Career Choice of Entrepreneurs, Inventors, and the Rise of Firms

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- New technologies emerge and translate into economic growth through the team effort of *inventors*, *entrepreneurs*, and *production workers* in *firms*.

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- Inventors or R&D workers play key function in idea creation.
- Entrepreneurs play key function in firm and job creation, team assembly, and commercialization.
- Occupational sorting (e.g. inventor *or* entrepreneur *or* production worker) matters
- The matching of talent in teams is central to firm dynamics and economic growth.

Who becomes an inventor or an entrepreneur and how does

this career sorting and affect firm dynamics, innovation, and economic growth?

Roadmap

Data and Empirical Facts

- Data from Statistics Denmark: universe of Danish economy
- Detailed micro-data: parental background, IQ, occupation, firm performance.
- Facts on occupational sorting, entrepreneurship and matching in firms + firm growth.

Model Framework

- Novel model of occupation choice, entrepreneur-inventor matching and firm dynamics.
- Endogenous sorting, wages, and firm growth.

Quantitative Results & Counterfactuals

- Counterfactuals on the importance of entrepreneurial/R&D worker heterogeneity.
- Quantify the role of matching.

Related Literature

Firm Dynamics and Economic Growth

- Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992) Davis-Haltiwanger (1992), Hopenhayn (1992), Klette-Kortum (2004), Atkeson-Burstein (2010), Eeckhout-Kircher (2018), Akcigit et al (2018), Akcigit-Alp-Peters (2021)

Entrepreneurs, Managers, and Inventors

- Schumpeter (1911), Blanchflower-Oswald (1998), Lazear (2004), Bloom-Van Reenen (2007), Hurst-Pugsley (2011), Lindquist, Sol, Praag (2015), Levine-Rubinstein (2016), Aghion et al (2017), Bell et al (2018)

Talent Allocation and Economic Growth

- Murphy et al (1991), Hsieh et al (2019), Akcigit-Pearce-Prato (2020)

Empirics

Empirical Facts

Career Choice

Fact 1 Individuals with parental exposure to entrepreneurship are much more likely to become entrepreneurs than individuals without parent entrepreneurs.

Fact 2 Individuals with more education and higher IQ are more likely to become R&D workers.

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Firm Dynamics

Fact 3 High-IQ entrepreneurs hire more R&D workers and higher IQ R&D workers, who innovate more.

Fact 4 High-IQ entrepreneurs create more innovative firms and grow faster.

Fact 1+2: Occupational Determinants

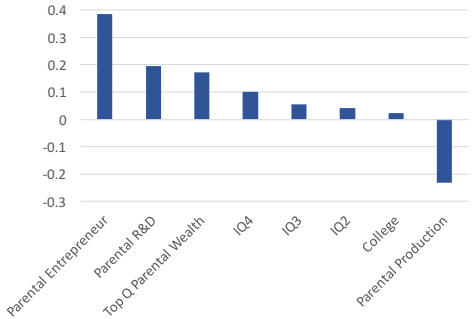
- Individuals are born and inherit certain talent and parental exposure.
- Individuals choose schooling and occupation.
- Occupational Determinants:
  - parental occupational background λ_f
  - parental wealth/income I
  - IQ z
  - schooling s
  - $o \in \{rd, e, p\}$: entrepreneur or R&D worker against baseline of p production worker
  - controls W

$$\frac{p_{ik}(z, \lambda_f, I, s, W)}{p_{ip}(z, \lambda_f, I, s, W)} = \beta_0 + \Gamma' z + \Lambda' \lambda_f + \beta s + \zeta I + \psi W + \epsilon$$

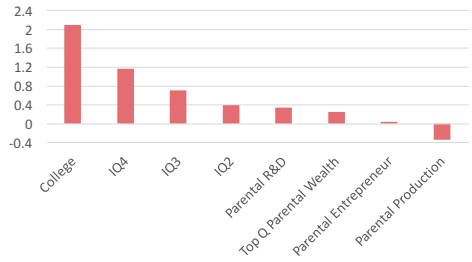
$\Rightarrow$ Logistic Regression.

Fact 1+2: Determinants of Becoming an Entrepreneur or R&D worker

Multinomial Logistic Regression (baseline: production worker):



(a) Entrepreneur



(b) R&D Worker

▸ Partial R2

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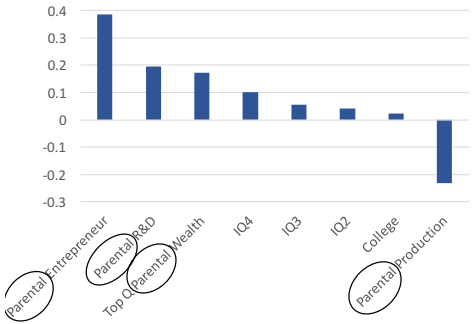

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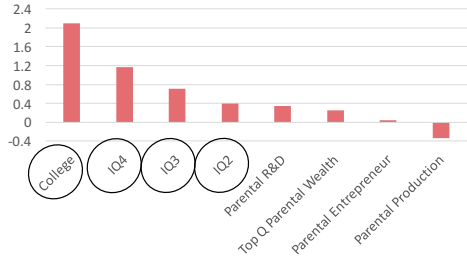


