The DNA of Enterprise: A Life-Cycle Model of Intergenerational Entrepreneurship

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Motivation: The Persistence of Entrepreneurship

- **The Fact:**
  - In the UK, 93% of private-sector firms are family businesses. (the Longitudinal Small Business Survey)
  - Children of entrepreneurs are at least twice as likely to become entrepreneurs compared to children of paid employees.
- **The Puzzle:** What drives this intergenerational persistence?

Opening the "Black Box" of Ability

- **The Limitation of Standard Models:** Standard economic models attribute persistence to *wealth* and *investment*. Initial ability is often treated as an unobserved, random residual.(De Nardi, 2004; Cagetti and De Nardi, 2006; Hamilton et al., 2019)
- **The Opportunity:** Recent advances in Genoeconomics (Polygenic Scores) allow us to measure these **genetic endowments** directly, moving from a "black box" residual to an observable mechanism. (Papageorge and Thom, 2020; Barth et al., 2022)

Model Framework: A Structural Approach

- We build an overlapping-generations (OLG) model in which individuals make choices on parental investment, inter-vivos transfers, occupation (worker vs. entrepreneur), and savings.

- The model unifies four channels of intergenerational transmission:
  - Genetic heritability: children inherit parental genes.
  - Nature via nurture: parental investments and type formation before labor-market entry.
  - Persistent shocks: business ideas and family social capital are partially passed across generations.
  - Wealth transfers: inter-vivos transfers relax collateral constraints for entrepreneurial capital.
- Through which channels do genetic endowments shape entrepreneurial entry, success, and their **intergenerational persistence**?

Preview of Key Findings

1. **Multidimensional Genetic Drivers**
   - Entrepreneurial success is not monogenic.
   - Both **Risk Tolerance (RT)** and **Educational Attainment (EA)** endowments are distinct, significant predictors of entry and earnings.

2. **Genetics Drive Intergenerational Persistence**
   - Ignoring genetic heterogeneity understates the Intergenerational Elasticity of Income (IGE) by **4%** and entrepreneurship persistence by **9%**.

3. **Policy Triggers Selection and Spillovers**
   - **Negative Selection:** Relaxing borrowing constraints lowers entry barriers, encouraging genetically "marginal" types to enter.
   - **Intergenerational Spillover:** Parents respond to this policy by increasing human capital investment, largely mitigating the entrants' initial genetic disadvantage.

Data

1. **Understanding Society (UKHLS):**
   - Our primary dataset for life-cycle analysis.
   - Rich data on occupation, income, savings, and parent–child links.
   - Crucially, contains **genetic data** for $\sim$ 10,000 individuals, including 970 parent–child pairs.

2. **National Child Development Study (NCDS):**
   - Follows a cohort born in 1958.
   - Provides detailed measures of **childhood parental investment** and skill development.
   - Also contains genetic data for the cohort members.

Polygenic Score (PGS): Construction

- A PGS is a cumulative index summarizing an individual's genotype-effect-size weighted contributions across all SNPs.
- For each individual i in our target samples (NCDS and Understanding Society):

$$PGS_i^y = \sum_{j=1}^{J} \beta_j^* G_{ij},$$

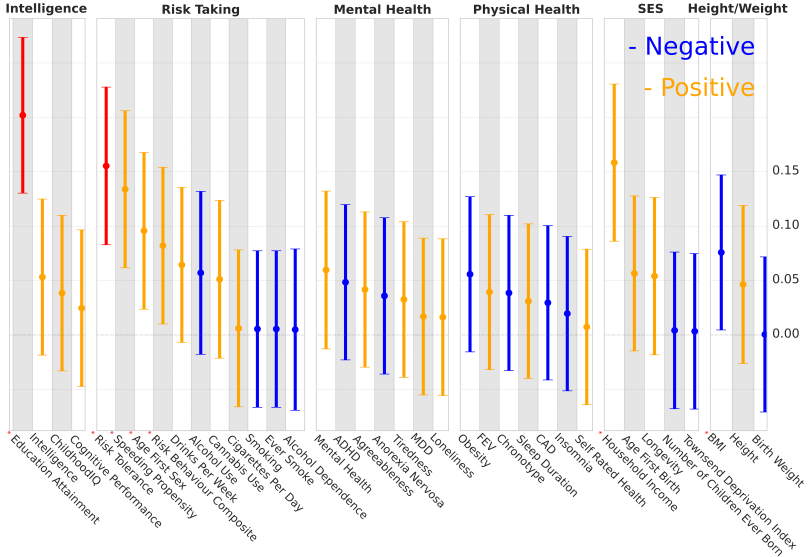
where β_j^* is the GWAS effect size and G_{ij} is the allele dosage.

