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Financial Crisis, Firm Dynamics and Aggregate Productivity in Japan

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Abstract

Using a dynamic general equilibrium model of firm dynamics that incorporates financial intermediation costs, we quantify the degree to which the deterioration in the health of banks during the Japanese banking crisis had an impact on aggregate productivity through firm dynamics. We find that the deterioration of bank health accounts for about 20 percent to 30 percent of the actual decline in the de-trended TFP during the crisis period (1996-2002). Our results suggest that differential impacts of financial intermediation costs between more and less productive firms or between entrants and incumbents are essential to quantitatively assess the aggregate consequences of financial crises.

Key Words: Financial Intermediation Costs, Firm Dynamics, Aggregate Productivity, Japan

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Financial Crisis, Firm Dynamics, and Aggregate Productivity in Japan

1. Introduction

Financial crises have serious impacts on the real economy. However, their impacts on firms are different between more and less productive firms or between entrants and incumbents. We investigate the impacts of a financial crisis on heterogeneous firms and their aggregate consequences based on the Japanese financial crisis in the 1990s.

Japan's decade-long stagnation in the 1990s, the "lost-decade," has attracted the attention of many researchers. Though there have been long debates over the causes of the stagnation, most of the researchers agree with the following "stylized facts" concerning the 1990s' Japanese economy.

1) Banks incurred huge losses from nonperforming loans until 2002 (Figure 1).
2) Firm turnover ratios, especially the entry rate, decreased significantly (Figure 2).
3) Aggregate total factor productivity (TFP) slowed down (Figure 3) [1].
4) The aggregate investment-to-output ratio did not show a declining trend, aside from cyclical movements (Figure 4).

We try to explain these facts consistently. Our hypothesis is as follows. Huge losses from nonperforming loans at banks raised financial intermediation costs, which seriously affected new entrants and productive firms who were willing to invest, resulting in a low firm-turnover ratio, misallocation of capital, and low aggregate productivity. To quantitatively assess these effects, we use a dynamic general equilibrium model of firm dynamics that incorporates financial intermediation costs, and we calibrate it to the Japanese economy during the banking crisis period.

We focus on the deterioration of bank health and assess its impact on the aggregate economy. Though there are some other factors that raised external financing costs in the 1990s' Japanese economy, including the deterioration of firm net worth due to the asset market collapse and the high real interest rates due to price deflation, focusing on bank health seems a natural first step given the huge amount of nonperforming loans at banks and the vast literature on their impacts on firm activities. Our model with financial intermediation costs fits well with the analysis of the banking crisis in Japan.

Our results suggest that differential impacts of financial intermediation costs

[1] Most growth accounting studies report a productivity slowdown in the 1990s, with the exception of Kawamoto (2004).

on heterogeneous firms are essential to understanding the aggregate consequences of banking crises. Because high financial intermediation costs are harmful, especially to entrants and highly productive firms, firm turnover and aggregate productivity is depressed. Our calibration shows that the deterioration of bank health decreased aggregate TFP by 0.4 to 0.6 percent, which corresponds to about 20 to 30 percent of the actual decline in the de-trended TFP during the banking crisis period (1996-2002). We also show that the aggregate share of investment does not decline even with a significant rise in the proportion of financially constrained firms.

Previous studies focus on one or some of the above facts, but few studies account for all of them. For example, many researchers point out that the banking problems caused the stagnation in the 1990s. One strand of the literature stresses the credit crunches by banks and under-investment by profitable firms (Gibson 1995, 1997; Nagahata and Sekine, 2005; Hosono and Masuda, 2005). The others stress that the perverse incentives of banks led to the misallocation of credit and caused over-presence or over-investment by poorly performing firms (Peek and Rosengren, 2005; Ahearne and Shinada, 2005; Caballero et al., 2008; Fukuda et al., 2006; Hosono and Sakuragawa, 2008; Nishimura et al., 2005).

