

The Macroeconomic Implications of Uncertainty and Learning for Entrepreneurship

Han Gao

University of New South Wales

Lichen Zhang

University of Hong Kong

11th Annual CIGS conference on Macroeconomic Theory and Policy

May 2023

Motivation

- A growing literature suggests **uncertainty and learning important for entrepreneurship & firms**
- Jovanovic (1982), Hopenhayn & Vereshchagina (2009), David, Hopenhayn, & Venkateswaran (2016), Bhandari, Kass, May, McGrattan, & Schulz (2022) etc.

Motivation

- A growing literature suggests **uncertainty and learning important for entrepreneurship & firms**
 - Jovanovic (1982), Hopenhayn & Vereshchagina (2009), David, Hopenhayn, & Venkateswaran (2016), Bhandari, Kass, May, McGrattan, & Schulz (2022) etc.
- In theory, individuals make entrepreneurial choices under imperfect information
 - Gradually learn about their innate entrepreneurial ability once becoming entrepreneurs, thus reducing such individual-level uncertainty over life cycle
 - Interacting with **financial frictions**

Motivation

- A growing literature suggests **uncertainty and learning important for entrepreneurship & firms**
 - Jovanovic (1982), Hopenhayn & Vereshchagina (2009), David, Hopenhayn, & Venkateswaran (2016), Bhandari, Kass, May, McGrattan, & Schulz (2022) etc.
- In theory, individuals make entrepreneurial choices under imperfect information
 - Gradually learn about their innate entrepreneurial ability once becoming entrepreneurs, thus reducing such individual-level uncertainty over life cycle
 - Interacting with **financial frictions**
- Yet little is known about quantitative importance of information frictions and learning for selection at different stages of individuals' **life cycle**
 - **matters for aggregates & policy** (e.g. impacts of tax reform)

What We Do

- Provide evidence on uncertainty faced by entrants and entrepreneurial learning process
 - Using individual-level subjective belief survey data on forecasts of business performances
 - Motivating & disciplining learning elements of model
- Develop a GE model with realistic life cycle where heterogeneous agents choosing to
 - Work for someone else or
 - Run own private business and
 - gradually learn about innate productivity s.t. ex-post transitory shocks
 - accumulate wealth & produce s.t. financial frictions
 - Other key determinants: bequests, non-pecuniary motives
- Quantify the value of learning & cost of information frictions
- Inform personal income tax design on reviving entrepreneurship

What We Find

- Value of learning about innate ability is decreasing in age
 - No learning in early stage reduces share of lifetime as an entrepreneur/lifetime income the most
- Cost of information frictions is increasing in entrep. innate ability
 - Removing information frictions benefits talented entrepreneurs the most
- Tax experiments show:
 - Targeting the young boosts entrepreneurship & improves occupational allocation earlier
 - ↑ entrepreneurship $\approx$ ↑ entrepreneurs with high innate ability
 - Abstracting from information frictions and learning may lead to misleading results

Empirical Motivation

Individual-level Uncertainty and Learning: Data

Panel Studies of Entrepreneurial Dynamics Wave 1 (PSED 1998–2004)

- Samples of nascent entrepreneurs (NE) in U.S., 4 waves
- 590 NEs + 227 non-NEs (controlled group)

Individual-level Uncertainty and Learning: Data

Panel Studies of Entrepreneurial Dynamics Wave 1 (PSED 1998–2004)

- Samples of nascent entrepreneurs (NE) in U.S., 4 waves
- 590 NEs + 227 non-NEs (controlled group)

Definition of entrepreneurs

- PSID: self-employed household heads who are business owners
- PSED: nascent entrepreneurs (active in business creation) + production
- In terms of legal forms, most of them (> 80%) are passthroughs

Individual-level Uncertainty and Learning: Data

Panel Studies of Entrepreneurial Dynamics Wave 1 (PSED 1998–2004)

- Samples of nascent entrepreneurs (NE) in U.S., 4 waves
- 590 NEs + 227 non-NEs (controlled group)

Definition of entrepreneurs

- PSID: **self-employed** household heads who are **business owners**
- PSED: nascent entrepreneurs (active in business creation) + production
- In terms of legal forms, most of them (> 80%) are passthroughs

Questions on NE's expectations about future of new business

- Wave 1 asks (1) expected sales in 1st full year of operation and (2) in 5th full year of operation
- Respondents in wave 2-4 report sales in current year and predicted sales in 5th full year of operation

Measuring Learning: Concepts

We thus define:

- ESale: forecasts on sales in a future year
- RSale: realized sales in current year

Measuring Learning: Concepts

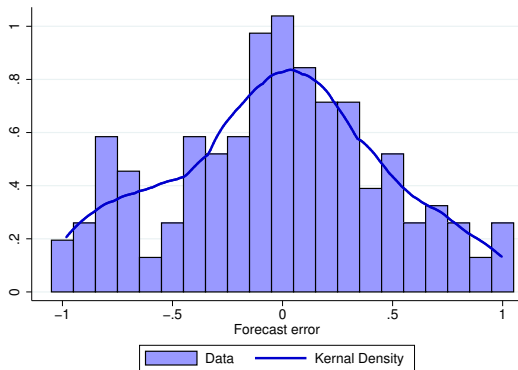
We thus define:

- **ESale**: forecasts on sales in a future year
- **RSale**: realized sales in current year

Further define:

- **Forecast errors**: deviation of **RSale** from **ESale**
- **Forecast revisions**: updates in **ESale** (on same objective)

Distribution of Forecast Errors



► Forecasts/Realizations

► Who exit

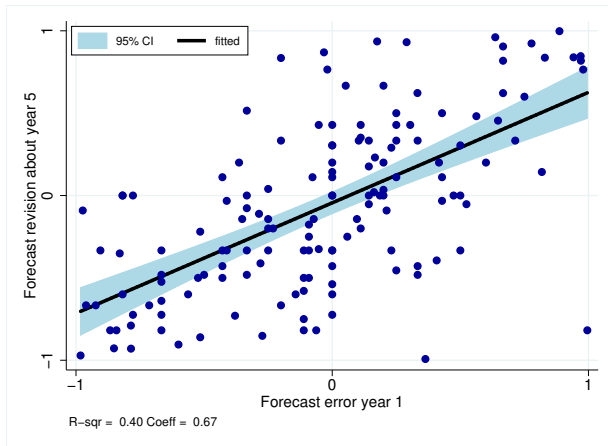
Forecasting error : forecast in year 0, reveal in year $s = 1$

$$\text{FError}_0^s = \frac{\text{RSale}_s - \text{ESale}_0^s}{\text{RSale}_s + \text{ESale}_0^s}$$

No significant difference in initial dist. of FEs by gender, age, edu, industry, previous experience as a worker etc.

► detail

Forecast Errors Predict Future Forecast Revisions

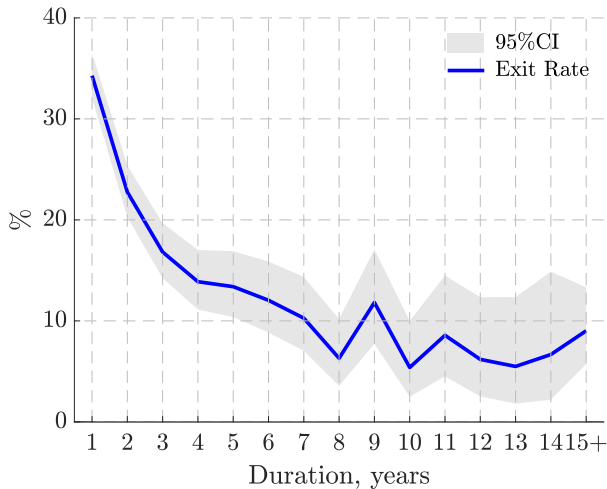


Year-1 forecast revision on year-5 sales $FRev_1^5 = \frac{ESale_1^5 - ESale_0^5}{ESale_1^5 + ESale_0^5}$

Robust to gender, education, industry, age, first-time entrep., previous exp. as a worker etc.

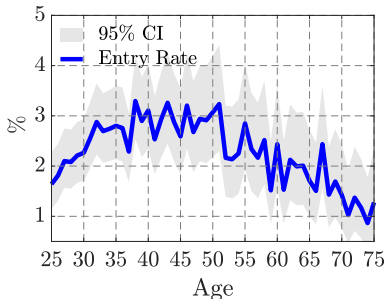
[▶ detail](#)

Exit Rate Decreases by Duration

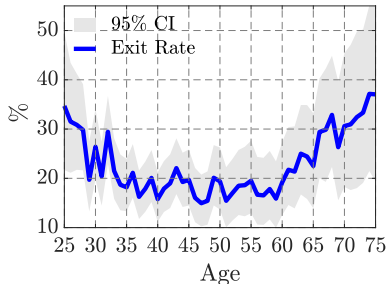


⇒ consistent with learning & experimentation with entrepreneurship

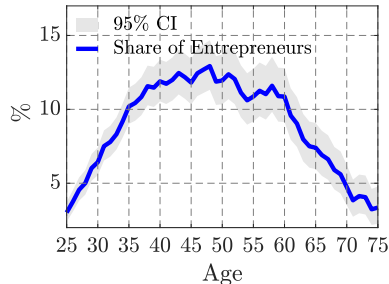
Life Cycle Patterns of Entrepreneurship: Entry/Exit



(a) Entry rate



(b) Exit rate



(c) Share in households

► CPS

► IRS

► Age Profile in PSID

► Earnings Dist. in PSID

► Age Profile in SCF

► Business Loss in SCF

► PSID v.s. PSED

► Variable definitions

Empirical Evidence Takeaways

Entrepreneurs

- ① forecast business performance (sales) with errors
- ② use new observed information to update forecasts
- ③ exit hazard declines as entrepreneurs become more experienced

Model

Model Outline: GE Aiyagari + Life Cycle OLG

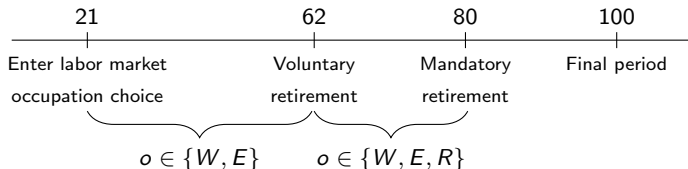
Agents: government, corporate firm, households (workers, entrepreneurs, retirees)

Government:

- Revenue: progressive personal income tax and flat consumption tax
- Expenditure: govt consumption and social security

Corporate firm: CRS technology; inputs are capital and labor efficiency units

Households: occupation choice $o \in \{W, E, R\}$ over life cycle *s.t.* stochastic mortality shocks

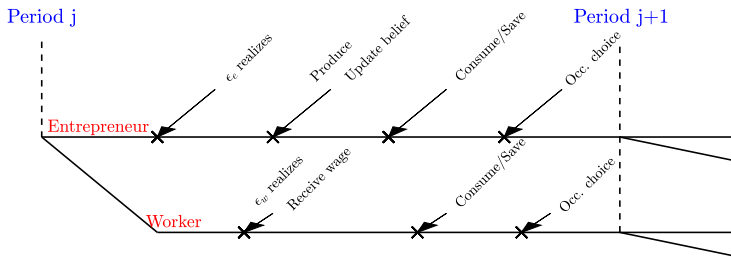


Determinants of Occupational Choice over Life Cycle

Households ex-ante endowed with

- x_e : permanent love of business characteristic (non-pecuniary motive)
- χ_w : permanent worker skill type
- μ : innate entrepreneurial ability, unobserved to agents
- a_0 : initial assets = 0, same to all agents

Households of age j (differ in assets a_j and beliefs $\{\tilde{\mu}_{e,j}, \tilde{\nu}_{e,j}, \epsilon_{e,j}\}$) make occupation choice before realization of wage income shock ϵ_w and entrep. productivity shock ϵ_e :



Worker: $\omega_j \chi_w \theta_j \epsilon_{w,j} h_j$

Entrepreneur: $\epsilon_{e,j} f(k_j, n_{b,j}) - \omega n_{b,j} - (r_j + \delta) k_j - \phi$ s.t. $k_j \leq \lambda a_j$

Determinants of Occupational Choice over Life Cycle

Households ex-ante endowed with

- x_e : permanent love of business characteristic (non-pecuniary motive)
- χ_w : permanent worker skill type
- μ : innate entrepreneurial ability, unobserved to agents
- a_0 : initial assets = 0, same to all agents

Households of age j (differ in assets a_j and beliefs $\{\tilde{\mu}_{e,j}, \tilde{\nu}_{e,j}, \epsilon_{e,j}\}$) make occupation choice:

- **Uncertainty and learning:** gradually learn μ only after working as entrepreneurs
incentive to enter earlier $\rightarrow$ earlier resolution of uncertainty helps make better occ. choice
- **Assets + incomplete markets + financial frictions:** obtain via (1) self-accumulation
and (2) bequests: inheritance with probability varied over life cycle and amount proportional to income
low wealth discouraging entry for the young

Entrepreneurial Productivity: Information Structure

- Agents' innate entrepreneurial productivity $\mu \sim N(\mu_e, \nu_e^2)$
- Before entering labor market, no information on μ

