

Misallocation under the Shadow of Death

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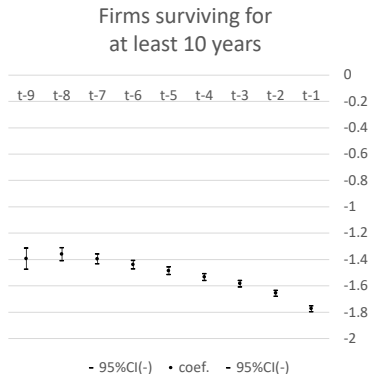
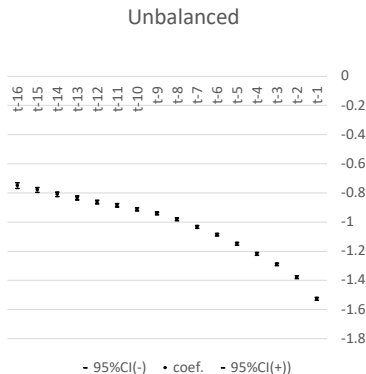
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Motivations

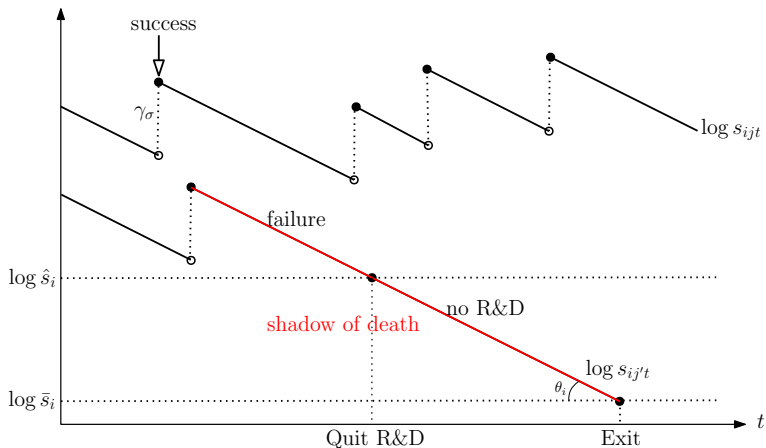
- Resource reallocation (through firm dynamics) matters for macroeconomic performance
 - ▶ Entry/exit, selection (incumbents $\langle$ productive $\longleftrightarrow$ unproductive firms $\rangle$), ...
- We focus on slow exit, specifically, “shadow of death.”
 - ▶ Declining trends in sales and productivity well before exit.
- We are interested in whether and how much the aggregate productivity and welfare improve if firms destined to exit quickly exit from the market.

Empirical Preview: Pre-exit Dynamics: Sales

Sales dynamics of firms exiting at t , relative to non-exitier



Model Preview: Dynamics of Relative Productivity



What We Do

- We build an endogenous growth model with the shadow of death.
 - ▶ endogenous R&D investment, entry, and exit
 - ★ Dynamic reallocation effect: firms with low performance have small incentive to improve their productivity
- We document facts about the shadow of death using firm-level data.
 - ▶ illustrate how sales change over time before exit and before/after R&D termination.
 - ▶ analyze how the shadow of death path is related to the external environment faced by firms.
- Simulate the effect of distortions on firm dynamics and the macroeconomy.

Main Findings

- Theoretical model

- ▶ There exist two sales thresholds that determine exit and R&D termination.
- ▶ A gap between the sales threshold for exit and that for R&D termination is an important indicator for the loss of optimality, proxy for the shadow of death.
- ▶ Shortening the shadow of death improves welfare.

- Empirical facts

- ▶ Sales of exiting firms are smaller than that of surviving firms and tend to decline, even well before their exit.
- ▶ The degree of shadow of death has a significant relationship with the external environment faced by firms
 - ★ such as corporate subsidies and the degree of development of the second-hand market.

- Simulation

- ▶ The quantitative impacts of reducing distortions are limited.

