Misallocation under the Shadow of Death

Daisuke Miyakawa[1] Koki Oikawa[2] Kozo Ueda[2]

[1]Hitotsubashi Univ

[2]Waseda Univ

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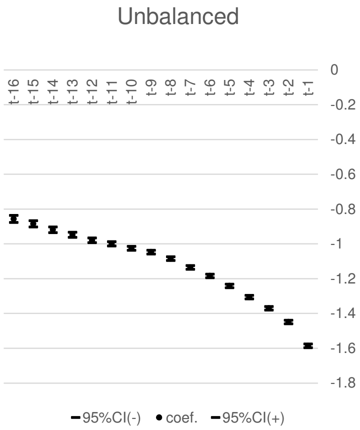
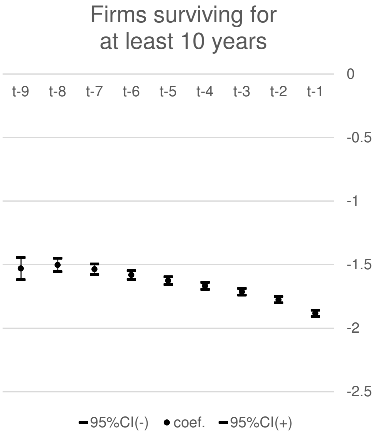
Motivation

- Japan's low exit rate may indicate resource misallocation, delaying the selection of firms.
- Market concentration is decreasing in Japan.
  - US-type superstar firm story doesn't work.
  - "Left-tail" of firm size distribution may matter in Japan.
- Focus: exit decision and behaviors before exit
  - Observation: Shadow of death
    - Declining trends in sales and productivity before exit.
  - Macroeconomic implications?
    - Resource reallocation
    - Dynamic effect: If firms can survive even with low performance, they wouldn't have so much incentive to improve their productivity.

Shadow of Death





Outline and Main Results

- Theoretical model
  - Endogenous growth model with endogenous shadow of death
  - Exit and R&D thresholds
  - Equilibrium shadow of death is too long.
- Empirical analysis
  - Sales dynamics of firms until exit
  - Sales dynamics before/after quitting R&D
  - Relationship between exit distortions, such as subsidies, and firm dynamics
- Simulation
  - Calibration to the Japanese economy
  - Exit distortions that lengthen the shadows of death reduce welfare, entry/exit rates, and market concentration. But its quantitative impact on real growth rate is limited.

Literature

- Misallocation
  - Hopenhayn & Rogerson (JPE '93); Restuccia & Rogerson (RED, '08); Hsieh & Klenow (QJE '09); etc.
- Declining business dynamism: Akcigit and Ates (AEJ macro, 2021)
  - Higher markups, lower entry/exit rates, stagnant job creation
- Zombie firm: Cabarello et al (AER, 2008)
- Models of endogenous exits
  - Jovanovic (ECMT '82); Hopenhayn (ECMT 92); Luttmer (QJE, 2007)
  - Ericson & Pakes (RES '95); Igami & Uetake (RES '19)
- Empirical studies on shadow of death
  - Griliches & Ragev (JE '95); Olley & Pakes (ECMT '96); Kiyota & Takizawa (RIETI '06)

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Model Setup

- Household: standard
- Firms:
  - Final goods firms, $i \in [0,1]$. Perfect competition.
  - Intermediate goods specific for each final good, $\mathscr{J}_{it}$. Monopolistic competition.
    - ★ They improve productivity by R&D.
    - ★ They may exit due to fixed operational costs.
    - ★ Only entrants create new varieties. (one firm, one intermediate good)
- Balanced growth with stationary distribution of intermediate goods firms size.