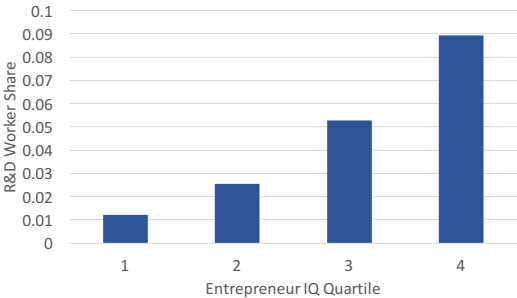
(b) R&D Worker

▸ Partial R2

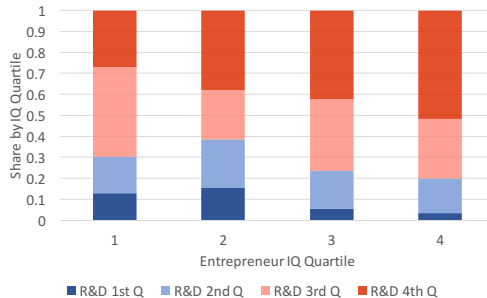
Parental background more important for entrepreneurs than R&D workers when each controlled.

Fact 3: Matching between Entrepreneurs and R&D workers

Figure: Amount and Type of R&D Workers by Entrepreneur IQ



(a) Fraction of R&D workers by Entrepreneur IQ



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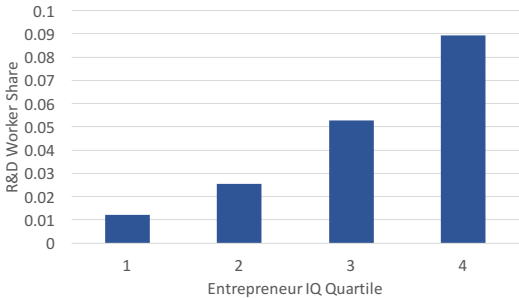

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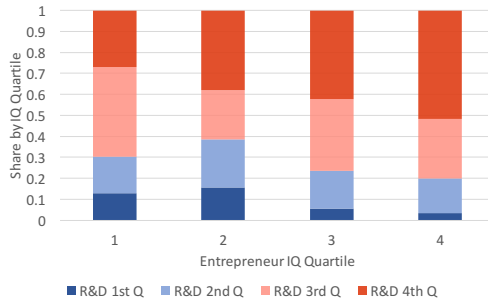
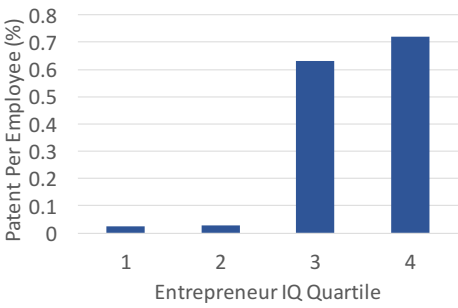


(b) IQ of R&D workers by Entrepreneur IQ

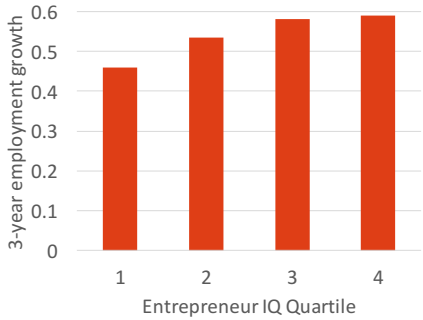
High IQ entrepreneurs hire more R&D workers, and high IQ R&D workers are a larger share of their workforce.

Facts 4: Entrepreneur Talent Determines Innovation and Firm Growth

Figure: Entrepreneur IQ and Firm Performance



(a) Patenting Rate and Entrepreneur IQ



(b) Growth Rate and Entrepreneur IQ

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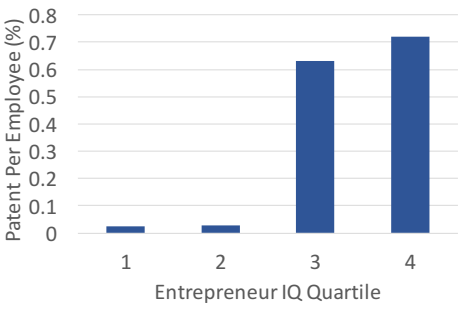

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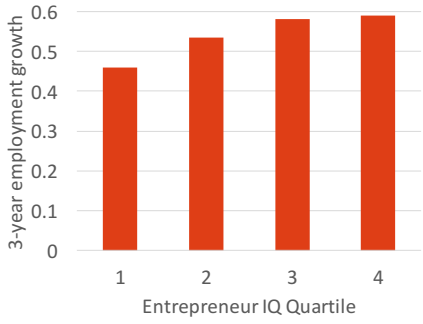