Agents' belief about $\mu = N(\mu_e, \nu_e^2)$

- Individuals observe a productivity shock (signal) ϵ_e
 - only after they become an entrepreneur and actively produce
 - $\epsilon_e = \text{innate ability } (\mu) + \text{transitory shock}$
 - Transitory shock $\overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma_e^2)$

Entrepreneurial Productivity: Learning Process

- The n -th observed realized entrep. productivity shock (signal): $\epsilon_{e,n}$
- n : number of periods being an entrepreneur
- Let the posterior belief after observing n th signals be $\mathcal{N}(\tilde{\mu}_{e,n}, \tilde{\nu}_{e,n}^2)$
- Following Bayesian updating:

$$\tilde{\nu}_{e,n}^2 = \frac{\nu_e^2 \sigma_e^2}{n\nu_e^2 + \sigma_e^2} = \frac{1}{n/\sigma_e^2 + 1/\nu_e^2}$$
$$\tilde{\mu}_{e,n} = \tilde{\nu}_{e,n}^2 \left(\frac{\tilde{\mu}_{e,n-1}}{\tilde{\nu}_{e,n-1}^2} + \frac{\epsilon_{e,n}}{\sigma_e^2} \right)$$

- ν_e^2 and σ_e^2 together determines forecast precision
- ν_e^2 relative to σ_e^2 determines learning speed
- Empirical Fact 1 (dispersion of forecast errors) and 2 (corr. btw forecast errors and forecast revision) identify ν_e^2 and σ_e^2 jointly

Recursive Problem

Normal working ages: $1 \leq j < J^V$, for $o \in \{W, E\}$

$$V_j^o(x_e, a, \epsilon_w, \tilde{\mu}_e, \tilde{\nu}_e, \epsilon_e) = \max_{l, a', o'} \{u(c, l; x_e) + \beta(1 - \zeta_{j+1})\mathbb{E} V_{j+1}^{o'}(x_e, a', \epsilon'_w, \tilde{\mu}'_e, \tilde{\nu}'_e, \epsilon'_e) + \beta\zeta_{j+1}\mathcal{V}(a')\}$$

where $l = 1 - h\mathbb{1}_{\{o=W\}} - g(x_e)\mathbb{1}_{\{o=E\}}$

- h = working hours as a worker
- $g(x_e)$ = fixed utility cost of being an entrepreneur
 x_e is permanent individual specific love of business characteristic

Warm-glow bequest function $\mathcal{V}(a)$

Recursive Problem

$$V_j^o(x_e, a, \epsilon_w, \tilde{\mu}_e, \tilde{\nu}_e, \epsilon_e) = \max_{l, a', o'} \{u(c, l; x_e) + \beta(1 - \zeta_{j+1})\mathbb{E}V_{j+1}^{o'}(x_e, a', \epsilon'_w, \tilde{\mu}'_e, \tilde{\nu}'_e, \epsilon'_e) + \beta\zeta_{j+1}\mathcal{V}(a')\}$$

$$s.t. \quad a' + c(1 + \tau_c) = a(1 + r) + (1 - \tau_{ss})y_{o,j}(a, \epsilon_w, \epsilon_e) - T_o(y_{o,j} + ra)$$

where: $y_{W,j} = \omega\chi_w\theta_j\epsilon_{w,j}(1 - l)$

$$y_{E,j} = \pi_e(a, \epsilon_e) = \max_{k, n_e} \{\epsilon_e f(k, n_e) - \omega n_e - (r + \delta)k - \phi\}$$

$$s.t. \quad 0 \leq k \leq \lambda a, \quad n_e \geq 0$$

$T_o(\cdot)$: personal income tax schedule a à HSV, same for E, W , imposing on
total pre-gov personal income = wage/business income + asset income ra

Recursive Problem

- **Normal working ages:** $1 \leq j < J^V$, for $o \in \{W, E\}$

$$V_j^o(x_e, a, \epsilon_w, \tilde{\mu}_e, \tilde{v}_e, \epsilon_e) = \max_{l, a', o'} \{u(c, l; x_e) + \beta(1 - \zeta_{j+1})\mathbb{E}V_{j+1}^{o'}(x_e, a', \epsilon'_w, \tilde{\mu}'_e, \tilde{v}'_e, \epsilon'_e) + \beta\zeta_{j+1}\mathcal{V}(a')\}$$

$$s.t. \quad a' + c(1 + \tau_c) = a(1 + r) + (1 - \tau_{ss})y_{o,j}(a, \epsilon_w, \epsilon_e) - T_o(y_{o,j} + ra)$$

$$\tilde{\mu}'_e, \tilde{v}'_e = \begin{cases} \Pi(\tilde{\mu}'_e, \tilde{v}'_e | \tilde{\mu}_e, \tilde{v}_e, \epsilon_e) & \text{for } o = E \\ \tilde{\mu}_e, \tilde{v}_e & \text{otherwise} \end{cases} \quad (\text{belief updating})$$

$$a' \geq \underline{a} \quad (\text{liquidity constraint})$$

- **Voluntary retirement ages:** $J^V \leq j < J^R$, for $o \in \{W, E, R\}$
 - an additional option to claim retirement and leave the labor market

Calibration

Parameterization

Data sources: PSID, PSED [▶ more](#)

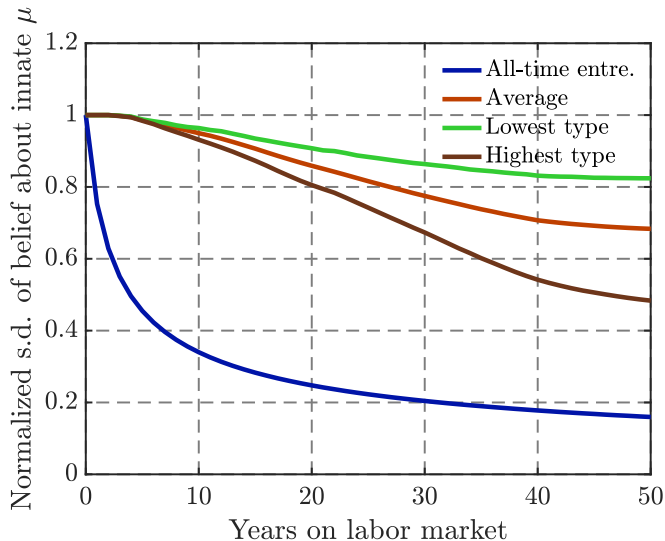
Parameters [▶ functional specifications](#)

- Externally estimated [▶ go](#)
- Internally calibrated [▶ go](#)

Key parameters

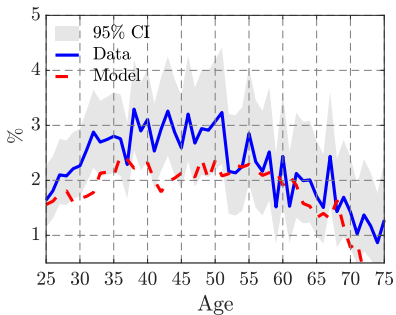
Parameter	Description	Value	Target
Learning process: Bayesian updating			
μ_e	Mean: dist. of innate entrep. prod.	1.25	Median business to wage income = 1.3
ν_e	Std: dist. of innate entrep. prod.	0.37	Std. dev. of forecasting error = 0.40
σ_e	Std: transitory i.i.d.shocks	0.50	Slope of forecast revision = 0.66
Financial friction			
λ	Collateral parameter	1.50	Median wealth entrep. to worker = 6.0
Government policy			
κ_1	Personal income tax: progressivity	0.10	Estimated by PSID ▶ Tax Schedule

Learning about Innate Ability by Age ($\tilde{\nu}_e$)

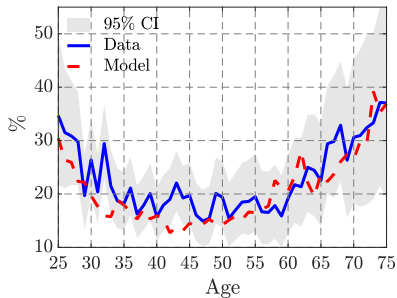


Model Fit

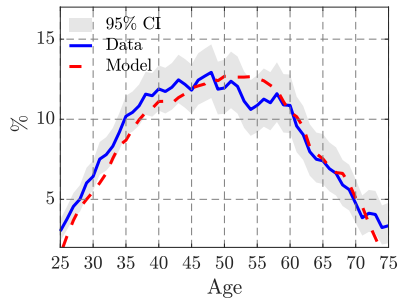
Model Fit: Entrepreneurship over the Life Cycle



(a) Entry rate



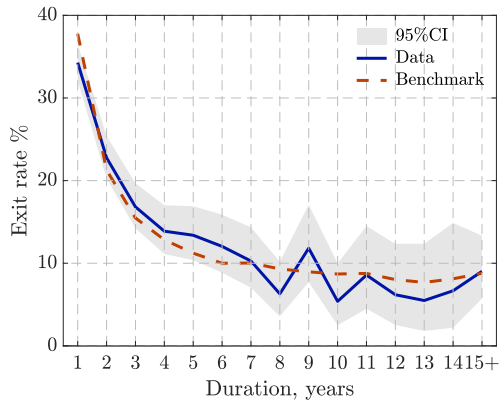
(b) Exit rate



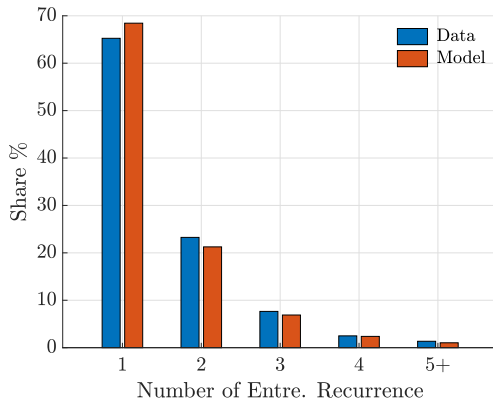
(c) Entre. share

► Exit hazard to worker/retirement

Model Fit: Exit and Recurrent Entre. Activities



(a) Exit Rate by Entre. Duration



(b) Recurrent Entre. Activities

More model fit results:

► Income & Wealth Distribution

► Entrepreneurial Earnings

► Aggregate Moments

► First Time Entry

► Perfect Information Case

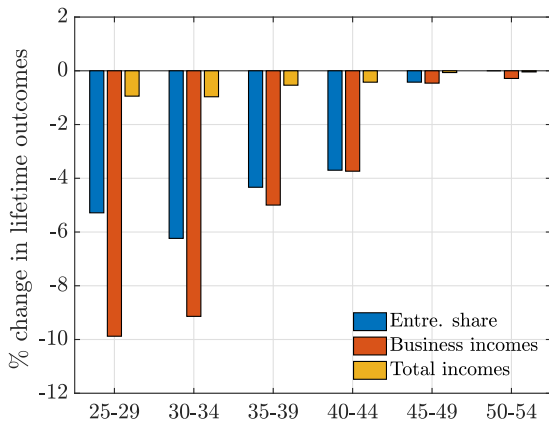
Aggregate Implications of Information Frictions and Learning

Value of Learning Over Life Cycle

- **Counterfactual:** what if agents do not update belief at specific age?
- Lifetime outcomes: (1) entre. share (2) discounted business inc./total inc.

Value of Learning Over Life Cycle

- **Counterfactual:** what if agents do not update belief at specific age?
- Lifetime outcomes: (1) entre. share (2) discounted business inc./total inc.