On the other hand, Hayashi and Prescott (2002), among others, shows that the output stagnation in the 1990s could be accounted for mostly by the decline in the TFP growth rate, and concludes that the "credit crunch" hypothesis could not account for the decade-long stagnation.[2]

Caballero et al., (2008) and Tomura (2007) are closely related to this paper in that they link banking problems with aggregate productivity. Caballero et al. (2008) focuses on the credit misallocation due to the banks' lending to almost insolvent borrowers ("zombies"). Tomura (2007) analyzes endogenous fluctuations of TFP in a collateral-constrained economy (Kiyotaki and Moore, 1997).[3] Neither of them, however, assesses to what extent financial frictions can account for the TFP slowdown during the financial crisis period in Japan. Dekle and Kletzer (2003) apply an endogenous growth model with financial intermediation to the Japanese banking crisis and compare the qualitative dynamics predicted by the model with the data. However, they do not quantify those impacts, either.

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[2] Kobayashi and Yanagawa (2008) present a theoretical model in which a high probability of bank failure discourages ex ante investments (e.g., R&D investment) by a firm and lowers its productivity. Ogawa (2007), however, reports that nonperforming loans at banks had no significant effects on firm investment in R&D.

[3] Unlike Tomura (2007), we consider capital accumulation.

Though we calibrate the model to the Japanese economy, our implication that a high financial cost during a crisis has a quantitatively significant impact on aggregate productivity through firm dynamics seems to be valid more generally. Caballero and Hammour (2000) asserts that crises freeze the restructuring process, such as job construction and destruction, and this effect is associated with the tight financial market conditions that follow.[4] Some researchers have explicitly explored the impacts of financial frictions on the aggregate economy through firm dynamics, i.e., entry, aging and exit (Cooley and Quadrini, 2001; Cabral and Mata, 2003; Clementi and Hopenhayn, 2006). Others investigate the effects of financial development combined with occupational shifts on aggregate productivity through firm dynamics (Caselli and Gennaioli, 2003; Jeong and Townsend, 2007; Antunes et al., 2008). By focusing on financial intermediation costs during a banking crisis, this paper builds on those preceding studies that investigate the implications of financial frictions on the aggregate economy.

This paper also contributes to the literature that is concerned with the effects of various policies on aggregate productivity through firm dynamics. Notable examples include Melitz (2003) for trade policies, Hopenhayn and Rogerson (1993) for government interference with job destruction, and Guner et al., (2008) for size-dependent policies.

The rest of the paper is organized as follows. Section 2 presents a model with financing intermediation costs. We calibrate the model to the pre-crisis Japanese economy in Section 3 and show the results of the simulation in Section 4. We refer to this model economy as the "benchmark economy." Section 5 compares the benchmark economy to the model economies with higher financial intermediation costs, which we refer to as "financially constrained economies." Section 6 presents results from the alternative specifications in which entrants incur higher financial costs than incumbents. Section 7 concludes.

2. The Model

To analyze the effects of financial intermediation costs on aggregate productivity, we present a dynamic general equilibrium model of firm dynamics based on Gomes (2001), which, in turn, is based on Brock and LeBaron (1990),

[4] For the effects of recessions on restructuring, see also Caballero and Hammour (2005). For the implications of financial frictions on the propagation mechanism of business cycles, see Bernanke and Gertler (1989), Carlstrom and Fuerst (1997) and Kiyotaki and Moore (1997), among others.

Jovanovic (1982), and Hopenhayn (1992).[5]

There are firms, households and financial intermediaries in the economy. Firms need the services of financial intermediaries to obtain outside funds. Financial intermediaries operate competitively and provide these services at some cost. 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 and households are described in detail below.

Firms

A continuum of firms produce outputs that can be consumed or invested. Figure 5 depicts the timing of events. In every period, each incumbent firm observes productivity shocks, hires labor, produces output, finances and invests, pays dividends to consumers, and decides whether to stay or exit in the next period.