(b) Growth Rate and Entrepreneur IQ

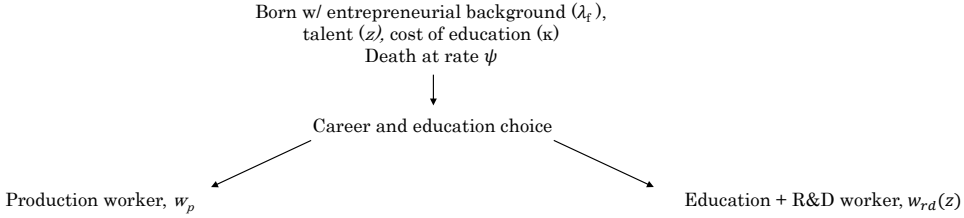
High IQ entrepreneurs innovate more and experience more firm growth.

Model

Goals

- Innovation-led model that features entrepreneurs, R&D workers, production workers, and parental background.
- Counterfactuals to understand the relevance of occupational sorting and assortative matching.
- Optimal policies for economic growth.

Model Overview



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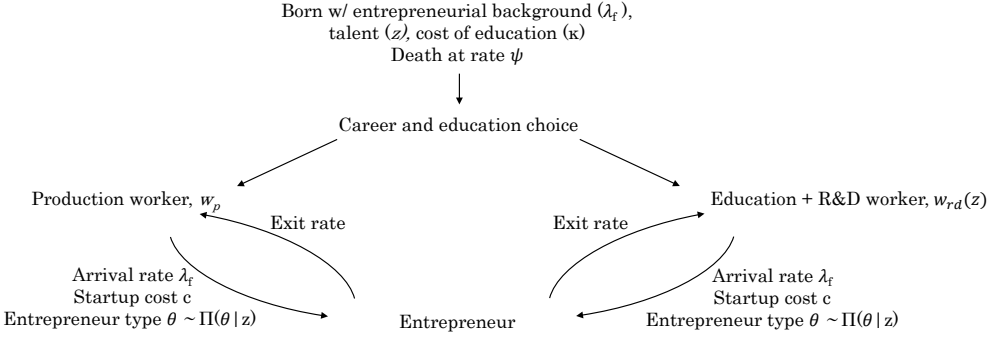

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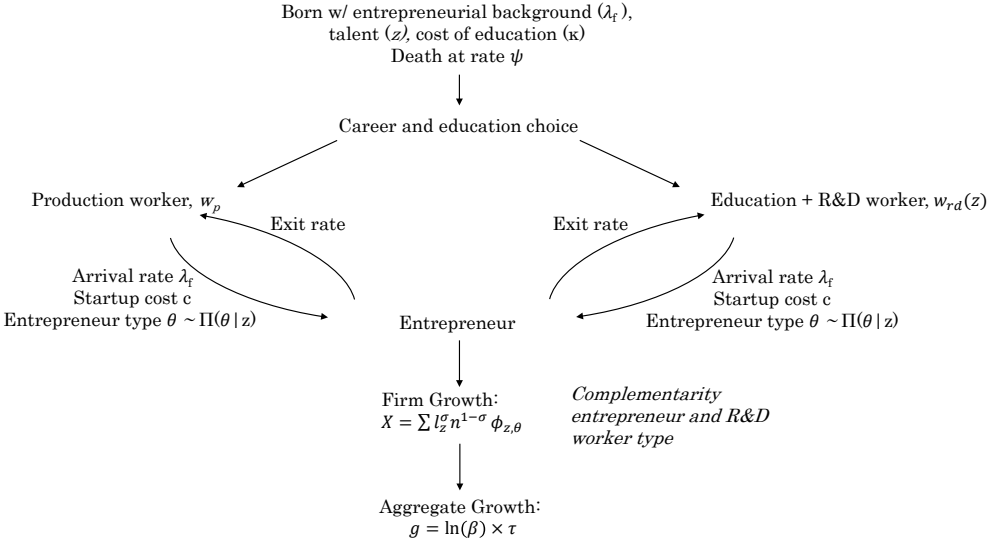

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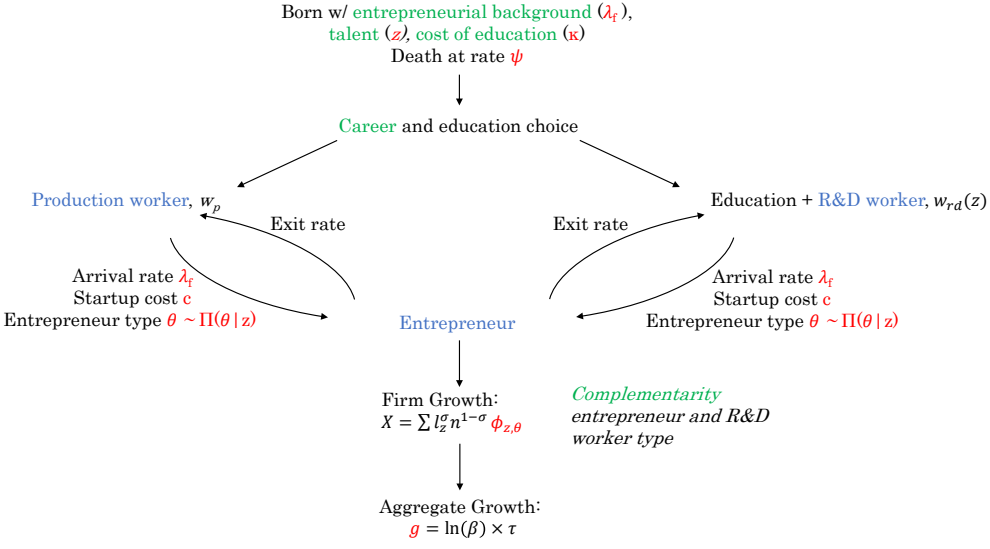