Literature

- Misallocation
 - ▶ Hopenhayn & Rogerson (JPE '93); Restuccia & Rogerson (RED, '08); Hsieh & Klenow (QJE '09); etc.
 - ▶ Dynamic, rather than static, misallocation in which R&D, entry, and exit are endogenous.
- Declining business dynamism (Akcigit and Ates 2021)
 - ▶ Higher markups, lower entry and exit rates, and stagnant job creation
 - ▶ However, in Japan, market concentration is decreasing. → Focus on left-tail
- Zombie; various support measures to SMEs; aging
- Model of endogenous exits
 - ▶ Hopenhayn (ECMT 92); Luttmer (QJE 07) → R&D endogenous
 - ▶ Ericson & Pakes (RES '95); Igami & Uetake (RES '19) → Macro
- Empirical studies on the shadow of death
 - ▶ Griliches & Ramey (JE '95); Olley & Pakes (ECMT '96); Kiyota & Takizawa (RIETI '06)

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Model Setup

- Household: standard
- Firms:
 - ▶ Final goods firms in industry $i \in [0, 1]$. Perfect competition.
 - ▶ Intermediate goods firms for each final good, $\mathcal{J}_{it}$. Monopolistic competition.
 - ★ Incumbents' R&D: productivity improvement
 - ★ Entrants R&D: new variety
 - ★ Exit due to fixed operational costs
- Balanced growth with stationary distribution of intermediate goods firms size.

Households

- Utility:

$$\int_0^{\infty} e^{-\rho t} \ln C_t dt,$$
$$\ln C_t = \int_0^1 \ln Y_{it} di.$$

- Set $P_{it} Y_{it} = 1$ for any i and t .
- Inelastic labor supply, L .

Final Goods Firms

- Final goods firms, $i \in [0, 1]$: Perfect competition, intermediate goods as input.
- Final goods Production:

$$Y_{it} = n_{it}^{\varepsilon} \left[\int_{\mathcal{J}_{it}} x_{ijt}^{\frac{\sigma-1}{\sigma}} dj \right]^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1, \varepsilon \in \left[-\frac{1}{\sigma-1}, 0 \right]$$

- ▶ $\mathcal{J}_{it} \subset \mathbb{R}$: set of active intermediate goods firms
 - ▶ n_{it} : measure of $\mathcal{J}_{it}$, or varieties
 - ▶ x_{ijt} , p_{ijt} : output and price of intermediate good j in industry i at time t .
- Demand for intermediate goods:

$$x_{ijt} = n_{it}^{\varepsilon(\sigma-1)} p_{it}^{\sigma} Y_{it} p_{ijt}^{-\sigma}$$

Intermediate Goods Firms: Production

- Production: $x_{ijt} = z_{ijt} \ell_{ijt}$
- Operational fixed cost, κ_o , in the labor unit
- Instantaneous profit

$$\pi_{ijt} = \frac{s_{ijt}}{\sigma} - \kappa_o w_t,$$

where s_{ijt} is relative productivity (= sales),

$$s_{ijt} \equiv \left(\frac{z_{ijt}}{Z_{it}} \right)^{\sigma-1}, \quad Z_{it} \equiv \left[\int_{\mathcal{J}_{it}} z_{ijt}^{\sigma-1} dj \right]^{\frac{1}{\sigma-1}}.$$

Incumbents' R&D

- Fixed R&D cost in the labor unit, κ_r .
- z_{ijt} evolves such that

$$\text{R\&D investment} \Rightarrow z_{ijt+dt} = \begin{cases} (1 + \gamma) z_{ijt} & \text{w.p. } \lambda dt \\ z_{ijt} & \text{w.p. } 1 - \lambda dt \end{cases}$$

- Expected growth of s_{ijt} :

$$E_t \frac{\dot{s}_{ijt}}{s_{ijt}} = \begin{cases} \lambda \gamma_{\sigma} - \theta_{it} & \text{with R\&D} \\ -\theta_{it} & \text{without R\&D} \end{cases}$$

- ▶ θ_{it} : industry-level aggregate productivity growth,

$$\theta_{it} \equiv \frac{(Z_{it}^{\sigma-1})}{Z_{it}^{\sigma-1}}$$

Exit and R&D Thresholds, $\bar{s}$ and $\hat{s}$

- Firm value:

$$r_t v(s_{ijt}, \theta_{it}, w_t) = \max \left\{ 0, \frac{s_{ijt}}{\sigma} - \kappa_o w_t \right. \\ \left. + E_t \max [-\kappa_r w_t + v_s \dot{s}_{ijt}|_{\text{R\&D}}, v_s \dot{s}_{ijt}|_{\text{non-R\&D}}] + \dot{v} \right\}$$

