln(y))$ and $\hat{b}_1$.

(3a) If model $Var(\ln(y))$ is too low (high), then increase (decrease) guess of a_0

(3b) If model $\hat{b}_1$ is too low (high), then increase (decrease) guess of a_1.

(4) Repeat from (2) until convergence.

Industry	γ_n Industry Share	α_n Capital Share	λ_n Complementarity
Agriculture, Hunting, Forestry and Fishing	0.0102	0.6798	0.235
Basic Metals and Fabricated Metal Products	0.0137	0.276	0.339
Chemical, Rubber, Plastics and Fuel Products	0.0283	0.5506	0.524
Construction	0.0471	0.3364	0.491
Education	0.051	0.0847	0.970
Electrical and optical equipment	0.0167	0.0443	0.521
Electricity, gas, and water supply	0.0171	0.7094	0.458
Financial intermediation	0.0807	0.4726	0.842
Food products and beverages	0.0154	0.5724	0.270
Health and social work	0.0653	0.1862	0.955
Hotels and restaurants	0.0289	0.3825	0.273
Leather, leather products and footwear	0.0002	0.1633	0.538
Machinery and equipment, n.e.c.	0.0089	0.2689	0.435
Manufacturing n.e.c. and recycling	0.0085	0.3445	0.355
Mining	0.0125	0.6802	0.446
Motor vehicles, trailers and semi-trailers	0.0104	0.3107	0.228
Other community, social and personal services	0.0415	0.3894	0.670
Other non-metallic mineral products	0.0037	0.3573	0.506
Other transport equipment	0.0061	0.2907	0.350
Post and telecommunications	0.0305	0.4952	0.316
Printing and publishing	0.0146	0.2183	0.756
Public admin. and defence - social security	0.0792	0.204	0.694
Pulp, paper and paper products	0.0047	0.4002	0.390
Real estate activities	0.1132	0.9514	0.920
Renting of machinery and equipments	0.1294	0.3247	0.656
Textiles	0.0023	0.2079	0.397
Transport and Storage	0.029	0.3173	0.500
Wearing apparel, dressing and dyeing of fur	0.0012	0.347	0.243
Wholesale and retail trade - repairs	0.1258	0.4337	0.218
Wood and products of wood and cork	0.0026	0.2226	0.356

Decomposing Mobility: Counterfactuals.

- To assess the explanatory power of the skill-substitutability mechanism we perform counterfactual experiments to answer the following question:

  ✓ **How different would IGE in the U.S. be if its industrial composition was that of country "X", but all other features remained the same?**

Counterfactual Analysis: Results.

Country	Literature IGE Estimates	Data Relative to US	Experiment Relative to US	Policy Change Experiment
USA	0.47			
Core Sample				
Canada	0.19	-0.28	-0.072	-0.004
Denmark	0.15	-0.32	-0.033	-0.062
Finland	0.18	-0.29	-0.043	-0.054
France	0.41	-0.06	-0.019	-0.040
Norway	0.17	-0.30	-0.061	-0.062
Sweden	0.27	-0.20	-0.019	-0.060
Germany	0.32	-0.15	-0.069	-0.048
UK	0.5	+0.03	-0.030	-0.037
Correlation	–		0.509	0.204
Relative s.d.	–		0.171	0.160
Core + Sample				
Australia	0.26	-0.21	-0.059	+0.002
Japan	0.34	-0.13	-0.078	+0.006
Korea	0.25	-0.22	-0.057	+0.012
Netherlands	0.23	-0.24	-0.011	-0.051
Switzerland	0.46	-0.01	-0.029	+0.011
Correlation	–		0.428	0.285
Relative s.d.	–		0.205	0.260

Conclusions.

- ✓ We have developed a theory in which international differences in intergenerational mobility, the return to human capital investments, education policies and inequality arise endogenously.
- ✓ Skill complementarity and intergenerational mobility are correlated in international data.
- ✓ Differences in complementarity can explain 20% of international variation in IGEs. This is similar to what can be explained by differences in tax and education policies.