Environment

- Agents draw a parental entrepreneurial exposure λ_f, where $f \in \{0, 1\}$, a cost of education, κ, and IQ z across K discrete types $\mathcal{Z} := \{z_1, z_2, ..., z_K\}$.
- Agents dies at rate ψ

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- Individuals have the opportunity to become an entrepreneur at rate λ_f, where they receive a draw of entrepreneurial skill $\theta \sim \Pi(\theta|z)$ and startup cost $c \sim \Upsilon(c)$.

Production and Innovation

- $\mathcal{N}$ product lines held by intermediate goods monopolist entrepreneurs with technology $q_{j,t}$ hire production workers to produce:

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- $\phi(z, \theta)$: non-parametric production function
- X: arrival rate of innovation.
- l_z: the quantity of R&D workers of ability type z that the firm hires from the market.

Value Functions

Production Worker

$$\begin{aligned}\rho V_p(z,f) = \omega_p & \\ &+ \lambda_f \left[\mathbb{E}_{\theta,c}\left(\max\left\{V_e(1,z,\theta,p,f) - c, V_p(z,f)\right\}\right) - V_p(z,f)\right] \\ &+ \psi\left[0 - V_p(z,f)\right]\end{aligned} \tag{2}$$

R&D Worker

$$\begin{aligned}\rho V_{rd}(z,f) = \omega_{rd}(z) & \\ &+ \lambda_f \left[\mathbb{E}_{\theta,c}\left(\max\left\{V_e(1,z,\theta,rd,f) - c, V_{rd}(z,f)\right\}\right) - V_{rd}(z,f)\right] \\ &+ \psi\left[0 - V_{rd}(z,f)\right]\end{aligned} \tag{3}$$

Entrepreneur

$$\begin{aligned}\rho V_e(n,\tilde{z},\theta,i,f) = \pi n + \tau n\left[V_e(n-1,\tilde{z},\theta,i,f) - V_e(n,\tilde{z},\theta,i,f)\right] & \\ + \max_{\{l_z\}_{z\in\mathcal{M}}}\left\{X_n(\theta)\left[V_e(n+1,\tilde{z},\theta,i,f) - V_e(n,\tilde{z},\theta,i,f)\right] - \sum_{z\in\mathcal{Z}} l_z\omega_{rd}(z)\right\} & \\ + \psi\left[0 - V_e(n,\tilde{z},\theta,i,f)\right] &\end{aligned} \tag{4}$$

R&D Employment

First-order condition:

$$\begin{aligned} l_z &= \left[\frac{\sigma\phi(z,\theta)\left[V_f(n+1,\tilde{z},\theta,i) - V_f(n,\tilde{z},\theta,i)\right]}{\omega_{rd}(z)}\right]^{\frac{1}{1-\sigma}} n \\ &= \Gamma(z,\tilde{z},\theta,i)n \end{aligned} \tag{5}$$

Proposition

The type of the entrepreneur, θ, determines the quantity of the R&D workers hired by a firm and thier composition in terms of ability as follows. For any z_H and z_L with $z_H > z_L$:

$$\frac{l_{z_H}(\theta)}{l_{z_L}(\theta)} = \left[\frac{\phi_{z_H,\theta}}{\phi_{z_L,\theta}}\right]^{\frac{1}{1-\sigma}} \left[\frac{\omega_{rd}(z_L)}{\omega_{rd}(z_H)}\right]^{\frac{1}{1-\sigma}}.$$

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The sorting pattern btw entrepreneurs + R&D workers and wage information identifies production function.

Quantitative Analysis

Quantitative Framework

- Four types of workers: z_1, z_2, z_3, z_4, split by IQ quartiles
- Two types of entrepreneurs θ_L, θ_H.
- 8 innovation parameters: $\phi_{z,\theta}$; cost of education, cost of entrepreneurship, 2 entrepreneur arrival rates (parent + no parents), 4 transition probabilities ($z \to \theta$).
- We use 38 moments to match 18 parameters.

Moments

- Simulated Method of Moments (SMM) to link data objects to underlying parameters.
- Key identification: sorting to occupation + wages by occupation/IQ + total employment by entrepreneur IQ + employment by entrepreneur/R&D IQ.

