The Intangible Borrowing Constraint of Entrepreneurship

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Motivation

Key differences between intangible and tangible capital

- intangible capital is knowledge and skill intensive and is produced to a large extent by human capital and embodied in skilled labor, whereas tangible capital is embodied in equipment (Corrado, Hulten and Sichel, 2005; Bhandari and McGrattan , 2021)
- the return on intangibles is riskier/more firm-specific than that on tangibles (Crouzet, Eberly, Eisfeldt and Papanikolaou, 2022; Haskel and Westlake, 2017)
- intangibles cannot be used as collateral the way tangibles can when borrowing to invest (Sun and Xiaolan, 2019)

How do the above features of intangible affect the entrepreneurial sector of an economy?

- How does the financing constraint affect selection into entrepreneurship?
- How does the financing constraint affect intangible and tangible investments of an entrepreneur?
- What does it imply for aggregate output, productivity and inequality?

We propose a model of occupational choice and endogenous productivity with financial constraints to answer these questions

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Motivating Evidence

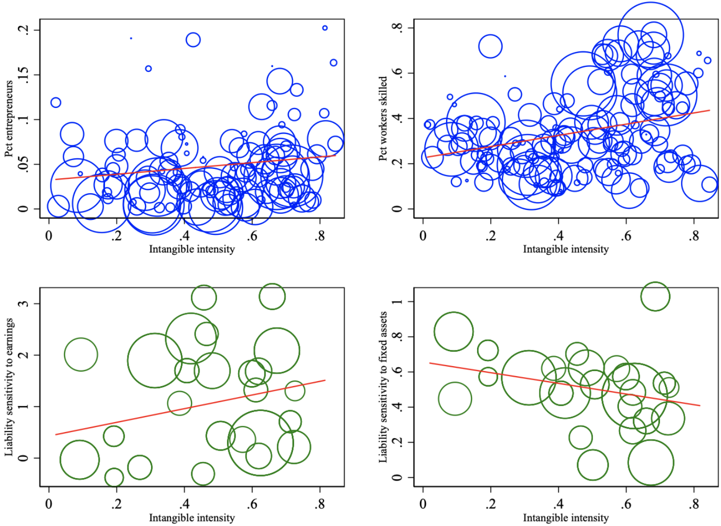
- Ideally we would like to observe at the firm level, the skill and wage of employees, investments in tangible and intangible capital, debt and revenue
  - Is intangible intensity positively correlated with share of skilled employees?
  - What are systematic differences between intangible/skill-intensive firms and tangible-intensive firms?
    - Do intangible/skill-intensive firms grow faster?
    - Is debt in intangible intensive firms more sensitive to earnings?
    - Is debt in tangible intensive firms more sensitive to fixed assets?
- We present at first only industry-level evidence on intangible, skill and debt financing from the US

Motivating Evidence

- Data source 1: The IPUMS 2019 CPS
  - all individuals between 15 and 64, either employed or self-employed in a sector other than agriculture, forestry and fishing, mining, public administration
  - industry-level share of entrepreneurs (i.e. self-employed with an incorporated business) and share of skilled employees (i.e. those who have completed University)
- Data source 2: The Compustat 2019
  - all firms excluding agriculture, mining, utilities, finance and insurance, public administration. Keep with known intangible assets
  - regress firm-level long-term debt on fixed assets and on EBITDA with state-fixed effects by industry
  - use industry-level intangible to tangible investment ratio as intangible intensity

Merge two samples by industry.

Motivating Evidence: Skill, Intangible, and Debt



Motivating Evidence: Summary

- Industries intensive in intangible hire more skilled workers
- Firms' borrowings correlate more with earnings and less with fixed assets in industries more intensive in intangible

A Two-Period Toy Model: Period 1

An entrepreneur starts Period 1 with (z_1, a_1). He chooses to invest in tangibles k_1 and intangibles $h_1 \in \{0, 1\}$:

- Tangibles are used in production:

$$y_1 = z_1 k_1^{\alpha}$$

- Intangible can enhance productivity in Period 2:

$$z_2 = \begin{cases} \gamma z_1 > z_1, & \textit{if } h_1 = 1; \\ z_1, & \textit{if } h_1 = 0. \end{cases}$$

- He borrows at interest rate R to finance k_1 and wh_1 subject to a no-default constraint
- After production is done, debt paid, he makes a savings decision

