March 6, 2010

Financial Crisis, Firm Dynamics and Aggregate Productivity in Japan

Kaoru Hosono

Gakushuin University

ACAES and Doshisha University

Motivation

Financial crises have serious impacts on the real economy.

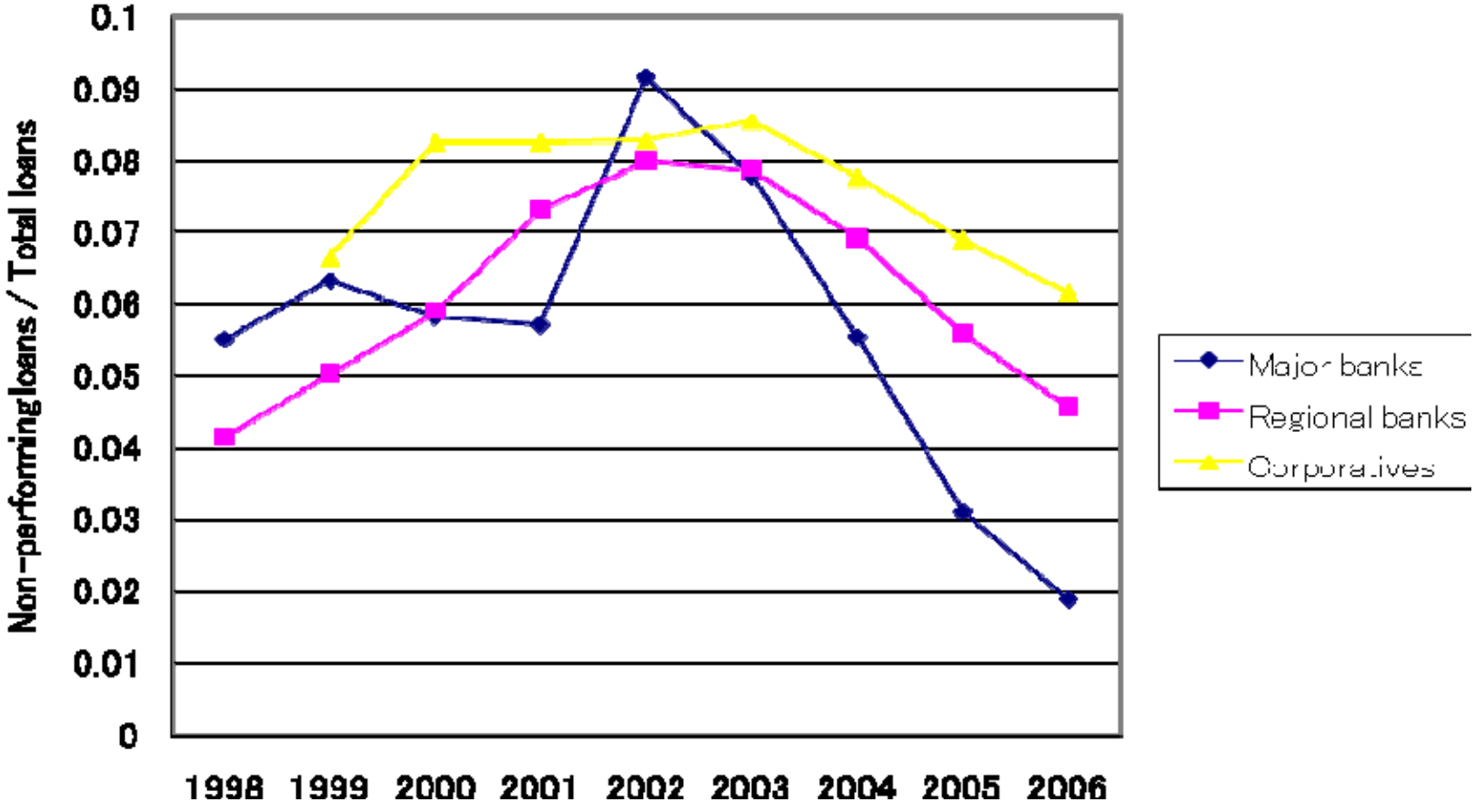
The impacts are differential between more and less productive firms or between entrants and incumbents.

We investigate the impacts of financial constraints on heterogeneous firms and their aggregate consequences based on the Japanese experience.