Representative Household

- Utility:

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

- 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:

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

  - $\mathscr{J}_{it} \subset \mathbb{R}$: set of active intermediate goods firms
  - n_{it}: measure of $\mathscr{J}_{it}$, 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

$$\max \underbrace{\left(p_{ijt}z_{ijt} - w_t\right)\ell_{ijt}}_{\pi_{ijt}} - \kappa_o w_t$$

$$p_{ijt} = \frac{\sigma}{\sigma - 1}\frac{w_t}{z_{ijt}}, \qquad \pi_{ijt} = \frac{s_{ijt}}{\sigma},$$

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

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

Intermediate Goods Firms: R&D

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

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

- Expected growth of s_{ijt}:

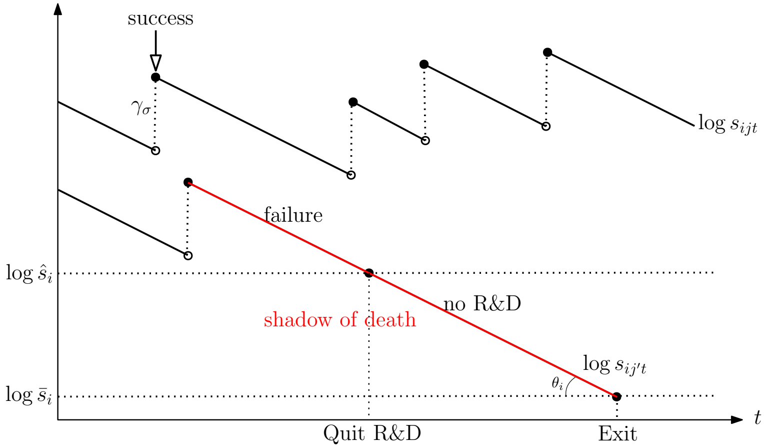
$$\mathrm{E}_t \frac{\dot{s}_{ijt}}{s_{ijt}} = \begin{cases} \lambda \gamma_\sigma - \theta_{it} & \text{with R\&D} \\ -\theta_{it} & \text{without R\&D} \end{cases}$$

  - The negative trend is determined by industry-level R&D efforts,

$$\theta_{it} \equiv \frac{(\dot{Z_{it}^{\sigma-1}})}{Z_{it}^{\sigma-1}} = \lambda \gamma_\sigma \left(\int_{\mathscr{I}_{it}^R} s_{ijt} dj \right), \qquad \gamma_\sigma \equiv (1+\gamma)^{\sigma-1} - 1$$

    - ★ $\mathscr{I}_{it}^R$: set of R&D firms

Dynamics of Relative Productivity



Firm Value, R&D Threshold, Exit Threshold

$$
\begin{aligned}
r_t v(s_{ijt}, \theta_{it}, w_t) = \max \Big\{ 0, \frac{s_{ijt}}{\sigma} - \kappa_o w_t \\
&+ \max_{\chi \in \{0,1\}} \mathrm{E}_t \Big[v_s(s_{ijt}, \theta_{it}, w_t) \dot{s}_{ijt}|_{\chi=0}, \\
&\qquad - \kappa_r w_t + v_s(s_{ijt}, \theta_{it}, w_t) \dot{s}_{ijt}|_{\chi=1} \Big] \\
&+ v_\theta(s_{ijt}, \theta_{it}, w_t) \dot{\theta}_{it} + v_w(s_{ijt}, \theta_{it}, w_t) \dot{w}_t \Big\}
\end{aligned}
$$

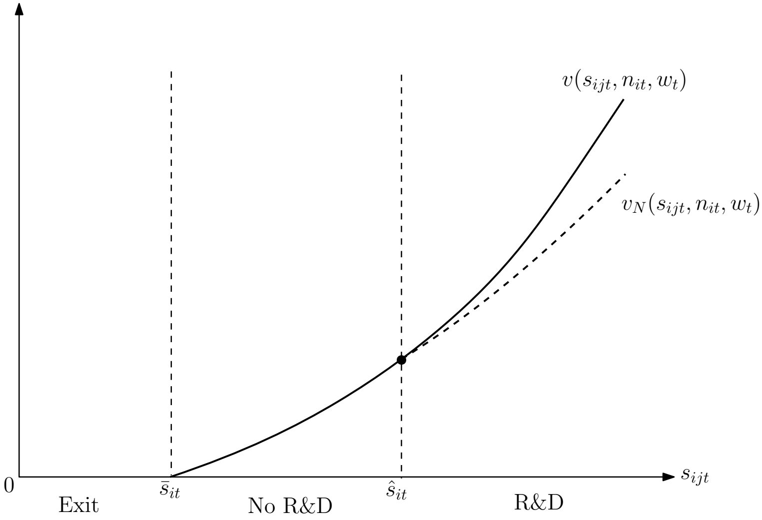
- R&D threshold, $\hat{s}_{it}$:

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

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

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

Firm Value



$v_N(s_{ijt}, \theta_{it}, w_t)$: Firm value when committing non-R&D.