A Two-Period Toy Model: Period 1

The no-default constraint is an extension of that in Buera, Kaboski and Shin (2011):

$$zk^\alpha + (1-\delta)k - R\ k \qquad + Ra \geq \qquad zk^\alpha + (1-\delta)k - R\left(1 - \frac{1}{\lambda}\right)k$$

$$\Leftrightarrow \frac{k}{\lambda} \qquad \leq a \qquad .$$

A Two-Period Toy Model: Period 1

The no-default constraint is an extension of that in Buera, Kaboski and Shin (2011):

$$zk^{\alpha} + (1-\delta)k - R(k + w_h h) + Ra \geq (1-\phi)zk^{\alpha} + (1-\delta)k - R\left(1 - \frac{1}{\lambda}\right)k$$

$$\Leftrightarrow \frac{k}{\lambda} + w_h h \leq a + \frac{\phi}{R} zk^{\alpha}.$$

The parameter λ governs the strength of the asset-based constraint (BKS, 2011) and ϕ governs the strength of the earnings-based constraint (Lian and Ma, 2021).

A Two-Period Toy Model: Period 2

In Period 2,

- z_2 realises depending on h_1. He borrows k_2 subject to the same constraint.
- He produces, repays debts and consumes.

In sum, the entrepreneur's problem:

$$\max_{h_1 \in \{0,1\}, k_1 \geq 0, a_2 \geq 0, k_2 \geq 0} u(c_1) + \beta u(c_2)$$

$$\text{s.t.} \quad c_1 + a_2 = z_1 k_1^\alpha - R(k_1 + w h_1) + R a_1$$

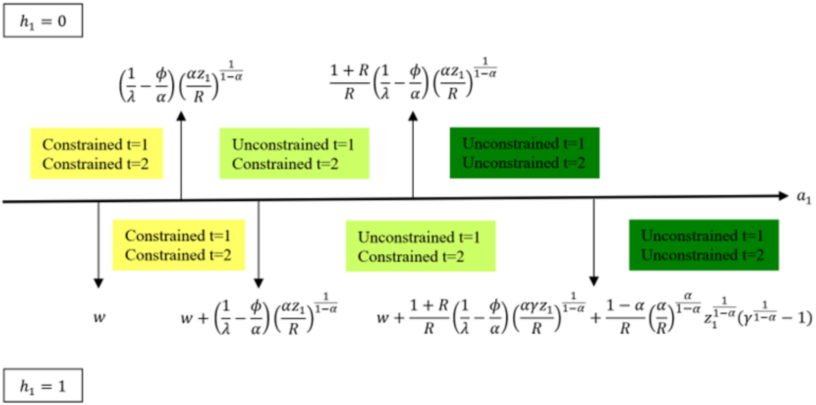
$$\frac{k_1}{\lambda} \leq a_1 - w h_1 + \frac{\phi}{R} z_1 k_1^\alpha$$

$$c_2 = z_2 k_2^\alpha - R k_2 + R a_2$$

$$\frac{k_2}{\lambda} \leq a_2 + \frac{\phi}{R} z_2 k_2^\alpha.$$

Suppose $u(c) = \log(c)$ and $\beta R = 1$.

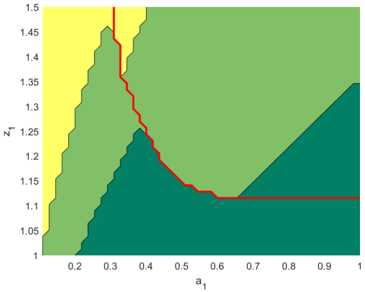
The Toy Model: Financial Condition



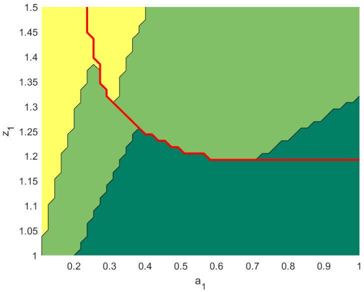
For an entrepreneur to hire h, the productivity improvement $(\gamma-1)z_1$ needs to be large enough relative to the cost w.