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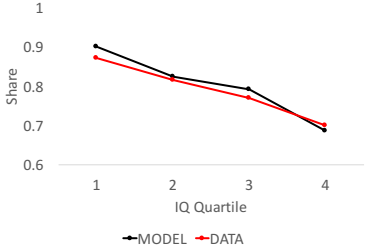
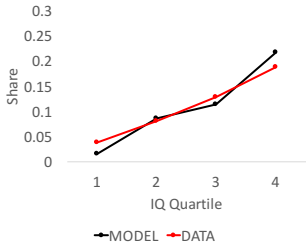
Moment	Number of Moments	Result
R&D worker share by IQ	4	In Figures
Production worker share by IQ	4	In Figures
Entrepreneur share by parent/non-parent	2	In Figures
Wage by R&D IQ	4	In Figures
R&D share by entrepreneur IQ	4	In Figures
Employment by Entrepreneur IQ	4	In Figures
R&D share (by IQ) by entrepreneur IQ	16	In Figures
Total Moments	38	

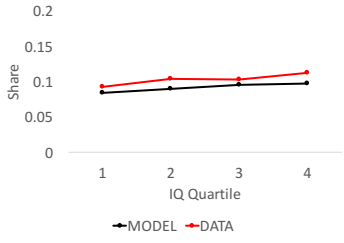
Worker Shares by IQ Level



(a) Production Worker



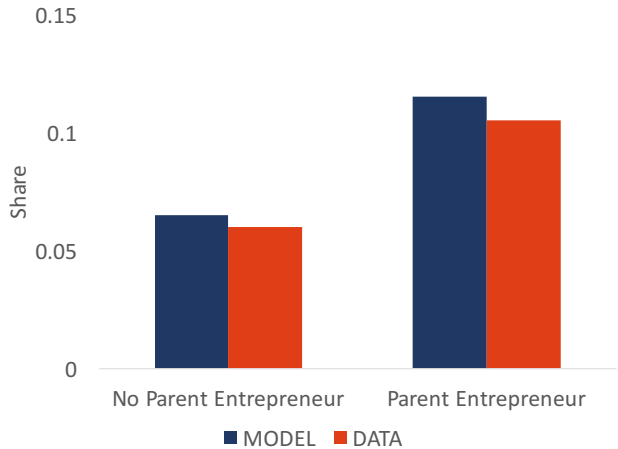
(b) R&D Worker



(c) Entrepreneur

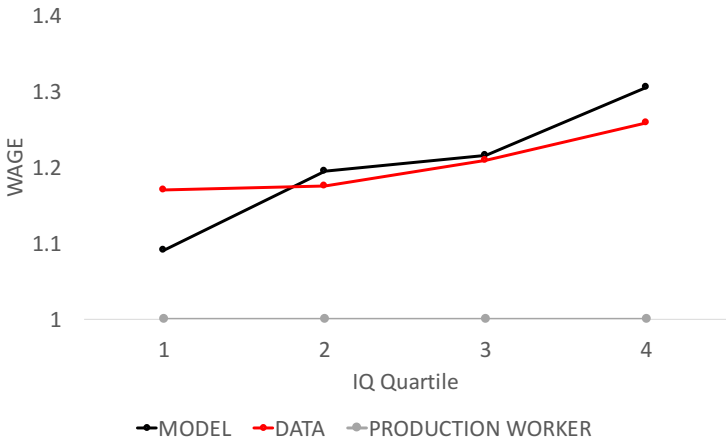
Entrepreneurship by Parental Exposure

Figure: Entrepreneurship Rates with and without Parent Entrepreneur

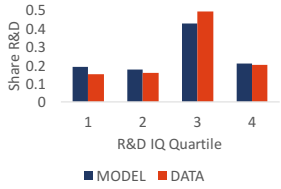


Model and Data Match on Wages

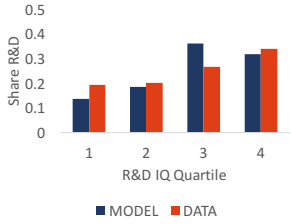
Figure: Worker Wages by IQ



Distribution of R&D types across entrepreneur type



(a) Entrepreneur 1st Quartile



(b) Entrepreneur 2nd Quartile

(c) Entrepreneur 3rd Quartile

(d) Entrepreneur 4th Quartile

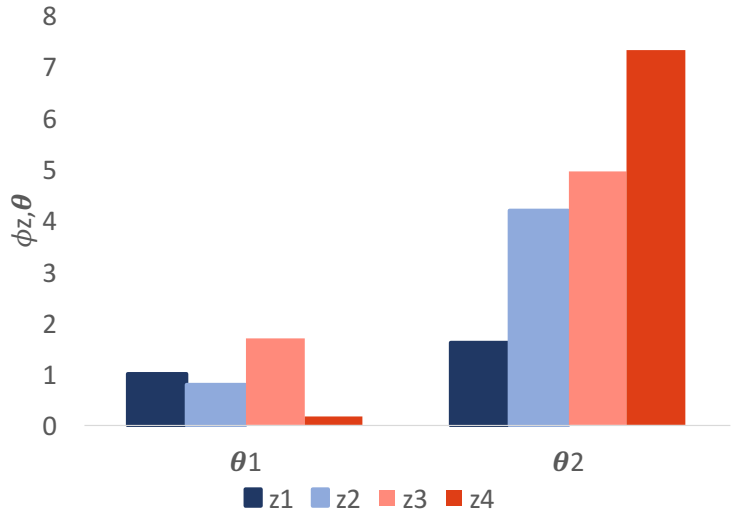
Parameters

Table: Parameter Values

Parameter	Description	Value
	— *Panel A. External Calibration* —	
ρ	Discount rate	0.02
ψ	Death rate rate	0.025
σ	labor share	0.50
β	Step size	1.30
	— *Panel B. Internal Calibration* —	
M	size of labor force	3.61
λ_1	Arrival rate with parent entrepreneur	0.089
λ_0	Arrival rate w/o parent entrepreneur	0.046
$\phi_{z,\theta}$	production function $m \times \theta$	Figure
$\Pi(z, \theta)$	transition from $m \to \theta$	4 parameters
μ	Cost parameter ($c \sim Logistic(\mu, 1)$)	0.201
ϖ	Innovation coefficient	0.045

Notes: All parameters are estimated jointly.

Estimated production function ($\phi_{z,\theta}$ by Type)



Counterfactuals and Policies

Counterfactuals

- The importance of entrepreneurial type
  - Exercise 1: Attenuate entrepreneurial draw quality.
- The matching market between entrepreneurs and R&D workers
