Government-Backed Financing and Aggregate Productivity

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Government-Backed Financing

Loan guarantees, direct loans, debt relief

- Used worldwide mainly to promote growth of small medium sized enterprises (SMEs)
  - Intended to fill the financing gap between large firms and SMEs (OECD)

These policies often change in response to crisis episodes

No consensus about these policies' effects on aggregate productivity

- Benefit: Help financially constrained yet productive firms grow

  Stiglitz (1993), Banerjee and Duflo (2014), Jiménez, Peydró, Repullo and Saurina Salas (2018)

- Cost: Help low-productivity firms survive (often called zombie firms)

  Tracey (2019), Acharya, Crosignani, Eisert and Steffen (2021), Faria-e-Castro, Paul and Sánchez (2021)

What I Do

1. Exploit an increase in government loans to firms: 1pp of GDP over 3 years
   - Expansion after 2017: newly elected government's policy agenda to promote SMEs

2. Document policy effects using new data
   - Data: panel of audited financial statements of Korean manufacturing firms (14,569)
     - Active + exiting firms (financial state at exit)
     - Policy eligibility: small-mid sized enterprises (SMEs)

3. Quantify aggregate effect using a heterogeneous-firm model

   Arellano, Bai and Kehoe (2019), Ottonello and Winberry (2020)

   - Endogenous borrowing costs - Study transitions after the introduction of government loans

Results

Firm-level policy effects based on difference-in-difference regression

- Borrowing costs of eligible firms decreased more relative to non-eligible firms
- Investment increased more for eligible firms with high pre-policy borrowing costs
- Exit rates decreased most among eligible low-productivity firms

Key trade-off of government-backed financing

- $\Uparrow$ investment of constrained firms
- $\Downarrow$ exit of low-productivity firms

Aggregate productivity: -0.3% (over 10-year)

- Capital allocation: $\Uparrow$ investment of constrained firms (+0.1%)
- Active firms' composition: $\Downarrow$ exit of low-productivity firms (-0.4%)

Related Literature and Contribution

Firm dynamics and financial frictions

Buera, Kaboski and Shin (2011), Moll (2014), Midrigan and Xu (2014)

Gopinath, Kalemli-Özcan, Karabarbounis and Villegas-Sanchez (2017), Arellano, Bai and Kehoe (2019)

Credit misallocation generated from subsidized loans

Caballero, Hoshi and Kashyap (2008), Tracey (2019),

Acharya, Crosignani, Eisert and Steffen (2021), Faria-e-Castro, Paul and Sánchez (2021)

Government's intervention in credit market

Banerjee and Duflo (2014), Jiménez, Peydró, Repullo and Saurina Salas (2018), Crouzet and Tourre (2021)

Contribution built on literature emphasizing financial friction

- Provide empirical evidence that suggests subsidized loans distort the selection
- Study policy effects outside crisis episodes, capturing the main trade-off

Korean Policy and Data

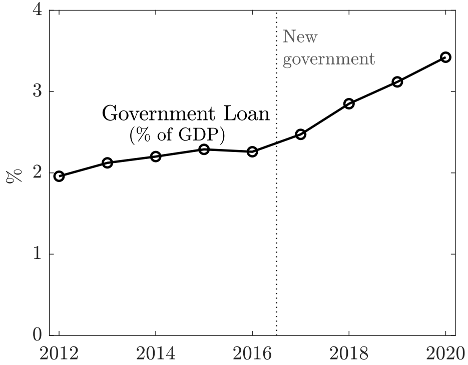
Government Loans in Korea

Eligibility: small-mid sized enterprises

1. Cutoff defined by the law
   - Total asset: 380 Mil USD (Top 3 %)
   - 3-year average sales: 60-120 Mil USD (varies by sectors)
2. Not affiliated with large conglomerate, *Chaebol* (e.g. Samsung)

Key features:

1. lower interest rates Compare
2. extended up to a fixed limit
3. partial debt relief during cash-shortages



Data and Empirical Strategy

Data: financial statements of Korean manufacturing firms

- Manufacturing firms with assets over 9 million USD subject to external audits
  - Revenue of sample firms $\approx$ 80 $\%$ of total sales
- Large (2,108) + SMEs (12,461) : eligibility for the policy
- Active firms (12,976) + Exiting firms (1,593): observe financial state at exit
- Key variables: sales, operating profit, interest expense, total debt, tangible assets

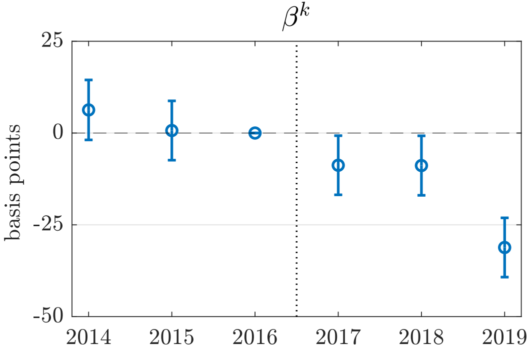
Difference-in-difference: borrowing costs (credit spread), investment, exit

- Before (2014-16) and After (2017-19) $\times$ Eligibility (status in 2020) BOK Keyrates
- Credit spread = $\frac{\text{interest expense}}{\text{total debt}}$ - prime rate   - Investment = Δ tangible asset

Firm Level Policy Effects

Empirical Fact 1: Borrowing Costs

$$\underbrace{\text{Credit Spread}_{ist}}_{\text{firm } i \text{ in sector } s \text{ of year } t} = \sum_{\substack{k=2014 \\ k\neq 2016}}^{2019} \beta^k D_t^k \underbrace{D_{is}^{\text{eligible}}}_{\substack{\text{=1 if eligible} \\ \text{for loans}}} + \gamma^x \underbrace{X_{ist-1}}_{\substack{\text{firms' } \\ \text{controls}}} + \underbrace{\gamma_{st}}_{\text{sector} \times \text{year FE}} + \underbrace{\gamma_i}_{\text{firm FE}} + \epsilon_{ist}$$



β^k: Difference in the spread gap between eligible and ineligible firms between year k and 2016

(with 90% confidence interval)

Credit spreads of eligible firms decreased more relative to credit spreads of ineligible firms.

Empirical Fact 2: Borrowing Costs Sensitivity to Debt Ratio

$$\text{Credit Spread}_{ist} = \beta_0 \text{Debt Ratio}_{ist-1} + \beta_1 D_{is}^{\text{eligible}} \text{Debt Ratio}_{ist-1} + \beta_2 \text{Debt Ratio}_{ist-1} D_t^{\text{After}} + \beta_3\, D_{is}^{\text{eligible}} \text{Debt Ratio}_{ist-1} D_t^{\text{After}} + \gamma_{st} + \gamma_i + \epsilon_{ist}$$

		Spread (bp)
β_0	Debt Ratio	0.46***
		(0.17)
β_1	Debt Ratio × Eligible	-0.12
		(0.18)
β_2	Debt Ratio × After	-0.05
		(0.10)
β_3	Debt Ratio × Eligible × After	-0.26***
		(0.09)
	Observations	57,625
	R^2	0.05

Difference in credit spread sensitivity Before:

- No discernible difference between eligible and ineligible firms

Credit spread sensitivity After:

- Ineligible firms: no discernible change
- Eligible firms: decrease

How Does Improved Credit Access Affect Investment?

Empirical strategy

- Before (2014-16) $\&$ After (2017-19)
- Diff-in-Diff with 4 groups: $\underbrace{\{\text{eligible}, \text{ineligible}\}}_{\text{eligibility}} \times \underbrace{\{\text{before credit spread high}, \text{low}\}}_{\text{pre-policy borrowing costs}}$

We cannot precisely measure the level of financial constraint..BUT

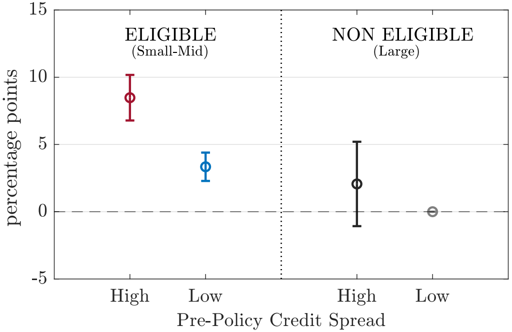
- Firms with *higher borrowing costs in Before* may have faced tighter financial constraint.