The Toy Model: Selection into Intangible Investment

Simulate the model for entrepreneurs whose first-period (z_1, a_1) is uniformly distributed over $[\underline{z}, \overline{z}] \times [\underline{a}, \overline{a}]$. Suppose $\lambda = 1.3$ and $\phi = 0.15$.



(a) $\gamma = 1.2$

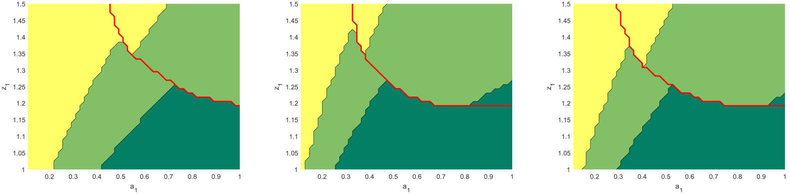


(b) γ from 1.1 to 1.3

Panel(a): selection more by asset; Panel(b): selection more by ability.
In what follows, we adopt the increasing gaps.

The Toy Model: Asset-Based vs. Earnings-Based Borrowing

From Panel (c), relax either asset-based or earnings-based borrowing constraint to achieve the same increment of aggregate H.

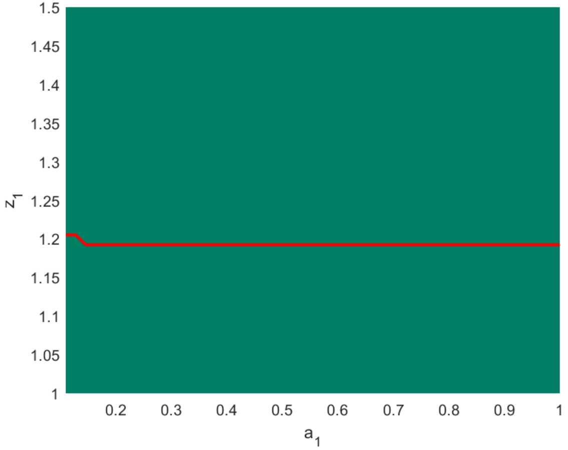


(c) $\lambda = 1$, $\phi = 0$ (d) $\lambda = 1.6$, $\phi = 0$ (e) $\lambda = 1$, $\phi = 0.1625$

Panel (c): Intan. gradient in debt's sensitivity to asset $= -0.0238$, to earnings $= 0.3592$.
Panel (d): Intan. gradient in debt's sensitivity to asset $= -0.0113$, to earnings $= 0.4161$.
Panel (e): Intan. gradient in debt's sensitivity to asset $= 0.0422$, to earnings $= 0.4857$.

The Toy Model: "Perfect" Credit Market

As $\lambda \to \infty$ and for any $\phi \in [0, 1]$



Under-investment in intan. for poor entrepreneurs. Lack of inter-temporal borrowing.

The Toy Model: Take-Away

- How selection into intan. investment interacts with financial condition depends on the fundamentals:
  - if there is increasing return to intan. investment
- Relaxing asset-based borrowing constraint tends to impact the financing condition for both types of entrepreneurs similarly:
  - Intan. gradients in debt's sensitivities similar to the no-borrowing case
- Relaxing earnings-based borrowing constraint tends to select constrained high-ability low-asset entrepreneurs into intan. investment:
  - debt's sensitivity to asset remains high for intan. entrepreneurs
- The fact that the empirical intan. gradient in debt's sensitivity to asset is negative suggests that ϕ is still low.
- Even under "perfect" credit market, there is too little intangible investment.

The Full Model: Main Features

- Discrete-time infinite-horizon dynamic incomplete markets model
- A measure H of skilled HHs and L of unskilled HHs, each endowed with 1 unit of labor and preference

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^{it} u(c_t) \right\}, \quad i = H, L$$

- Skilled HHs face an occupational choice between entrepreneurship and employment, in addition to consumption and savings decisions.
  - Entrepreneurs face decisions in intangible and tangible investment.
  - Intangible investment improves the probability of getting a better business idea tomorrow.
  - Tangible investment used in production today.
  - Both investments face an endogenous borrowing constraint.
- Unskilled HHs are homogenous and supply unskilled labor to a corporate sector.

Time-line (1)

At the beginning of a period, a skilled HH with idea/ability z_n and asset a choose between becoming an entrepreneur or a skilled worker. $n \in \{0, 1, ..., N\}$ and $a \in \mathbf{R}_+$.