- Value of learning is monotonically decreasing in age except for very young

The Cost of Information Frictions

- To quantify the cost of information frictions — agents have no info. on their innate entrepreneurial ability upon entering the labor market

The Cost of Information Frictions

- To quantify the cost of information frictions — agents have no info. on their innate entrepreneurial ability upon entering the labor market
- Consider a perfect information case (nested by the benchmark)
 - Before entering labor market, individuals perfectly know their innate entre. ability
 - Transitory shock to true type realizes after they decide to be an entrepreneur
- Steady state comparisons to perfect information case show that removing information frictions
 - ↑ aggregate entrepreneur share from 9.0% to 15.1%
 - ↑ average lifetime income by 5.0%
 - ↓ average age of first entry from 39.4 to 35.3

The Cost of Information Frictions

by Innate Entrepreneurial Ability

Types	-3 sd	-2 sd	-1 sd	0 sd	+1 sd	+2 sd	+3 sd
Benchmark with Info. friction and learning							
Lifetime entrepreneur share							
Lifetime y^b in total y							
Lifetime incomes (normalized)							
Perfect information							
Lifetime entrepreneur share							
Lifetime y^b in total y							
Lifetime incomes (normalized)							

Lifetime Outcomes by Innate Entrepreneurial Ability

Types	-3 sd	-2 sd	-1 sd	0 sd	+1 sd	+2 sd	+3 sd
Benchmark with Info. friction and learning							
Lifetime entrepreneur share	0.01	0.01	0.02	0.04	0.14	0.34	0.39
Lifetime y^b in total y	0.00	0.00	0.01	0.02	0.12	0.40	0.61
Lifetime incomes (normalized)	1.00	1.00	1.00	1.00	1.06	1.35	1.87
Perfect information (PI)							
Lifetime entrepreneur share							
Lifetime y^b in total y							
Lifetime incomes (normalized)							

- Entrepreneur share & business income/total income increase in type

Lifetime Outcomes by Innate Entrepreneurial Ability

Types	-3 sd	-2 sd	-1 sd	0 sd	+1 sd	+2 sd	+3 sd
Benchmark with Info. friction and learning							
Lifetime entrepreneur share	0.01	0.01	0.02	0.04	0.14	0.34	0.39
Lifetime y^b in total y	0.00	0.00	0.01	0.02	0.12	0.40	0.61
Lifetime incomes (normalized)	1.00	1.00	1.00	1.00	1.06	1.35	1.87
Perfect information (PI)							
Lifetime entrepreneur share	0.00	0.00	0.00	0.00	0.12	0.71	0.94
Lifetime y^b in total y	0.00	0.00	0.00	0.00	0.09	0.64	0.99
Lifetime incomes(normalized)	1.00	1.00	1.00	1.00	1.04	1.48	2.56

- In PI case: only high type choose to be entrepreneurs

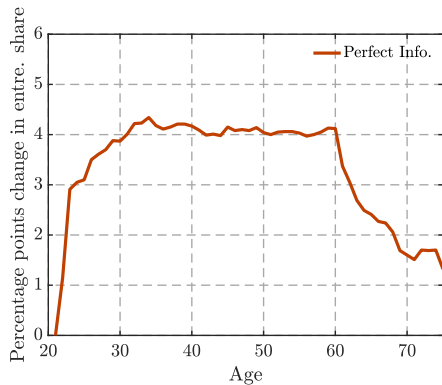
Lifetime Outcomes by Innate Entrepreneurial Ability

Types	-3 sd	-2 sd	-1 sd	0 sd	+1 sd	+2 sd	+3 sd
Benchmark with Info. friction and learning							
Lifetime entrepreneur share	0.01	0.01	0.02	0.04	0.14	0.34	0.39
Lifetime y^b in total y	0.00	0.00	0.01	0.02	0.12	0.40	0.61
Lifetime incomes (normalized)	1.00	1.00	1.00	1.00	1.06	1.35	1.87
Perfect information (PI)							
Lifetime entrepreneur share	0.00	0.00	0.00	0.00	0.12	0.71	0.94
Lifetime y^b in total y	0.00	0.00	0.00	0.00	0.09	0.64	0.99
Lifetime incomes(normalized)	1.00	1.00	1.00	1.00	1.04	1.48	2.56

- Switching to PI makes high type gain more (relative to middle/low type)
 $\Rightarrow$ cost of uncertainty higher for high type & value of learning higher for high type

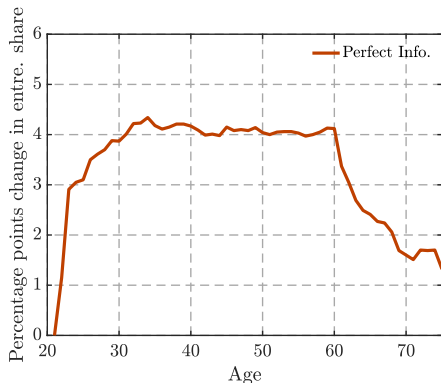
Interaction between Financial Frictions and Information Frictions

- Increase collateral param. λ from 1.5 to 2.0, i.e. borrowing up to 50% (100%) of own's assets
- Check how entrepreneur share increases over life cycle



Interaction between Financial Frictions and Information Frictions

- Increase collateral param. λ from 1.5 to 2.0, i.e. borrowing up to 50% (100%) of own's assets
- Check how entrepreneur share increases over life cycle

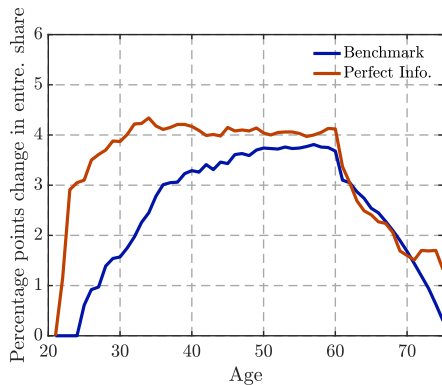


Relaxing collateral constraint ▶ Saving behavior under benchmark and PI

- PI: high types to enter immediately – collateral constraint binding for high types

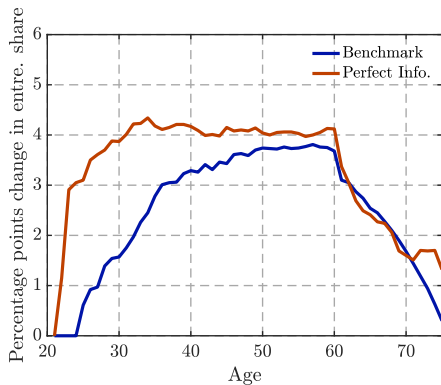
Interaction between Financial Frictions and Information Frictions

- Increase collateral param. λ from 1.5 to 2.0, i.e. borrowing up to 50% (100%) of own's assets
- Check how entrepreneur share change over life cycle for benchmark and PI



Interaction between Financial Frictions and Information Frictions

- Increase collateral param. λ from 1.5 to 2.0, i.e. borrowing up to 50% (100%) of own's assets
- Check how entrepreneur share change over life cycle for benchmark and PI



Relaxing collateral constraint

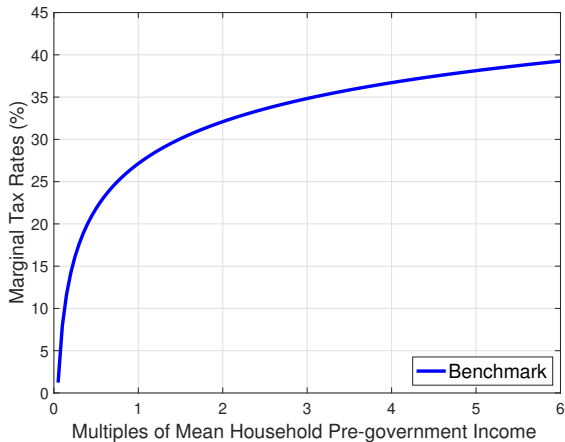
- PI: high types to enter immediately – collateral constraint binding for high types
 - Benchmark: much slower increase – liquidity constraint is still potentially binding with uncertainty
- Information frictions exacerbate financial frictions!

Tax Policy Experiments

Tax Experiments Overview

Evaluating impacts of current progressive income tax system in US on entrepreneurship

Benchmark economy: HSV tax functional form with progressivity = 0.10



Tax Experiments Overview

Evaluating impacts of current progressive income tax system in US on entrepreneurship

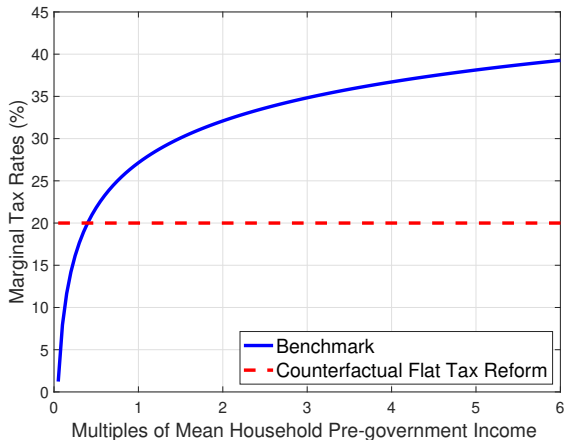
Benchmark economy: HSV tax functional form with progressivity = 0.10

- Progressive tax mimics the age-dependent tax in the absence of age-dependent tax codes
- Intuition: favoring the young (high uncertainty + low asset)
by providing lower tax burden and higher insurance value
- Compare impacts with a counterfactual revenue-neutral flat business income tax reform
 - Stationary equilibrium comparisons
 - Fix wage income tax schedule
 - Apply flat tax rate to business income
 - Compare with the case of perfect information

Switch to Flat Business Tax Reform from Benchmark Progressive Tax

Revenue neutral flat rate = 20%

- close to the peak of revenue Laffer curve



Switch to Flat Business Tax Reform from Benchmark Progressive Tax

Overall impacts

- entrep. share 9.0% → 6.0%
- AMTR 26.0% → 24.1%
- wage rate -1.1%, GDP -1.6%, CEV -2.0%

Switch to Flat Business Tax Reform from Benchmark Progressive Tax

Overall impacts

- entrep. share 9.0% → 6.0%
- AMTR 26.0% → 24.1%
- wage rate −1.1%, GDP −1.6%, CEV −2.0%

Age	Entre. Share	ATR	Assets	Output
25-34	−33.6	29.4	5.0	4.7
35-44	−35.7	−1.7	14.2	10.4
45-54	−35.0	−9.0	17.9	11.3
55-64	−38.0	−16.0	26.0	16.4
65-74	−43.0	−20.0	36.9	22.6

Table: Percentage change relative to benchmark, %

- **Dynamic persistent effect:** delayed learning further reduces entry at older ages

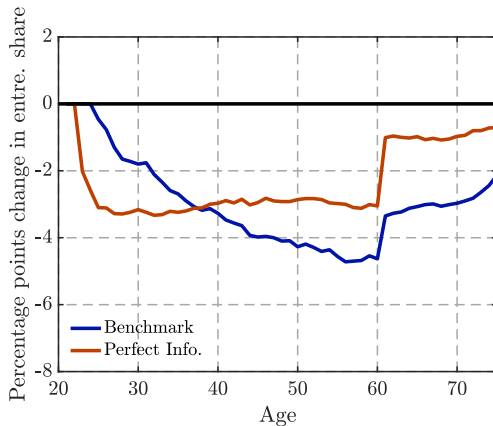
Compare with Perfect Information

Age	Entre. Share	ATR	Assets	Output
<i>Benchmark with learning</i>				
25-34	-33.6	29.4	5.0	4.7
35-44	-35.7	-1.7	14.2	10.4
45-54	-35.0	-9.0	17.9	11.3
55-64	-38.0	-16.0	26.0	16.4
<i>Perfect information</i>				
25-34	-36.6	36.3	14.0	12.8
35-44	-19.8	3.7	7.2	7.5
45-54	-14.8	-6.0	10.7	8.8
55-64	-13.3	-11.5	15.5	11.0

Compare with Perfect Info.: Change in Entre. Share by Age

Impact of flat tax reform on entrepreneur share over the life cycle

— deviation relative to economy under progressive income tax



- Much less persistent dynamic effect in the case of PI [▶ PE](#)

Comparing with Perfect Info.: Lifetime Outcomes by Innate Type

Flat tax reform relative to benchmark

Types	-3 sd	-2 sd	-1 sd	0 sd	+1 sd	+2 sd	+3 sd
Benchmark with info. friction and learning, GE							
Lifetime entre share, p.p.	-0.52	-0.72	-1.18	-2.59	-4.44	-7.15	-7.76
Lifetime incomes, %	-1.15	-1.15	-1.30	-2.11	-3.82	-6.93	-8.00

⇒ losses monotonically increasing in types

Comparing with Perfect Info.: Lifetime Outcomes by Innate Type

Flat tax reform relative to benchmark

Types	-3 sd	-2 sd	-1 sd	0 sd	+1 sd	+2 sd	+3 sd
Benchmark with info. friction and learning, GE							
Lifetime entre share, p.p.	-0.52	-0.72	-1.18	-2.59	-4.44	-7.15	-7.76
Lifetime incomes, %	-1.15	-1.15	-1.30	-2.11	-3.82	-6.93	-8.00

⇒ losses monotonically increasing in types

Perfect information, GE

Lifetime entre share, p.p.	0	0	0	-0.91	-4.35	-9.12	-4.30
Lifetime incomes, %	0.01	0.03	0.02	-0.42	-1.55	-2.60	2.60

⇒ redistribution effect leads to gains for highest type

Comparing with Perfect Info.: Lifetime Outcomes by Innate Type

Flat tax reform relative to benchmark

Types	-3 sd	-2 sd	-1 sd	0 sd	+1 sd	+2 sd	+3 sd
Benchmark with info. friction and learning, GE							
Lifetime entre share, p.p.	-0.52	-0.72	-1.18	-2.59	-4.44	-7.15	-7.76
Lifetime incomes, %	-1.15	-1.15	-1.30	-2.11	-3.82	-6.93	-8.00

⇒ losses monotonically increasing in types

Perfect information, GE

Lifetime entre share, p.p.	0	0	0	-0.91	-4.35	-9.12	-4.30
Lifetime incomes, %	0.01	0.03	0.02	-0.42	-1.55	-2.60	2.60

⇒ redistribution effect leads to gains for highest type

High ability entrepreneurs lose more from flat tax reform in benchmark!

Concluding Remarks

- **Main takeaway:** Incorporating life-cycle learning dynamics under imperfect information into the model of entrepreneurial choice is important
- **Data:** direct evidence on uncertainty faced by nascent entrepreneurs and learning
+ indirect evidence on age profile of entry/exit of entrepreneurs informing the theory
- **Policy implication:** entrepreneurship-boosting policies should prioritize the young

Concluding Remarks

- **Main takeaway:** Incorporating life-cycle learning dynamics under imperfect information into the model of entrepreneurial choice is important
 - **Data:** direct evidence on uncertainty faced by nascent entrepreneurs and learning
+ indirect evidence on age profile of entry/exit of entrepreneurs informing the theory
 - **Policy implication:** entrepreneurship-boosting policies should prioritize the young
- **Broad implications:**
 - Empirically, dynamic effect over life cycle complicates identifying the causal relationship btw tax progressivity and entrepreneurship across time: cohort effect matters!