- We examine which PGS predicts entrepreneurial entry using:

$$\mathbb{1}_{\text{entrepreneur}} = \alpha_0^y + \alpha_1^y PGS_i^y + \alpha_2^y PC_i + \alpha_3^y SEX_i + \epsilon_i^y.$$

note: PC = a vector of top 10 principal components

Which PGS Predicts Entrepreneurship?



Determinants of Entrepreneurship and Earnings

	Ever an Entrepreneur			Log Earnings: All Workers			Log Earnings: Entrepreneurs		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PGS_{edu}	0.011***	0.008**	0.004	0.078***	0.023***	0.018***	0.121***	0.061***	0.065***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.021)	(0.021)	(0.022)
PGS_{risk}	0.009**	0.007*	0.007*	0.006**	-0.006**	-0.008***	0.075***	0.066***	0.067***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.020)	(0.020)	(0.021)
Family SES controls	No	No	Yes	No	No	Yes	No	No	Yes
Observations	7,118	7,118	7,118	127,900	127,900	127,900	3,722	3,722	3,722

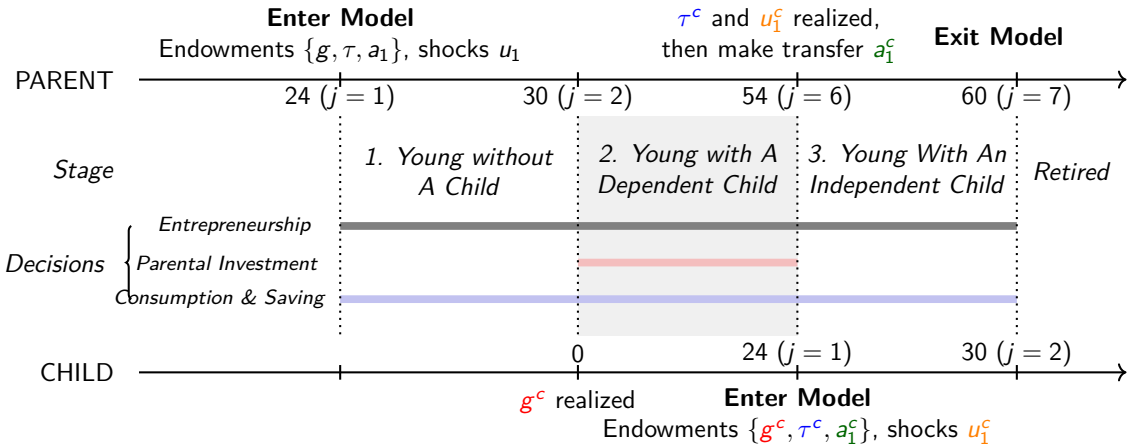
Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Model: Settings

The state space includes genes (g, g^c), pre-market type (τ), assets (a_j), and two occupation-specific shocks $u_j = (u_{j,W}, u_{j,E})$.

1. **Genes**
   - Two polygenic scores: Educational Attainment (EA) and Risk Tolerance (RT).
   - Four genetic types: (H,H), (H,L), (L,H), (L,L).
   - Child genes are inherited as $g_c \sim G(\cdot \mid g)$.
2. **Assets** (a_j)
   - Overlapping-generations structure: parents retire and exit as the child enters adulthood.
   - Upon exit, parents make a wealth transfer, which becomes the child's initial asset position.
3. **Occupation-specific shocks** $u_j = (u_{j,W}, u_{j,E})$
   - $u_{j,E}$: entrepreneurial shock capturing business ideas, family social capital, and network advantage.
   - $u_{j,W}$: worker shock capturing unobserved productivity in paid employment (e.g., family "dining-table" human capital).

Model: Timeline



Pre-market type (τ) and Formation

Summarizing pre-market types at age 24. Realized education and risk-taking serve as mediating phenotypes. Pre-market types arise through a nature–nurture interaction:

$$\Lambda\left(\underbrace{\tau^c}_{\text{child type}} \,\middle|\, \underbrace{g}_{\text{parent genes}}, \underbrace{g^c}_{\text{child genes}}, \underbrace{\text{inv}}_{\text{parental investment}}, \underbrace{\tau}_{\text{parent type}}\right).$$

Channels shaping pre-market type τ^c

- **Direct genetic transmission** g^c; **Genetic nurturing** g; **Active G-E interaction** (inv); **Passive G-E interaction** (τ).