- If choose to be skilled worker,
  - He works for an entrepreneur and get w_H per efficiency unit of labor
  - His efficiency unit of labor evolves according to (for small τ)

$$
\begin{aligned}
Pr(z_{n-1,t+1}|z_{n,t}, h_t) &= \tau; \\
Pr(z_{n,t+1}|z_{n,t}, h_t) &= 1 - 2\tau; \\
Pr(z_{n+1,t+1}|z_{n,t}, h_t) &= \tau.
\end{aligned}
$$

  - He consumes and saves.
  - With an exogenous probability κ, he redraws ability for the next period and his assets is distributed to all survivors equally.

Time-line (2)

- If choose to be an entrepreneur,
  - He hires skilled labor, h_t, to improve on z_n for the next period:

$$\begin{aligned} Pr(z_{n-1,t+1}|z_{n,t},h_t) &= \tau; \\ Pr(z_{n,t+1}|z_{n,t},h_t) &= 1-\tau-\tau(1+f(h_t)); \\ Pr(z_{n+1,t+1}|z_{n,t},h_t) &= \tau\left(1+f(h_t)\right), \end{aligned}$$

    where $f(h) = 1 - \exp(-\gamma h) \in [0,1)$.
  - He borrows to finance the tangible capital k_t and intangible expense $w_t h_t$ subject to the borrowing constraint:

$$\frac{k_t}{\lambda} + w_t h_t \leq a_t + \frac{\phi}{1+r} z_t k_t^{\alpha}.$$

  - He produces with $y_t = z_{n,t} k_t^{\alpha}$ and repays the debt, saves and consumes.
  - With an exogenous probability κ, he redraws ability for the next period and his assets is distributed to all survivors equally.

An unskilled HH supplies unskilled labor to the corporate sector inelastically and get w_L, consumes and saves.

The Rest of the Model

- Corporate sector produces using capital and unskilled labor: $Y = AK_c^{\alpha_c} L_c^{1-\alpha_c}$.
- The unskilled HH does not have labor income risk. We capture its impact reduced-form by having a higher β^L for the unskilled.
- Assume a degenerate wealth distribution among the unskilled HHs.

HH's Problem (1)

A skilled HH with (z_n, a) solves

$$V_n(a) = \max\{V_n^e(a), V_n^w(a)\}, \quad n = 0, ..., N$$

As an example, for some $n \in \{1, ..., N-1\}$, the value of an entrepreneur $V_n^e(a)$ is

$$\begin{aligned}
V_n^e(a) = \max_{c,h,k,a'} u(c) + \beta^H \Bigg((1-\kappa) \Bigg[& \tau V_{n-1}(a') \\
& + [1 - \tau - \tau\,(2 - \exp(-\gamma h_t))]\, V_n(a') \\
& + \tau\,(2 - \exp(-\gamma h_t))\, V_{n+1}(a') \Bigg] + \kappa\, \mathbb{E}_{z'}\, V_{z'}(a^{tr}) \Bigg)
\end{aligned}$$

$$\begin{aligned}
\text{s.t.} \quad & c + a' = z_n k^\alpha + (1-\delta)k - (1+r)(k + w_H h) - \kappa_H + (1+r)a + a^{tr} \\
& \frac{k}{\lambda} + wh \le a + \frac{\phi}{1+r} z_n k^\alpha \\
& c \ge 0, h \ge 0, k \ge 0, a' \ge 0.
\end{aligned}$$

HH's Problem (2)

The value of a skilled worker is

$$V_n^w(a) = \max_{c,a'} u(c) + \beta^H \Bigg((1-\kappa)\Big[\tau V_{n-1}(a') + (1-2\tau)V_n(a') + \tau V_{n+1}(a')\Big] + \kappa\, \mathbb{E}_{z'} V_{z'}(a^{tr}) \Bigg)$$

$$\text{s.t.} \quad c + a' = z_n w_H + (1+r)a + a^{tr}.$$

The value of an unskilled worker is

$$W(a) = \max_{c,a'} u(c) + \beta^L W(a')$$

$$\text{s.t.} \quad c + a' = w_L + (1+r)a + a^{tr}.$$

The steady state optimum implies $(1+r)\beta^L = 1$ and optimal policies are $c^L(a) = ra_0 + w_L + a^{tr}$ and $a'^L(a) = a_0$.