Concluding Remarks

- **Main takeaway:** Incorporating **life-cycle learning dynamics under imperfect information** into the model of entrepreneurial choice is important
 - **Data:** direct evidence on uncertainty faced by nascent entrepreneurs and learning
+ indirect evidence on age profile of entry/exit of entrepreneurs informing the theory
 - **Policy implication:** entrepreneurship-boosting policies should prioritize the young
- **Broad implications:**
 - Empirically, dynamic effect over life cycle complicates identifying the causal relationship btw tax progressivity and entrepreneurship across time: **cohort effect matters!**
 - Implications on sources of secular declining entrepreneurship: good or bad?
 - Salgado (2021): decline in entrepreneurship is an efficient consequence of SBTC
 - Our model: bad if induce too little entry of young entrepreneurs

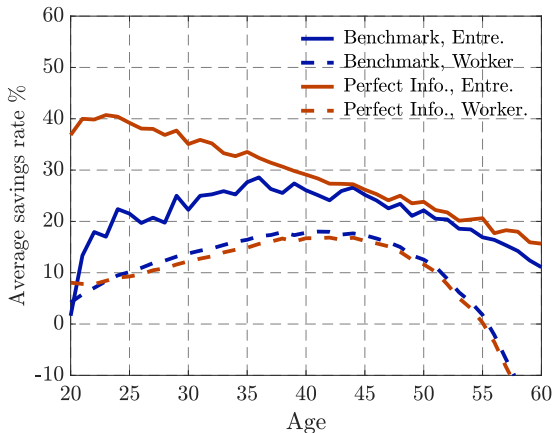
Appendix

- Data (PSID): More on Life Cycle Patterns
- Data (PSED): Expectations and Learning
- Data (PSED): Personality Traits
- Model Details
- More on Calibration and Model Fit
- More on Quantitative Results

Interaction between Financial Frictions and Information Frictions

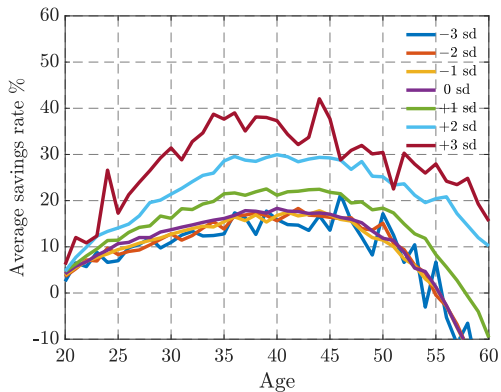
Different saving behavior in benchmark and PI

- Average saving rates of worker by age are the same regardless of information frictions [▶ Back](#)
- Average saving rates of entrepreneurs by age demonstrate different patterns:
 - PI: very high at early career
 - Benchmark: gradually increases until middle age (35-40)

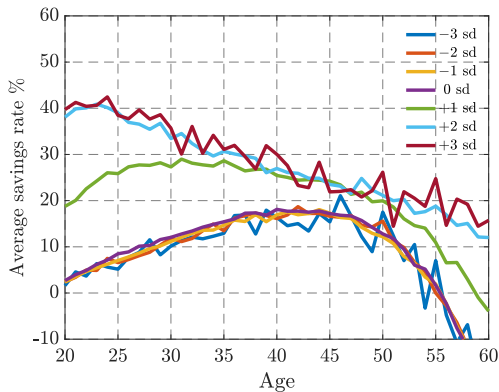


Interaction between Financial Frictions and Information Frictions

Different saving behavior in benchmark and PI by Ability Types



(a) Benchmark



(b) PI

Data (PSED): Expectations and Learning

Panel Studies of Entrepreneurial Dynamics

- Currently use PSED-I (1998-2004)
- Four waves
- Observations:
 - Nascent Entrepreneur (NE): 590
 - Controlled Group (CG): 227
- Variables in aspects of:
 - business: business status, capital structure, legal form, expectations, performance (sales/employment)
 - individual: demographics, labor market experience, personality

Definition of Nascent Entrepreneurs (NE) in PSED

To be considered a NE, individuals need to satisfy the following four criteria

- First, the individual had to currently consider himself or herself as involved in the firm creation process.
- Second, he or she had to have engaged in some business startup activity in the past 12 months.
- Third, the individual had to expect to own all or part of the new firm being created.
- Fourth, the initiative, at the time of the initial screening survey, could not have progressed to the point that it could have been considered an operating business.

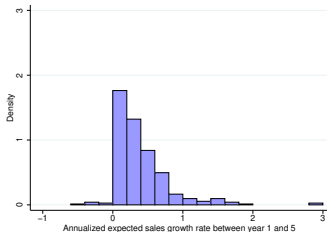
Key Features of Nascent Entrepreneurs (NE) in PSED

- **Legal form:** more than 84% are passthroughs
 - 50% of NE go with Sole Proprietorships, 20% go with Partnerships, 14% go with S-corp or LLC, 11% go with C-corp, 5% undecided
- **Attached to paid job:** about half of NE have a paid job (parttime or fulltime)
 - 31% of men and 25% of women work full time on their new businesses (≥ 35 hrs per week)
 - Large majority of both sexes work for a paid job: Of the 70% of men working for pay, 55% did so full time. The analogous statistics for women are 62% and 39%.
- **Size:** around 40% of men and 50% of women choose to be "merely" self-employed, while the rest expect to become employers over the first five years of operation
- **Industry choice:** Health, Education, and Social services, Retail and Restaurants
 - A large fraction of the men (35%) is starting a business in Health, Education, and Social services. Among the female NE this is also a strong category (20%)
 - Retail and Restaurants account for 28% of the men and 45% of the women
 - 15% of the women and 8% of the men chose manufacturing

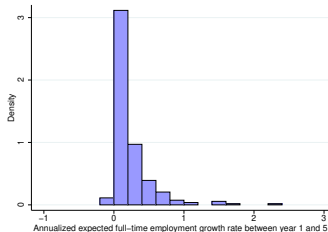
Summary Stats of Sales in PSED

	Mean	25%	Median	75%	Max	Std. Dev.	Skewness	Frac. zero sales	Exit rate
<i>Expected sales in wave 1 (\$1000), conditional on entry</i>									
Year 1	214	10	30	100	10,000	823	9.22	0.03	
Year 5	1,789	10	100	350	80,000	7,401	7.40	0.01	
<i>Realized sales in following-up waves (\$1000)</i>									
Wave2	241	5	25	90	10,000	1,004	7.34	0.04	0.50
Wave3	508	10	25	185	25,000	2,817	8.38	0.03	0.16
Wave4	887	11	50	200	45,000	5,502	7.87	0.06	—

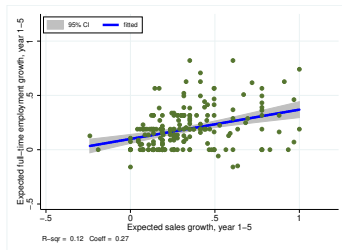
Annualized expected growth in wave 1



(a) Sales



(b) Employment



(c) Correlation

Note: around 40% of men and 50% of women choose to be "merely" self-employed, while the rest expect to become employers over the first five years of operation

► Back

Entrepreneurial Learning: Measurement

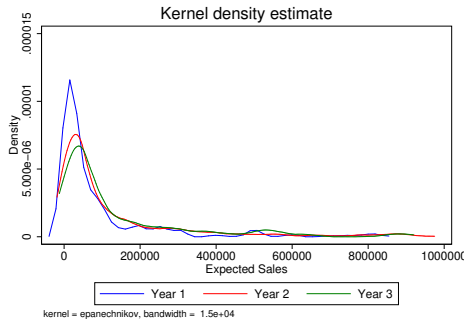
- ESale_t^{t+q} : period- q ahead expectation of sales as of period- t
- RSale_{t+q} : realization of sales in period $t + q$
- **Forecast error:**

$$\text{FError}_t^{t+q} = \frac{\text{RSale}_{t+q} - \text{ESale}_t^{t+q}}{\text{RSale}_{t+q} + \text{ESale}_t^{t+q}}$$

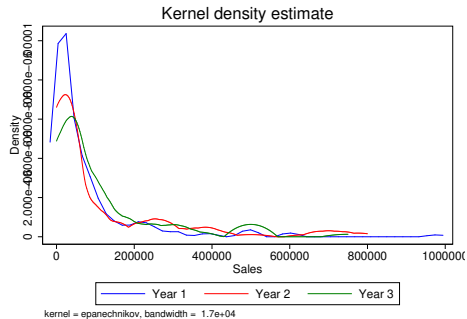
- **Forecast revision** in year t on year $t + q$ performance:

$$\text{FRev}_t^{t+q} = \frac{\text{ESale}_t^{t+q} - \text{ESale}_0^{t+q}}{\text{ESale}_t^{t+q} + \text{ESale}_0^{t+q}}$$

Dispersion of forecasts and realizations



Forecasts



Realizations

Forecast errors

Forecasting error by categories

Variable		Frac. obs.	Mean	Std. Dev.	Frac. missing	t-test	sd-test
Overall			-0.02	0.48			
Female	Yes	0.45	-0.03	0.44	0.01	0.76	0.13
	No	0.55	-0.01	0.52			
Age $\geq$ 40	Yes	0.55	-0.04	0.50	0.05	0.54	0.58
	No	0.45	0.01	0.47			
College edu.	Yes	0.46	0.00	0.47	0.01	0.60	0.57
	No	0.54	-0.04	0.50			
Retail ind.	Yes	0.23	-0.03	0.48	0.00	0.90	0.99
	No	0.77	-0.02	0.49			
First business	Yes	0.40	0.01	0.43	0.50	0.97	0.66
	No	0.60	0.01	0.46			
Ind. exp.	Yes	0.86	0.03	0.45	0.50	0.50	0.70
	No	0.14	-0.07	0.40			
Manage exp.	Yes	0.18	-0.08	0.46	0.51	0.42	0.85
	No	0.82	0.03	0.45			

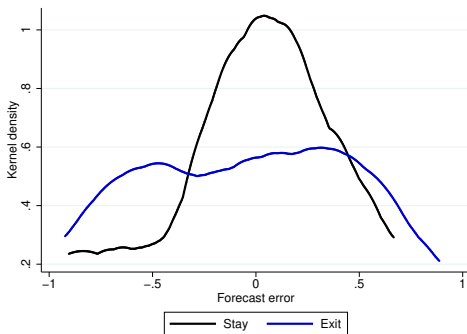
FR regression with controls

	(1)	(2)	(3)	(4)
FE	0.606*** (5.19)	0.576* (1.89)	0.642*** (3.01)	0.724* (1.88)
FE× female	0.00531 (0.04)	0.0215 (0.14)	0.162 (0.67)	0.353 (1.37)
FE× college	0.00546 (0.04)	-0.00310 (-0.02)	-0.243 (-1.01)	-0.222 (-0.90)
FE× retail	0.293* (1.75)	0.310* (1.76)	0.359 (0.97)	0.183 (0.49)
FE× age		0.000339 (0.05)		
FE× age ²		-2.86e-08 (-0.04)		
FE× first business			-0.308 (-1.23)	
FE× log exp				-0.109 (-0.86)
Personality controls	No	Yes	No	No
Obs.	146	146	72	61
adj. R^2	0.395	0.373	0.254	0.269

► Back

By Exit

		Mean	Std. Dev.	t test	sd test
Expected sales (\$1000)	Stay	242	623	0.9938	0.0001
	Exit	244	1059		
Realized sales (\$1000)	Stay	303	808	0.8237	0.0000
	Exit	374	2318		
Forecast error	Stay	0.00	0.44	0.7104	0.3473
	Exit	-0.04	0.50		

[► Back](#)

Data (PSID)

	PSID (96-04)	SCF (97-03)	PSED (98-04)
Frac. of Entrep. who have wage income	60%	77%	66%
Frac. of Entrep. whose businc > 0.5*total inc	49%	56%	-
Share of unincorporated	67%	75%	>70%
Exit rate after 1 year operation	29%	-	50%

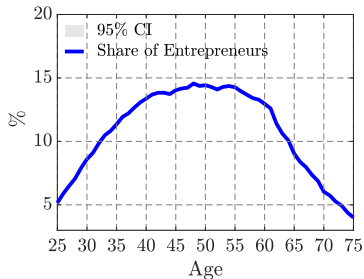
Notes: In IRS integrated business data, share of unincorporated is around 79% in 1996. Among all corporations, around 50% are s-corps.