Firms with higher borrowing costs in Before are expected to increase investment more

Empirical Fact 3: Investment

$$\text{Investment}_{ist} = \beta_1 D^{\text{eligible}}_{is} D^H_{is} D^{\text{After}}_t + \beta_2 D^{\text{eligible}}_{is}(1 - D^H_{is}) D^{\text{After}}_t$$
$$+\beta_3 (1 - D^{\text{eligible}}_{is}) D^H_{is} D^{\text{After}}_t + \gamma^x X_{ist-1} + \gamma_{st} + \gamma_i + \epsilon_{ist}$$

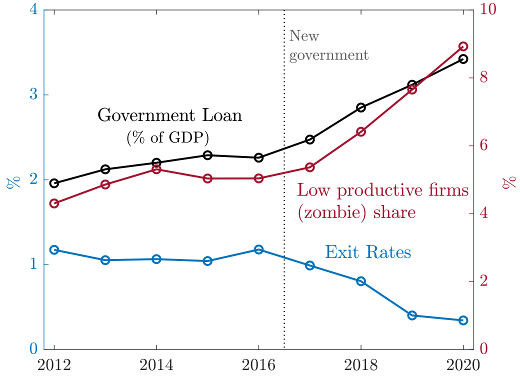
$D^H_{is} = 1$ if a firm's pre-policy credit spread is in the upper 10th percentile



- Greater investment response by firms with higher pre-policy credit spread
- Ineligible: no significant effect

Variables Continuous Eventstudy

Exit Rates Decreased and the Share of Low-Productivity Firms Increased



Classify low-productivity firms based on definition of ***zombie firms*** Detail Alternative

1. debt service > operating profit for 3 years in a row
2. over 10-year old

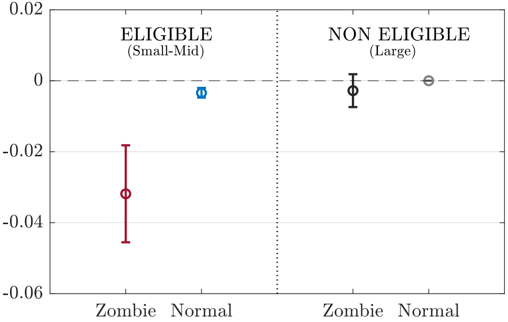
Empirical strategy

- Before (2014-16) & After (2017-19)
- Diff-in-diff with 4 groups:

$$\underbrace{\{\text{eligible}, \text{ineligible}\}}_{\text{eligibility}} \times \underbrace{\{\text{zombie}, \text{normal}\}}_{\text{one-year lagged indicator}}$$

Empirical Fact 4: Exit

$$\text{Exit}_{it} = \quad \beta_1 D_i^{\text{eligible}} D_{it-1}^{Z} D_t^{\text{After}} + \beta_2 D_i^{\text{eligible}} (1 - D_{it-1}^{Z}) D_t^{\text{After}} + \beta_3 (1 - D_i^{\text{eligible}}) D_{it-1}^{Z} D_t^{\text{After}}$$
$$+\gamma_x X_{it-1} + \gamma_t + \epsilon_{it} \qquad D_{ist-1}^{z} = 1 \text{ if zombie in } t-1$$



- Higher survival probability of low-productivity firms
- Ineligible: no significant effect

Variables | Exit and Zombie | Before exit | Spread and Exit

Key Takeaways

After the policy: significant increase in Korean government loans after 2017

- Credit spread of eligible firms (SMEs) decreased more than ineligible firms (large).
- Investment increased more for eligible firms with high pre-policy credit spread.
- Exit rates decreased more for eligible low-productivity firms.

$\rightarrow$ *Model to quantify the aggregate effect!*

Model

Model Summary: Heterogeneous Firms Dynamics Model

- Final good firms convert intermediate good (Y) into a final good (y_F)
- Intermediate good firms differ in cash-on-hand (x), capital (k), productivity (z)
  - Produce homogeneous good using capital (k).
  - Sell at price p Price
  - Repay $\&$ continue vs default $\&$ exit
  - Default risk $\rightarrow$ endogenous borrowing constraint
- Risk-neutral private lenders
- Government loans are available to active firms (not potential entrants)
  - Loans at subsidized rate ($0 \sim$ risk free rate) and up to fixed limit ($\overline{b_g}$)
  - The loan program is financed with lump-sum tax from households.
- Representative household consumes profit from firms. (no labor)

Cash Shortage

- Cash on hand (x) depends on: capital (k), debt (b, b_g) and two idiosyncratic shocks:
  - Persistent productivity (AR(1)): z Transitory productivity shock (i.i.d): ϕ

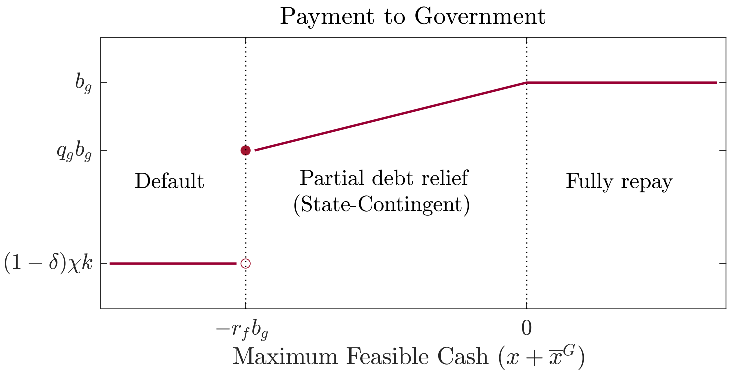
$$\underbrace{x(k, b + b_g, z, \phi)}_{\text{cash on hand}} = \underbrace{(1-\tau)pz\exp(\phi)\,k^{\alpha}}_{\text{After-tax revenue}} - \underbrace{(f + f_k k)}_{\text{Operating cost}} - \underbrace{b}_{\text{Private loans}} - \underbrace{b_g}_{\text{Gov't loans}} + \underbrace{\tau(\delta k + r_f(b + b_g))}_{\text{Tax benefit}}$$

- Maximum fund a firm can raise:

$$\overline{x}^G(k, z) = \max_{k', b', b'_g} \underbrace{q(k', b', b'_g, z)}_{\text{private loan price}} b' + \underbrace{\overbrace{q_g}^{\beta}}_{\text{fixed rate}} b'_g - \underbrace{(k' - (1-\delta)k)}_{\text{investment}} - \underbrace{\psi(k, k')}_{\text{adjustment cost}} \quad \text{s.t } \underbrace{b'_g \leq \overline{b_g}}_{\text{up to limit}}$$

- Maximum feasible cash = $x + \overline{x}^G(k, z) < 0 \rightarrow$ Cash shortage

Default Rule and Government Loans



Government loans decrease financing cost by

1. lending at risk free rate   2. debt relief if cannot pay interest

Continuing Firm's Problem

- Value of continuing firms:

$$V(x,k,z) = \max_{k',b',b'_g} d + \beta \sum_{z'} \pi(z' \mid z) \left[\int_{\phi' > \tilde{\phi}^G(k',b',b'_g,z')} V\left(x'\left(k',b',b'_g,z',\phi'\right),k',z'\right) d\Phi(\phi') \right]$$

$$\underbrace{+ \beta \sum_{z'} \pi(z' \mid z) \left[\left(\Phi(\tilde{\phi}^G(k',b',b'_g,z')) - \Phi(\hat{\phi}^G(k',B',z')\right) V\left(x'\left(k',b',b'_g,z',\tilde{\phi}^G\right),k',z'\right) \right]}_{\text{Value from government's debt relief}}$$

subject to

1. $d = x - \psi(k,k') + q\left(k',b',b'_g z\right) b' + q_g b'_g \geq 0$
2. $x(k',b',b'_g,z',\phi') = (1-\tau)pz' \exp(\phi') k'^{\alpha} - f_k k' - f - (b' + b'_g) + \tau\left(\delta k' + r_f(b' + b'_g)\right)$
3. $\tilde{\phi}^G(k',b',b'_g,z')) = \log\left(\frac{-\bar{x}^G(k',z') + f + f_k k' + b' + b'_g - \tau\left(\delta k' + r_f\left(b' + b'_g\right)\right)}{(1-\tau)pz'k'^{\alpha}}\right)$: Full-repayment cutoff
4. $\hat{\phi}^G(k',b',b'_g,z')) = \log\left(\frac{-\bar{x}^G(k',z') + f + f_k k' + b' + b'_g - (1-q_g)b'_g - \tau\left(\delta k' + r_f(b' + b'_g)\right)}{(1-\tau)pz'k'^{\alpha}}\right)$: Default cutoff