Firm Entry and Labor Market Clearing

- Fixed entry cost, κ_e, in the labor unit.
- An entrant draws s from an exogenous distribution F_0.
  - An entrant drawing $s < \bar{s}_{it}$ exits immediately.
- Free entry condition:

$$\int_{\bar{s}_{it}}^{\infty} v(s, \theta_{it}, w_t) dF_0 = \kappa_e w_t$$

- Labor market clearing condition:

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

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
- Symmetric industries, dropping i.

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.

Equilibrium Values

- Growth

$$g = \frac{\theta}{\sigma - 1}, \qquad \text{where } \theta = \lambda \gamma_\sigma n \int_{\hat{s}}^{\infty} s dF, \quad n = \left[\int_{\bar{s}}^{\infty} s dF \right]^{-1}$$

- Welfare

$$U = \frac{\log C_0}{\rho} + \frac{g}{\rho^2} \qquad \text{where } \frac{C_t}{Z_t} = \frac{Y_t}{Z_t} = n^{\varepsilon} L_X$$

- Entry/Exit rates

$$\delta = \theta \bar{s} f(\bar{s}) = \mu \left[1 - F_0(\bar{s}) \right]$$

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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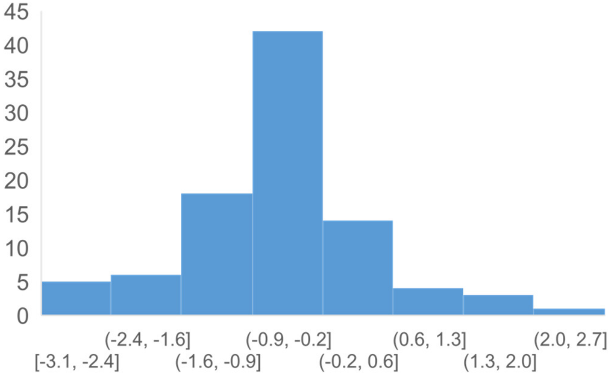
Exit Distortion

- Degree of exit distortion: $1 - \tau$

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

  - $\tau_{ij} = 1$ indicates no distortion.



Response to Exit Distortion

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, $\hat{s}/\bar{s} \uparrow$
- Also applicable to the outside option, ξ: $\tau = 1 + \frac{r\xi}{\kappa_o w}$

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, $\hat{s}/\bar{s} \uparrow$

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TSR Data

- Firm-level data by TSR
  - TSR: one of the largest credit rating companies in Japan
- Sales: 2001-2019; Exit: 2008-2019
- The number of firm observations is around 0.8-0.9 millions per year
  - Covering more than 20% of all firms
- Focus on "closure" and "dissolution" as voluntary exit
  - Exits are classified into closure, dissolution, bankruptcy (default), merger, or other.
  - Closure and dissolutions explain around 90% of total exit records.

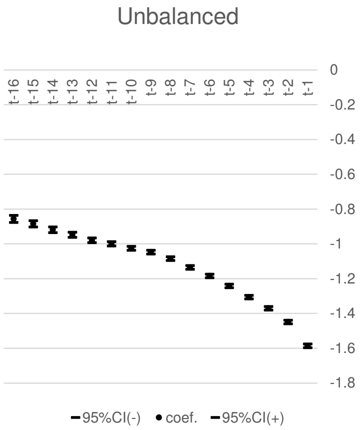
Estimation for Pre-exit Dynamics

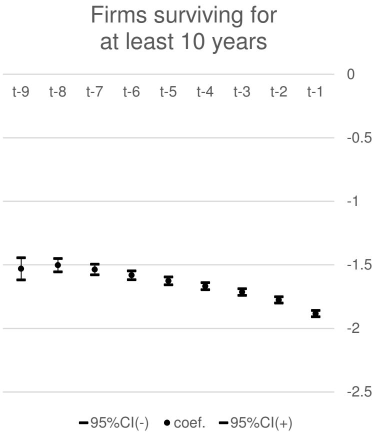
- Dynamics of firm size measured by log(sales)
  - Exit = voluntary closure
  - As of *h*-year prior to exit timing

$$\log\left(\text{sales}_{i,t}\right) = \alpha + \sum_{h=0}^{H} \beta_h \mathbb{1}\left(\text{exit}_{i,t+h}\right) + \eta_t + \varepsilon_{i,t}$$