PSID Definition

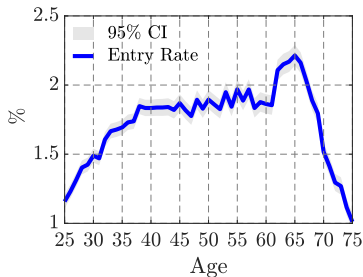
- **Entrepreneurs:** The heads of households who are self-employed and are business owners.
- **Self-employed:** At any period, conditional on having declared to be working, working for money, or only temporarily laid off, individuals answer a version of the following question: "On your main job, are you self-employed, are you employed by someone else, or what?." The answer options are "Someone else," "Both someone else and self," "Self-employed only," and "Don't Know." Entrepreneurs are defined as those individuals who have positive working hours and declare to be self-employed only
- **Income and Earnings:** Labor income of heads = income from wages, salaries, commissions, bonuses, overtime and the labor part of self-emp income.
Earnings of heads = both labor income and business income, which is equal to the labor income of head plus the asset part of business income. Note that the variable on the asset part of business income only applies to individuals who runs unincorporated businesses.
- **Wealth:** sum of values of several asset types (family farm business, family accounts, assets, stocks, houses, and other real estate etc.) net of debt value
- **Labor force:** employment status is either "Working now", "Only temporarily laid off, sick leave or maternity leave", or "Looking for work, unemployed".
- **Worker:** (1) employment status is "Working now" or "Only temporarily laid off, sick leave or maternity leave", (2) neither self-employed nor a business owner, (3) labor income is positive, and (4) annual hours is greater than 260.
- **Retirement:** (1) employment status is "Retired", and (2) social security income is positive.

Life Cycle Entry/Exit patterns in CPS

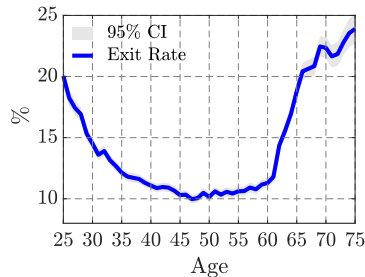
► Back



(a) Share in population



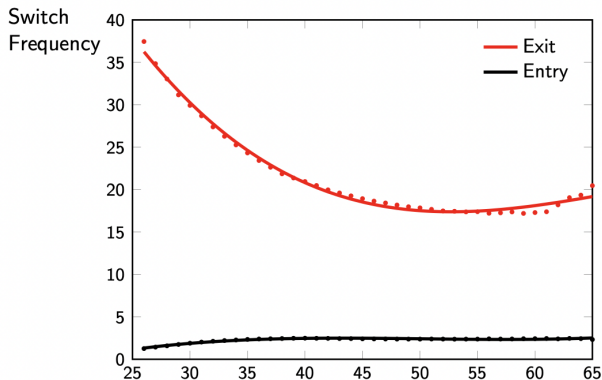
(b) Entry rate



(c) Exit rate

- CPS 1975 – 1996
- Entry/exit at monthly frequency
- Definition of entrepreneurs: [self-employed](#) household heads

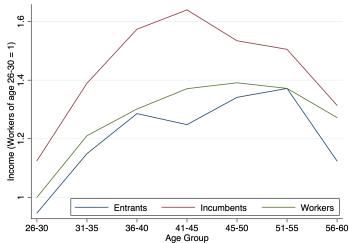
Life Cycle Entry/Exit patterns in IRS



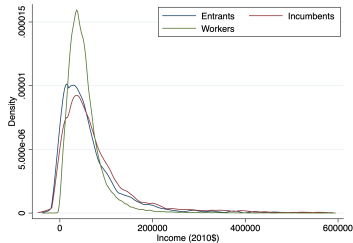
► Back

- Source: Bhandari, Kass, May, McGrattan, & Schulz (2022)
- IRS data
- Definition of entrepreneurs: $|SE\ income| > 5000$ in 2012\$ and at least one:
(1) $|SE\ income| > |PE\ income|$; (2) $Share\ in\ business \times employee \geq 1$;
(3) $Share\ of\ gross\ profits > PE\ income$

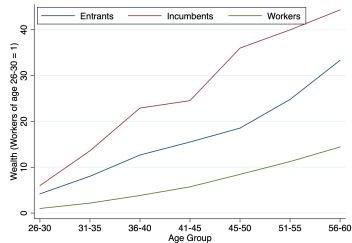
Wealth and Earnings



(a) Median earnings



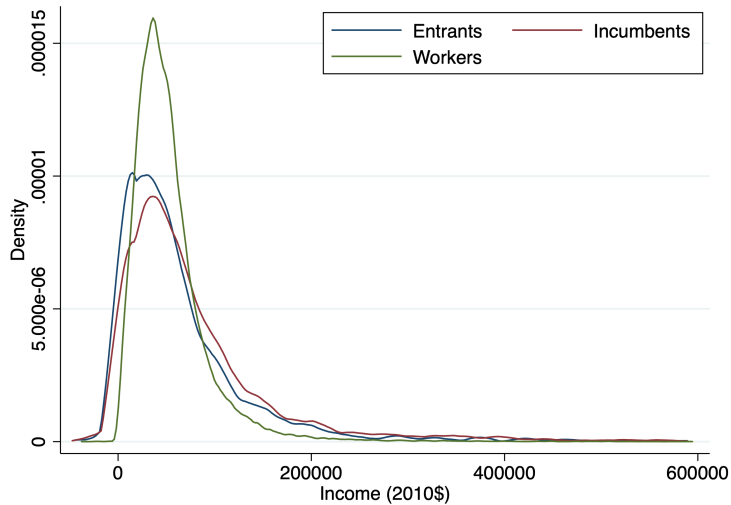
(b) Earnings distribution



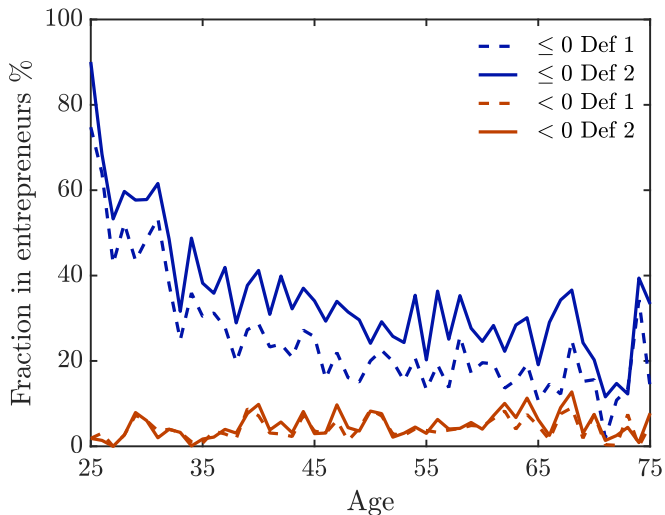
(c) Median wealth

► Back

Earnings distribution



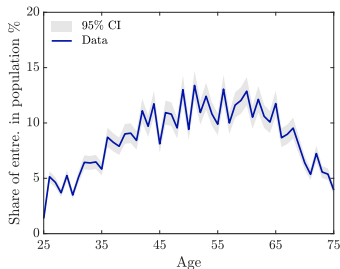
Fraction of Entrepreneurs with Non-positive Incomes in SCF



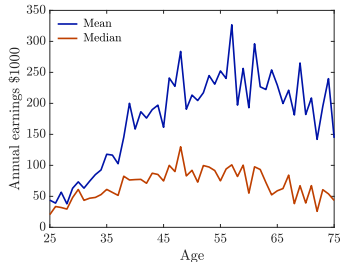
Definition of business incomes in SCF

- 1 schedule-C business inc + taxable interest + dividend + capital gains + schedule-E business inc + net operating loss

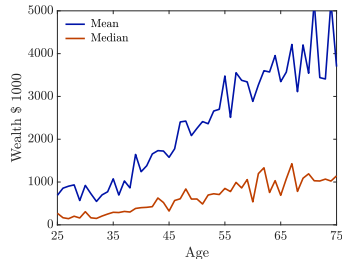
Age Profiles of Entrepreneur Share/Income/Wealth in SCF



(a) Entre. share



(b) Earnings



(c) Wealth

► Back

More on Model Details

Flow Utility

$$u(c_j, l_j; x_e) = \frac{(c_j^\gamma l_j^{1-\gamma})^{1-\nu}}{1-\nu}, \quad \gamma \in (0, 1), \nu > 0$$
$$l_j = 1 - h_j \mathbb{1}_{\{o_j=W\}} - g(x_e) \mathbb{1}_{\{o_j=E\}}$$

- c_j : consumption
- h_j : working hours as a worker
- l_j : leisure
- o_j : occupational choice
- $g(x_e)$: fixed utility cost of being an entre.
 - x_e permanent individual specific love of business characteristic

Government

- Consumption tax rate: τ_c
- Personal income tax $T_o(y)$
on wage/business incomes (entrepreneurial profits)+ asset income ra
- Social security:
 - Linear tax rate τ_{ss}
 - Social security income: z

► Details

► Back

Recursive Problem: Retirement

For $j = J$,

$$V_J^R(a) = \mathcal{V}(a) \quad \forall a$$

For $J^V < j < J$

$$\begin{aligned} V_j^R(a) &= \max_{a'} \{ u(c, 1) + \beta(1 - \zeta_{j+1})V_{j+1}^R(a) + \beta\zeta_{j+1}\mathcal{V}(a') \} \\ \text{s.t.} \quad &a' + c(1 + \tau_c) = a(1 + r) + z \\ &a' \geq \underline{a} \end{aligned}$$

i.e. spanning both voluntary and mandatory retirement ages

Social Security Taxes

- Taxable income : labor + entrepreneurial income

$$y_{ss,t} = y_{w,t} + y_{b,t}$$

- Social security tax:

$$T_{ss} = \tau_{ss} \min\{\bar{y}_{ss}, y_{ss}\}$$

$\bar{y}_{ss} = \$142800$ under current policy

- Note: how entrepreneurs divide labor/capital income does not matter for social security tax

Properties of the Bequest Function

- Consider the problem of the last period, after which individuals die with prob. 1

$$\begin{aligned} \max_{c, b} \quad & u(c) + \mathcal{V}(b) \\ \text{s.t.} \quad & c + b = y \end{aligned}$$

- F.O.C. (assuming an interior solution) gives:

$$\begin{aligned} u'(c) &= \mathcal{V}'(b) \quad \text{i.e.} \quad c^{-\tilde{\zeta}} = \left(\frac{\phi_b}{1 - \phi_b}\right)^{\tilde{\zeta}} \left(\frac{\phi_b}{1 - \phi_b} c_b + b\right)^{-\tilde{\zeta}} \\ \rightarrow c &= c_b + \left(\frac{\phi_b}{1 - \phi_b}\right)^{-1} b \end{aligned}$$

- Thus, the optimal choice of bequest b^*

$$b^* = \begin{cases} 0 & \text{if } y \leq c_b \\ \phi_b(y - c_b) & \text{if } y > c_b \end{cases}$$

Competitive Stationary Equilibrium

◀ Back

- 1 Individuals' optimization problems are solved
- 2 Representative corporate firm profit maximization problem is solved
- 3 Capital market clears: $\sum_{j=1}^J \int a^W(\mathbf{x}_j) d\Gamma_j^W(\mathbf{x}_j) + \sum_{j=1}^J \int a^E(\mathbf{x}_j) d\Gamma_j^E(\mathbf{x}_j) = K_C + \sum_{j=1}^{J^R-1} \int k(\mathbf{x}_j) d\Gamma_j^E(\mathbf{x}_j)$
- 4 Labor market clears: $\sum_{j=1}^{J^R-1} \int \epsilon_{\omega,j} \theta_j h_j(\mathbf{x}_j) \mathbb{I}_{\{h_j > 0\}} d\Gamma_j^W(\mathbf{x}_j) = N_C + \sum_{j=1}^{J^R-1} \int n(\mathbf{x}_j) d\Gamma_j^E(\mathbf{x}_j)$
- 5 The Social Security system clears:

$$\tau_{ss} \left(\sum_{j=1}^{J^R-1} \int y_j^w(\mathbf{x}_j) d\Gamma_j^W(\mathbf{x}_j) + \sum_{j=1}^{J^R-1} \int y_j^b(\mathbf{x}_j) d\Gamma_j^E(\mathbf{x}_j) \right) = \sum_{j=J^R}^J z$$

- 6 The government balances its budget:

$$G = \tau_c C + \sum_{j=1}^{J^R-1} \int T^w(y_j^w(\mathbf{x}_j)) d\Gamma_j^W(\mathbf{x}_j) + \sum_{j=1}^{J^R-1} \int T^b(y_j^b(\mathbf{x}_j)) d\Gamma_j^E(\mathbf{x}_j)$$

- 7 Bequests left by age 85 or individuals hit by mortality shocks are redistributed in a lump-sum fashion across individuals alive
- 8 The distributions of workers and entrepreneurs at the beginning of period j respectively, $\{\Gamma_j^W(\mathbf{x}_j), \Gamma_j^E(\mathbf{x}_j)\}_{j=1}^J$, evolve based on the individuals' policy functions and the autoregressive process for the exogenous productivity states.