HH's Problem (2)

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A Steady State Recursive Competitive Equilibrium

The steady state recursive CE is defined in the usual way, where all HHs optimally choose consumption and saving, skilled HHs optimally choose the occupation, entrepreneurs optimally choose intangible and tangible investments. Prices (interest rate, wages of skilled and unskilled labor) clear markets:

$$K_e + K_c = \sum_{n=0}^{N} \int \mathbf{1}_{o_n(a)=e} k_n(a) d\Phi(n,a) + K_c = \sum_{n=0}^{N} \int a d\Phi(n,a) + \int a d\Psi(a);$$

$$\sum_{n=0}^{N} \int \mathbf{1}_{o_n(a)=e} h_n(a) d\Phi(n,a) = \sum_{n=0}^{N} \int \mathbf{1}_{o_n(a)=w} z_n(a) d\Phi(n,a).$$

$$L = \int d\Psi(a).$$

The distributions $\Phi(a,n)$ for the skilled HHs and $\Psi(a)$ for the unskilled HHs are the fixed points of the aggregate law of motion.

Algorithm

- For a given β^L, compute r.
- Guess w_H and a^{tr}. Given w_H, a^{tr} and r, compute the optimal capital, $k_n^*(a,h)$.
  1. Guess $V_n(a)$.
  2. Given $V_n(a)$, Golden search on a' to compute $\hat{v}_n(a,h)$ and derive policies $\hat{a}'^{e}_n(a,h)$ and $\hat{c}_n^e(a,h)$.
  3. Given $\hat{v}_n(a,h)$, grid search on h to compute $V_n^e(a)$ and derive policies ${a'}_n^H(a)$, $c_n^H(a)$, $h_n(a)$ and $k_n(a)$.
  4. Given $V_n(a)$, Golden search on a' to compute $V_n^w(a)$, and derive policies ${a'}_n^H(a)$ and $c_n^H(a)$.
  5. Given $V_n^w(a)$ and $V_n^e(a)$, find the optimal occupational choice, and update $V_n(a)$.
  6. Add a preference (Gumbel) shock on the occupational choice.
  7. Iterate until it converges.
- Check that skilled labor market clears. If not, adjust w_H. Check that transfers balance. If not, adjust a^{tr}.
- Given $\frac{K_c}{K}$, obtain K_c. Solve for a^L of unskilled HHs such that asset market clear.
- Given L_c, we can solve for $\frac{K_c}{L_c}$. Given r, obtain A, Y_c and w_L.

Simulations

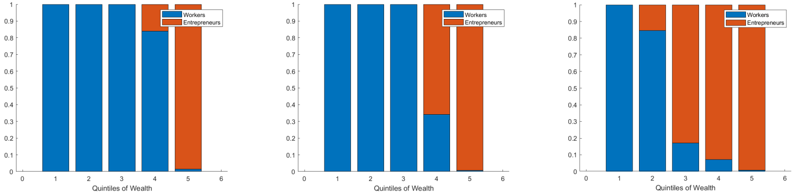
- We calibrated, in a previous version of the paper, an economy which corresponds $(\lambda = 1.37, \phi = 0)$ to target the credit to GDP ratio of the non-corporate sector (22%) and the proportion of entrepreneurs (10%) in the US economy.
- We contrast the above economy with one with $(\lambda = 1, \phi = 0)$, keeping other parameters constant, to evaluate the effects of relaxing the borrowing constraint.
- We now consider an alternative economy with $(\lambda = 1, \phi = 0.62)$, which delivers the target 22% credit to GDP ratio and evaluate how the selection into entrepreneurship and into intangible investment compare to the one above $(\lambda = 1.37, \phi = 0)$.
- This should inform us how we calibrate the full model.