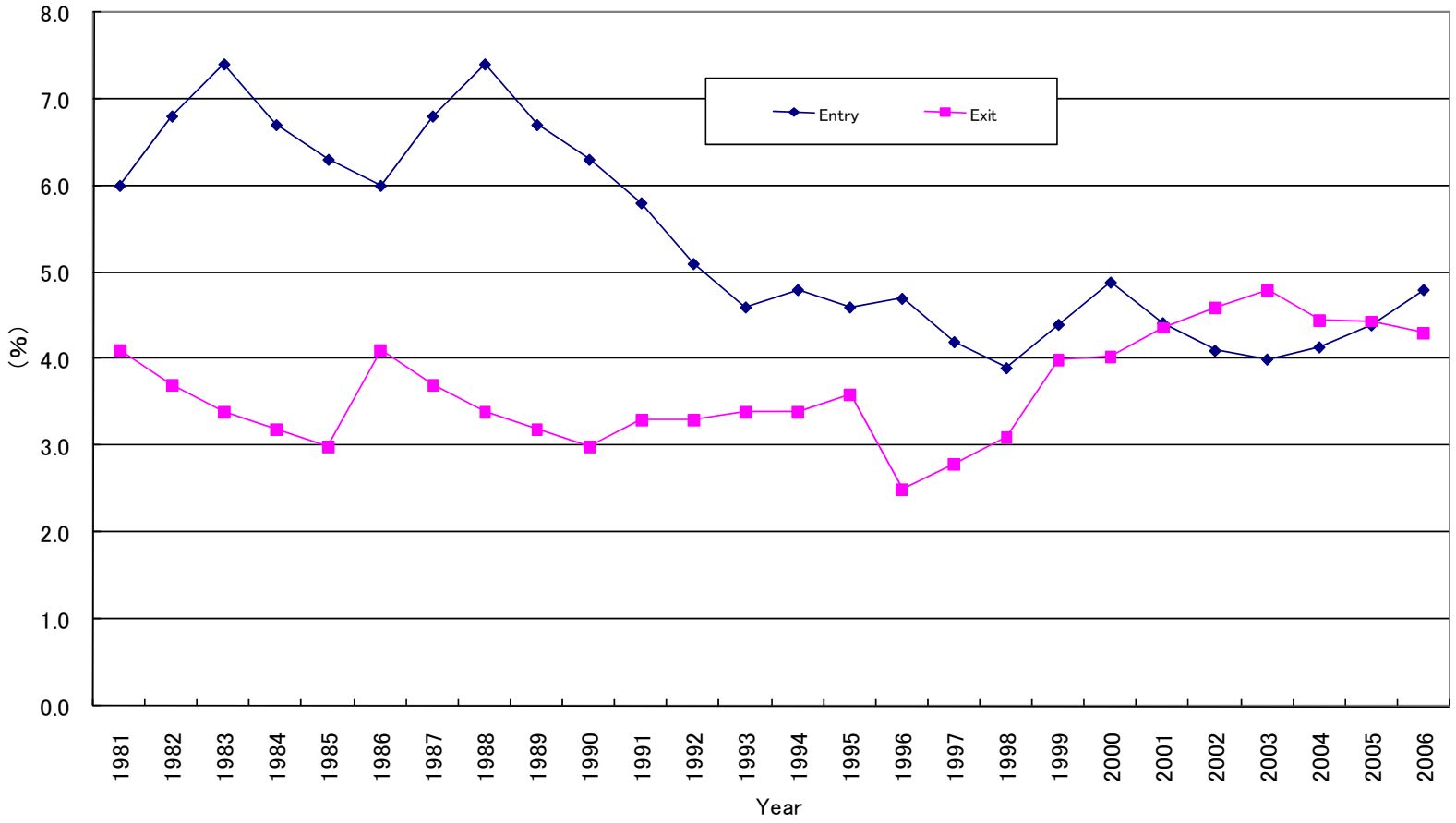
“Stylized Facts” about the “Lost Decade.”

1. Huge losses from NPLs at banks
2. Firm turnover ratio, esp. entry rate, decreased.
3. Aggregate TFP slowed down.
4. Aggregate investment-to-GDP ratio did not show a declining trend.

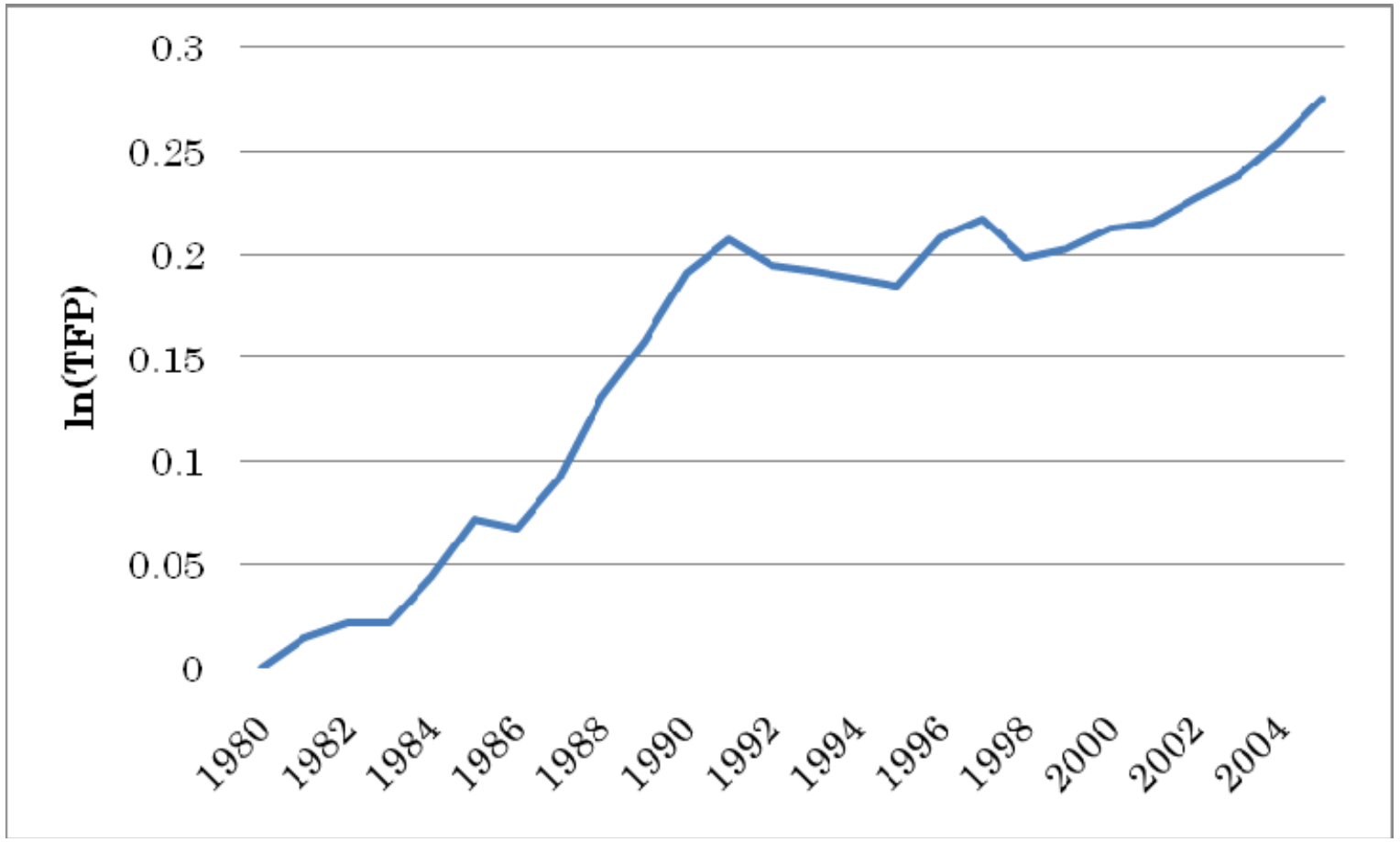
Fact 1. Non-performing loan ratio at banks