  - ★ $\alpha + \eta_t$: Average sales of non-exiting firms in t.
  - ★ β_h: How much "eventually-exiting firms" are smaller than the average of non-exiting firms as of h years prior to exit (i.e., size difference between exit & non-exit firms)

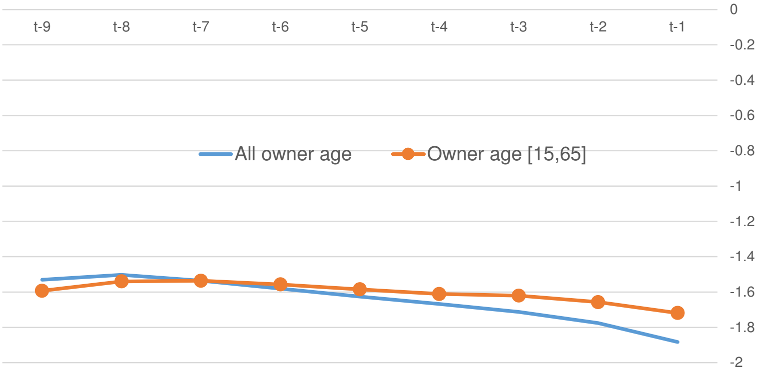
Pre-exit Dynamics: Sales





Robustness: Owner's Age

- Population aging in Japan.
- Retiring firm owners without successors may gradually shrink their business.



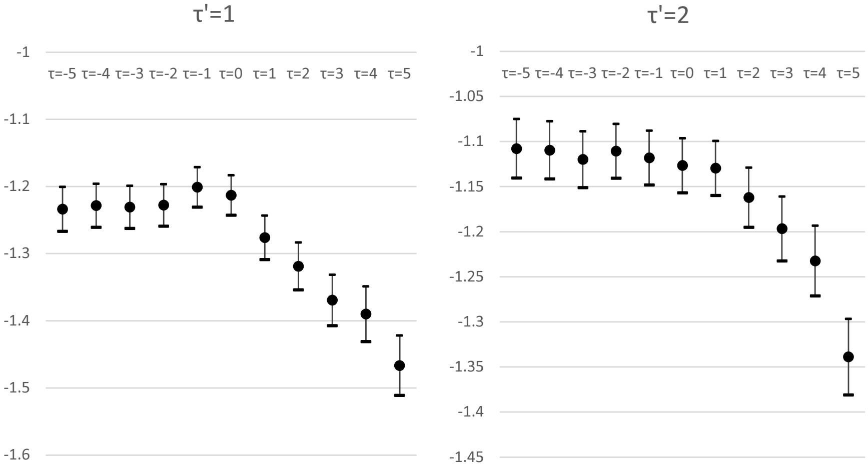
R&D Investment and Firm Dynamics

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

$$\log(\text{sales}_{i,t}) = \gamma + \delta_h \mathbb{1}\left(R\&D_{i,t-h,t-h+h'} = 0\right) + \eta_t + \varepsilon_{i,t}$$

- R&D is lumpy: we consider that a firm stops R&D when it does not make R&D investment for $h' + 1$ years.
- $\gamma + \eta_t$: Average size of R&D of R&D firms in t.
- δ_h: How much sales declines before/after R&D stoppage.

Firm Dynamics Before/After R&D Stoppage



Exit Distortion and the Shadow of Death

- $\text{distortion}_{i,t}$: industry×year-level distortion measures
  - Net subsidy rate: IO table

$$\frac{\text{Subsidy} - \text{Indirect Tax}}{\text{Value added}}$$

  - Capital resalability: SNA

$$\frac{\text{Investment on used assets}}{\text{Total capital investment}}$$

    - ★ Capital resalability works as negative distortion.