Firm Entry

Value fcn

- A mass (M_e) of potential entrants receive a signal ν about productivity. (Clementi and Palazzo, 2016)
  - Productivity z distribution upon entry : $G(z \mid \nu)$
- Value of potential entrant with signal ν

$$V^e(\nu) = \max_{k',b'} \beta \sum_{z'} \int_{\phi' > \hat{\phi}} V\left(x'\left(k', b', z', \phi'\right), k', z'\right) d\Phi\left(\phi'\right) dG\left(z' \mid \nu\right)$$

$$\text{s.t} \qquad -\psi(k_e, k') + q^e(k', b', \nu)b' \geq 0$$

- To enter, firms must pay entry fee c_e.
- Firms with good signal for productivity $\nu \geq \hat{\nu}$ will enter: $V^e(\hat{\nu}) = c_e$

Final Good Firm

Back

- Final good firms convert intermediate good (Y) into a final good (y_F),

$$\max_{Y} \underbrace{\bar{z}(Y)^{\alpha_y}}_{y_F} - pY$$

  - Y: Sum of intermediate good firms' production.

$$Y(p^*) = \int y(x,k,z)d\mu(x,k,z)$$

p^*: market-clearing price, $\mu(x,k,z)$: firm measure

  - $\bar{z}$: Intermediate good firms' average productivity.

$$\bar{z} = \int_{z_i} z_i m(z_i) d(z_i)$$

where, $w(z_i) = \frac{\int \mathbf{1}(z=z_i) y(x,k,z) d\mu(x,k,z)}{\int y(x,k,z) d\mu(x,k,z)}$

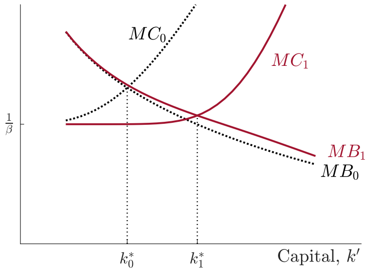
Role of Endogenous Borrowing Constraint

Equation

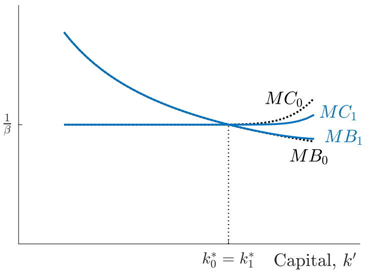
- Default risk and positive credit spread $\rightarrow$ dispersion of capital by cash-on-hand
- Government loans: financing cost$\Downarrow$ $\rightarrow$ more capital by constrained firms
  $\rightarrow$ *Capital allocation is closer to the one in the economy without default risk*

Same current capital (k) and productivity (z)

(a) Low cash on hand: more borrowing



(b) High cash on hand: less borrowing



Quantification

Quantitative Exercises Overview

What I do: parameters target untarget1 untarget2 untarget3 policy fcns

1. Calibrate the model without government loans to match Korean firm data (2010-2016)
   - Main target moments: investments, spread, exit rates, sale-asset ratio at exit and entry
2. Introduce government loans:
   - Calibrated to capture changes in exit rates after the policy change
3. Transition path between two steady states with and without gov't loans

Main exercices:

1. Model validation: data vs simulated firms $\rightarrow$ micro effects
   - Simulated firms: 3-year after the introduction of gov't loans
2. Transition path and steady state comparison $\rightarrow$ macro effects

Model Validation: Normal vs Zombie Firms (Untargeted)

Zombie firms:

- Data: Operating profit < debt service for 3 consecutive years + over 10 years old
- Model: Negative cash-on-hand for 3 consecutive years + over 10 years old

Mean Difference: Zombie from Normal

		Data	Model
(%)	Log capital size	115.2	111.0
	Debt to Asset Ratio	9.7	10.1
(pp)	Profitability	-11.2	-15.5
	Investment	-12.2	-7.1

- Share of zombie firms before the policy
  - Data: 5.1% Model: 8.0%
- Change in the share of zombie firms
  - Data: 2.5pp Model: 4.0pp
- Zombie firms are relatively
  - Large, indebted, unprofitable, low-investment

Investment Increases More for Firms with High Pre-policy Spread

Data panel regression:

$$\text{Investment}_{ist} = \beta_1 D_{is}^{\text{eligible}} D_{is}^{H} D_t^{\text{After}} + \beta_2 D_{is}^{\text{eligible}} (1 - D_{is}^{H}) D_t^{\text{After}} + \beta_3 (1 - D_{is}^{\text{eligible}}) D_{is}^{H} D_t^{\text{After}} + \gamma^x X_{ist-1} + \gamma_{st} + \gamma_i + \epsilon_{ist}$$

Regression with simulated firms: $\text{Investment}_{it} = \alpha_1 D_i^H D_t^{\text{After}} + \gamma^x X_{it-1} + \gamma_t + \gamma^h D_i^H + \epsilon_{it}$

- Two groups by pre-policy credit spread ($D^H = 1$: High pre-policy credit spread)

Heterogeneity by pre-policy credit spread

Δ Investment (pp)	
Data ($\beta_1 - \beta_2$)	Model (α_1)
5.14	4.02
[3.41 6.86]	(0.28)

Exit Rate Decreases More for Less Productive Firms

Data panel regression:

$$\text{Exit}_{it} = \beta_1 D_i^{\text{eligible}} D_{it-1}^Z D_t^{\text{After}} + \beta_2 D_i^{\text{eligible}} (1 - D_{it-1}^Z) D_t^{\text{After}} + \beta_3 (1 - D_i^{\text{eligible}}) D_{it-1}^Z D_t^{\text{After}} + \gamma_x X_{it-1} + \gamma_t + \epsilon_{it}$$

Regression with simulated firms: $\text{Exit}_{it} = \alpha_1 D_{it-1}^Z D_t^{\text{After}} + \gamma^z D_{it-1}^Z + \gamma_t + \epsilon_{it}$

- Two groups by zombie indicator ($D^z = 1$: zombie)

Heterogeneity by zombie indicator

Δ Probability to exit	
Data ($\beta_1 - \beta_2$)	Model (α_1)
−0.028	−0.023
[−0.012 −0.045]	(0.009)

Zombie transitions Exit and credit spread

General Equilibrium Effect

Exit $\downarrow$+ Investment by financially constrained firms $\uparrow \rightarrow$ Eq. price $\downarrow$ Price

- Firm's average production and profitability decreases
- Discourages potential entrants from entering the market

  $\rightarrow$ Indirectly worsening composition of active firms' productivity

  - Fewer high-productive firms enter and more low-productivity firms survive
  - Potential entrants at entry margin are more productive than incumbent firms at exit margin.