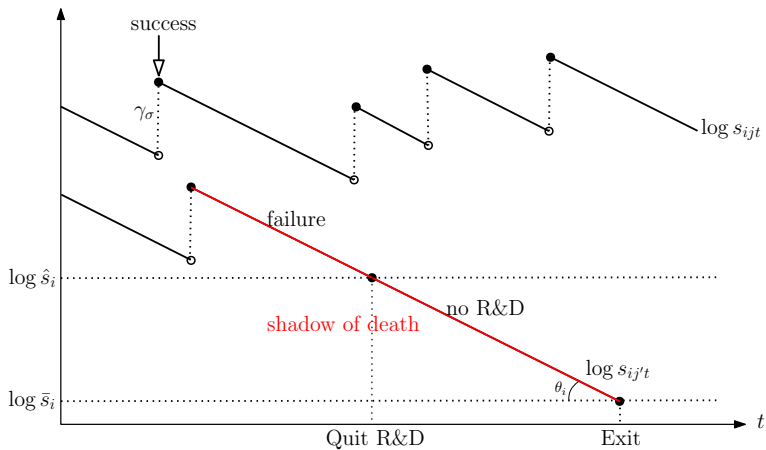
- R&D threshold, $\hat{s}_{it}$: They invest in R&D if $s \geq \hat{s}_{it}$, where

$$v_s(\hat{s}_{it}, \theta_{it}, w_t) \hat{s}_{it} = \frac{\kappa_r w_t}{\lambda \gamma_\sigma}$$

- Exit threshold, $\bar{s}_{it}$:

$$0 = \frac{\bar{s}_{it}}{\sigma} - \kappa_o w_t + v_\theta(\bar{s}_{it}, \theta_{it}, w_t) \dot{\theta}_{it} + v_w(\bar{s}_{it}, \theta_{it}, w_t) \dot{w}_t$$

Shadow of Death



Entrants' R&D

- Fixed entry cost, κ_e , in the labor unit.
- An entrant draws s from an exogenous distribution F_e .
 - ▶ An entrant drawing $s < \bar{s}_t$ exits immediately.
- Free entry condition:

$$\int_{\bar{s}_t}^{\infty} v(s, \theta_{it}, w_t) dF_e = \kappa_e w_t$$

Aggregate Productivity Growth

- Aggregate productivity growth, θ_{it} , is determined by
 - ▶ Aggregate R&D
 - ▶ Replacement through Entry/Exit

$$\theta_{it} = n_{it} \left[\underbrace{\lambda \gamma_{\sigma} \int_{\hat{s}_{it}}^{\infty} s dF_{it}}_{\text{R\&D}} + \underbrace{\mu_{it} \int_{\bar{s}_t}^{\infty} s dF_e - \delta_{it} \bar{s}_t}_{\text{Entry/Exit}} \right],$$

where

$$\gamma_{\sigma} \equiv (1 + \gamma)^{\sigma-1} - 1.$$

★ μ_{it} : entry rate, δ_{it} : exit rate

Stationary Equilibrium (Balanced Growth Path)

- Stationary distribution, F_i
- Stationary equilibrium: $\{\bar{s}_i, \hat{s}_i, n_i, \theta_i, \mu_i, \delta_i\}_{i \in [0,1]}$ and w that satisfy
 - ▶ Households' optimization: consumption
 - ▶ Firm's optimization: production, R&D, exit
 - ▶ Free entry
 - ▶ Labor market clearance

$$L = \frac{\sigma - 1}{\sigma w_t} + \int_0^1 n_{it} [\kappa_o + \kappa_r (1 - F_{it}(\hat{s}_{it})) + \kappa_e \mu_{it}] di$$

- Assume symmetric industries, dropping i below.

R&D and Exit Thresholds in Stationary State

Proposition

In a stationary state with $\theta > 0$, the thresholds for exit and R&D are uniquely determined and satisfy

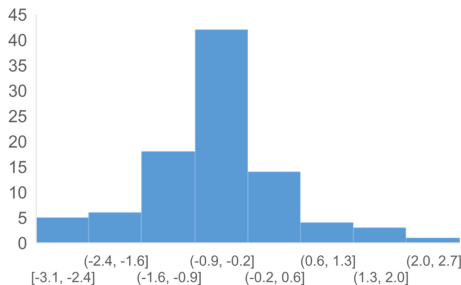
$$\bar{s} = \sigma \kappa_o w,$$
$$\frac{1}{r + \theta} \left(\frac{\hat{s}}{\bar{s}} - \left(\frac{\hat{s}}{\bar{s}} \right)^{-\frac{r}{\theta}} \right) = \frac{\kappa_r / \kappa_o}{\lambda \gamma_\sigma}.$$

Moreover, $\hat{s}$ increases in θ , ceteris paribus.