- Equations regressed

$$\log\left(\text{sales}_{i,t}\right) = \alpha + \beta_h \mathbb{1}\left(\text{exit}_{i,t+h}\right) + \theta \text{distortion}_{i,t} + \beta_h^D \mathbb{1}\left(\text{exit}_{i,t+h}\right) \times \text{distortion}_{i,t} + \eta_{Ii} + \eta_t + \varepsilon_{i,t}$$

$$\log\left(\text{sales}_{i,t}\right) = \gamma + \delta_h \mathbb{1}\left(\text{R\&D}_{i,t-h,t-h+h'} = 0\right) + \phi \text{distortion}_{i,t} + \delta_h^D \mathbb{1}\left(\text{R\&D}_{i,t-h,t-h+h'} = 0\right) \times \text{distortion}_{i,t} + \eta_{Ii} + \eta_t + \varepsilon_{i,t}$$

- Predictions for net subsidy rate:
  - slower exit: $\beta_h^D < 0$
  - longer shadow of death: $\delta_h^D - \beta_h^D > 0$
  - Opposite signs for resalability.

(i) Distortion: Net subsidy/Value-added

	Pre-exit dynamics						Pre/post-R&D termination dynamics					
	$\tau = 1$			$\tau = 3$			$\tau = -1, \tau' = 1$			$\tau = 1, \tau' = 1$		
	Coef.	s.e.		Coef.	s.e.		Coef.	s.e.		Coef.	s.e.	
β_τ	-1.443	0.011	***	-1.311	0.012	***						
β_τ^D	-0.929	0.136	***	-0.804	0.149	***						
δ_τ							-0.900	0.021	***	-0.946	0.023	***
δ_τ^D							0.473	0.195	**	0.556	0.210	***
Distortion	0.025	0.037		0.987	0.042	***	0.740	0.476		0.764	0.513	
Fixed-effect												
Year	yes			yes			yes			yes		
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	0.1346			0.1373			0.3673			0.3706		

(ii) Distortion: Capital investment on used assets / Total capital investment

	Pre-exit dynamics						Pre/post-R&D termination dynamics					
	$\tau = 1$			$\tau = 3$			$\tau = -1, \tau' = 1$			$\tau = 1, \tau' = 1$		
	Coef.	s.e.		Coef.	s.e.		Coef.	s.e.		Coef.	s.e.	
β_τ	-1.442	0.018	***	-1.384	0.019	***						
β_τ^D	-0.028	0.068		0.265	0.074	***						
δ_τ							-1.286	0.036	***	-1.311	0.039	***
δ_τ^D							1.115	0.154	***	1.027	0.165	***
Distortion	0.177	0.016	***	0.061	0.017	***	-0.397	0.196	**	-0.155	0.216	
Fixed-effect												
Year	yes			yes			yes			yes		
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	0.1110			0.1168			0.3472			0.3489		

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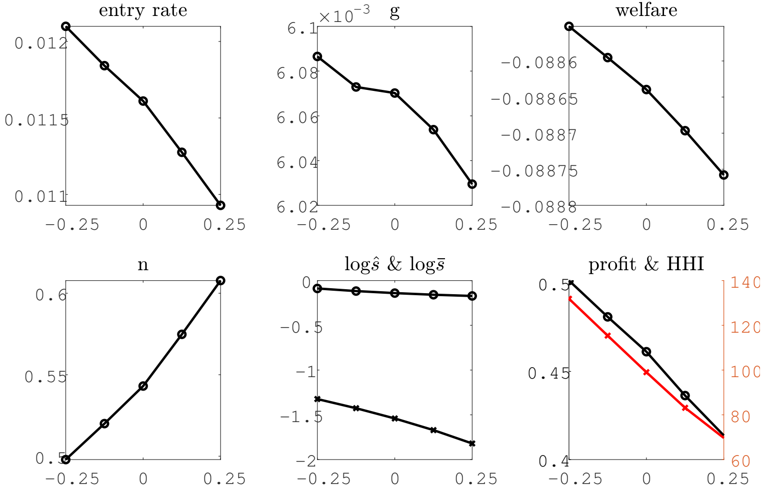
Calibration

- Simulate the effects of distortions
  - Calibrate the model to the Japanese economy based on TSR data
  - Key parameters: $\lambda = 0.037$, $\bar{\delta} = 0.0028$, $\gamma = 0.155$, $\kappa_o = 0.052$, $\kappa_r = 0.030$.