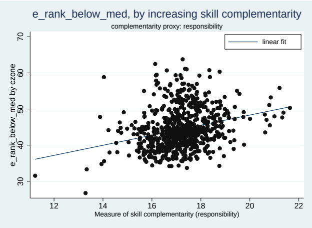
Identification and Estimation, continued

- Human capital and shocks ▸ Idiosyncratic risk ▸ Heritable traits
- Preferences and Government ▸ Preference parameters ▸ Government policies
- Industry shares ▸ Measuring industry shares
- Estimates ▸ Parameter values

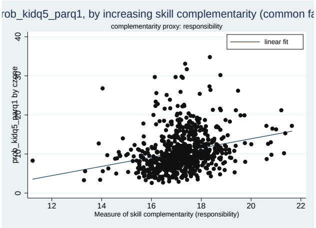
Equilibrium and Numerical Results

- Equilibrium ▸ Equilibrium definition
- Properties of the benchmark model ▸ Properties

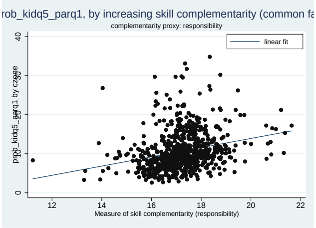
Figure: Measures of US mobility vs Complementarity Index. ONET proxy: responsibility for work outcomes of others.



(a) Expected rank



(b) Fifth quintile



(c) Slope of rank relation

Optimal Policy Example.

- Consider constrained SP problem where we maximize ex-ante welfare by choosing proportional HC subsidy, s, and proportional tax, τ

$$\max_{s,\tau} \int V_p(h_p; s, \tau) dF(h_p) \qquad \textit{subject to}$$

$$(1) \quad c_p + (1-s)h_c = (1-\tau) y_p^{1-\lambda} h_p^{\lambda} \qquad \textit{and} \qquad c_c = y_c^{1-\lambda} h_c^{\lambda}$$

$$(2) \quad \tau y_p = s \int h_c di$$

$$(3) \quad h_c = \frac{1-\tau}{1-s} \cdot \frac{\beta\lambda}{1+\beta\lambda} y_p^{1-\lambda} h_p^{\lambda}$$

$\Rightarrow$ After algebra, one gets

$$s^* = 1-\lambda$$

$$\tau^* = (1-\lambda)\frac{\beta}{1+\beta}$$

Back

Stationary Competitive Equilibrium.

An equilibrium is a collection of:

(i) decision rules $\{c(h, \theta', z), m(h, \theta', z)\}$ for consumption and HC investments, and value function $V(h, \theta', z)$;
(ii) Aggregate industry specific human capital attainment measures $\{q_n(h)\}$;
(iii) Wages $\{w(h)\}$;
(iv) and state-space measure μ; such that

such that the following is true:

- The decision rules solve the household optimization problem, and $V(h, \theta', z)$ is the associated value function.
- The representative firm optimally hires human and physical capital.
- Each skill-specific labor market clears

$$\sum_{n=1}^{N} q_n(h) \quad = \quad \int_{H\times\Theta\times Z} 1_h d\mu \;\; \forall \;\; h \in H$$

  where 1_h is an indicator function for the state variable h.
- The goods market clears:

$$Y = \int_{H\times\Theta\times Z} c(h, \theta', z) d\mu + \int_{H\times\Theta\times Z} m(h, \theta', z) d\mu + G$$

- The government budget constraint holds.
- Individual and aggregate behaviors are consistent: measure μ is the fixed point of $\mu(S) = Q(S, \mu)$ where (i) $Q(S, \cdot)$ is a transition function generated by the individual decision rules and the exogenous laws of motion for θ' and z; and (ii) S is the generic subset of the Borel-sigma algebra $\mathcal{B}_S$ defined over the state space $H \times \Theta \times Z$.

Method of Moments Estimates

Other parameters estimated via SMM.

- **Idiosyncratic income risk.** Storesletten et al. (2004) suggest post market-entry factors account for 40% of income variation in U.S. data, which we adopt as a target. This is achieved precisely by setting σ_z^2 appropriately. Given σ_z^2, the mean of log income risk, μ_z, can be set so that the mean of the level of z is unity.