  - Exercise 2: Restrict ability of entrepreneurs to target by type.

Policies

- The importance of R&D workers + R&D type
  - Exercise 3: Optimal R&D subsidies by IQ.

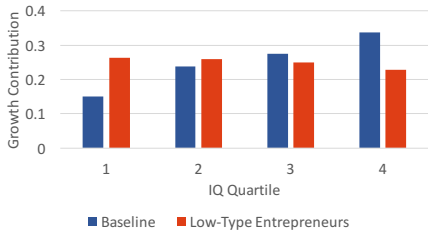
Exercise 1: Entrepreneurial Type Same as Lowest Worker

- To understand the role of entrepreneurial ability: fix expected entrepreneurial ability at the lowest IQ level for all IQ types.

Figure: Entrepreneurial Type Change and Outcomes

Object	Main Model	General Eq'm
Aggregate Growth (%)	1.37	1.26
Incumbent Growth Share	0.73	0.78
Firm Size (rel. entry)	2.89	3.40
Welfare	1	0.981

(a) Outcomes



(b) Entrepreneur Contribution

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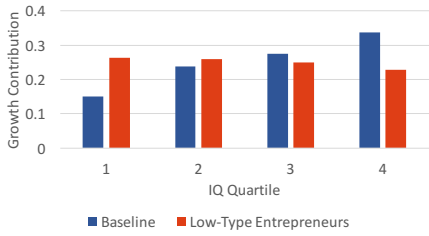


(b) Entrepreneur Contribution

Decline in high-type entrepreneurship, loss in 8% of growth rate, but increase in R&D workers.

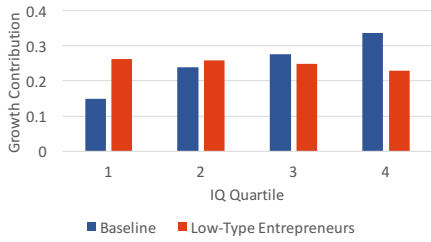
Exercise 1: Entrepreneurial Type Same as Lowest Worker

- To understand the key component of entrepreneurial ability type: fix expected entrepreneurial ability at the lowest IQ level for all IQ types.

Figure: Entrepreneurial Type Change and Outcomes

Object	Main Model	General Eq'm	Partial Eq'm
Aggregate Growth (%)	1.37	1.26	1.14
Incumbent Growth Share	0.73	0.78	0.75
Firm Size (rel. entry)	2.89	3.40	3.06
Welfare	1	0.981	0.970

(a) Outcomes



(b) Entrepreneur Contribution

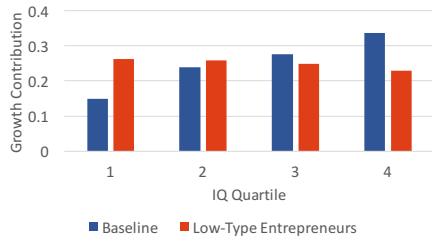
Exercise 1: Entrepreneurial Type Same as Lowest Worker

- To understand the key component of entrepreneurial ability type: fix expected entrepreneurial ability at the lowest IQ level for all IQ types.

Figure: Entrepreneurial Type Change and Outcomes

Object	Main Model	General Eq'm	Partial Eq'm
Aggregate Growth (%)	1.37	1.26	1.14
Incumbent Growth Share	0.73	0.78	0.75
Firm Size (rel. entry)	2.89	3.40	3.06
Welfare	1	0.981	0.970

(a) Outcomes



(b) Entrepreneur Contribution

Decline in high-type entrepreneurship, loss in 17% of growth rate when fixing R&D share.