Simulations

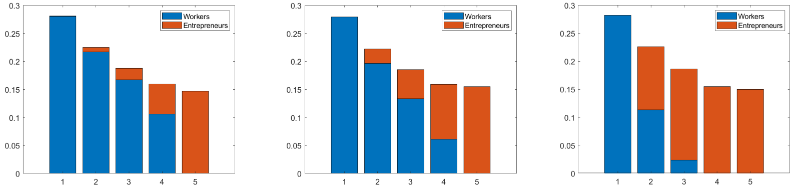
Moment	$(1, 0)$	(λ, ϕ) $(1.37, 0)$	$(1, 0.62)$
Credit-output ratio	0%	22%	22%
Share of entrepreneurs	6.9%	9.9%	17.4%
Credit	0	0.33	0.40
Output	0.96	1.46	1.80
Capital-output ratio	2.66	2.88	2.81
Intan. to tan. income ratio	1 (norm.)	1.5	2
Skilled wage	1 (norm.)	3.09	9.21
Skill premium	1 (norm.)	1.54	1.88

Simulations: Selection into Entrepreneurship

Occupations by wealth quntiles

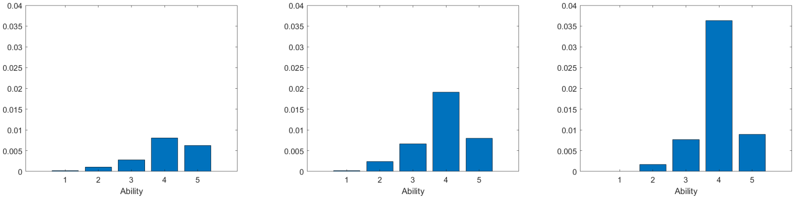


Occupations by ability grids



Simulations: Selection into Intangible Investment

Intan. to tan. income ratio, $\frac{w_h h}{(r+\delta)k}$, by ability grids



Simulations: Decomposing Output Gaps

For firm i, $y_i = z_i k_i^{\alpha}$ and $k_i = \left(\frac{\alpha z_i}{r_i}\right)^{\frac{1}{1-\alpha}} \Rightarrow K = \alpha^{\frac{1}{1-\alpha}} \sum_{i \in \mathcal{E}} \left(\frac{z_i}{r_i}\right)^{\frac{1}{1-\alpha}}$.

We can write the aggregate output as

$$Y = \sum_{i \in \mathcal{E}} y_i = \frac{K^{\alpha}}{\left[\sum_{i \in \mathcal{E}} \left(\frac{z_i}{r_i}\right)^{\frac{1}{1-\alpha}}\right]^{\alpha}} \sum_{i \in \mathcal{E}} \frac{z_i^{\frac{1}{1-\alpha}}}{r_i^{\frac{\alpha}{1-\alpha}}}$$

or,

$$\log Y = \alpha \log K + \underbrace{\log \left(\sum_{i \in \mathcal{E}} \frac{z_i^{\frac{1}{1-\alpha}}}{r_i^{\frac{\alpha}{1-\alpha}}}\right) - \alpha \log \left(\sum_{i \in \mathcal{E}} \frac{z_i^{\frac{1}{1-\alpha}}}{r_i^{\frac{1}{1-\alpha}}}\right)}_{\textit{log TFP}}$$

Simulations: Decomposing Output Gaps

For any economy A and B, we can decompse the output gap into a capital gap and a TFP gap:

Relative to $(1, 0)$	(λ, ϕ) $(1.37, 0)$	$(1, 0.62)$
Output gap	0.34	0.58
Capital gap	0.20	0.28
Contribution	*60%*	*48%*
TFP gap	0.14	0.30
Contribution	*40%*	*52%*

Simulations: Debt's Sensitivities and Interactions with Intangible Investment

	Debt		
	$(1, 0)$	$(1.37, 0)$	$(1, 0.62)$
Assets	1.025***	1.027***	0.507***
	(985.75)	(1153.80)	(708.32)
Earnings	-0.187***	-0.112***	0.440***
	(-72.28)	(-83.97)	(319.17)
Assets × Intangibles	-0.0509***	-0.0904***	-0.00640***
	(-146.72)	(-317.04)	(-11.20)
Earnings × Intangibles	0.0993***	0.149***	0.115***
	(123.65)	(244.96)	(73.91)

Interim Summary

- We use a quantitative macro model with occupational choice and endogenous productivity to study the impact of asset-based borrowing constraint and earnings-based borrowing constraint on
  - Occupational structure
  - Output and productivity
  - Inequality
- Our current findings suggest that, compared to the asset-based borrowing constraint, the earnings-based constraint is more pro-entrepreneurial, better for productivity, but induce higher inequality.
- The next step is to carefully choose targets to calibrate the full model to the US economy and estimate the strength of the two types of borrowing constraints.