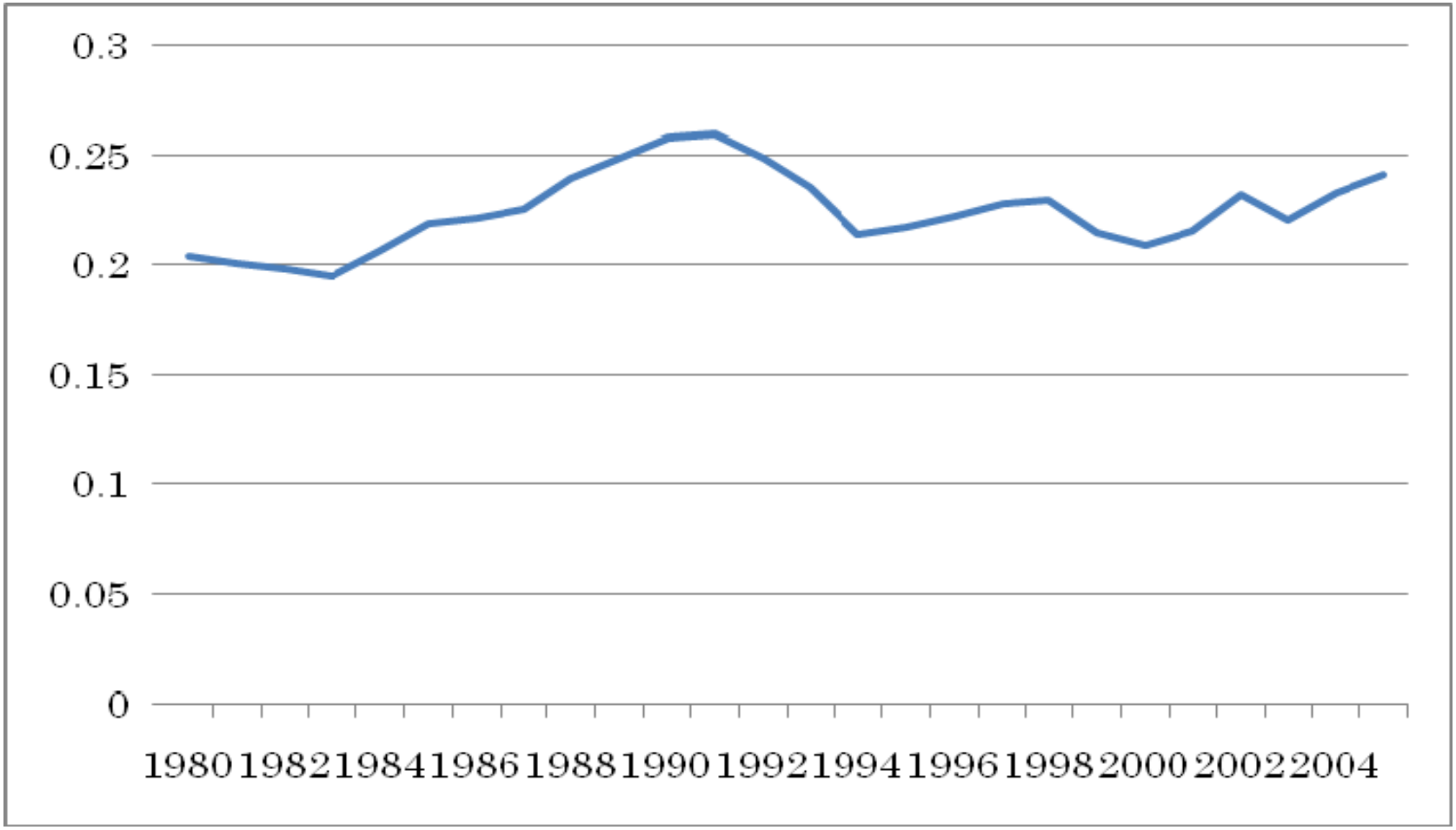
Fact 2. Turnover of Establishments



Fact 3. Aggregate TFP



Fact 4. Investment/GDP



We try to explain these facts consistently.

Our hypothesis

[Huge losses from NPLs at banks.→]

Higher external financial costs at firms.

→ Entrants and productive firms are hit hard.

→ Entry is depressed. Capital allocation becomes inefficient.

→ Aggregate TFP slowed down.

The aim of this paper

We quantitatively investigate the effects of the deterioration of bank health on aggregate productivity through the allocation of capital by calibrating a dynamic general equilibrium model to the Japanese economy.

Focus

Among various factors that raised financial costs in the 1990s' Japanese economy, we focus on the *deterioration of bank health* as a natural first step given the huge non-performing loans at banks and literature on their impacts on firm activities.

Literature on the "Lost Decade"

1. Bank distress: Credit crunch Gibson 1995, 1997; Nagahata and Sekine, 2005; Fukuda, Kasuya and Nakajima, 2006, Hosono and Masuda, 2005; Ogawa, 2005.

2. Bank distress: Soft budget Peek and Rosengren, 2005; Ahearne and Shinada, 2005; Fukuda et al., 2007; Hosono and Sakuragawa, 2008; Nishimura et al., 2005.

3. TFP slowdown Hayashi and Prescott, 2002

4. Impacts of bank distress on productivity Fukuda et al, 2007; Kobayashi and Akiyoshi, 2006; Miyagawa et al., 2008; Caballero et al., 2006; Tomura 2007

All focus on only one or some of the stylized facts!

Related Literature

Financial Crises freeze the restructuring process, such as job construction and destruction (Caballero and Hammour 2000).