Firm entry Value fcn

Aggregate output and aggregate productivity

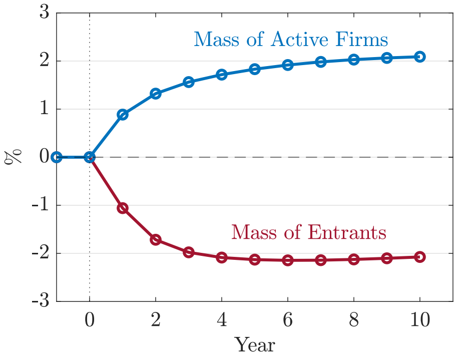
$$Y = \underbrace{M^{1-\alpha}}_{\text{Size effect}} \times \overbrace{\underbrace{\mathbf{E}\left[\tilde{z}^{\frac{1}{1-\alpha}}\right]^{1-\alpha}}_{\text{Composition}} \times \underbrace{\frac{Y}{Y^*}}_{\text{Capital allocation}}}^{\text{Aggregate Productivity}} \times \underbrace{K^{\alpha}}_{\text{Capital qtys.}}$$

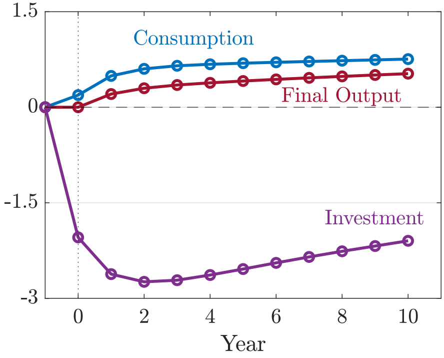
$$\tilde{z} = \sum_z z\pi\left(z \mid z_{-1}\right) \quad M = \int d\mu(x_{-1}, k_{-1}, z_{-1}) \quad K = \int k(x_{-1}, k_{-1}, z_{-1}) d\mu(x_{-1}, k_{-1}, z_{-1})$$

- Y^*: Maximum output given the mass of firms M and aggregate capital K
  - Capital is distributed for the marginal product of capital to be equalized across firms.

Macro: Transition Path

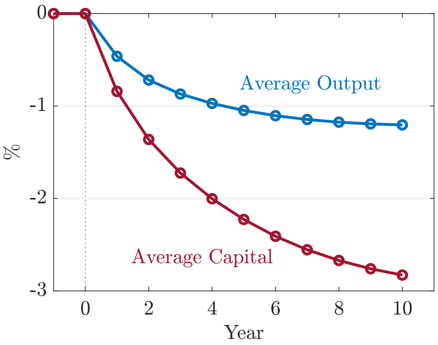
- Entrants $\downarrow$ (GE) but incumbents exit rates $\downarrow$ (GE + gov't loans) $\rightarrow$ active firms $\Uparrow$
- Investment decreases (GE + composition), but output increases due to more active firms.

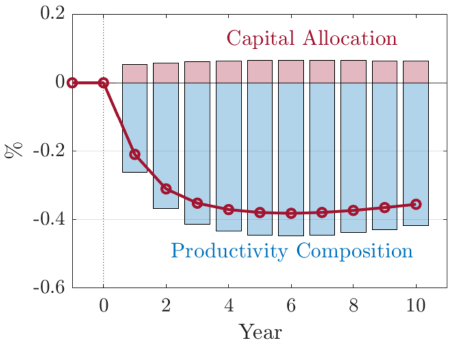




Average Firms' Size Decreases and Average Productivity Decreases

- Average output and capital decreases.
- Aggregate productivity decreases.
  - Capital allocation ↑: increased invt. by constrained firms and less capital dispersion
  - Productivity composition ↓: less exit by low-productivity firms + less entry Decomposition Bartik





Long Run Effects: Steady States Comparison

- Aggregate productivity effects mostly materialize in the first 10 years.
- Aggregate effects after 10 years mostly come from changes in the mass of active firms.

	Δ		Δ		Δ
Productivity	-0.3	Active Firms	+2.6	Capital	-0.4
(Capital allocation)	+0.1	Entrants	-2.2	Final output	+1.1
(Composition)	-0.3			Consumption	+1.3

Conclusion

Conclusion

- Effects of a significant increase in government loans for SMEs using Korea's case
  1. Credit spread of SMEs (eligible) decreased more than large firms (ineligible)
  2. Investment increased more for eligible firms with high pre-policy credit spread.
  3. Exit rates decreased more for eligible low-productivity firms.
- Heterogeneous response that captures trade-off: model $\longleftrightarrow$ data
- Quantify the aggregate productivity effects of the government loans (over 10-year)
  - Productivity (-0.3%): improved capital allocation (+0.1%) but worsened composition (-0.4%)

THANK YOU!

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Appendix: Empirical

How to Define Zombie Firms

Zombie firms: continuously unable to cover debt costs from current profits

(Banerjee and Hofmann, 2018, McGowan, Andrews and Millot, 2017, Hong, Igan and Lee, 2021)

1. Meet one of the following conditions for 3 consecutive years.
    - Interest coverage ratio (ICR) $= \frac{\text{Operating profit}}{\text{Interest expense}} < 1$
    - Negative operating profit
2. Firm's age $\geq$ 10 years (For exclusion of start-ups)

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Government Loans Benchmark Rates

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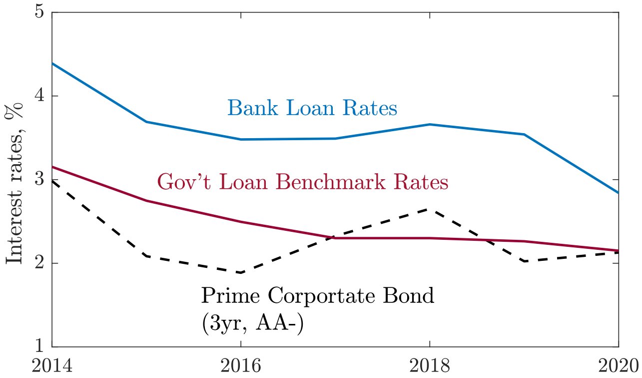
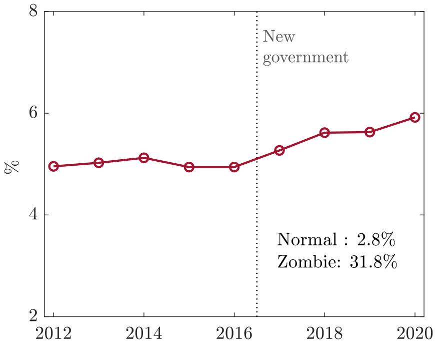


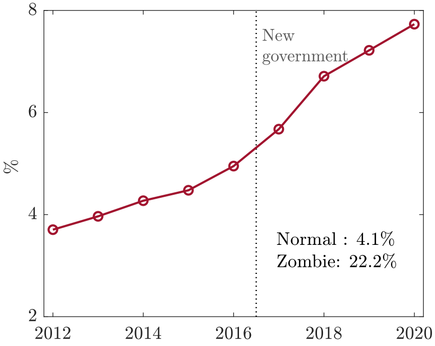
Share of Firms with Indicators Lower Than the Cutoff

Cutoff: the indicator's 5th percentile for each sector in the year 2016

(a) Sales-Cost Ratio



(b) Sale-Asset Ratio



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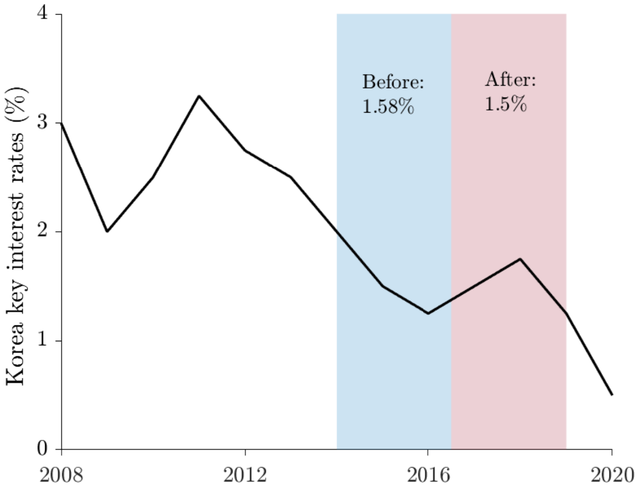
Bank of Korea Key Rates



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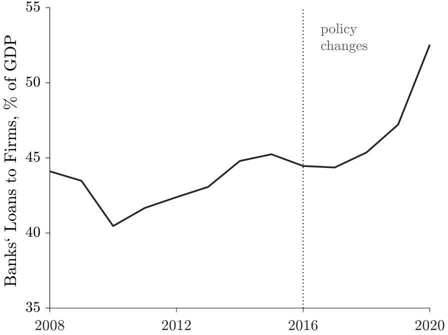
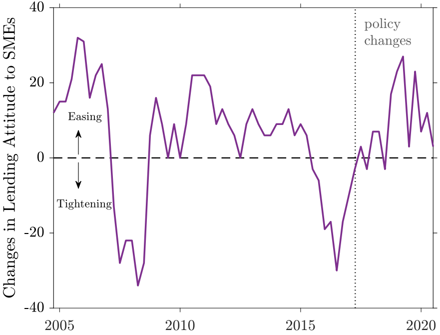
The Private credit market has also become easing.