Earning Process: Worker

$$y_{j,W} = \underbrace{w}_{\text{per–unit price}} \overbrace{f_{j,W}\left(\underbrace{g}_{\text{Gene}}, \underbrace{\tau}_{\text{Pre-market type}}, \underbrace{u_{j,W}}_{\text{Persistent shock}}\right)}^{\text{efficient units of worker ability}}$$

Three channels of intergenerational earnings persistence (worker)

- **Direct genetic channel**: transmission of the child's genetic endowment g.
- **Nature–nurture (investment) channel**: the child's pre-market type τ^c.
- **Worker-specific shocks**: "dining table" human capital and information running within the family, modelled as

$$u_{j,W} = \rho_W \, u_{j-1,W} + \eta_{j,W},$$

with the initial shock inherited from the parent $u^c_{1,W} = \rho^c_W \, u_{6,W} + \epsilon_W$.

Earnings Process: Entrepreneur

$$y_{j,E} = \max_{0 \le k_j \le \bar{a}_j} \left\{ \underbrace{P}_{\text{per–unit productivity}} \overbrace{f_E\left(\underbrace{g}_{\text{Gene}}, \underbrace{\tau}_{\text{Pre-market type}}, \underbrace{u_{j,E}}_{\text{Persistent shock}} \right) k_j^{\nu}}^{\text{efficient units of entrepreneurial ability}} - (r+\delta)k_j \right\}$$

Four channels of intergenerational earnings persistence

- **Direct genetic channel** g and **Nature-nurture interaction** τ.
- **Entrepreneur-specific shocks** (business idea/social capital):

$$u_{j,E} = \rho_E \, u_{j-1,E} + \eta_{j,E},$$

  with the initial shock inherited from the parent $u^c_{1,E} = \rho^c_E \, u_{6,E} + \epsilon_W$.
- **Inter-vivos transfer**: parental support a^c_1 for entrepreneurial capital $k_j \in [0, \bar{a}_j]$, with borrow constraint $\bar{a}_j - a_j \le \lambda a_j$.

Untargeted Moment Fit: Intergenerational Indicators & Wealth

Metric	Model	Data
IGE of earnings	0.45	0.35–0.45
IGE of consumption	0.48	0.50
IG correlation of type	0.23	0.21
Wealth Gini	0.56	0.60
Top 10% Wealth Share	0.40	0.43

Quantitative Exercise 1: How Much Does Genetic Heterogeneity Drive Intergenerational Persistence?

Genetic endowments affect intergenerational persistence through two channels:

- **Direct channel (type formation):** $\tau^c = \Lambda(g,\, g^c,\, \tau,\, inv)$.
- **Indirect channel (earnings):** Genetic traits affect productivity in $y_{j,W}$ and $y_{j,E}$.

Exercise: Set $g = \bar{g}$ and $g^c = \bar{g}^{\,c}$ to eliminate all individual heterogeneity arising from genetic endowments.

Quantitative Exercise 1: Results

Metrics	Benchmark	No genetic heterogeneity	Change (%)
Intergenerational Elasticity of Income (IGE)	0.446	0.428	−4.1%
Intergenerational correlation of type	0.226	0.184	−18.6%
Entrepreneur parents → Entrepreneur children	8.18%	7.45%	−8.9%
Worker parents → Entrepreneur children	3.33%	2.77%	−16.8%
Wealth Gini	0.56	0.55	−1.2%

Intuition

- Removing genetic heterogeneity reduces intergenerational persistence.
- The drop in "worker → entrepreneur" transitions shows the role of the genetic lottery in enabling entry from non-entrepreneurial families.

Quantitative Exercise 2: What Does the Model Miss Without Genetic Heterogeneity?

We re-estimate a nested version of the model that removes all genetic effects.

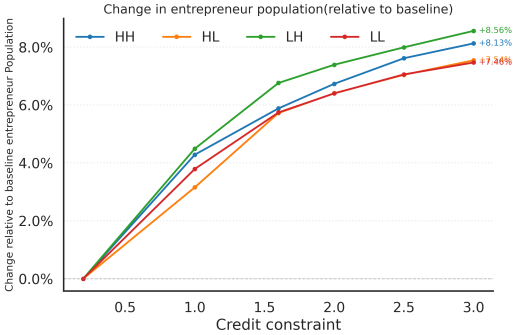
	With Genetics	Without Genetics
Persistence of Ability Shocks		
Intergenerational persistence of worker shock (ρ_W^c)	0.004	0.150 ↑
Intergenerational persistence of entrepreneur shock (ρ_E^c)	0.905	0.850 ↓
Production Function Parameters		
Return to high type in entrepreneur production ($\beta_{2,E}$)	0.364	0.461 ↑
Return to entrepreneurial capital (ν)	0.512	0.528 ↑

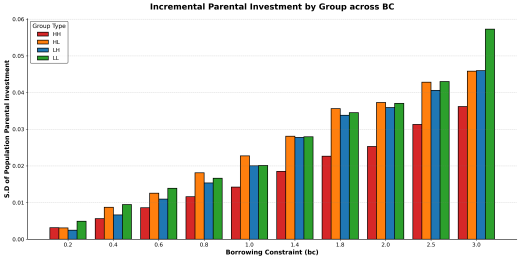
- Without genes, persistent shocks absorb the missing transmission ($\rho_W^c \uparrow$).
- Business-idea persistence becomes understated ($\rho_E^c \downarrow$).
- Without genetic heterogeneity, the model struggles to generate the fat right tail of the wealth distribution.