Permanent Types (Worker)

- Following Conesa, Kitao, and Krueger (2009)
- We consider two ability types, with equal population mass $p_i = 0.5$
- and fixed effects $\chi_1 = e^{-\sigma_x}$ and $\chi_2 = e^{\sigma_x}$ s.t.

$$E(\log(\chi_i)) = 0, \text{var}(\log(\chi_i)) = \sigma_x^2$$

Discussion on Model Elements

- **Asset accumulation + collateral constraint:**
 - young more likely to be constrained
- **Entrepreneurial productivity learning:**
 - help to match life-cycle moments: exit rate, dispersion of earnings
 - forecast precision increases by age
- **Voluntary retirement and bequest:**
 - help to match life-cycle moments: assets, exit rate around retirement
 - increase entrep. choice elasticity around retirement
- **Non-pecuniary utilities:**
 - permanent heterogeneity in taste
 - help to match earnings differentials between entrepreneurs and workers

More on Calibration and Model Fit

Functional Specifications

- **Utility cost of being an entrepreneur:**

$$g(x_e) = \phi_{e,0} + \phi_{e,1}x_e$$

- **Production functions:**

$$f(k, n_b) = (k^\alpha n_b^{1-\alpha})^\eta, \quad \eta < 1$$

$$F_C(K_C, N_C) = A_C K_C^\mu N_C^{1-\mu}$$

- **Personal income tax:** same for W, E

$$T(y) = y - (1 - \kappa_0)y^{(1-\kappa_1)}$$

- **Bequest:** following De Nardi (2004) and Lockwood (2018)

$$\mathcal{V}(b) = \left(\frac{\phi_b}{1 - \phi_b}\right)^{\tilde{\nu}} \frac{\left(\frac{\phi_b}{1 - \phi_b}c_b + b\right)^{1-\tilde{\nu}}}{1 - \nu}$$

► Properties of $\mathcal{V}(b)$

Data Sources

PSID: life cycle

- Entrepreneur entry/exit
- Moments on assets, earnings, and bequests [▶ Prob. of Receiving Bequest](#)

PSED Wave 1 (1998-2004): NE (entrants)

- Love of business (LoB) characteristic:
 - use Principal Component Analysis (PCA) to convert 25 survey questions into 6 personality traits:
love of business + 'Big 5' (OCEAN) [▶ PCA Details](#)
 - stable over life, no gender difference [▶ Details](#)
 - only LoB is found to affect the entrepreneur choice [▶ Regression](#)
- Entrepreneurial productivity learning [▶ Graphics](#)

Parameters Calibrated Internally

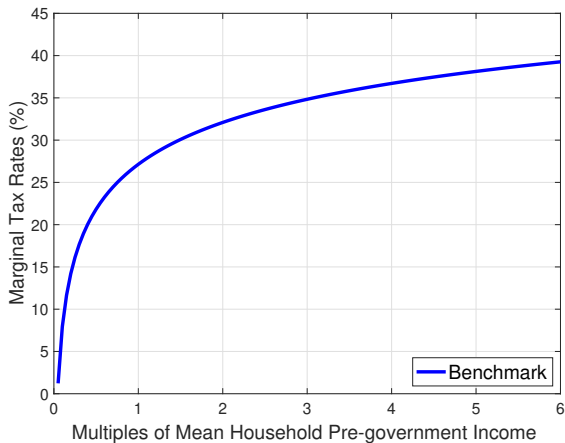
Parameter	Description	Value	Target
Non-pecuniary utility			
$(\beta_{e,1}, \beta_{e,2})$	Beta distribution: LoB state x_e	(3.2, 2.8)	PSED-LoB score ▶ Detail
$\phi_{e,0}$	Fixed util. cost of entrep.: intercept	0.60	Share of entrepreneur = 9.0%
$\phi_{e,1}$	Fixed util. cost of entrep.: slope	-0.09	Diff. in mean LoB score: entrep. & worker= 0.20
Learning process: Bayesian updating			
μ_e	Mean: dist. of innate entrep. prod.	1.25	Median business to wage income = 1.3
ν_e	Std: dist. of innate entrep. prod.	0.37	Std. dev. of forecasting error = 0.40
σ_e	Std: transitory i.i.d.shocks	0.50	Slope of forecast revision = 0.66
Financial friction & bequest function			
λ	Collateral parameter	1.50	Median wealth entrep. to worker = 6.0
c_b	Threshold consump. level	0.30	17000 USD (2010\$)
ϕ_b	Marginal propensity to bequeath	0.95	Bequest as a share of total wealth = 0.60
Preferences			
ζ	Risk aversion	4	IES = 0.5
γ	Intensity of consumption	0.38	2,000 annual hours for workers
β	Discount factor	0.96	K/Y= 2.7
ϕ_ω	Fixed cost of working	0.25	Employment rate

Parameters Calibrated/Estimated Externally

Parameter	Description	Value	Source/Target
Wage income			
$\{\theta_j\}_{j=1,\dots,60}$	Age-dependent labor productivity	▶ Figure	Hansen (1993)
ρ_w	Wage income shock: persistence	0.98	Consea, Kitao, Krueger (2009)
σ_w	Wage income shock: std. dev	0.17	Consea, Kitao, Krueger (2009)
σ_χ	Permanent types dist.: std. dev	0.37	Consea, Kitao, Krueger (2009) ▶ Detail
Technology			
ξ	Capital share: corporate	0.36	Corporate labor share
α	Capital share: entrepreneurs	0.36	-
η	Scale parameters: entrepreneurs	0.79	Buera, Kaboski, Shin (2011)
δ	Capital depreciation rate	0.06	BEA fixed asset tables
Government policy			
τ_c	Consumption tax rate	0.065	Bhandari and McGrattan (2020)
τ_{ss}	Payroll tax rate	0.124	Consea, Kitao, Krueger (2009)
κ_0	Personal income tax: level shifter	2.43	Estimated by PSID
κ_1	Personal income tax: progressivity	0.10	Estimated by PSID

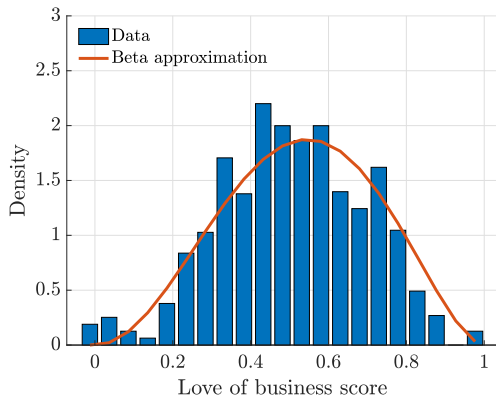
Tax Schedule

Benchmark economy: HSV tax functional form with progressivity = 0.10



Distribution of Love of Business Scores

- Approximation $Beta(3.2, 2.8)$

[◀ Back](#)

Grid (x_e)	0.17	0.50	0.83
Probability	0.12	0.67	0.21

Discretized distribution

Disciplining learning process

- Individuals' true entrepreneurial productivity $\mu \sim N(\mu_e, \nu_e^2)$
- n -th signal $\epsilon_{e,n} = \mu + \varepsilon, \varepsilon \text{ i.i.d. } \sim N(0, \sigma_e^2)$
- Posterior belief after observing n -th signal be $N(\tilde{\mu}_{e,n}, \tilde{\nu}_{e,n}^2)$
- Bayesian updating:

$$\tilde{\nu}_{e,n}^2 = \frac{\nu_e^2 \sigma_e^2}{n\nu_e^2 + \sigma_e^2}$$
$$\tilde{\mu}_{e,n} = \tilde{\nu}_{e,n}^2 \left(\frac{\tilde{\mu}_{e,n-1}}{\tilde{\nu}_{e,n-1}^2} + \frac{\epsilon_{e,n}}{\sigma_e^2} \right)$$

- ν_e^2 determines how noisy the initial information:
variance of forecast errors in data
- σ_e^2 given ν_e^2 determines the belief updating speed:
slope of forecast revision in data

► data

► data

Disciplining the Bequest Function

- Consider the problem of the last period, after which individuals die with prob. 1

$$\begin{aligned} \max_{c, b} \quad & u(c) + \mathcal{V}(b) \\ \text{s.t.} \quad & c + b = y, \mathcal{V}(b) = \left(\frac{\phi_b}{1 - \phi_b}\right)^{\tilde{\zeta}} \frac{\left(\frac{\phi_b}{1 - \phi_b} c_b + b\right)^{1 - \tilde{\zeta}}}{1 - \tilde{\zeta}} \end{aligned}$$

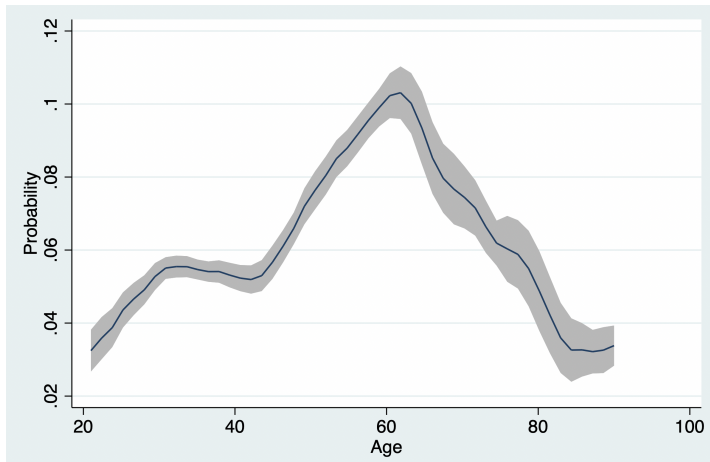
- The optimal choice of bequest b^*

$$b^* = \begin{cases} 0 & \text{if } y \leq c_b \\ \phi_b(y - c_b) & \text{if } y > c_b \end{cases}$$

- c_b : consump. threshold above which people bequest

→ 17000 USD, 2010\$ (estimation from Lockwood (2018, AER))

Probability of Receiving a Bequest (PSID)



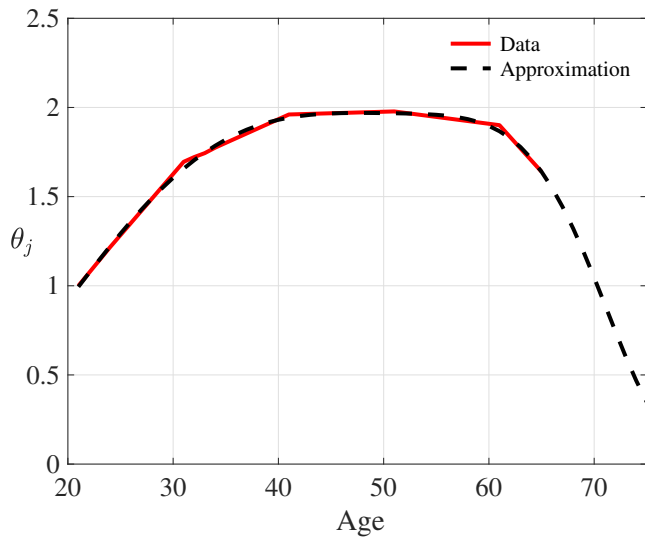
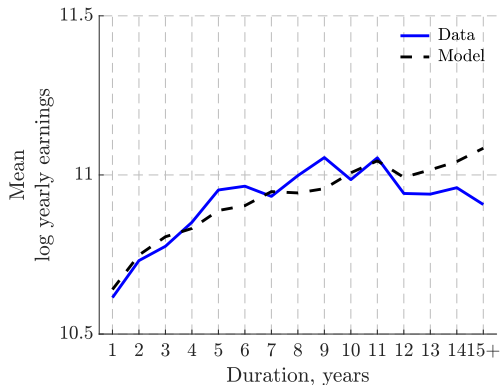
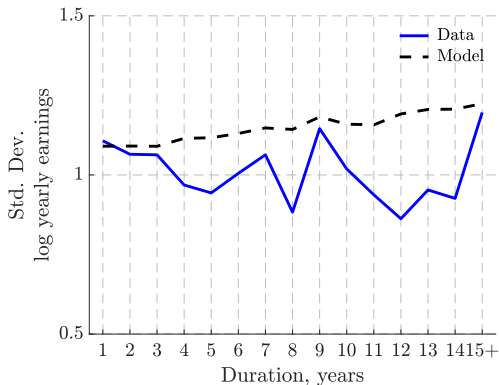