- **Human capital production.** Skill formation technology specified as:

$$h' = \theta'(m + s)^{\psi}.$$

Elasticity of human capital to expenditures, determined by ψ, regulates how much parents will spend on child's human capital. To identify ψ we use proportion of GDP spent on eduction by private households. According to OECD data this was 2.3% of GDP in 2010.

Preferences and Taxes.

- **Preferences.** CRRA with $\sigma = 2$; discount factor set to $\beta = 0.5$
  - discount factor reflects time gap between child's and parent's outcomes. Based on 25 year gap, annualized discount factor is 0.972
- **Government.** Marginal tax rate: $\tau = 0.27$; lump-sum tax rebate to match progressivity of U.S. tax policy
  - given τ, transfer T replicates ratio of the variance of log net-income to the variance of log gross-income (0.61 in the data)
  - Parameter T solves:

$$\frac{Var\left(\ln\left[(1-\tau)\cdot z\cdot w(h)+T\right]\right)}{Var\left(\ln\left[z\cdot w(h)\right]\right)} = 0.61$$

Law of Motion for Heritable Traits.

- **Transmission of Heritable Traits.** Persistence of heritable traits influences degree of intergenerational income mobility

$$\ln(\theta') = \rho \ln(\theta) + \eta$$

  – high $\rho \Rightarrow$ parents and children share similar advantages in HC production

  $\Longrightarrow$ ceteris paribus, IGE comoves with persistence of heritable traits

- How to identify variance of heritable trait shocks, σ_η^2?
  - use subtle information from income quintile transition matrices
  - Jannti et al. (2006) propose measure of mobility based on trace of $(k \times k)$ transition matrix, P_k:

$$M_T = \frac{k - tr(P_k)}{k - 1}$$

  - statistic M_T provides information about off-diagonal transitions

  $\Longrightarrow$ dispersion of heritable traits estimated by replicating $M_T = 0.86$ (for U.S.)

Summary of Parametrization (except industry level parameters).

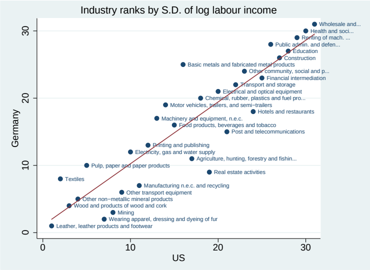
Table: This table reports parameters, except industry-technology shares and elasticities.

Parameter	Notation	Value
Calibrated		
Idiosyncratic Risk Variance	σ_z^2	0.070
Idiosyncratic Risk Mean	μ_z	-0.035
Heritable Trait Persistence	ρ	0.429
Heritable Trait Variation	σ_η^2	0.362
Human Capital Production Weight	ψ	0.254
Substitution Parameter Constant	a_1	0.504
Substitution Parameter Slope	a_2	1.801
Fixed		
Intergenerational Discount Factor	β	0.5
CRRA Parameter	σ	2.0
Net Annualized Interest Rate	r	0.03
Annualized Depreciation Rate	δ	0.06

Industry Technology: Shares and Capital Intensity.

- **Industry-specific physical capital.** Physical capital intensity in each industry depends on capital share α_n and on (exogenous) gross return on capital $r + \delta$
  - set depreciation and real interest rates so that annualized values are 6.0% and 3.0%
  - $\Longrightarrow$ industry-specific share of output paid to capital is measured using OECD STAN data and is set equal to α_n
- **Industry-specific weights.** Share of aggregate output paid to each industry equal to weight of that industry, γ_n.
  - thus, aggregation weights parameterized by setting them equal to share of total output attributed to each industry
  - $\Longrightarrow$ measures taken from STAN OECD data (averages across years 2001 to 2005)

Figure: US vs Germany: industry ranked by dispersion. ”Residual” refers to unexplained variation after controlling for industry, education, age, sex, region (state or province), and year.



(a) Log labour income dispersion ranks

(b) Log labour income residual dispersion ranks

Comparison of Optimal Policies

Ramsey planning problem with choice of s and τ to maximize ex-ante average utility under a balanced budget restriction. We do this four times under different industry compositions.