Counterfactual Experiment: Relaxing Credit Constraints

- **Policy:** Government provides additional guarantees that relax the collateral constraint on entrepreneurial borrowing (increase in λ).
- **Expectation:**
  1. Existing entrepreneurs are less likely to be credit constrained.
  2. More individuals enter entrepreneurship.
  3. Parents increase investment in their children to better prepare them for entrepreneurship.

Counterfactual Experiment: Results





Left: Entrepreneurship share increases.
Right: Parental investment increases (Compensatory Nurture).

Key Takeaways

- **Genetic Foundations of Mobility:** Genetic endowments are a fundamental, quantifiable driver of entrepreneurial selection, distinct from pure wealth transmission or environmental luck.

- **Bias from Omission:** Ignoring genetic heterogeneity distorts structural estimates: it inflates the perceived returns to entrepreneurship and masks the true nature of intergenerational persistence.

- **Policy Spillovers on "Nurture":** Financial interventions (e.g., credit relaxation) are not neutral. They trigger behavioral responses, inducing parents to adjust human capital investments to compensate for genetic disadvantages.

Thank you.

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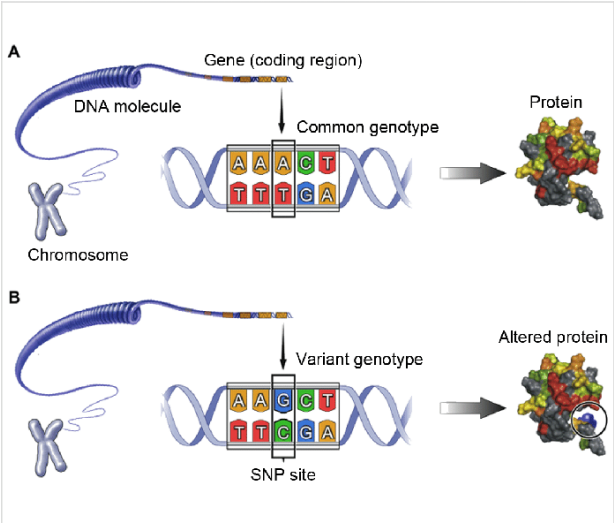
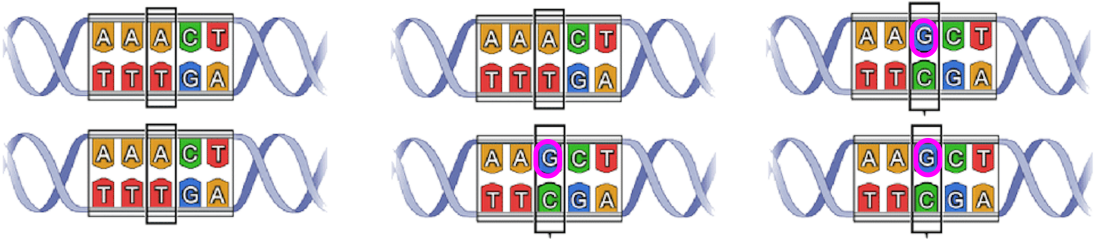
Genetic endowments I: SNP

Basic unit of genetic variation: Single Nucleotide Polymorphism (SNP)



Genetic endowments II: Genotype

- Humans inherit two sets of chromosomes from parents.
  - One from father, one from mother.
- At each location, genotype equals number of variant SNPs (0,1,2).



Polygenic Score (PGS) 1: Genome-Wide Association Study (GWAS)

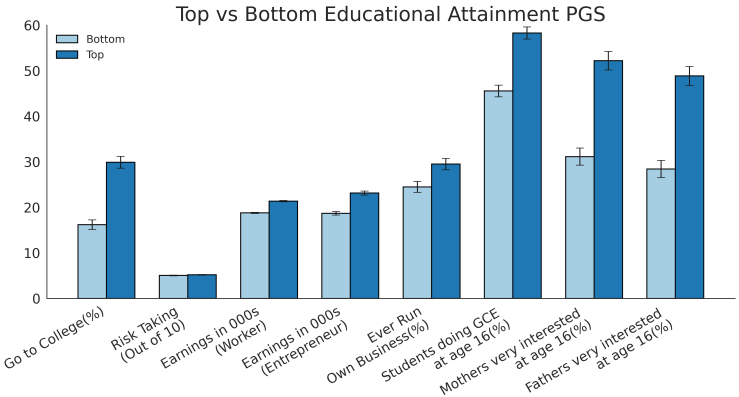
- In "Discovery Sample" (UK Biobank, 23andMe), for each SNP $j \in \{1, ..., J\}$, regress