Financial constraints have impacts on firm dynamics and hence on aggregate productivity. (Cooley and Quadrini, 2001; Cabral and Mata, 2003; Clementi and Hopenhayn, 2006; Caselli and Gennaioli, 2003; Jeong and Townsend, 2007, Antunes et al., 2008, This paper)

Summary of Results

Our results suggest that the deterioration of bank health accounts for about 20 percent to 30 percent of the actual decline in the detrended TFP during the banking crisis period (1996-2002).

Model

A dynamic general equilibrium model of firm dynamics (based on Gomes (2001), Brock and LeBaron (1990), Jovanovic (1982), and Hopenhayn (1992)).

Firms, households and financial intermediaries.

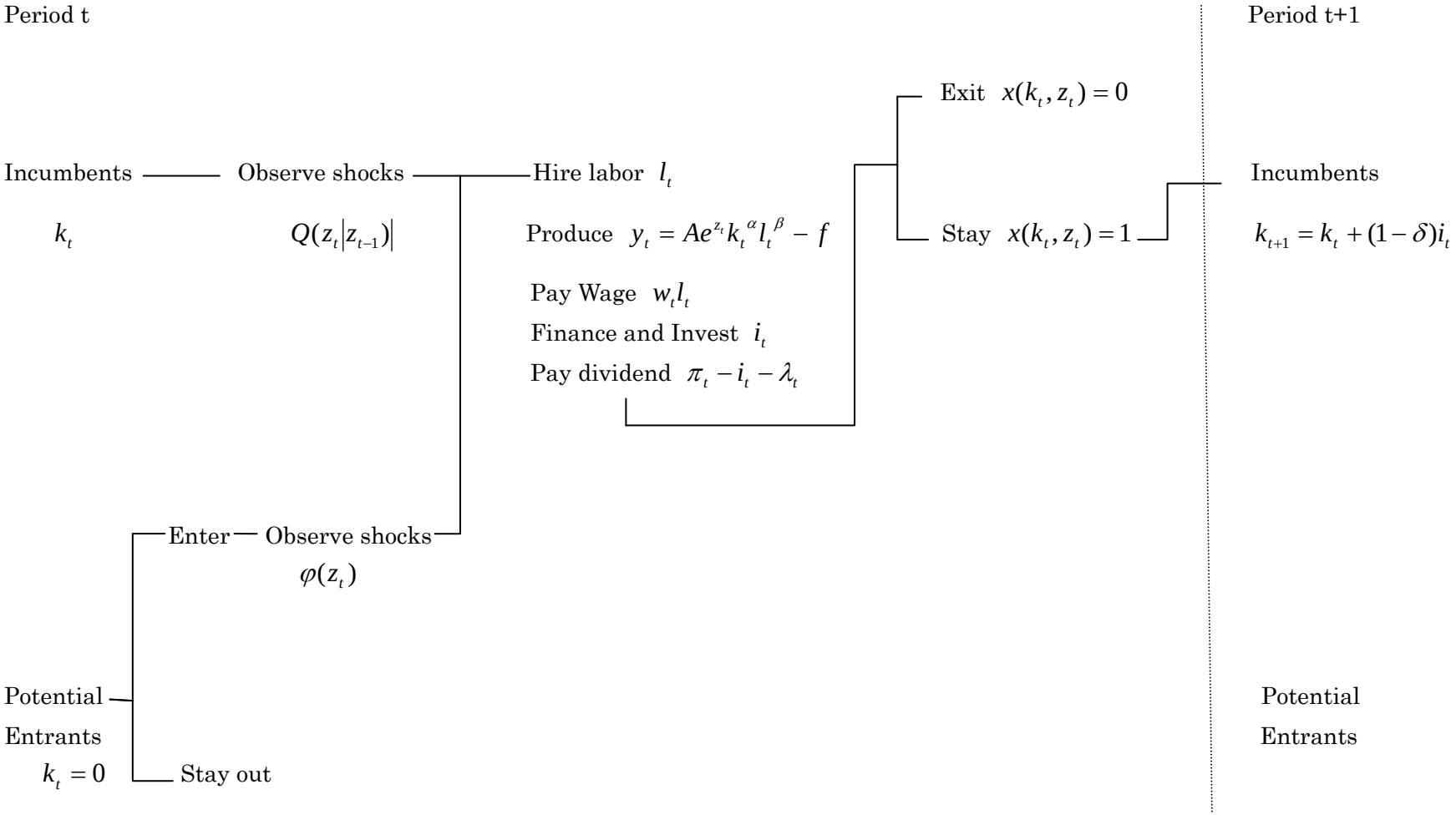
Firms need the services of financial intermediaries to obtain outside funds. Financial intermediaries operate competitively and provide these services at some cost.

Model (continued)

To allow for *differential impacts* of financial costs between more and less productive firms or between new entrants and incumbents, we assume that firms are hit by idiosyncratic productivity shocks. Thus we can analyze the impacts of financial costs on capital allocation and firm turnover.

Firms

Figure 5. Sequence of Events



Production

(1) $y_t = AF(k_t, l_t; z_t)$, decreasing returns to scale

Transition of productivity shocks:

For incumbents, $Q(z', z)$.