Figure: Age profile of wage incomes

Model Fit: Entrepreneurial Earnings

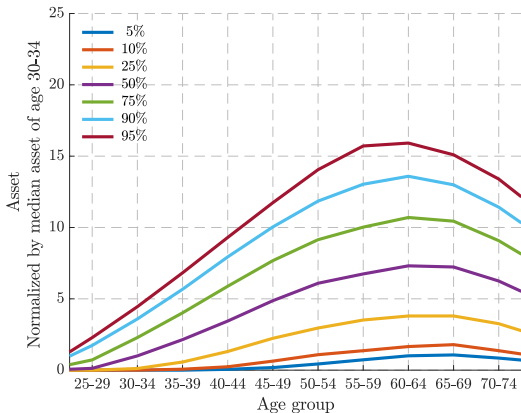


(a) Mean of log earnings

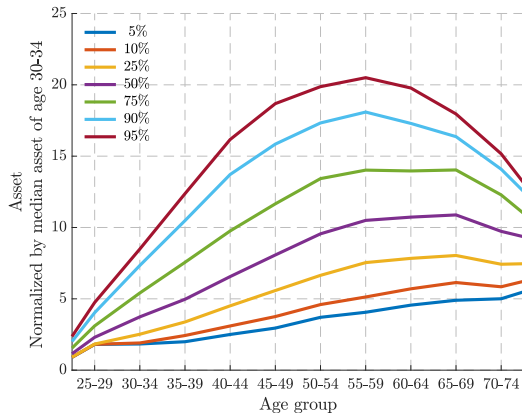


(b) Std. Dev. of log earnings

Model Asset Distribution



(a) All

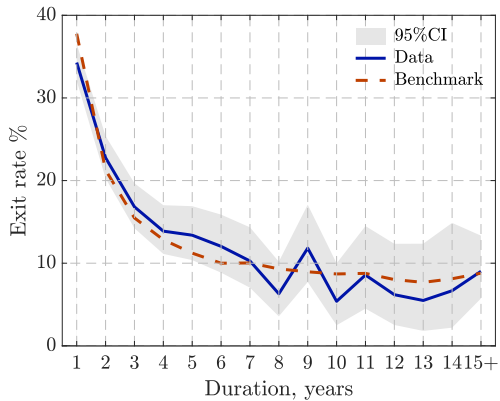


(b) Entrepreneurs

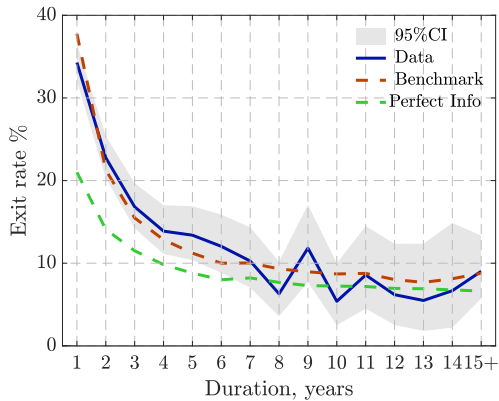
Exit of Entrepreneurs Around Retirement



Exit by Duration



(a) fit

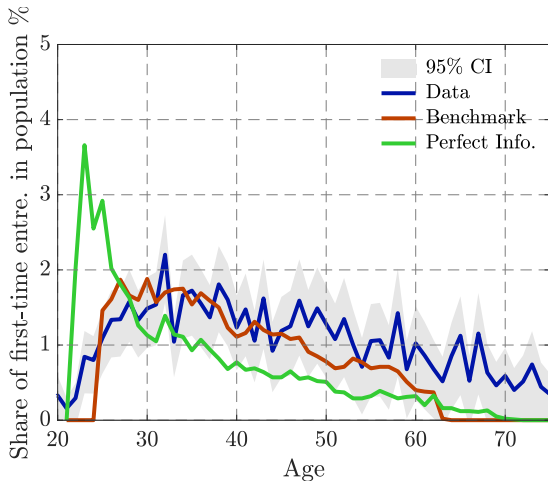


(b) with PI

Model Fit: Income & Wealth Distribution

	Benchmark	Perfect info.	Data
Gini coefficient			
Income - all	0.54	0.58	0.55
Income - worker	0.29	0.30	0.38
Income - entre	0.59	0.52	0.66
Wealth - all	0.64	0.72	0.85
Income/wealth ratios: entrepreneur to worker			
Income median	1.60	2.10	1.30
Income mean	2.60	2.70	2.50
Wealth median	5.90	12.10	6.00
Fraction of entrepreneurs in wealth percentiles			
Top 1%	0.56	0.63	0.54
Top 5%	0.48	0.65	0.39
Top 10%	0.31	0.60	0.32
Top 20%	0.22	0.42	0.22

First Time Entry: Compare with Perfect Information



- PI: high type enters at very young age (no need to learn)

Model Fit - Dispersion of LoB Characteristic

	All	Workers		Entrepreneurs	
		Data	Model	Data	Model
Mean	0.531	0.521	0.524	0.614	0.612
Std. Dev.	0.190	0.193	0.189	0.123	0.171

Table: Love of business characteristic by entrepreneur status

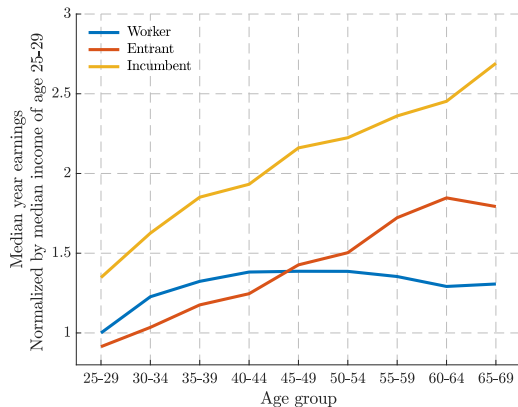
Model Fit - Entrepreneurial Firm Distribution

	Data	Model
Share of entre. in population	7.6	5.4
Share of hiring entre.	66.1	51.9
Frac. of entre. in top wealth percentiles		
1%	54	15.8
5%	39	9.3
10%	32	7.9
20%	22	7.2
Firm size distribution		
1-5 Employees	69.2	58.3
6-10 Employees	11.9	37.2
11-20 Employees	6.5	4.5
>20 Employees	12.5	0.0

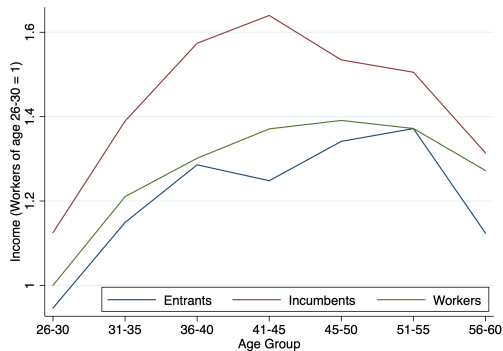
Model Fit - Aggregate Moments

Values	
Taxes to GDP ratios, %	
Total taxes	29.1
Consumption tax	3.5
Wage income tax	18.3
Business income tax	1.1
Assets/sales to GDP ratios, %	
Corporate fixed asset	237.4
Entrepreneurial fixed assets	24.3
Entrepreneurial sales	15.4

Median Income: Entrants vs Incumbents

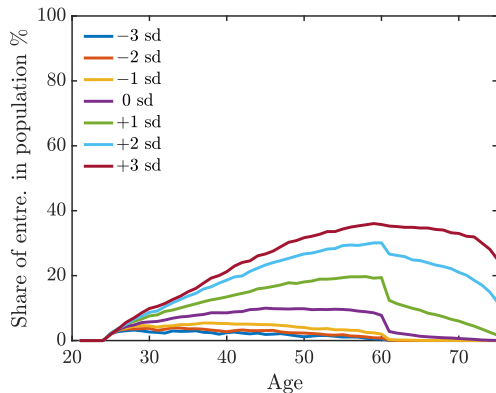


(a) Model

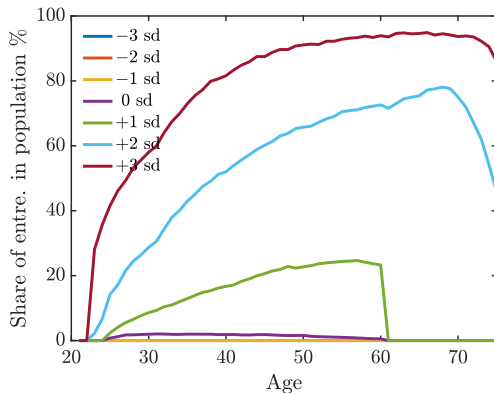


(b) Data

Entrepreneur Share by Innate Ability Type over Life Cycle



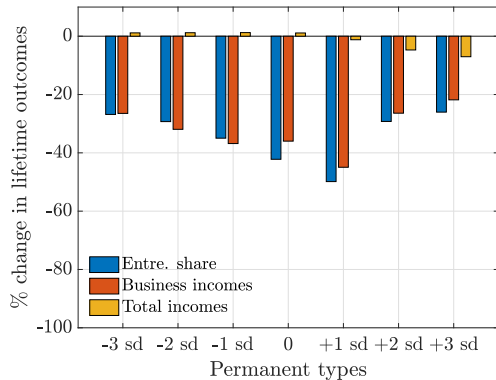
(a) Benchmark with learning



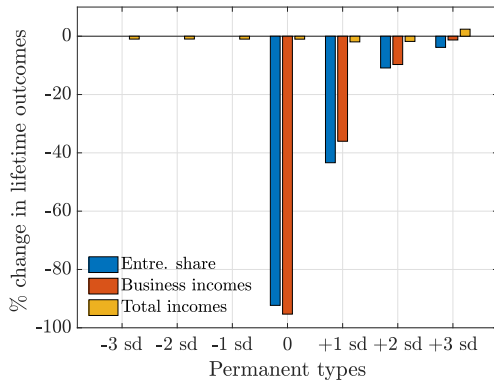
(b) Perfect information

More on Quantitative Results

Change in Lifetime Outcomes by Innate Type



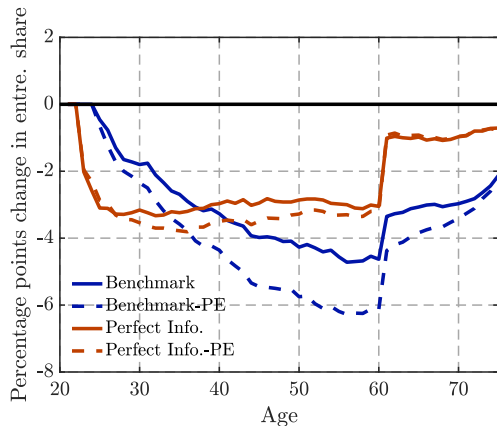
(a) Benchmark with learning



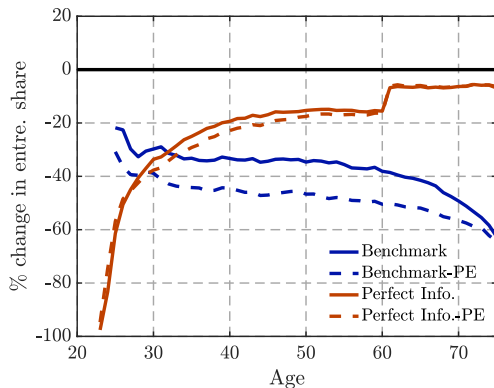
(b) Perfect information

sCompare with Perfect Information

Impact of flat tax reform on entrepreneur share over the life cycle



(a) Level change



(b) % change

- PE: qualitatively the same & quantitatively impact a bit larger

Impacts on Aggregate Moments

	With learning	Perfect information
Self-employment rate	-36.3%	-16.3%
Interest rate	4.7%	-5.0%
Wage rate	-1.1%	0.9%
Total output	-1.6%	1.8%
Private business	-26.5%	-1.4%
Corporate	16.5%	10.4%
Ave. private business output	16.1%	18.1%
Agg. employee hours	1.0%	1.3%
Agg. capital	5.5%	10.3%
AMTR-worker	1.4%	0.9%
AMTR-entre.	-46.3%	-45.6%
ATR-worker	0.8%	1.0%
ATR-entre.	-15.1%	-12.7%

Alternative Model: Perfect Information

- Prior to entering the labor market, individuals know their true entrepreneurial productivity
 $\mu \sim N(\mu_e, \nu_e^2)$
- After they decide to be an entrepreneur, i.i.d. shock to true type realizes
- The benchmark model nests this alternative model by shutting down the belief updating margin
- The benchmark model nests Aiyagari-styled occupation choice model with ex post risk but perfect information in the literature (e.g. Vereshchagina & Hopenhayn (2009), Boháček & Zubrický (2012), Boar & Knowles (2020))

add picture, show qualitatively different trend

Alternative Model: Human Capital Accumulation

- Prior to entering the labor market, individuals know their true entrepreneurial productivity
 $\mu \sim N(\mu_e, \nu_e^2)$
- After they decide to be an entrepreneur, i.i.d. shock to true type realizes
- The longer they've been entrepreneurs, the more human capital they accumulated which accrued to productivity
- Now, entrep. output becomes $\epsilon_e n^\iota f(k, n_b)$ where n : num. periods being an entrepreneur

add picture, show comparison trend

discipline curvature parameter ι to target mean entrep. earnings by duration?