- Even though a firm gets high s by R&D, the advantage disappears soon under high θ . This reduces R&D incentives.

Exit Distortion

- If $\bar{s} = \sigma \kappa_o w$, then sales just before exit should be the same across firms after controlling fixed costs. But we observe dispersion of $\bar{s}$ across industries.



- Introduce the degree of exit distortion: $1 - \tau_{ij}$

$$\bar{s}_{ij} = \tau_{ij} \sigma \kappa_o w$$

- ▶ Source of τ : subsidy, outside value.

Response to Exit Distortion: Uniform Subsidy

Proposition

Suppose that the economy is at a stationary state, and an individual firm receives flow subsidy K . Then, this firm chooses $\bar{s}_\tau$ and $\hat{s}_\tau$, such that

$$\bar{s}_\tau = \tau \sigma \kappa_o w,$$
$$\frac{1}{r + \theta} \left(\frac{\hat{s}_\tau}{\bar{s}_\tau} - \left(\frac{\hat{s}_\tau}{\bar{s}_\tau} \right)^{-\frac{r}{\theta}} \right) = \frac{1}{\tau} \frac{\kappa_r / \kappa_o}{\lambda \gamma_\sigma},$$

where $\tau = 1 - \frac{K}{\kappa_o w}$. Both $\bar{s}_\tau$ and $\hat{s}_\tau$ monotonically increase in τ . Moreover, $\hat{s}/\bar{s}$ decreases in τ .

- More subsidy ($\tau \downarrow$) implies
 - ▶ Exiting firm survives longer, $\bar{s} \downarrow$
 - ▶ Delays quit of R&D, $\hat{s} \downarrow$ ($\because$ benefit from surviving longer)
 - ▶ **Longer shadow of death**, $\hat{s}/\bar{s} \uparrow$

Another Type of Distortion: Size-dependent Subsidy

- A firm can obtain a flow subsidy of K if its sales volume is below an exogenous threshold $\tilde{s}$.
- Assuming $\tilde{s} \in [\bar{s}, \hat{s})$ in equilibrium. Higher subsidy ($\tau \downarrow$) implies
 - ▶ Exiting firm survives longer, $\bar{s} \downarrow$
 - ▶ Quit R&D earlier, $\hat{s} \uparrow$ ($\because$ benefit from getting small)
 - ▶ **Longer shadow of death**, $\hat{s}/\bar{s} \uparrow$

Equilibrium Shadow of Death is Too Long

Proposition

The market equilibrium has a wider range of firms that are not engaged in R&D, that is,

$$\frac{\hat{s}}{\bar{s}} > \frac{\hat{s}^*}{\bar{s}^*}.$$

- Private firms look at relative productivity, s , and their R&D incentives are reduced by θ .
- For the social planner, absolute productivity, z , is important.
- Shortening shadows of death is welfare-improving.
- Note:
 - ▶ no inefficiency about $\bar{s}$.
 - ▶ R&D subsidy can achieve social optimum.

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TSR Data

- We provide empirical facts on the shadow of death using firm-level data for Japan; through this, we aim to check whether our model is consistent with the data.
- Firm-level data by TSR
 - ▶ TSR is one of the largest credit rating companies in Japan
- Sales from 2001 to 2019 and exits from 2008 to 2019
- The number of firm observation is around 0.8 to 0.9 million per year.
 - ▶ cover more than 20% of all firms.
- Focus on closure and dissolution, which we name as “voluntary closure.”
 - ▶ Reasons for firm exit are classified to closure, dissolution, bankruptcy (default), merger, or others. Explain around 90% of total exit records.