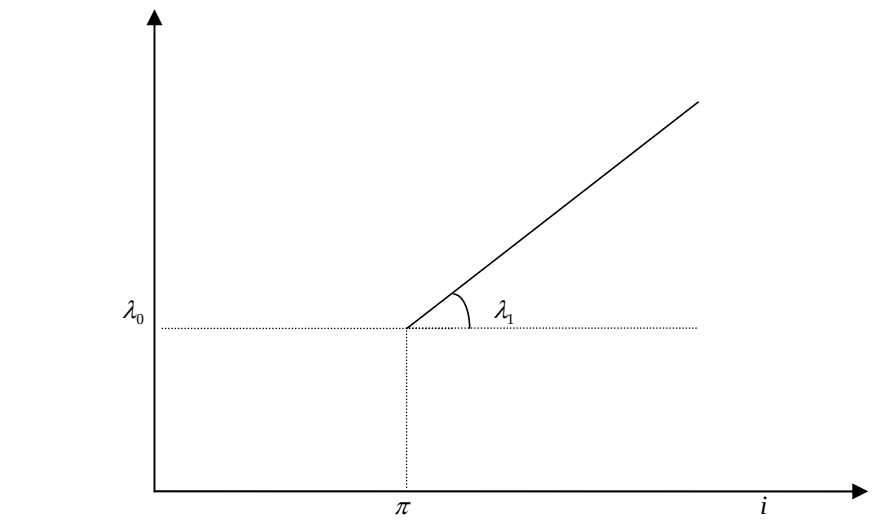
For entrants, $\varphi(z)$

(2) $\pi(k, z; w) = \max_{l \geq 0} \{F(k, l; z) - wl - f\}$, f: fixed cost

(3) $y_t = Ae^{z_t} k_t^{\alpha_K} l_t^{\alpha_L}$, $\alpha_K + \alpha_L < 1$,

Financing costs

(8) $\lambda(k, k', z; w) = \lambda(i(k, k') - \pi(k, z; w))$



Fixed financial costs include screening and monitoring costs. They imply lumpy investment.

The firm's dynamic problem

$$(10)\quad v(k,z;w)=\max_{k'\geq 0}\left\{\begin{array}{l}\pi(k,z;w)-i(k,k')-\lambda(k,k',z,w)\\ +\beta\max\left(k',\int v(k',z';w)\times Q(dz'|z)\right)\end{array}\right\},$$

Capital accumulation

$$(11)\quad k(k,z;w)=\min\left\{\arg\max_{k'\geq 0}\left\{\begin{array}{l}\pi(k,z;w)-i(k,k')-\lambda(k,k',z,w)\\ +\beta\max\left(k',\int v(k',z';w)\times Q(dz'|z)\right)\end{array}\right\}\right\}.$$

Exit decision

Exit $\Leftrightarrow$ (12) $\int v(k', z'; w) Q(dz' | z) < k'$.

(13) $$x(k, z; w) = \begin{cases} 1 \ \ (stay) \ \ if \ \ z > z^* \\ 0 \ \ (exit) \ \ if \ \ z \le z^* \end{cases}$$

(14) $$z^*(k, z; w) = \min\left\{\inf\left\{z : \int v(k', z'; w) \times Q(dz' | z) \ge k'\right\}, \ \bar{z}\right\}$$

Entry decision

(15) $\int v(0, z; w) \varphi(dz) \le 0$, with equality if entry is positive.

Aggregation

$\mu(k,z)$: mass of firms in the state (k,z)

B: mass of new entrants.

For any set $\Theta=(K,Z)$, the law of motion of μ is

$$(16)\quad \mu'(\Theta)=\underbrace{\int T(\Theta,(k,z))\mu(dk,dz)}_{\text{mass of incumbents moving from } (k,z) \text{ to } \Theta, \text{ conditional on the firm's staying in the market.}}+\underbrace{B\int \mathrm{X}(K)\varphi(dz)Q(dz'|z)}_{\text{mass of new entrants.}},$$

$$(17)\quad T(\Theta,(k,z))=\int \mathrm{X}(K)x(k,z;w)Q(dz'|z)$$

$$(18)\quad \mathrm{X}(K)=\begin{cases}1 & \text{if } k(k,z;w)\in K\\ 0 & \text{otherwise}\end{cases}$$

Aggregation (ctn'd)

Given μ and B,

output: (19) $Y(\mu, B; w) = \int (y(k, z; w) - f)\mu(dk, dz) - Bf$,

labor: (20) $L(\mu, B; w) = \int l(k, z; w)\mu(dk, dz)$

productivity: (25) $\Omega(\mu, B; w) = \int Ae^{z}\mu(dk, dz) / \int \mu(dk, dz)$

Households

$$(26)\quad \max_{c_t, l_t, s_t(k_t, z_t)} E_0\left[\sum_{t=0}^{\infty} \tilde{\beta}^t U(c_t, 1-l_t)\right]$$

s.t.

$$c_t + \int \{\tilde{v}(k,z) - d_t(k,z)s_t(k,z)\}\mu(dk,dz)$$

$$= \int \max\{\tilde{v}(k,z), k\}s_{t-1}(k,z)\mu(dk,dz) + w_t l_t$$

Note that in the stationary equilibrium, the discount factor of firms (β) is identical with that of the households ($\tilde{\beta}$) and the firm value ($v(k,z)$) is equal to the share price ($\tilde{v}(k,z)$).

In the stationary equilibrium,

(27) $\max_{c,l\geq 0} U(c,1-l)$

s.t. $c = wl + \Pi(\mu, B; w) - I(\mu, B; w) - \Lambda(\mu, B; w)$

Momentary utility function (Hansen, 1985)

(28) $U(c,1-l) = \log(c) + H(1-l)$,

(29) $C(\mu, B, w) = \frac{1}{H} w$

(30) $L^S(\mu, B, w) = \frac{1}{H} - \frac{\Pi(\mu, B; w) - I(\mu, B; w) - \Lambda(\mu, B; w)}{w}$

Stationary Competitive Equilibrium

All the markets clear, the free-entry condition (15) is satisfied, and all prices, aggregate quantities and the distribution of firms across states are constant.

(31) $L^S(\mu, B, w) = L(\mu, B; w)$,

(32) $C(\mu, B; w) + I(\mu, B; w) + \Lambda(\mu, B; w) = Y(\mu, B; w)$.

Consumption + Investment + Financial costs = Output

There is a unique stationary competitive equilibrium with positive entry.

Calibration: Methodology

Step 1. We calibrate the model to the pre-crisis period: 1980-95. ("*Benchmark economy*")

Step 2. We change the financial cost parameters so as to be consistent with the micro data evidence during the crisis period: 1996-2002. ("*Constrained Economies*)

Step 3. We compare the *stationary equilibria of financially constrained economies* with the stationary equilibrium of *benchmark economy*.