Data (PSED): Personality Traits

	By gender			By age		
	Men	Women	<i>p</i> -value	Age < 40	Age ≥ 40	<i>p</i> -value
Love of Business	0.5742 (0.0086)	0.5749 (0.0085)	0.9538	0.5727 (0.0088)	0.5774 (0.0094)	0.7189
Openness	0.5016 (0.0078)	0.4685 (0.0072)	0.0018	0.4823 (0.0075)	0.4871 (0.0083)	0.6694
Conscientiousness	0.6021 (0.0074)	0.6237 (0.0075)	0.0410	0.6250 (0.0083)	0.6006 (0.0076)	0.0311
Extraversion	0.5623 (0.0071)	0.6117 (0.0072)	0.0000	0.5847 (0.0078)	0.5876 (0.0079)	0.7984
Agreeableness	0.6203 (0.0065)	0.6237 (0.0066)	0.7123	0.6174 (0.0067)	0.6270 (0.0072)	0.3297
Neuroticism	0.5912 (0.0063)	0.5946 (0.0067)	0.7235	0.5945 (0.0069)	0.5908 (0.0071)	0.7106
Sample size	379	395		337	337	

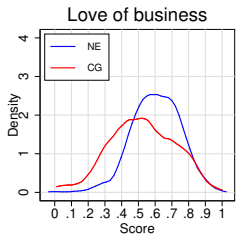
Table: Comparison of personality traits by gender and age

Note: standard deviation in parenthesis

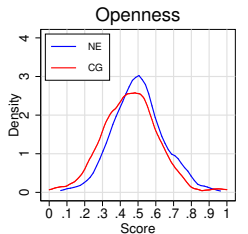
Personality traits in PSED

- 'Big 5': Psychological methods summarize an individual's personality
- We additionally add a general trait for running a business, called Love of Business (LoB)
- *Question QL1d: I would rather have my own business than pursue another promising career*
- *Answers from 1. Completely untrue 2. Mostly untrue 3. It depends 4. Mostly true 5. Completely true*
- We use Principal Component Analysis to summarize the original 25 questions into the 'Big 5' plus "Love of Business" personal traits
- We assign a score to each answer option in a linear way
- We rescale the constructed traits to lie in $[0, 1]$ so that we can obtain the distribution of scores of a certain personal trait

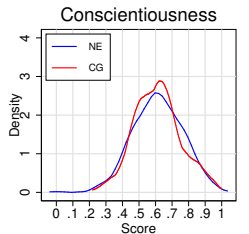
Distribution by group



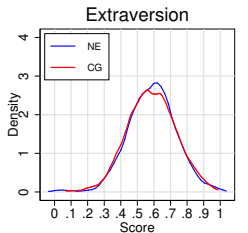
kernel = epanechnikov, bandwidth = 0.0371



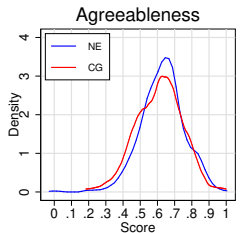
kernel = epanechnikov, bandwidth = 0.0343



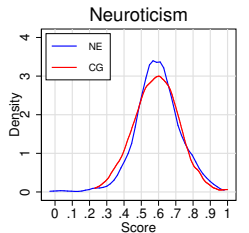
kernel = epanechnikov, bandwidth = 0.0392



kernel = epanechnikov, bandwidth = 0.0362



kernel = epanechnikov, bandwidth = 0.0296



kernel = epanechnikov, bandwidth = 0.0300

► [Back to data overview](#)

► [No Love of Business](#)

► [More alternatives](#)

Personality traits in PSED

- 25 questions on personality
including 5 directly related to business
- Asking respondents whether a statement accurately describes her
example: QL1a: I can do anything I set my mind on doing
- Answers from
 1. *Completely untrue*
 2. *Mostly untrue*
 3. *It depends*
 4. *Mostly true*
 5. *Completely true*

Measuring personality traits

- Problem:

$$d_{s,i} = \sum_m \alpha_s^m x_i^m + u_{s,i}$$

- Questions: $s = 1, \dots, 25 \rightarrow$ Underlying traits: $m = 1, \dots, M$
- Individual: $i = 1, \dots, N$ both NE and CG
- $d_{s,i}$: answer to question s for individual i
- x_i^m : personality traits m for individual i
- α_s^m : sensitivity of measurement s to personality m
- Identification
 - Normalize $d_{s,i}$ to have mean zero and variance one for each s
 - Impose M exclusion restriction: a certain question perfectly reveals a certain personality trait
example: prior that question s perfectly reveals personality k

$$\alpha_s^m = \begin{cases} 1 & \text{for } m = k \\ 0 & \text{for } m \neq k \end{cases}$$

Personality traits

Love of business + 'OCEAN' (Big 5)

- **Love of business:** general love of business
- **Openness** (to experience): inventive/curious vs. consistent/cautious
- **Conscientiousness:** efficient/organized vs. extravagant/careless
- **Extraversion:** outgoing/energetic vs. solitary/reserved
- **Agreeableness:** friendly/compassionate vs. critical/rational
- **Neuroticism:** sensitive/nervous vs. resilient/confident

Personality traits & restrictions

- **Love of business:** general love of business
QL1d: I would rather have my own business than pursue another promising career
- **Openness** (to experience): inventive/curious vs. consistent/cautious
QL1q: I enjoy the challenge of situations that many consider “risky”
- **Conscientiousness:** efficient/organized vs. extravagant/careless
QL1b: I do every job as thoroughly as possible
- **Extraversion:** outgoing/energetic vs. solitary/reserved
QL1h: I have no trouble making and keeping friends
- **Agreeableness:** friendly/compassionate vs. critical/rational
QL1x: I am a good judge of other people
- **Neuroticism:** sensitive/nervous vs. resilient/confident
QL1i: When I make plans I am almost certain to make them work

Measuring Personality Traits

Consider number M types of main traits:

- ① Use survey answers as scores to each question and normalize;
- ② Run Principal Component Analysis (PCA) on question scores and keep the first M principal components;
- ③ Recover traits indices by recombining predicted principal components in such a way that they satisfy M certain exclusion restrictions;
(this step just involves matrix operation of PCA results)
- ④ Rescale the constructed traits to lie in $[0,1]$.

PSED Questions on Personality 1-13

- ① I can do anything I set my mind on doing
- ② I do every job as thoroughly as possible (**C**)
- ③ I spend a considerable amount of time making organizations I belong to function better
- ④ I would rather have my own business than pursue another promising career (**B**)
- ⑤ There is no limit as to how long I would give maximum effort to establish my business
- ⑥ My personal philosophy is to “do whatever it takes” to establish my own business
- ⑦ Owning my own business is more important than spending time with my family
- ⑧ I have no trouble making and keeping friends (**E**)
- ⑨ When I make plans I am almost certain to make them work (**i**)
- ⑩ When I get what I want, it is usually because I worked hard for it
- ⑪ If I am about to leave home for a game or concert and discover I lost the ticket, I will buy another ticket and go anyway
- ⑫ When I decide whether to keep or sell an investment, I consider the investment's current value rather than what I paid for it

PSED Questions on Personality 13-25

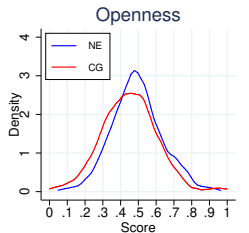
- 13 I am very happy with my life overall
- 14 I would be proud of my children if they started their own business
- 15 I have been very impressed with the people I know well who have their own business
- 16 All things considered, I would probably choose the same career path again
- 17 I enjoy the challenge of situations that many consider “risky” (**O**)
- 18 When confronted with a difficult problem I tend to delay a decision so I can collect more information
- 19 I rarely show my feelings
- 20 I usually know what is appropriate in any social situation
- 21 I consider myself a loner
- 22 Whatever emotion I feel on the inside tends to show on the outside
- 23 I am often concerned about what others think of me
- 24 I am a good judge of other people (**A**)
- 25 I can talk to almost anybody about almost anything

Alternative Specifications of Personality Traits

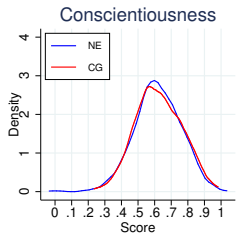
- ① Drop trait 'Love of business', estimate with all survey questions [▶ Details](#)
- ② Drop trait 'Love of business', estimate with all but business-related questions [▶ Details](#)
- ③ Drop trait 'Love of business' and 'Agreeableness', estimate with all survey questions [▶ Details](#)
- ④ Drop trait 'Love of business' and 'Agreeableness', estimate with all but business-related questions [▶ Details](#)

[◀ Back](#)

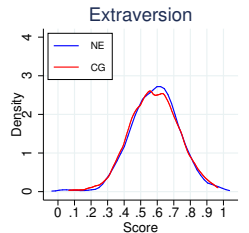
No 'Love of business' trait



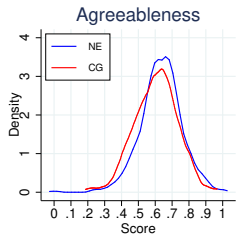
kernel = epanechnikov, bandwidth = 0.0344



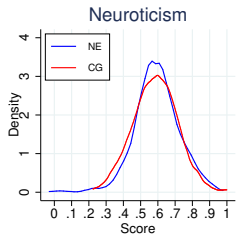
kernel = epanechnikov, bandwidth = 0.0353



kernel = epanechnikov, bandwidth = 0.0370

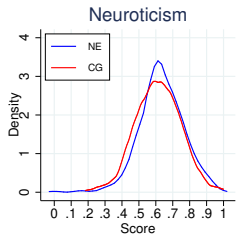
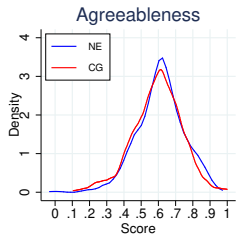
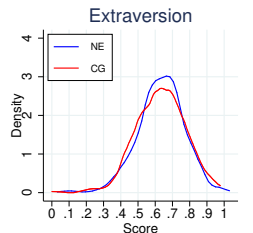
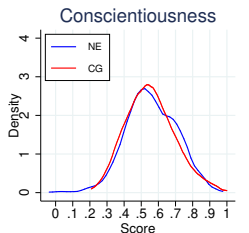
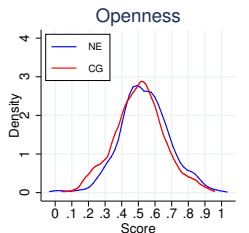


kernel = epanechnikov, bandwidth = 0.0271

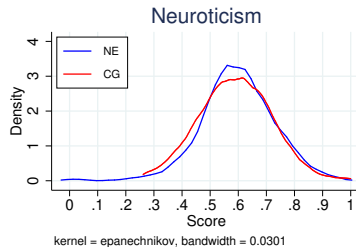
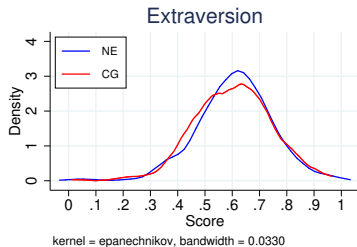
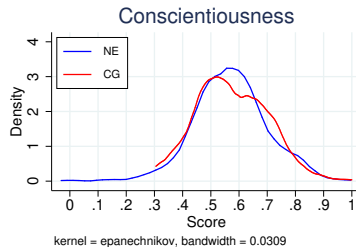
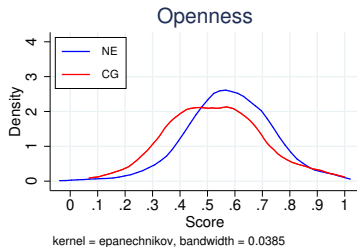


kernel = epanechnikov, bandwidth = 0.0299

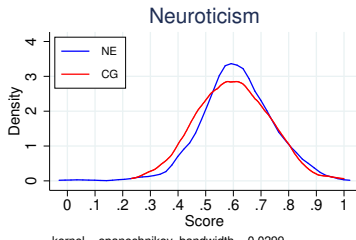
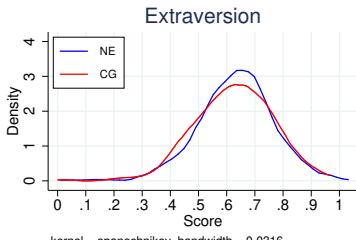
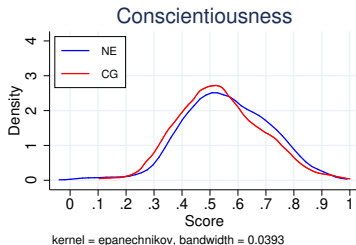
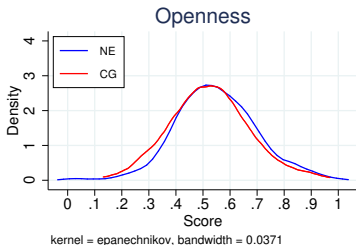
No 'Love of business' trait + Drop business-related questions



Further no 'Agreeableness' trait



Further no 'Agreeableness' trait + Drop business-related questions



Heckman Two-Step Regression

- First stage: $Probit(E = 1|Z) = \Phi(Z\gamma)$
where $E = 1$ if the respondent is an entrepreneur and $E = 0$ otherwise
- Second stage: $entrep. income = X\beta + u$

		OLS		Heckman Two-step	
Heckman Stage 2 /OLS	Love of Business	0.24	- 0.27	0.21	- 0.49
	Openness	- 1.00	- 0.81	- 0.99	- 0.71
	Conscientiousness	- 0.43	- 1.21	- 0.38	- 0.78
	Extraversion	- 1.68	- 0.78	- 1.70	- 0.76
	Agreeableness	- 0.43	- 2.13	- 0.35	- 1.61
	Neuroticism	2.90	4.50	2.80	3.64
	Age/100	- 0.11	- 0.11	- 0.11	- 0.11
	log(experience)		0.11		0.11
	College	-0.02	- 0.13	- 0.02	- 0.15
	Female	0.05	- 0.13	0.05	- 0.15
	White	0.25**	0.24	0.24	0.21
Heckman Stage 1	Love of Business			2.97***	3.42***
	Openness			- 0.93	- 1.64
	Conscientiousness			- 4.91	- 6.90
	Extraversion			1.24	- 0.32
	Agreeableness			- 7.89	- 8.54
	Neuroticism			10.20	13.95
	Age/100			- 0.02	0.33
	log(experience)				- 0.15**
	White			0.36***	0.52***
	College			0.27**	0.30**
	Female			0.08	0.30*
Observations		141	70	773	540
R^2		0.1143	0.1251		

*, **, *** refer to significance at 10%, 5%, and 1% respectively.