$$y_i = \alpha_j + \beta_j G_{ij} + \epsilon_{ij}$$

- y_i is an outcome for individual i.
- $G_{ij} \in \{0, 1, 2\}$ is the genotype of individual i for SNP j.
- $\{\hat{\beta}_j\}_{j=1}^{J}$ is the estimated value.
- Next, calculate $\{\beta_j^*\}_{j=1}^{J}$ which is $\{\hat{\beta}_j\}_{j=1}^{J}$, adjusted to address different statistical issues (e.g., correlation of SNPs).

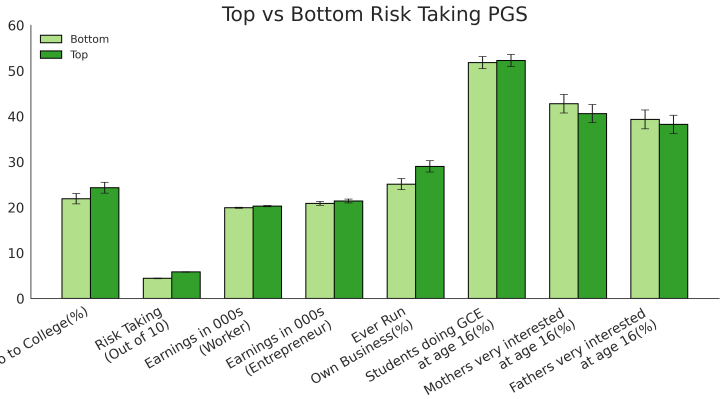
Key Facts: Those with high EA PGS ...

- Attain more years of education
- Earn more in paid employment
- Earn even more in own business
- Are more likely to become entrepreneurs
- Receive greater parental investment
- Do not exhibit higher risk tolerance



Key Facts: Those with high RT PGS ...

- Attain more years of education
- Earn similar in paid employment
- Earn even more in own business
- Higher probability to be entrepreneurs
- Do not receive more parental investments
- Exhibit higher risk tolerance



Preferences (Appendix)

c_j: consumption, $\omega_j \in \{W, E\}$: worker / entrepreneur choice
b_τ: type–specific non-pecuniary return to entrepreneurship

$$U(c_j, \omega_j; \tau) = \frac{c_j^{1-\gamma}}{1-\gamma} + b_\tau \, I[\omega_j = E]$$

- Consumption utility follows a standard CRRA specification.
- Being entrepreneurs receive a (relative) non-pecuniary reward b_τ that varies by type.

Problem for Young without a Child: $j = 1$

$S_1 = (g, \tau, a_1)$, $u_1 = (u_{1,W}, u_{1,E})$: persistent shocks
g: PGSs, τ: pre-market type, a_1: asset, g_c: child's PGSs

$$V_1(S_1, u_1) = \max_{\omega_1 \in \{E,W\}} \begin{cases} V_1^{\omega} = \max_{c_1} \left\{ U(c_1; \omega_1, \tau) + \beta \sum_{g_c} G(g_c \mid g) \int_{u_2} V_2(S_2, u_2) dF(u_2 \mid u_1) \right\} \\ \text{s.t.} \quad c_1 + a_2 = y_{1,\omega} + a_1(1 + r) \end{cases}$$

Problem for Young with Dependent Child: $j = 2$

$S_2 = (g, g_c, \tau, a_2)$, $u_2 = (u_{2,W}, u_{2,E})$: persistent shocks
g: PGSs, τ: pre-market type, a_2: asset, g_c: child's PGSs

$$V_2(S_2, u_2) = \max_{\omega_j \in \{E,W\}} \left\{ \begin{array}{l} V_2^{\omega} = \max\limits_{c_j, inv} \left\{ U(c_2; \omega_2, \tau) + \beta \int_{u_3} V_3(S_3, u_3; inv)\, dF(u_3 \mid u_2) \right\} \\ \text{s.t.} \quad c_2 + a_3 = y_{2,\omega}(1 - inv) + a_2(1 + r) \end{array} \right\}$$

Problem for Young with Dependent Child: $j = 3 - 4$

$S_j = (g, g_c, \tau, a_j)$, $u_j = (u_{j,W}, u_{j,E})$: persistent shocks
g: PGSs, τ: pre-market type, a_j: asset, g_c: child's PGSs

$$V_j(S_j, u_j; inv) = \max_{\omega_j \in \{E,W\}} \left\{ \begin{array}{l} V_j^{\omega} = \max_{c_j} \left\{ U(c_j; \omega_j, \tau) + \beta \int_{u_{j+1}} V_{j+1}(S_{j+1}, u_{j+1}; inv)\, dF(u_{j+1} \mid u_j) \right\} \\ \text{s.t.} \quad c_j + a_{j+1} = y_{j,\omega}(1 - inv) + a_j(1 + r) \end{array} \right\}$$