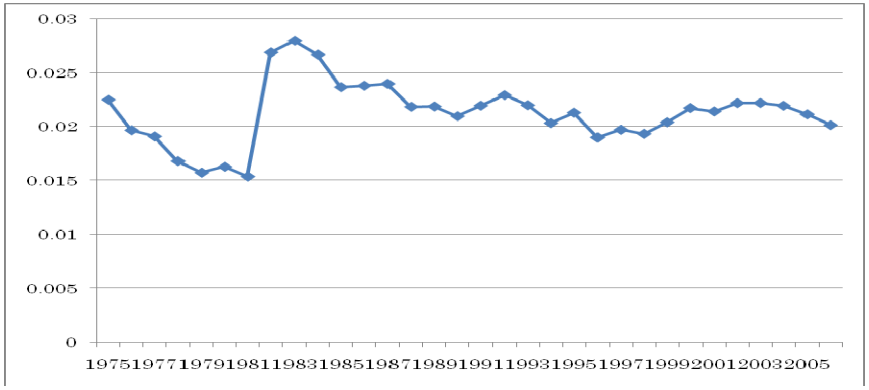
Calibration (*Benchmark economy*)

Table. 1 Calibration

Parameters	Benchmar Economy	Empirical Restrictions
Technology		
α k	0.3	Degree of returns to scale
α l	0.65	Labor share
δ	0.1	Investment to capital ratio
f	0.01	Turnover ratio
Technology Shock		
ρ	0.6	Serial correlation of I/K
σ	0.05	Std. dev of I/K
Financing Costs		
λ 0	0.035	Share of financially constrained firms
λ 1	0.022	Interest rate margins between bank loans and deposits
Preferences		
β	1/1.03	Interest rate
H	0.6	Employment share

Financing Costs (Benchmark Economy)

1) Unit financing cost is set to 2.2%, the average interest rate margins of Japanese banks during the pre-crisis period.



2) Fixed financial cost is set so as to match the U.S. evidence of the share of financially constrained firms (Gomes, 2001) in the *benchmark economy*.

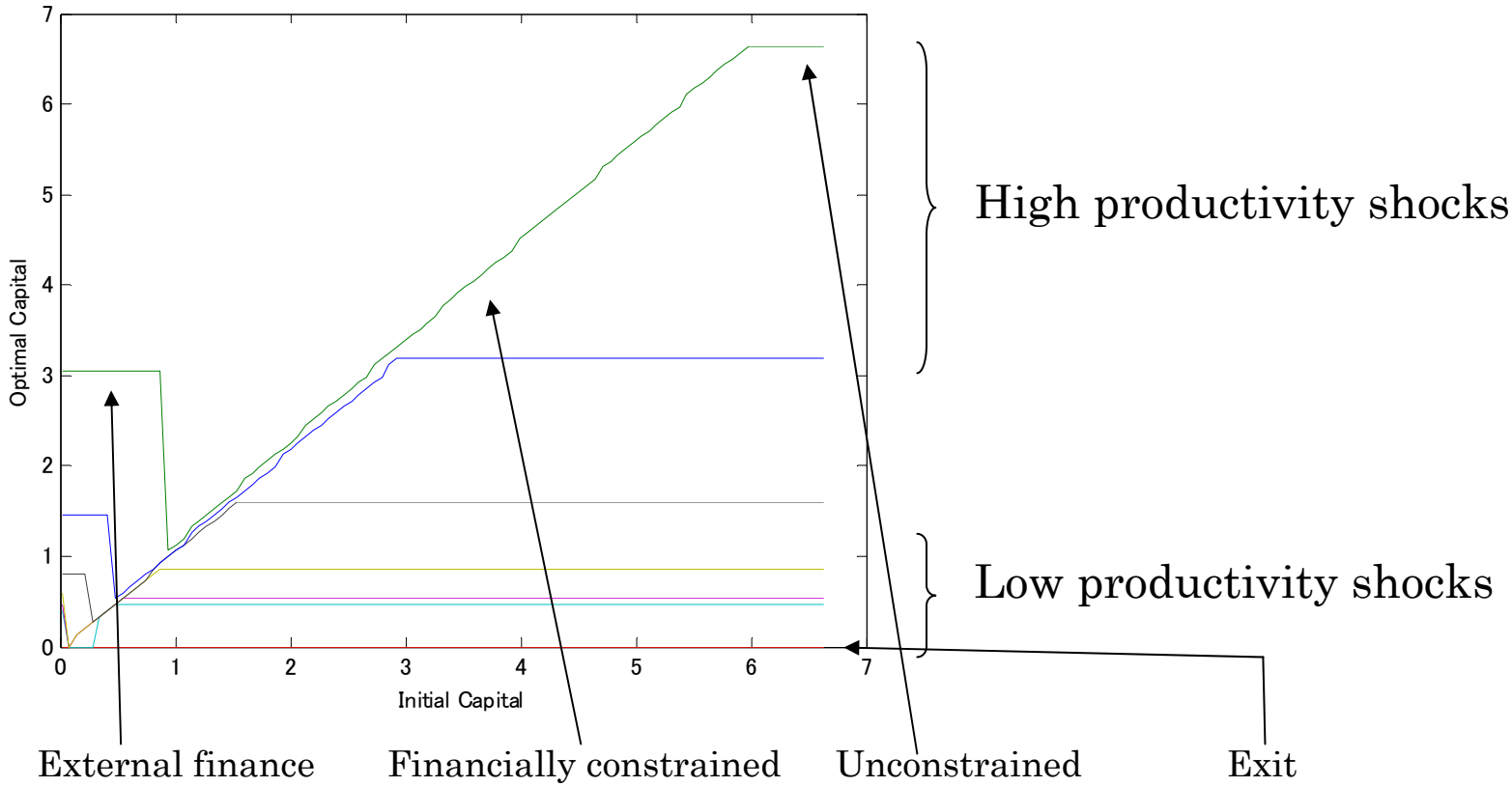
Aggregate results: Benchmark Economy

Variable	Japanese 1980–95	Benchmark Economy
Matched quantities		
Investment rate I/K	0.113	0.094
Firm turnover rate (Entry)	0.061	0.058
Other quantities		
Investment share I/Y	0.225	0.220
Cash flow / Y	0.341	0.323
Share of financing costs Λ/Y	0.039	0.013
Tobin's Q	2.058 (1.443)	1.098