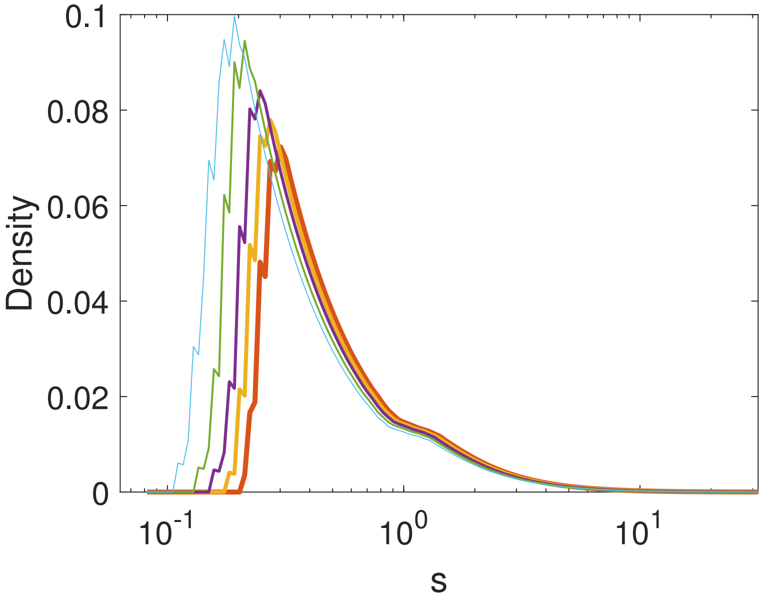
		Data	Simulation
Targeted moments			
	Prob. of sales share increase for R&D firms	0.037	0.037
	Prob of exit for R&D firms	0.0028	0.0028
	Entry rate	0.006 (0.051)	0.012
	Share of fixed costs in sales	0.050	0.050
	Share of R&D costs in sales for R&D firms	0.028	0.029
	Ratio of R&D threshold to exit threshold	4.080	4.058
Untargeted moments			
	Ratio of the mean of sales of all firms to entrants	0.971	0.630
	Ratio of the SD of sales of all firms to entrants	0.534	0.697
	Speed of sales change for non R&D firms	-0.040	-0.020

Simulation Result: Size-dependent Subsidy

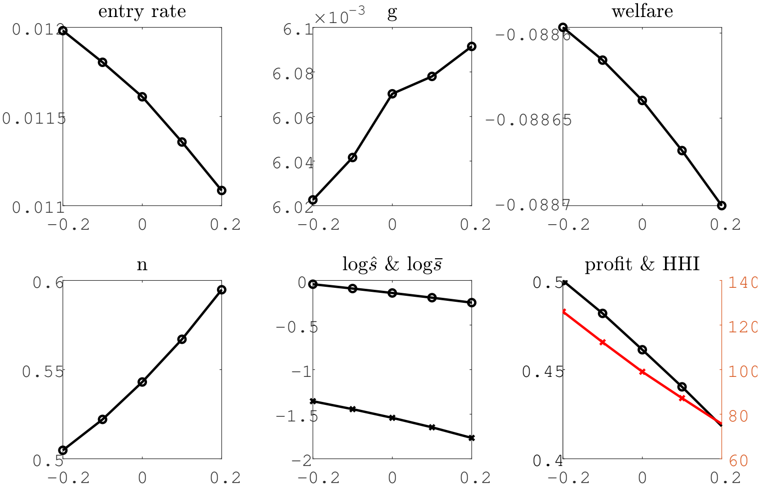
- Horizontal axis: distortion $1-\tau$
- Distortion increases the gap $\hat{s}/\bar{s}$ and worsen welfare.



Firm Value, Stationary Distribution



Outside Option



Concluding Remarks

- New framework to analyze the macroeconomic impact of the left-tail changes of firm distributions.
  - Shadow of death as misallocation
  - Weak business dynamism in Japan
- Future work
  - Transition
  - Friction at labor mobility
  - Left-tail vs right-tail
  - How important in other countries?