Estimation for Pre-exit Dynamics

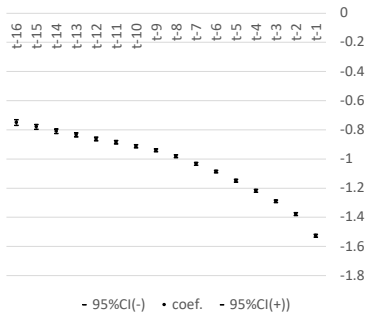
- Dynamics of firm size measured by $\log(\text{sales})$
 - ▶ Exit = voluntary closure
 - ▶ As of h -year prior to exit timing

$$\log(\text{sales}_{j,t}) = \alpha + \sum_{h=0}^H \beta_h \mathbb{1}(\text{exit}_{j,t+h}) + \eta_{l_j,t} + \varepsilon_{j,t}, \quad (1)$$

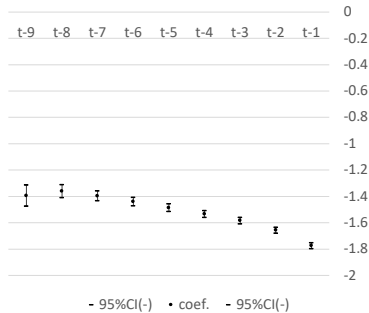
- ★ $\alpha + \eta_{l_j,t}$: Average sales of non-exiting firms in industry l_j in t .
- ★ β_h : How much “eventually-exiting firms” are smaller than the average of non-exiting firms as of h years prior to its exit

Pre-exit Dynamics: Sales

Unbalanced



Firms surviving for at least 10 years



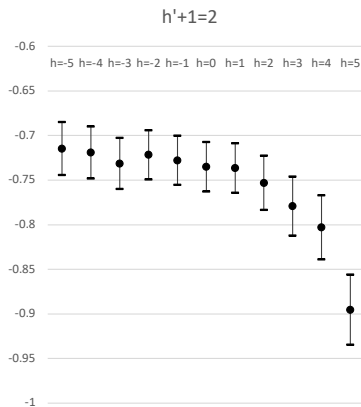
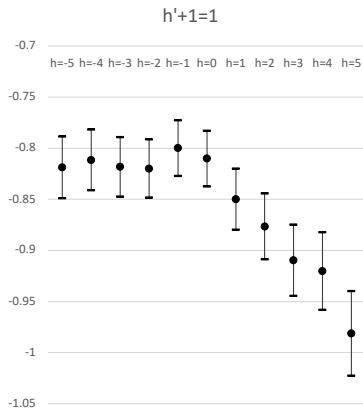
R&D Investment and Firm Dynamics

- What happens before/after a firm ends efforts to improve its performance by R&D?

$$\log(\text{sales}_{j,t}) = \gamma + \delta_h \mathbb{1}(R\&D_{j,t-h,t-h+h'} = 0) + \eta_{lj,t} + \varepsilon_{j,t}. \quad (2)$$

- ▶ R&D lumpy: we consider that a firm stops R&D when it does not make R&D investment for a certain duration ($h' + 1$ years).
- ▶ $\gamma + \eta_{lj,t}$: Average sales size of R&D firms in t .
- ▶ δ_h : How much sales declines before/after R&D termination.

Sales Drop after R&D Stoppage



Distortions and the Shadow of Death

- Distortions: industry-level time-variant
 - ▶ Subsidy: IO table
 - ▶ Capital resalability: SNA
- Equations regressed

$$\begin{aligned}\log(\text{sales}_{j,t}) = & \alpha + \beta_h \mathbb{1}(\text{exit}_{j,t+h}) \\ & + \beta_h^D \mathbb{1}(\text{exit}_{j,t+h}) \times \text{distortion}_{l_j,t} + \eta_{l_j,t} + \varepsilon_{i,t},\end{aligned}\quad (3)$$

$$\begin{aligned}\log(\text{sales}_{j,t}) = & \gamma + \delta_h \mathbb{1}(R\&D_{j,t-h,t-h+h'} = 0) \\ & + \delta_h^D \mathbb{1}(R\&D_{j,t-h,t-h+h'} = 0) \times \text{distortion}_{l_j,t} + \eta_{l_j,t} + \varepsilon_{j,t}.\end{aligned}\quad (4)$$

- $\beta_h^D - \delta_h^D$ is negative if distortions increase the degree of the shadow of death.