Well fitted! (Except for Tobin's Q)

CF>Investment

Optimal Firm Behavior and Classification of Firm Types



Investment by firms that raise external finance is *lumpy!*

Financing, Size, and Productivity: Benchmark Economy

	All firms			Incumbent firms							
	Share	Inv. Share	K Share	I/K	I/Y	CF/Y	Λ/Y	Y/L	Q	Ln(TFP)	K
External Finance	0.012	0.934	0.004	2.581	3.732	0.330	0.181	1.621	1.318	0.177	0.476
Financially Constrained	0.613	0.648	0.568	0.107	0.229	0.325	0.000	1.607	1.130	0.042	0.546
Unconstrained	0.317	−0.220	0.390	−0.053	−0.139	0.326	0.000	1.612	1.050	−0.025	0.724
Exit	0.058	−0.362	0.038	−0.900	−3.146	0.303	0.000	1.558	0.987	−0.116	0.487

1) The proportion of firms that raise external finance and make positive investment is very small but accounts for most of aggregate investment, consistent with the data.

2) Firms that raise external finance and invest are most productive, followed by financially constrained firms and unconstrained firms, in terms of the total factor productivity and Tobin's Q.

3) Firms that raise external finance or financially constrained are smaller than financially unconstrained firms.

4) Exit firms are least productive, consistent with some empirical evidences (, though other evidences show that productive firms were likely to exit.)

Constrained Economies

The interest rate margin did not increase in the crisis period.

Nonetheless, the proportion of financially constrained firms seemed to increase during the crisis period.
(7.4 percent of firms were rejected by their main bank and could not find alternative financing sources on average during 1999-2001: the *Corporate Finance Survey)*.

How does NPLs increase financial costs?

Bank capital deteriorated.

→ Screening standards tightened.

→ More resources needed to persuade banks to accept loan applications or to find alternative financing sources on the side of firms.

Resource allocated to manage NPLs at banks

→ Inefficient information handling by banks

→ Interest rates raised to cover poor average quality of borrowers.

Constrained Economies (continued)

We change the financial costs in the following two ways.

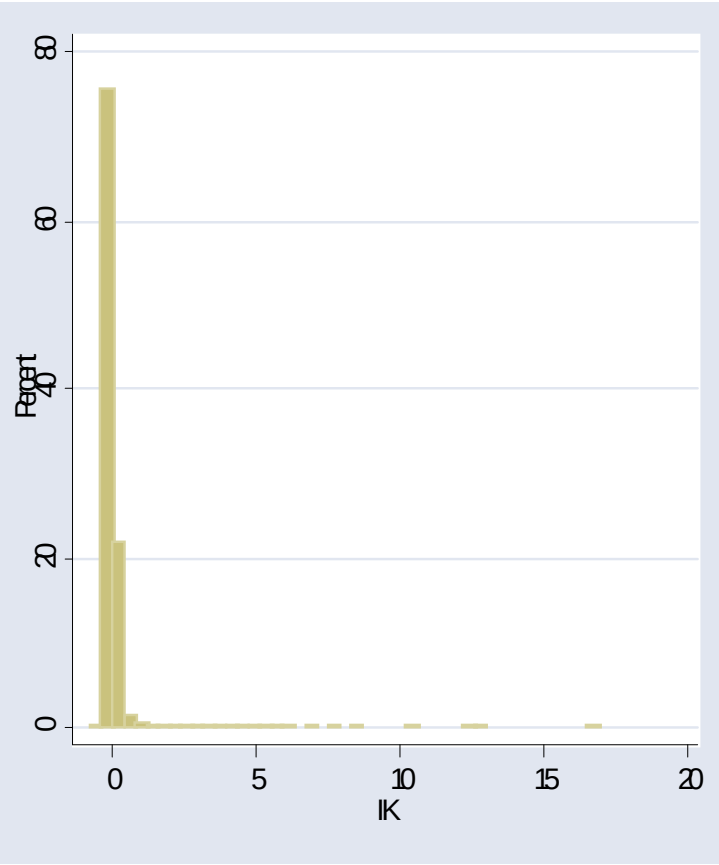
1) *Constrained Economy A*

Using the Survey, we estimate the rate of increase in the number of firms who were financially constrained due to bank distress. We increase *the fixed financial costs* so as to match this estimate.

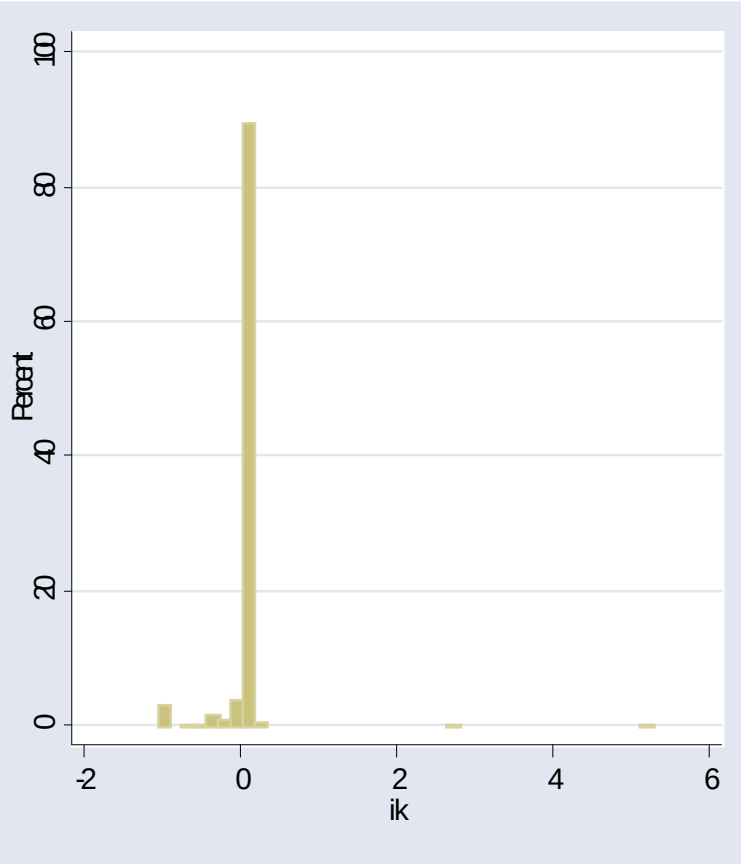
2) Constrained Economy B

We increase *the unit financial costs* by the loan losses as a proportion of total loans.