Problem for Young with Dependent Child: $j = 5$

$S_5 = (g, g_c, \tau, a_5)$, $u_5 = (u_{5,W}, u_{5,E})$: persistent shocks
g: PGSs, τ: pre-market type, a: asset, g_c: child's PGSs

$$V_5(S_5, u_5; inv) = \max_{\omega_j \in \{E,W\}} \left\{ \begin{array}{l} V_5^{\omega} = \max\limits_{c_5} \left\{ U(c_5; \omega_5, \tau) + \beta \int_{u_6} \sum\limits_{\tau_c} \tilde{V}_6(\tilde{S}_6, u_6) \cdot \Lambda(\tau_c \mid S_5, inv)\, dF(u_6 \mid u_5) \right\} \\ \text{s.t.} \quad c_5 + \tilde{a}_6 = y_{5,\omega}(1 - inv) + a_5(1 + r) \end{array} \right\}$$

Problem for Inter-vivos Transfer: $j = 6$

$$\tilde{S}_6 = (\overbrace{g, \tau, \tilde{a}_6 - a_1^c}^{S_6} + \overbrace{a_1^c, g^c, \tau^c}^{S_1^c}), \; u_6 = (u_{6,W}, u_{6,E}) \; , \; u_1^c = (u_{1,W}^c, u_{1,E}^c)$$

g: PGSs, τ: pre-market type, $\tilde{a}_6$: total asset, g^c: child's PGSs, τ^c: child's pre-market type, a_1^c: inter-vivos transfer

$$\tilde{V}_6(\tilde{S}_6, u_6) = \max_{a_1^c} \left\{ V_6(S_6, u_6) + \lambda \cdot \beta \int_{u_1^c} V_1(S_1^c, u_1^c) dF(u_1^c \mid u_6) \right\}, \quad a_1^c \geq 0$$

$$V_6(S_6, u_6) = \max_{\omega_6 \in \{E,W\}} \left\{ \begin{array}{l} V_6^\omega = \max\limits_{c_6} \{U(c_6; \omega_6, \tau) + \phi(a_{retire}; \tau)\} \\ \text{s.t.} \quad c_6 + a_{retire} = y_{6,\omega} + a_6(1+r) \end{array} \right\}$$

Equilibrium Conditions

Labor Supply

$$L_W = \int_{\Delta \in \Delta_W} f_W \, d\Delta$$

Production Capital

$$K_W = \int_{\Delta} a \, d\Delta \; - \; \int_{\Delta \in \Delta_E} k \, d\Delta$$

Aggregate Production

$$F(K_W, L_W) = A \, K_W^{\alpha} L_W^{1-\alpha}$$

Market-Clearing Prices

$$w = (1-\alpha) A \left(\frac{K_W}{L_W} \right)^{\alpha}, \qquad r = \alpha A \left(\frac{K_W}{L_W} \right)^{\alpha - 1} - \delta$$

Econometric specification

$$\Lambda(\tau \mid \tau_p, g, inv) = \frac{\exp\left(\delta_{\tau_c} + \delta_{\tau,\tau_c} \cdot \tau + \delta_{g,\tau_c} \cdot g_c + \delta_{inv,\tau_c} \cdot inv\right)}{\sum_j \exp\left(\delta_j + \delta_{\tau,j} \cdot \tau + \delta_{g,j} \cdot g_c + \delta_{inv,j} \cdot inv\right)}$$

Key Structural Parameter Estimates by Occupation

Parameter	Entrepreneur	Worker
Earnings Returns by PGS Group (Mean as reference group)		
High PGS_{edu} – High PGS_{risk}	0.18	0.05
High PGS_{edu} – Low PGS_{risk}	0.07	0.04
Low PGS_{edu} – High PGS_{risk}	0.08	0.00
Low PGS_{edu} – Low PGS_{risk}	-0.21	-0.14
Ability Shock Process		
Persistence (ρ)	0.24	0.80
Standard Deviation (σ)	0.62	0.38
Non-Pecuniary Benefits		
High type	0.0007	–
Low type	-0.0195	–