Table: Distortions and Firm Dynamics

(i) Distortion: Net subsidy/Value-added												
	Pre-exit dynamics						Pre/post-R&D termination dynamics					
	$h = 1$		***	$h = 3$		***	$h = -1, h' = 1$		$h = 1, h' = 1$		***	
	Coef.	s.e.		Coef.	s.e.		Coef.	s.e.	Coef.	s.e.		
β_h	-1.393	0.011	***	-1.278	0.012	***						
β_h^D	-0.401	0.134	***	-0.492	0.148	***						
δ_h							-0.889	0.021	***	-0.934	0.023	***
δ_h^D							0.416	0.204	**	0.544	0.219	**
Fixed-effect												
Year×Industry	yes			yes			yes			yes		
Number of observations	9,064,930			6,983,006			80,344			70,021		
Prob>F	0.0000			0.0000			0.0000			0.0000		
Adj R-squared	0.1585			0.1373			0.3810			0.3844		

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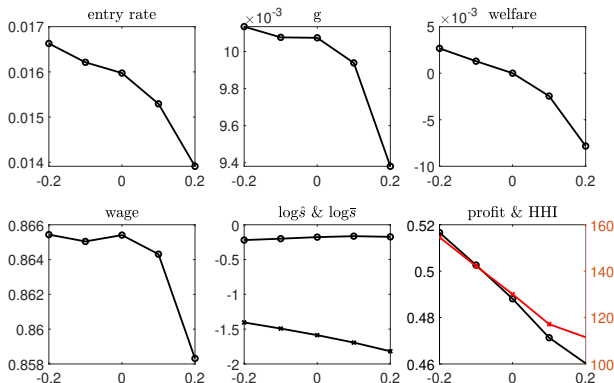
Calibration

- Simulate the effects of distortions
 - ▶ Calibrate the model to the Japanese economy based on the TSR data
 - ▶ Key parameters such as $\lambda = 0.037$, $\bar{\delta} = 0.0028$, $\gamma = 0.11$, $\kappa_o = 0.055$, and $\kappa_r = 0.035$.

	Data	Simulation
Targeted moments		
Prob. of sales share increase for R&D firms	0.037	0.037
Prob of exit for R&D firms	0.0028	0.0028
Entry rate	0.006 (0.051)	0.016
Share of fixed costs in sales	0.050	0.047
Share of R&D costs in sales for R&D firms	0.028	0.030
Ratio of R&D threshold to exit threshold	4.080	4.091
Untargeted moments		
Ratio of the mean of sales of all firms to entrants	0.971	0.667
Ratio of the SD of sales of all firms to entrants	0.534	0.691
Speed of sales change for non R&D firms	-0.040	-0.033

Results

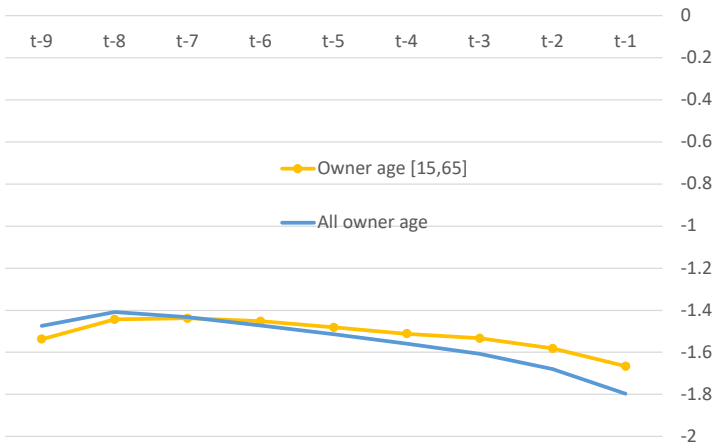
- Horizontal axis: distortion $1 - \tau$ (subsidy to firms below $\hat{s}$)
- Distortion increases the gap $\hat{s}/\bar{s}$ and worsens welfare.
 - ▶ entry decreases; profit and HHI decrease; g decreases.
- However, quantitatively small effects.