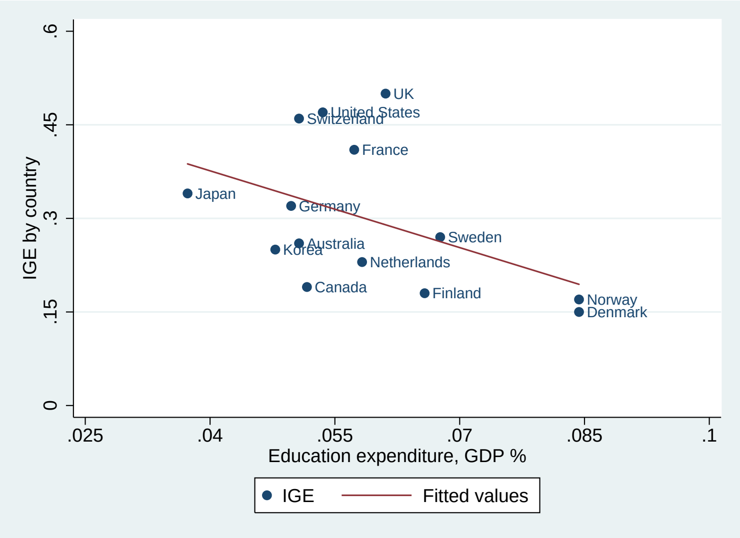
Country	Tax Rate (τ)	Education Subsidy (GDP ratio)
United States	32.36%	8.84%
Canada	34.17%	11.45%
Norway	35.65%	13.71%
Finland	34.09%	10.76%
Actual Policies		
United States	29.60%	5.5%
Canada	30.80%	5.3%
Norway	37.60%	8.8%
Finland	42.50%	6.8%

Public education expenditure levels and labor income tax burdens, OECD data.

Table: Column 2 reports % of GDP spent (all levels of government) on education. Column 3 reports % of labor earnings paid as income/payroll taxes or social security contributions. Source: OECD.

Country	Public Education Spending as % of GDP	Taxes as % of Labor Income
Core Sample		
United States	5.5%	29.6%
Canada	5.3%	30.8%
Denmark	8.8%	38.6%
Finland	6.8%	42.5%
France	5.9%	50.2%
Norway	8.8%	37.6%
Sweden	7.0%	42.8%
Germany	5.1%*	49.7%
UK	6.3%	32.3%
Core + 5 Sample		
Australia	5.2%	27.2%
Japan	3.8%	31.2%
Korea	4.9%	21.0%
Netherlands	6.0%	38.6%
Switzerland	5.2%	21.5%

IGE vs education expenditure (as a share of GDP).



Some properties of the benchmark equilibrium.

- **Sources of Persistence.** Exogenous persistence due to heritable traits across generations ⇒ quantify these effects by eliminating persistence of heritable traits, holding dispersion constant.

✓ In equilibrium, US IGE reduced to 0.324: about 1/3 of intergenerational persistence due to exogenous transmission of traits. Unexplained 2/3: endogenous persistence due to human capital investments.

- **A Validation Result.** Restuccia and Urrutia (2004) find that a 20% increase in education spending as a fraction of GDP is associated to a 5.8% in IGE (US data). The equivalent effect in our benchmark economy is 6.1%.

VarIdentification of Complementarity Parameters (λ_n)

- $$w(h, n) = \gamma_n \cdot \frac{1 - \alpha_n}{\lambda_n} \cdot Y \cdot \left(\frac{h}{\ell_n}\right)^{\lambda_n}$$
- $$\ln(z \cdot w(h)) = \ln\left[\gamma_n \frac{1 - \alpha_n}{\lambda_n} Y \left(\frac{1}{\ell_n}\right)^{\lambda_n}\right] + \ln(z) + \lambda_n \cdot \ln(h)$$
   - variance of wages within industry n (Var_n) is

$$Var_n(\ln(y)) = Var(\ln(z)) + \lambda_n^2 \cdot Var(\ln(h))$$

Back