Structural Parameter Estimates for the Type Formation Process

Variable	**Coefficient**
Child's Genetic Endowments (vs. Low-Low)	
High PGS_{edu}, High PGS_{risk}	0.61
High PGS_{edu}, Low PGS_{risk}	0.37
Low PGS_{edu}, High PGS_{risk}	0.12
Parental Genetic Endowments (vs. Low-Low)	
High PGS_{edu}, High PGS_{risk}	0.48
High PGS_{edu}, Low PGS_{risk}	0.36
Low PGS_{edu}, High PGS_{risk}	0.31
Parental Background	
High Type (vs. Low)	1.12
Parental Investment Index	2.33

Estimation: First Stage

Parameter	Description	Source
$G(g_c \mid g)$	Intergenerational Genetic Transmission	Understanding Society
r	Interest Rate	Jorda et al. (2019)
δ	Depreciation Rate	Cagetti and De Nardi. (2006)
$\overline{a}$	Credit Constraint	Evans and Jovanovic (1989)

Estimation: Second Stage

Parameter	Description	Source
$\Lambda(\tau^c \mid g, g^c, inv, \tau)$	Pre-market Type Formation Function	NCDS
$f_{j,W}(g, \tau, u_{j,W})$	Efficient units of worker ability	Understanding Society
w	Wage per-unit price	Understanding Society
$f_{j,E}(g, \tau, u_{j,E})$	Efficient units of entrepreneurial ability	Understanding Society
ν	Return to capital in entrepreneurial sector	Understanding Society
P	Entrepreneurial sector per-unit productivity	Understanding Society
β	Discount factor	Understanding Society
γ	Risk aversion	Understanding Society
λ	Intergenerational altruism	ELSA
$b(\tau)$	Non-pecuniary return of being entrepreneur	Understanding Society
A	Productivity in non-entrepreneurial sector	Understanding Society
α	Output Elasticity of capital	Understanding Society

Identification: Parameters and Moments

Parameters	N	Target Moments	N
$\beta_{g,W}$	4	Worker earnings by genes	4
$\beta_{\tau,W}$	2	Worker earnings by labor types	2
w	1	Mean worker earnings	1
ρ_w	1	Autocorrelation of worker earnings	1
σ_w	1	Std. Dev. of worker earnings	1
$\beta_{g,E}$	4	Entrepreneur earnings by genes	4
$\beta_{\tau,E}$	2	Entrepreneur earnings by labor types	2
P, ν	2	Mean entrepreneur earnings	1
ρ_E	1	Autocorrelation of entrepreneur earnings	1
σ_E	1	Std. Dev. of entrepreneur earnings	1
β, γ	2	Saving Ratio	1
λ	1	Mean Inter-vivos transfer	1

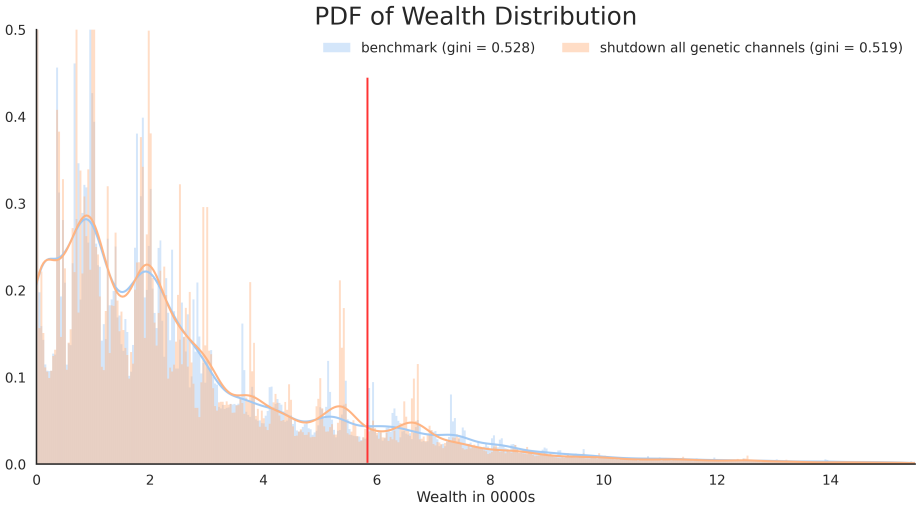
Identification: Parameters and Moments (Cont.)