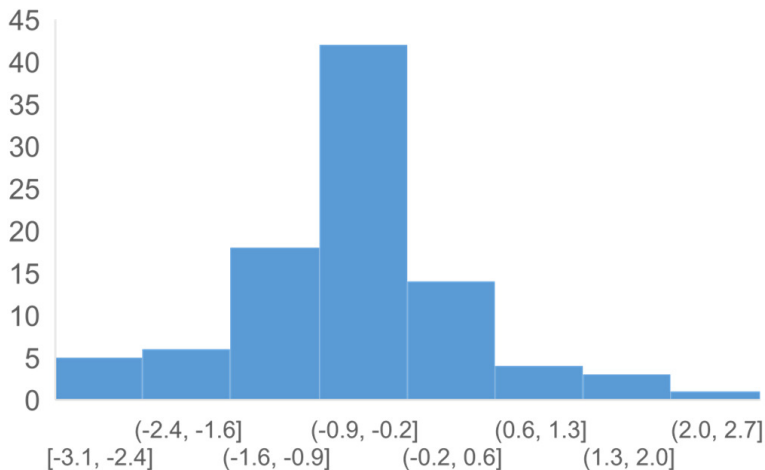
Final Notes

- Effects on R&D and real growth turn out to be small.
- Transition
- Superstar firms

Robustness: Owner's Age



Dispersion of Exit Thresholds



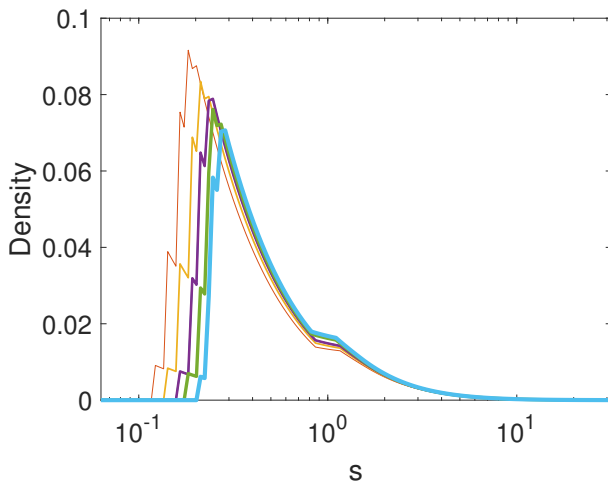
Note: The horizontal axis indicates $\bar{s}$ over fixed costs, where $\bar{s}$ is calculated as $\exp(\beta_1 + \alpha)$ for the regression of equation (1). The vertical axis is the number of industries.

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(i) Distortion: Net subsidy/Value-added												
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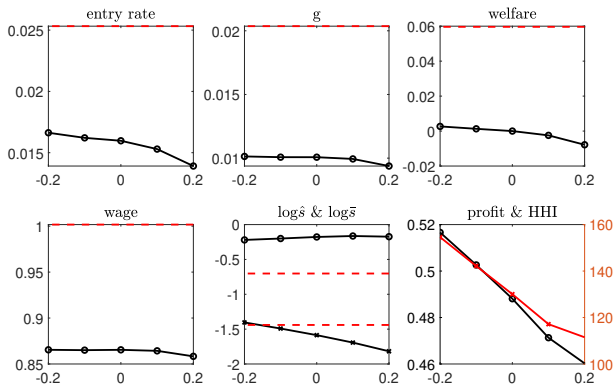
(ii) Distortion: Capital investment on used assets / Total capital investment												
	Pre-exit dynamics					Pre/post-R&D termination dynamics						
	$h = 1$		***	$h = 3$		$h = -1, h' = 1$			$h = 1, h' = 1$			
	Coef.	s.e.		Coef.	s.e.	Coef.	s.e.		Coef.	s.e.		
β_h	-1.493	0.018	***	-1.421	0.019	***						
β_h^D	0.259	0.067	***	0.494	0.073	***						
δ_h							-1.305	0.036	***	-1.332	0.039	***
δ_h^D							1.269	0.154	***	1.181	0.166	***
Fixed-effect												
Year×Industry	yes			yes			yes			yes		
Number of observations	4,756,232			3,577,931			49,401			43,321		
Prob>F	0.0000			0.0000			0.0000			0.0000		
Adj R-squared	0.1393			0.1420			0.3614			0.3633		

Results: Firm-size Distribution



Note: Firm distribution is drawn for various values of subsidy $(1 - \tau)$, where the horizontal axis is sales s . The line width becomes thinner as subsidy increases.

Results: Socially Optimal State



Note: The red dashed line represents the socially optimal state achieved by (i) no exit distortion, (ii) appropriate R&D subsidy, and /or (iii) entry subsidy.