Investment is lumpy and its distribution is right-skewed.



A. SMEs in Japanese Manufacturing Industries: 1999-2002



B. Financially Constrained Economy A

Variable	Benchmark Economy	Constrained Economy A	Change from Benchmark	Constrained Economy B	Change from Benchmark	Japanese economy 1980–1995	1996–2002
A. Financial Costs							
Fixed cost of external finance (λ_0)	0.035	0.036	0.001	0.035	0.000		
Unit cost of external finance (λ_1)	0.022	0.022	0.000	0.039	0.017		
B. Share of Firm Types							
External Finance	0.012	0.008	−0.004	0.005	−0.007		
Financially Constrained	0.613	0.740	0.126	0.824	0.211		
Unconstrained	0.317	0.213	−0.104	0.144	−0.173		
Exit	0.058	0.040	−0.018	0.027	−0.031		
C. Aggregate Results							
Investmetn Ratio (I/K)	0.094	0.096	0.002	0.096	0.003	0.113	0.092
Investment share (I/Y)	0.220	0.228	0.008	0.227	0.007	0.225	0.222
Cashflow share (CF/Y)	0.323	0.323	0.000	0.321	−0.002	0.341	0.295
Log (Y/L)	0.472	0.472	−0.001	0.464	−0.009	0.009	−0.009
Firm turnover rate (Entry)	0.058	0.040	−0.018	0.027	−0.031	0.061	0.044
Log(Real Wage) (log(W))	0.082	0.082	−0.001	0.077	−0.005	0.010	0.023
Log(TFP)	0.015	0.011	−0.004	0.008	−0.006	0.007	−0.012

1. The aggregate productivities of the constrained economies decrease by 0.4 % to 0.6%, about 20 % to 30 % of the decline in detrended TFP (1.9 %).

2. Firm turnover ratios decrease from 5.8% to 4.0% or 2.7%.

3. I/K or I/Y does not decrease.

Why does the aggregate productivity decline?

High financial costs

→Entrants and productive firms incur losses because they tend to raise external finance.

→Real wage decreases so as to make the entrant's value zero (free entry condition).

→Less productive firms gain from low real wage while they do not incur losses from high financial costs because they are less likely to raise external finance.

→Less productive firms are more likely to stay in the market.

Differential impacts between productive and less productive firms!

Is this story plausible?

1. The actual detrended real wage *increased* by 1.3% during the crisis period.

2. However, real wage deviates from marginal labor productivity due to the aging of workers and some other reasons (Hosono et al., 2008).

Alternative Specifications: Only entrants incur higher financial costs during the crisis period.

Variable	Benchmark Economy	Constrained Economy C	Change from Benchmark	Constrained Economy D	Change from Benchmark	Japanese economy 1980–1995	Japanese economy 1996–2002
A. Financial Costs							
Fixed cost of external finance (λ_0) for incumbents	0.035	0.035	0.000	0.035	0.000		
for entrants	0.035	0.036	0.001	0.035	0.000		
Unit cost of external finance (λ_1) for incumbents	0.022	0.022	0.000	0.022	0.000		
for entrants	0.022	0.022	0.000	0.039	0.017		
B. Share of Firm Types							
External Finance	0.012	0.008	−0.004	0.012	0.000		
Financially Constrained	0.613	0.740	0.126	0.823	0.210		
Unconstrained	0.317	0.213	−0.104	0.146	−0.171		
Exit	0.058	0.040	−0.018	0.019	−0.038		
C. Aggregate Results							
Investmetn Ratio (I/K)	0.094	0.096	0.002	0.098	0.004	0.113	0.092
Investment share (I/Y)	0.220	0.228	0.008	0.231	0.011	0.225	0.222
Cashflow share (CF/Y)	0.323	0.323	0.000	0.321	−0.002	0.341	0.295
Log (Y/L)	0.472	0.472	0.000	0.464	−0.008	0.009	−0.009
Firm turnover rate (Entry)	0.058	0.040	−0.018	0.019	−0.038	0.061	0.044
Log(Real Wage) (log(W))	0.082	0.082	−0.001	0.077	−0.005	0.010	0.023
Log(TFP)	0.015	0.011	−0.004	0.007	−0.008	0.007	−0.012

TFP decline accounts for 20 % to 40 % of the actual decline.

Conclusion

1. Our results suggest that high financial costs significantly decrease aggregate productivity through depressed firm turnover and distorted investment decision while they do not decrease aggregate investment share.
2. Our model fits well to the analysis of the increase in financial intermediation costs. Incorporating collateral constraints due to incomplete contract enforcement and labor market frictions is an important extension that may help explain the decline in TFP in the 1990s' Japanese economy.
3. Differential impacts of external financial costs between more and less productive firms or between entrants and incumbents are essential to understand their aggregate consequences.

Appendix. Solution Methods

1. Given an arbitrary value of w, we solve the Bellman equation for the firm, (9), and compute the optimal decision rule, using the value function iteration method.

2. We determine w that satisfies the free entry condition (14) for $B>0$.

3. We iterate the law of motion for μ, (15), to compute the stationary measure μ with $B=1$.

4. Using the market clearing conditions, (30) or (31), we determine the equilibrium level of entry B and the corresponding stationary measure μ.