(a) Banks' loan to firms



(b) Banks' lending attitude toward SMEs



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Financial States Before Firms Exit

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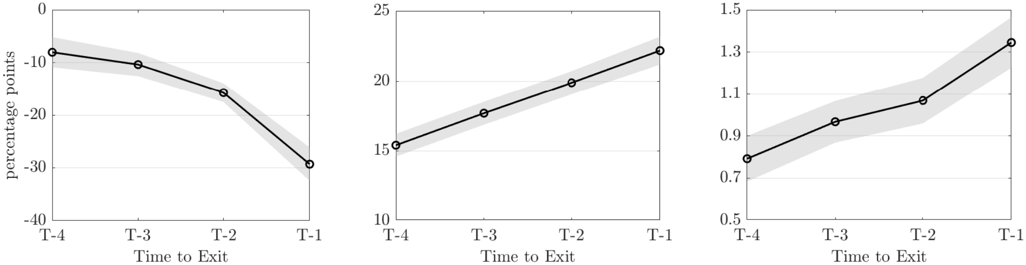
Cash shortage ↑, debt ratio ↑, and credit spreads ↑ → exit

(a) Net-income ratio **(b)** Debt ratio **(c)** Credit spread



Notes: These plots show the relative financial state of firms with specific distance to exit. Specifically, those are series of coefficient of $y_i = \alpha + \sum_{k=1}^{4} \beta_k D_i^{T-k} + \epsilon_i$, where D_i^{T-k} is an indicator whether a specific firm i closes down and exits after k periods. The shaded area indicates the 90% confidence interval.

Effects of the Eligibility: SMEs vs Large Firms

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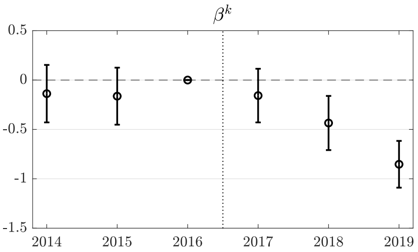
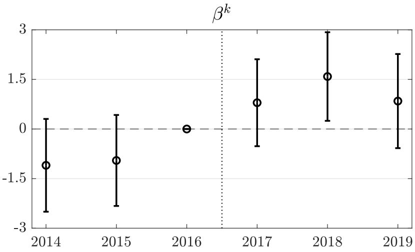
$$\text{Y}_{it} = \sum_{k \neq 2016} \beta^k \text{Year}_k D_i^{sme} + \gamma_t + \epsilon_t$$

(a) Exit rates (pp)



(b) Zombie share (pp)



Credit Spread and Exit Rates

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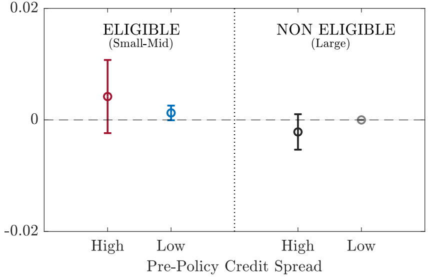

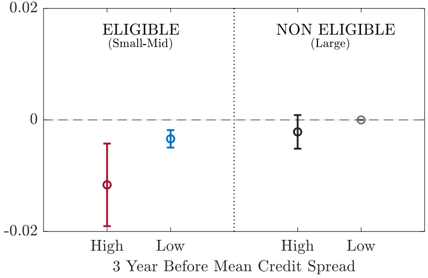

Detailed Explanatory Variables

$$\text{Spread}_{ist} = \sum_{k\neq 2016} \beta^k \text{Year}_t D_{is}^{sme} + \gamma^x X_{ist-1} + \gamma_{st} + \gamma_i + \epsilon_{ist}$$

- D^{sme}: SMEs indicator X_{ist}: equity to asset, cash to asset, debt to asset
- γ_{st}: sector-year fixed effect γ_i : firm fixed effect

Spread

$$\text{Investment}_{ist} = \beta_1 D_{is}^{sme} D_{is}^{H} D_t^{\text{After}} + \beta_2 D_{is}^{sme}(1-D_{is}^{H}) D_t^{\text{After}} + \beta_3 (1-D_{is}^{sme}) D_{is}^{H} D_t^{\text{After}} + \gamma^x X_{ist-1} + \gamma_{st} + \gamma_i + \epsilon_{ist}$$

- D^{sme}: SMEs indicator γ_{st}: sector-year fixed effect γ_i : firm fixed effect
- D^{H}: an indicator of whether the pre-policy credit spread is in the upper 10th percentile
- X_{ist}: log of tangible asset, operating profit to asset

Investment

$$\text{Exit}_{it} = \beta_1 D_{i}^{sme} D_{it-1}^{Z} D_t^{\text{After}} + \beta_2 D_{i}^{sme}(1-D_{it-1}^{Z}) D_t^{\text{After}} + \beta_3 (1-D_{i}^{sme}) D_{it-1}^{Z} D_t^{\text{After}} + \gamma_x X_{it-1} + \gamma_t + \epsilon_{it}$$

- D^{sme}: indicator of SMEs D^{Z}: indicator of zombie firms γ_t: year fixed effect
- X_{it} : Interaction terms of indicator of SMEs and zombie firms

Exit

Exposure Analysis: Aggregate Effects with Reduced Form

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Sector (s) level regression using regional data (r)

- Given government loans in period t, sector s has a higher exposure to the policy:
  - Higher share of small-mid enterprises (SMEs) in region r of relatively higher output share

$$y_{st} = \beta \text{Exposure to Gov' Loan}_{st} + \gamma_t + \gamma_s + \epsilon_{st}$$

$$\text{Exposure to Gov' Loan}_{st} = \sum_{r=1}^{13} \underbrace{\frac{\text{number of SMEs}_{sr}}{\text{number of firms}_{sr}}}_{\text{SMEs share in } r \text{ region } s \text{ industry}} \times \overbrace{\underbrace{\frac{\text{total output}_r}{\text{total output}}}_{\text{output share in region } r} \times Gov_t}^{Shock}$$

	Exit rates	Investment	Zombie share	Zombie K share	Δ log $\frac{\text{sales}}{\text{assets}}$
β	-0.009**	-0.065***	0.027*	-0.029	-0.002**
	(0.003)	(0.021)	(0.013)	(0.051)	(0.001)

Heterogeneous Responses to Policy: Continuous Variables

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$$\text{Investment}_{ist} = \beta_1 D_{is}^{sme} \text{Before CR}_{is} D_t^{\text{After}} + \beta_2 \text{Before CR}_{is} D_t^{\text{After}} + \gamma^x X_{ist-1} + \gamma_{st} + \gamma_i + \epsilon_{ist}$$

	Investment(pp)
Before CR $\times$ SME$\times$ After (β_1)	1.33*** (0.28)
Before CR $\times$ After (β_2)	0.05 (0.26)

Heterogeneous Responses to Policy

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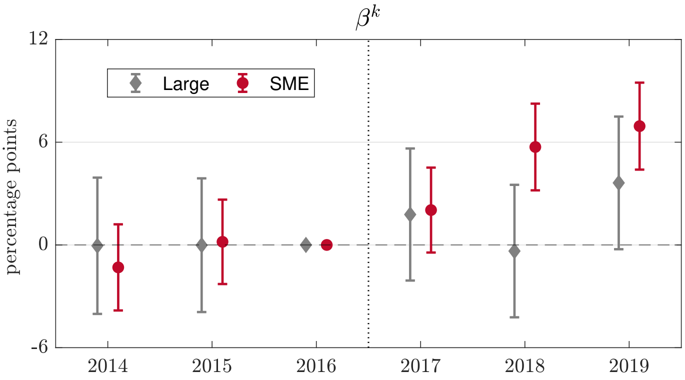
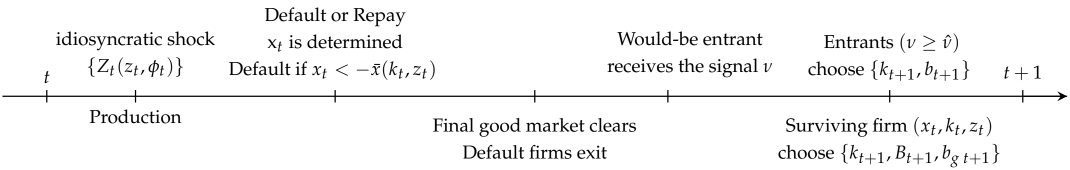
$$\text{Investment}_{ist} = \sum_{k \neq 2016} \beta^k \text{Year}_k D_i^{\text{High}} + \gamma^x X_{\text{ist}-1} + \gamma_{st} + \gamma_i + \epsilon_{\text{ist}}$$