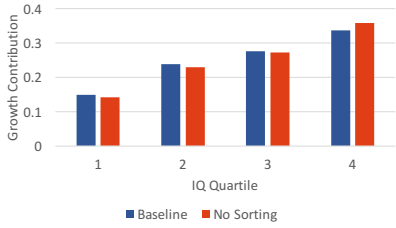
Exercise 2: Shut Down Assortative Matching

- Heterogeneity and complementary are key elements of the framework.
- What if attenuated: e.g. firms must hire *aggregate* quantity (e.g. $l_z = l \; \forall \; z$).

Figure: No Sorting

Object	Main Model	No sorting
Aggregate Growth (%)	1.37	1.09
Incumbent Growth Share	0.73	0.71
Firm Size (rel. entry)	2.89	2.39
Welfare	1	0.972

(a) Outcomes

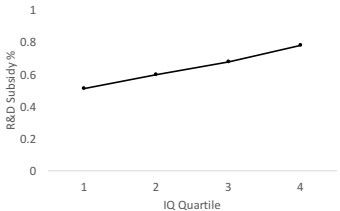


(b) Entrepreneur Contribution

Loss of 20% growth, but high-type entrepreneurs more important for growth.

Exercise 3: R&D Workers and Optimal R&D Subsidies

Figure: R&D Subsidies and Outcomes



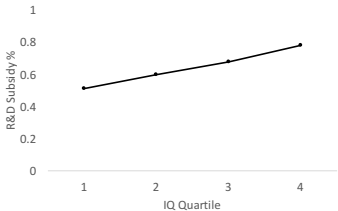
(a) Optimal Subsidies

Object	Main Model	With subsidies
Aggregate Growth (%)	1.37	2.11
Incumbent Growth Share	0.73	0.89
Firm Size (rel. entry)	2.89	6.10
Welfare	1	1.067

(b) Model & Subsidy Outcomes

Exercise 3: R&D Workers and Optimal R&D Subsidies

Figure: R&D Subsidies and Outcomes



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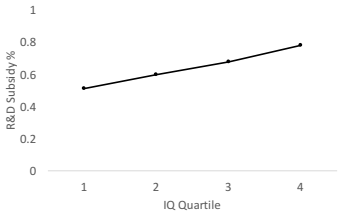
(b) Model & Subsidy Outcomes

- Two key takeaways:
  - i Subsidies for all R&D workers are positive.
  - ii Subsidies are higher for higher IQ, boost high IQ workers most.

Exercise 3: R&D Workers and Optimal R&D Subsidies

Figure: R&D Subsidies and Outcomes



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(b) Model & Subsidy Outcomes

- Two key takeaways:
  - i Subsidies for all R&D workers are positive.
  - ii Subsidies are higher for higher IQ, boost high IQ workers most.
- Introduce optimal R&D subsidies by IQ $\Rightarrow$ *54% increase in growth*.

Conclusion

This Paper

- Occupational sorting and entrepreneur-worker matching linked to new data from Denmark.
- Entrepreneur-led teams at the center of a model of innovation and economic growth.

Takeaways

- Heterogeneous entrepreneurial ability and R&D worker ability each have first-order effects on firm dynamics, innovation, and economic growth.
- Matching the right talent together at firms is essential for job creation and economic growth.
- Optimal policies should focus on groups due to heterogeneous spillovers by ability.
- (NEXT) Schooling impacts sorting, interacting with firm dynamics

Schooling and Sorting

Steady State for Product Lines and Workers

$\Psi(n, m, \theta, i, f)$: equilibrium mass of firms
$\Phi(m, i, f, e)$: equilibrium mass of workers ($e = 1$ if previously entrepreneur),
$\delta(m, i, f, \theta)$: prob type (m, i, f) chooses to become entrepreneur if they draw θ

$$\underbrace{(\tau + \psi)\Psi(1, m, \theta, i, f)}_{\text{creative destruction/death. } n=1} = \underbrace{\lambda_f \Pi(\theta|m)\delta(m, i, f, \theta) \sum_e \Phi(m, i, f, e)}_{\text{arrival} \times \text{prob. } \theta \times \text{prob. accept } e \times \text{mass of workers}}$$

$$\underbrace{(x + \tau + \psi)\Psi(1, m, \theta, i, f)}_{\text{innovation+creative destruction/death. } n=1} = \underbrace{\tau 2\Psi(2, m, \theta, i, f)}_{\text{mass of firm } n=2 \text{ to } n=1} + \lambda_f \Pi(\theta|m)\delta(m, i, f, \theta) \sum_e \Phi(m, i, f, e)$$

$$\underbrace{[\tau n + xn + \psi]\,\Psi(n, m, \theta, i, f)}_{\text{innovation+creative destruction/death for } n} = \underbrace{\tau(n+1)\Psi(n+1, m, \theta, i, f)}_{\text{mass of firm } n+1 \text{ to } n} + \underbrace{x(n-1)\Psi(n-1, m, \theta, i, f)}_{\text{mass of firm } n-1 \text{ to } n}; \qquad n \geq 2$$