Parameters	**N**	**Target Moments**	**N**
δ_{inv}	3	Parental investment by child genes	4
δ_{τ}	4	Child pre-market type by parent types and genes	8
δ_{g_c}	3	Fraction ever entrepreneur by genes	4
ρ_W^c, ρ_E^c	2	Intergen. transmission & mobility	2
$b(g)$	2	Fraction ever entrepreneur by type	4
A, α	2	Wage & Interest rate	2
Total	**38**		**44**

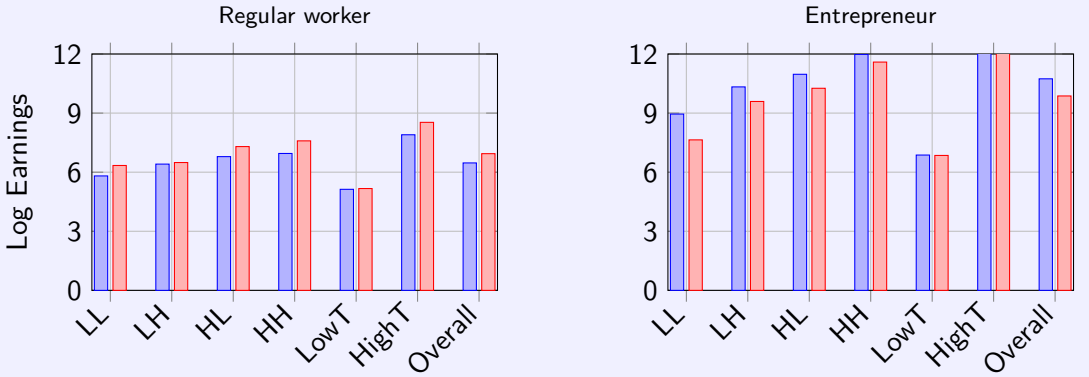
Model Fit: Mean Transfers and Savings

Moment	**Simulated**	**Target**
Annual saving-to-earnings ratio	0.123	0.120
Mean inter vivos transfer to child	1.13	1.17

Quantitative Exercise 2: Wealth Distribution Bias

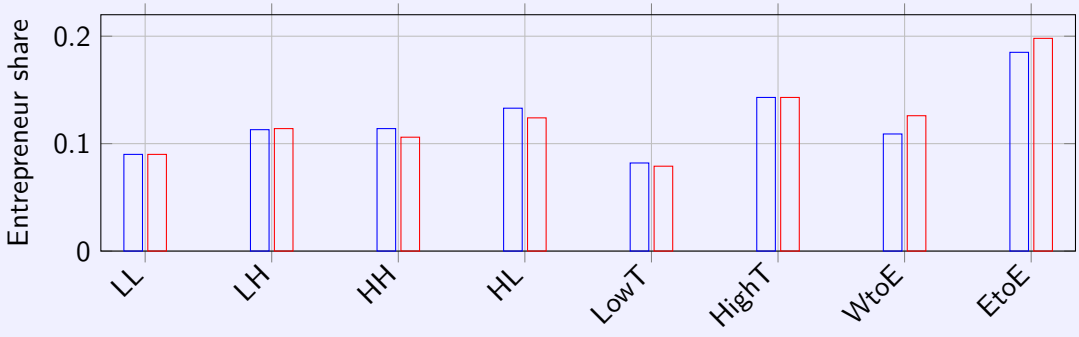


Simulated vs Data Average Log Earnings



Notes: LL = Low PGS_{edu}, Low PGS_{risk}; LH = Low–High; HL = High–Low; HH = High–High. LowT = Low pre-market type; HighT = High pre-market type;

Simulated vs Data: Entrepreneur Shares and Intergenerational Transitions

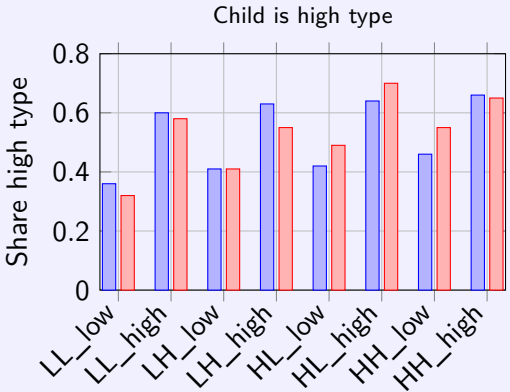


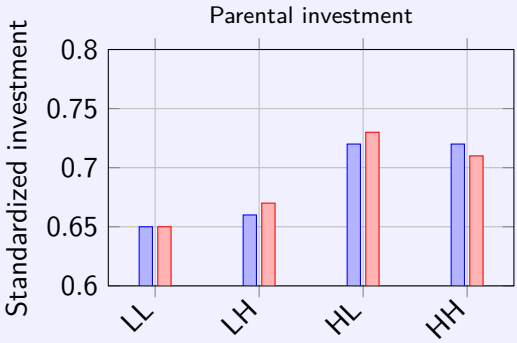
Notes:

WtoE = share of children who become entrepreneurs when parents were always workers; EtoE = share of children who become entrepreneurs when parents had ever been entrepreneurs.

Simulated Data

Simulated vs Data: Type Transmission and Parental Investment





Notes: LL = Low PGS_{edu}, Low PGS_{risk}; LH = Low–High; HL = High–Low; HH = High–High. "low/high" subscript denotes parental pre-market type.

Simulated Data

Reference

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