Appendix: Quantitative

Timeline



z_t: firm's AR(1) idiosyncratic productivity ϕ_t: firm's i.i.d. idiosyncratic shock

x: cash on hand $\bar{x}$: maximum funds the firm can raise k: capital b: debt

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Investment Cost and Related Adjustment Cost

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$$c(k_t, k_{t+1}) = \begin{cases} (k_{t+1} - (1-\delta)k_t) + p_k^+ \frac{(k_{t+1}-(1-\delta)k_t)^2}{2(1-\delta)k_t} & \text{if} \quad k_{t+1} - (1-\delta)k_t \geq 0 \\ (k_{t+1} - (1-\delta)k_t) + p_k^- \frac{(k_{t+1}-(1-\delta)k_t)^2}{2(1-\delta)k_t} & \text{if} \quad k_{t+1} - (1-\delta)k_t < 0 \end{cases}$$

where, $p_k^+ < p_k^-$

Debt Price Schedule with the Government Policy

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$$q\left(k', B', b_g', z\right) = \beta \sum_{z'} \left[\left(1 - \Phi\left(\hat{\phi}^G\right)\right) + \Phi\left(\hat{\phi}^G\right) R^G(B', b_g', k')\right] \pi(z' \mid z)$$

where,

$$\hat{\phi}^G\left(k', B', b_g', z')\right) = \log\left(\frac{-\bar{x}^G\left(k', z'\right) + f + f_k k' + B' - \left(1 - q_g\right) b_g' - \tau\left(\delta k + r_f B'\right)}{(1-\tau) p z' k'^{\alpha}}\right)$$

$$R^G(B', b_g', k') = \min\left(1, \max\left(0, \frac{\chi(1-\delta)k' - b_g' - \eta}{B' - b_g'}\right)\right)$$

Potential Entrants' Value Function and Debt Price Schedule

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$$V^{e}(\nu) = \max_{k',b'} \beta \sum_{z'} \int_{\phi' > \hat{\phi}} V\left(x'\left(k',b',z',\phi'\right),k',z'\right) d\Phi\left(\phi'\right) dG\left(z' \mid \nu\right)$$

s.t $\quad -c(k_e,k') + q^{e}(k',b',\nu)b' \geq 0$

$$x(k',b',z',\phi') = (1-\tau)pz'\exp(\phi')k'^{\alpha} - f_k k' - f - b' + \tau\left(\delta k' + r_f b'\right)$$

$$\hat{\phi}\left(k',b',z'\right) = \log\left(\frac{-\bar{x}\left(k',z'\right) + f + f_k k' + b' - \tau\left(\delta k' + r_f b'\right)}{(1-\tau)pz'k'^{\alpha}}\right)$$

$$q_e\left(k',b',\nu\right) = \beta \sum_{z'} \left[\left(1 - \Phi\left(\hat{\phi}\right)\right) + \Phi\left(\hat{\phi}\right) R\left(b',k'\right)\right] dG\left(z' \mid \nu\right)$$

s.t $\quad \hat{\phi}\left(k',b',z'\right) = \log\left(\frac{-\bar{x}\left(k',z'\right) + f + f_k k' + b' - \tau\left(\delta k' + r_f b'\right)}{(1-\tau)pz'k'^{\alpha}}\right)$

$$R(b',k') = \min\left(1, \max\left(0, \chi\frac{(1-\delta)k'}{b'} - \eta\right)\right)$$

Government Loans and Default Rule

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Government loans: fixed limit $(\overline{b_g})$ and contingent rates $(0 \sim r_f =$ risk free rate$)$

- Cash shortage: $x^{FR} + \overline{x}^G(k, z)$
  - $x^{FR}(k, b + b_g, z, \phi) = \underbrace{(1-\tau)pz\exp(\phi)\,k^{\alpha}}_{\text{After-tax revenue}} - \underbrace{(f + f_k k)}_{\text{Operating cost}} - b - b_g + \underbrace{\tau(\delta k + r_f(b + b_g))}_{\text{Tax benefit}}$

1. No cash shortage: $x^{FR} + \overline{x}^G(k, z) \geq 0 \rightarrow$ pay b_g (r_f)
2. Cash shortage less than some limit: $-\overbrace{(1-q_g)\,b_g}^{r_f b_g} \leq x^{FR} + \overline{x}^G(k, z) < 0$
   $\rightarrow$ Partial debt relief: pay $b_g +$ cash shortage $(0 \sim r_f)$
3. Cash shortage greater than some limit: $x^{FR} + \overline{x}^G(k, z) < -(1-q_g)\,b_g \rightarrow$ Default

Detailed equation

$$\frac{\beta \sum_{z'} \pi(z' \mid z) \left[\int_{\phi' > \tilde{\phi}_g} MPK(k', z', \phi') d\Phi(\phi') + \left(\Phi(\tilde{\phi}_g) - \Phi(\hat{\phi}_g) \right) MPK(k', z', \tilde{\phi}_g) + \left(-\frac{\partial \hat{\phi}_g}{\partial k'} \right) \phi(\hat{\phi}_g) \tilde{V} \right]}{\sum_{z'} \pi(z' \mid z) \left[\left(1 - \Phi\left(\hat{\phi}_g \right) \right) + \frac{\partial \hat{\phi}_g}{\partial B'} \phi(\hat{\phi}_g) \tilde{V} \right]}$$

$$= \frac{1 - \frac{\partial q}{\partial k'} \left(B'(x, k', z) - b_g \right)}{q(1 - \epsilon)}$$

where, $\epsilon = -\dfrac{\partial q}{\partial B'} \dfrac{(B' - b_g)}{q}$

$$MPK(k', z', \phi') = pz' \exp\left(\phi'\right) \alpha k'^{\alpha - 1} - f_k - \frac{\partial c\left(k', k''\left(x'\left(k', B'(x, k', z), z', \phi'\right), k', z'\right)\right)}{\partial k'}$$

$$\tilde{V} = V\left(x'\left(k', B'(x, k', z), z', \tilde{\phi}^G \right), k', z' \right)$$

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Solution Algorithm: Firm decision rules

1. Given the price p, construct xmin$(k, z) = -\bar{x}(k, z)$ and bond price schedule $q(k', b', z)$

2. Solve for the cutoff xmax$(k, z) = \hat{x}(k, z)$ which makes firms' decisions not dependent on the level of x.

$$\hat{x}(k, z) = c\left(k, \hat{k}'(k, z)\right) - q\left(\hat{k}'(k, z), \hat{b}'(k, z), z\right)\hat{b}'(k, z)$$

where $\hat{k}'$, $\hat{b}'$ is a solution to this problem

$$V_{nb}(k, z) = \max_{k', b'} -c(k, k') + q(k', b', z)b' + \beta \sum_{z'} \pi\left(z' \mid z\right) \int_{\phi' > \hat{\phi}} V\left(x'\left(k', b', z', \phi'\right), k', z'\right) d\Phi\left(\phi'\right)$$

3. Solve for decisions at the intermediate points between xmin(k, z) and xmax(k, z).

Solution Algorithm: Firm decision rules

4. Update value function using obtained policy functions with linear interpolations.

$$V^{n+1}(x,k,z) = x - c(k,k'(x,k,z)) + q(k'(x,k,z)b'(x,k,z),z)b'(x,k,z)$$
$$+ \underbrace{\beta \sum_{z'} \int_{\phi' > \hat{\phi}} V^n(x'(k'(x,k,z),b'(x,k,z),z',\phi'),k'(x,k,z),z')}_{W(k'(x,k,z),b'(x,k,z),z)}$$

where

$$V^{n+1}(x',k',z') = x' + V^n_{nb}(k',z') \quad \text{if} \quad x' \geq \text{xmax}(k',z')$$