Mass of Workers (Φ) and Newborns (Λ)

$$\left(\lambda_f \sum_{\theta} \Pi(\theta|m)\delta(m,i,f,\theta) + \psi\right) \Phi(m,i,f,0) = \Lambda(m,i,f) \tag{6}$$

$$\left(\lambda_f \sum_{\theta} \Pi(\theta|m)\delta(m,i,f,\theta) + \psi\right) \Phi(m,i,f,1) = \tau \sum_{\theta} \Psi(1,m,\theta,i,f) \tag{7}$$

$$\Lambda(m,i,0) = \gamma(m,i,0)\left[\psi \sum_{i}\sum_{f} \Phi(m,i,f,0)\right] \tag{8}$$

$$\begin{aligned}\Lambda(m,i,1) &= \gamma(m,i,1)\left[\psi\left(\sum_{n}\sum_{\theta}\sum_{i}\sum_{f} \Psi(n,m,\theta,i,f) + \sum_{i}\sum_{f}\Phi(m,i,f,1)\right)\right] \\ &= \gamma(m,i,1)\left[\psi\left(M\Omega(m) - \sum_{i}\sum_{f}\Phi(m,i,f,0)\right)\right]\end{aligned} \tag{9}$$

$\gamma(m,i,f)$: the fraction of new born agents that choose to become i-type worker

	(1) Pr Entrepreneur	(2) Pr R&D Worker
Parent Entrepreneur	0.591	0.104
	(0.015)	(0.017)
Parent R&D Worker	0.003	0.038
	(0.003)	(0.001)
Parent Production Worker	0.003	-0.008
	(0.002)	(0.001)
College	0.043	1.623
	(0.013)	(.013)
IQ 2nd Quartile	-0.025	0.38
	(0.015)	(0.020)
IQ 3rd	-0.069	0.636
	(0.016)	(0.020)
IQ 4th	-0.015	1.06
	(0.017)	(0.019)
Observations	362022	
Pseudo R^2	0.142	

standard errors in parentheses

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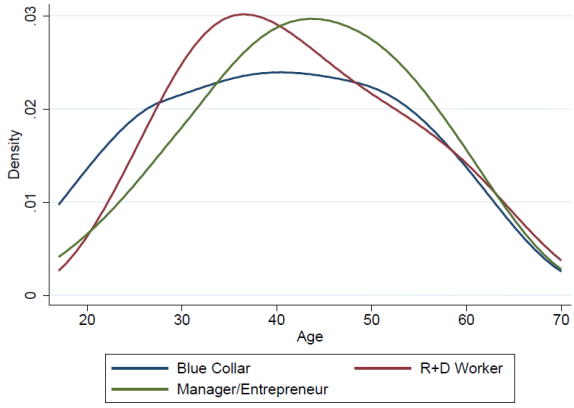
	(1) Pr Entrepreneur	(2) Pr R&D Worker
Parent Entrepreneur	0.575	0.148
	(0.022)	(0.023)
Parent R&D Worker	0.002	0.034
	(0.002)	(0.002)
Parent Production Worker	0.003	-0.009
	(0.002)	(0.001)
College	0.042	1.580
	(0.015)	(0.014)
IQ 2nd Quartile	-0.009	0.359
	(0.18)	(0.019)
IQ 3rd Quartile	-0.063	0.611
	(0.019)	(0.020)
IQ 4th Quartile	-0.010	1.025
	(0.020)	(0.019)
Parent Income 2nd Quartile	-0.136	0.044
	(0.019)	(0.019)
Parent Income 3rd	-0.083	0.091
	(0.019)	(0.020)
Parent Income 4th	0.110	0.125
	(0.019)	(0.019)
Observations	292258	
Pseudo R^2	0.145	

standard errors in parentheses

Labor Market Experience: Age

Figure: Age Distribution and Occupations



Takeaway: entrepreneurs are older than R&D and production workers.

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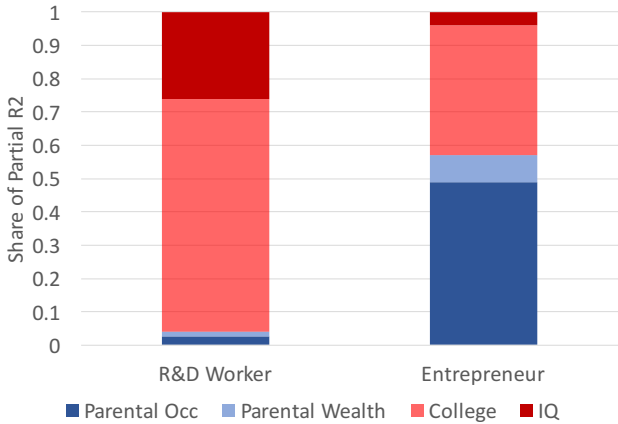
Partial R2 on Linear Probability Model

Figure: Linear Probability Model w/ Probability of Occupation



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