5. Iterate the process until $W(k,b,z)$ converges.

Solution Algorithm: Stationary Distribution and p

1. Given the policy function, update the distribution until it converges.

$$\mu'(x_i, k_j, z') =$$

$$\sum_{x,k,z} \int_{\phi' \geq \hat{\phi}(k',b',z')} \omega_x \left(x_i, x' \left(k'(x,k,z), b'(x,k,z), z', \phi'\right)\right) \omega_k \left(k_j, k'\left(x,k,z\right)\right) dF(\phi')\pi(z' \mid z)\mu(x,k,z)$$

$$+ M \int_{\nu \geq \hat{\nu}} \int_{\phi' \geq \hat{\phi}(k',b',z')} \omega_x \left(x_i, x' \left(k'(\nu), b'(\nu), z', \phi'\right)\right) \omega_k \left(k_j, k'\left(\nu\right)\right) dF(\phi')H(z' \mid \nu)dG(\nu)$$

2. Determine the price with a bisection search.

3. Repeat the procedure until convergence.

Parameters Value

Description	*Parameter*	*Source*
Fixed parameters		
Discount rate	$\beta = 0.97$	Annual interest rate 3%
Share of capital	$\alpha = 0.3$	Standard business cycle models
Depreciation	$\delta = 0.1$	Standard business cycle models
Tax rate	$\tau = 0.275$	Korea's corporate tax rate
Bond recovery rate	$\chi = 0.47$	Xiao (2020)
Persistence of z	$\rho_z = 0.9$	Foster, Haltiwanger and Syverson (2008)
Returns to scale	$\alpha_y = 0.85$	Atkeson and Kehoe (2005)
Fitted parameters from moment matching		
Volatility of z, ϕ	$\sigma_z = 0.1, \quad \sigma_\phi = 0.13$	
Invest & dis-invest adj cost	$p_k^+ = 1.8, \quad p_k^- = 2.8$	
Fixed & capital proportional cost	$f = 0.52, \quad f_k = 0.07$	
Default cost	$\eta = 0.2$	Internally calibrated
Entry cost & initial capital	$c_e = 3.2 \quad k_e = 0.2$	
Pareto exponent	$\xi = 3.2$	
Government loans	$\bar{b}_g = 0.134$	

Parameterization: Targeted Moments

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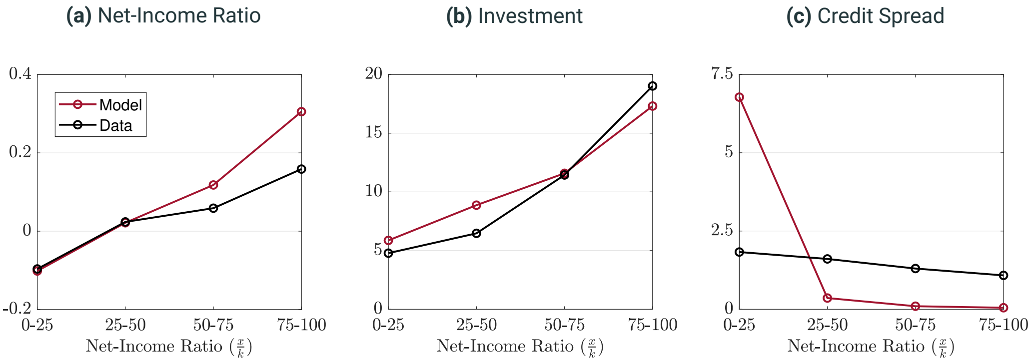
Description	*Data*	*Model*
Incumbents		
Mean investment	0.11	0.11
Mean investment ($\frac{x}{k}$ $<$ median)	0.06	0.07
Mean investment ($\frac{x}{k}$ $\geq$ median)	0.15	0.14
Mean spread (%p)	1.46	1.61
Exit rates (%)	1.10	1.12
Entrants		
Median relative size at enter	0.16	0.17
Mean relative sale-asset ratio at enter	1.81	1.55
Age 1 firms' mean investment	0.43	0.46
Firms that exit		
Mean net-income asset ratio at exit	-0.27	-0.30
Mean relative sale-asset ratio at exit	0.61	0.59

Untargeted Moments: Cross-Sectional Moments



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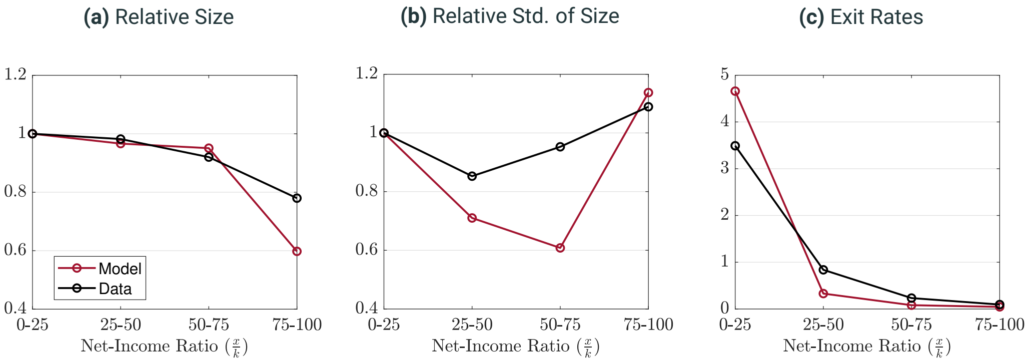
Untargeted Moments: Cross-Sectional Moments



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Parameterization: Untargeted Moments

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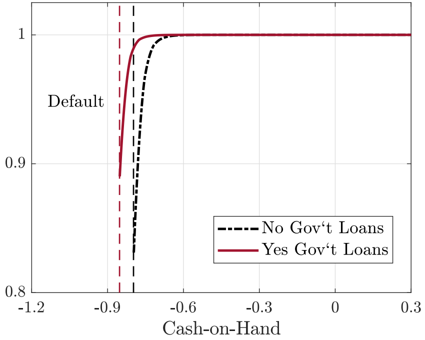
- Overall model captures well cross-sectional distribution except spreads.

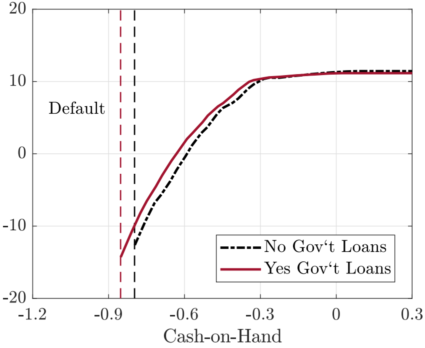
	Net-income asset ratio $(\frac{x}{k})$			
Moments	[0,25]	[25,50]	[50,75]	[75,100]
Data				
Net-income asset ratio	-0.10	0.02	0.06	0.16
Investment	0.05	0.06	0.11	0.19
Spread	1.83	1.61	1.30	1.08
Exit rate (%)	3.49	0.84	0.23	0.09
Log size (Relative)	1.00	0.98	0.92	0.78
Std of log size (Relative)	1.00	0.85	0.95	1.09
Model				
Net-income asset ratio	-0.10	0.02	0.12	0.31
Investment	0.06	0.09	0.12	0.17
Spread	6.78	0.36	0.10	0.05
Exit rates (%)	4.66	0.33	0.08	0.05
Log size (Relative)	1.00	0.97	0.95	0.60
Std of log size (Relative)	1.00	0.71	0.61	1.14

Firms Decision Rule with Government Loans (p fixed)

(a) Survival Probability (%)



(b) Investment (%)



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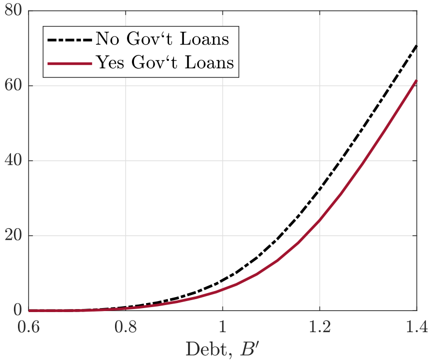
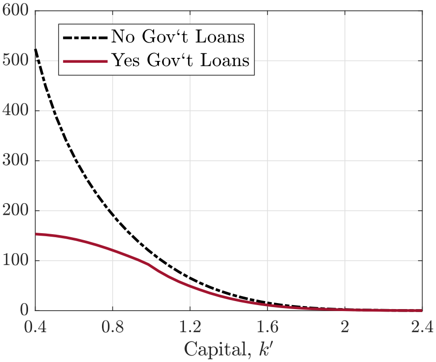
Credit Spread Schedules (p fixed)

(a) Credit spread against debt (%p)



(b) Credit spread against capital (%p)



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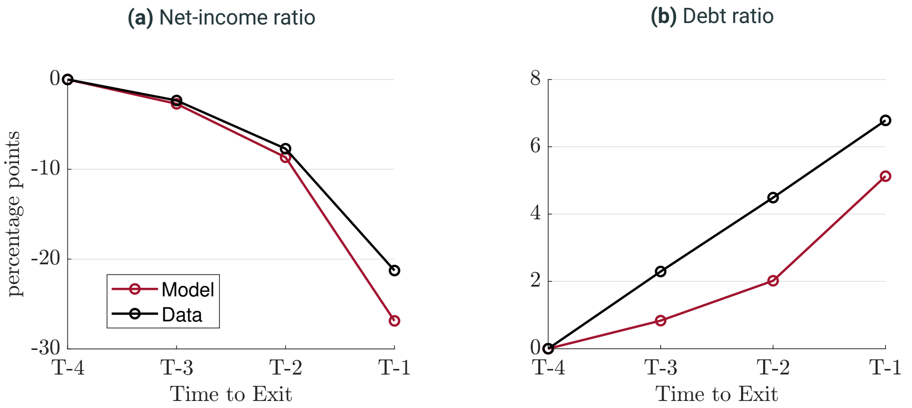
Model Validation: Financial States Before Firm Exits (Untargeted)



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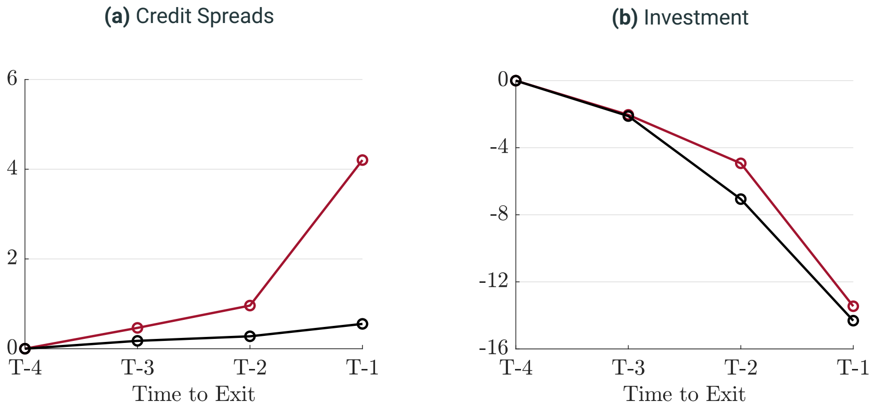
Model Validation: Financial States Before Firm Exits (Untargeted)



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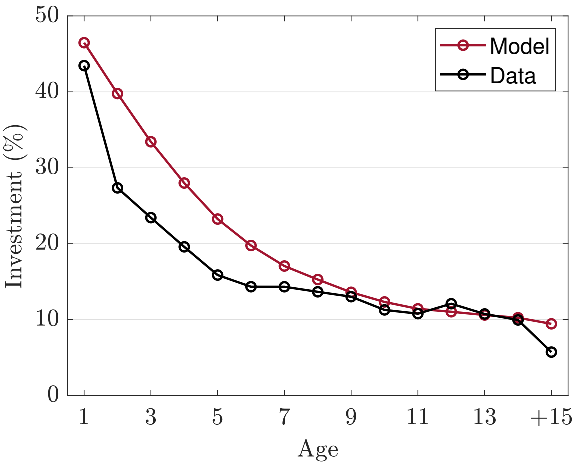
Model Validation: Investment by Age



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Transition Probability: Pre-Policy

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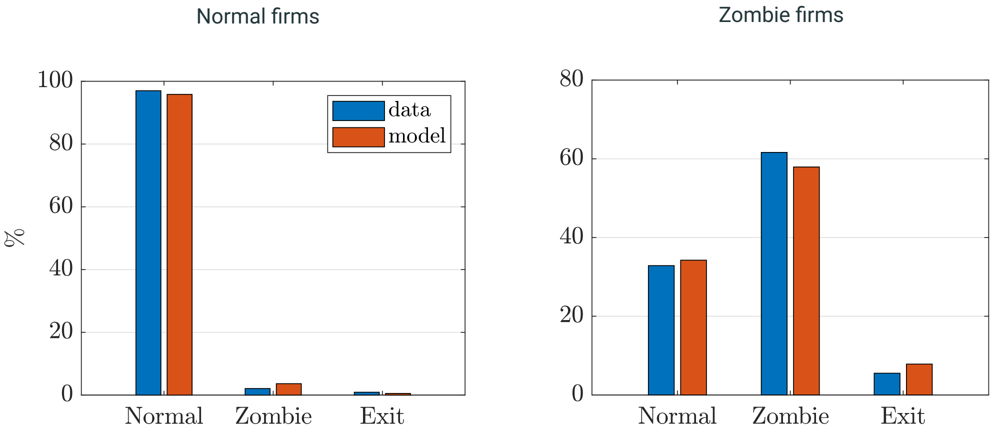

Change in Transition Probability

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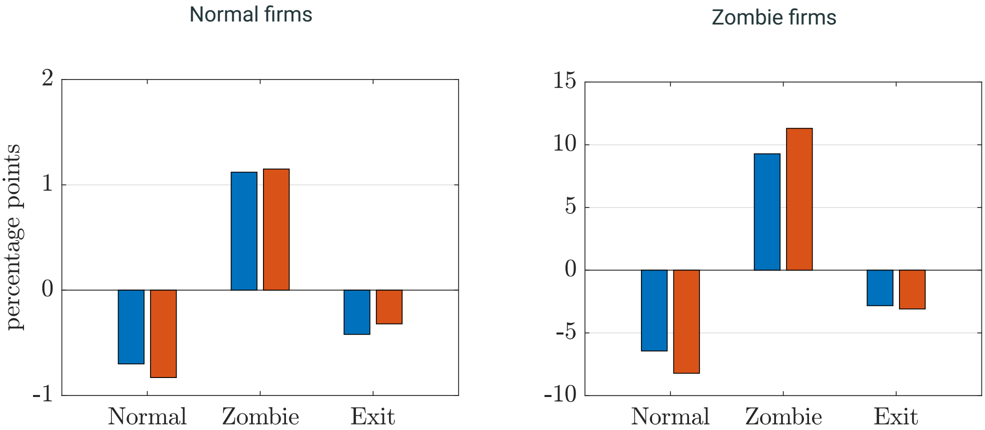

Credit Spread and Exit Rates

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Data panel regression:

$$\text{Exit}_{it} = \beta_1 D_i^{sme} D_{it-1}^{High} D_t^{\text{After}} + \beta_2 D_i^{sme}(1 - D_{it-1}^{High}) D_t^{\text{After}} + \beta_3 (1 - D_i^{sme}) D_{it-1}^{High} D_t^{\text{After}} + \gamma_t + \epsilon_{it}$$

- D_{it-1}^{High}: Indicator 3-year average credit spread is in the upper 10th percentile

Regression with simulated firms: $\text{Exit}_{it} = \alpha_1 D_{it-1}^{High} D_t^{\text{After}} + \gamma^z D_{it-1}^{High} + \gamma_t + \epsilon_{it}$

- Two groups by lagged 3-year mean credit spread

Heterogeneity by lagged 3-year average credit spread

Data ($\beta_2 - \beta_1$)	Model (α_1)
-0.008	-0.013
$[-0.017 \quad 0.001]$	(0.007)