There is also a continuum of potential entrants that decide whether to enter or stay out. If an entrant decides to enter, it observes productivity shocks after entering the market, produces and invests just as an incumbent.

The production process is assumed to be required of a fixed cost and to have decreasing returns to scale. These assumptions imply a U-shaped average cost, which, in turn, implies a well-defined distribution of firms and endogenous entry/exit decisions. The production function is

(1) $y_t = AF(k_t, l_t; z_t)$,

where y_t denotes output, k_t capital, l_t labor, and A is a productivity measure that is common across firms and constant across periods, while z_t denotes an idiosyncratic productivity shock that is uncorrelated across firms. For incumbent firms, the idiosyncratic shocks have a common stationary and monotone Markov transition function $Q(z', z)$ for the support over the bounded interval $[\underline{z}, \bar{z}]$, where z' denotes the next period shock. For new entrants, the idiosyncratic productivity shock is drawn from a common distribution $\varphi(z)$ over the same interval $[\underline{z}, \bar{z}]$.

[5] Cooley and Quadrini (2001) also establish an industry dynamics model with financial frictions, though the entry/exit rate is exogenous.

We first describe the firm's within-period decisions given the capital stock. The firm's problem is to maximize profit,

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

where w denotes the wage rate and f a fixed cost of production that a firm must pay every period as long as it stays. We use profit and cash flow interchangeably hereafter. Specifying the production function in the Cobb-Douglas form:

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

we solve Equation (2) and get the following labor demand, supply of output, and profits[6].

(4) $l(k,z;w) = \left(\frac{1}{w} Ae^{z} \alpha_L k^{\alpha_K}\right)^{\frac{1}{1-\alpha_L}},$

(5) $y(k,z;w) = Ae^{z_t} k^{\alpha_K} l(k,z;w)^{\alpha_L},$

(6) $\pi(k,z;w) = y(k,z;w) - wl(k,z;w) - f.$

Next, we proceed to the firm's dynamic problem. The next-period capital stock, k', is accumulated as

(7) $i(k,k') = k' - (1-\delta)k, \qquad 0 < \delta < 1,$

where i denotes investment and δ the depreciation rate.

The firm incurs a financing cost of λ if it needs to raise funds from outside, i.e., if the profit falls short of investment.

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

The financing cost function is assumed to depend on the amount of external funds and to be positive and increasing for a positive range of external funds. We

[6] We assume that labor is chosen optimally in every period given initial capital stock. If we instead assume that firm-specific human capital is accumulated over time, firms incur external financial costs to increase firm-specific human capital as well, which will cause labor wedge (the gap between the marginal productivity of labor and the marginal rate of substitution between leisure and consumption). Because this extension increases the number of state variables and makes the numerical analysis difficult, we chose a simple assumption, though introducing labor wedge would be a useful future work.

specify the financing cost function as

$$\text{(9)}\quad \lambda(k,k',z;w)=\begin{cases}\lambda_0+\lambda_1(i(k,k')-\pi(k,z;w)) & \text{if}\quad i(k,k')-\pi(k,z;w)>0\\ 0 & \text{otherwise}\end{cases},$$

where λ_0 and λ_1 are positive constants. Figure 6 depicts the financing cost function. It seems natural to assume that significant economies of scale exist in the transaction costs of external finance; firms incur higher average costs when they raise smaller amounts. Actually, based on the evidence on the floatation costs associated with issuing new equity provided by Smith (1977), Gomes (2001) finds that external funding costs can be well-approximated by a linear function of Equation (9). In the case of bank loans, the borrowers will be burdened with some fixed costs for screening and monitoring that banks incur in order to decide whether to accept or reject borrowers' applications. Introducing fixed financial costs induces a lumpy kind of investment as we shall see below. [7]

The firm's dynamic problem is to maximize the expected value of the discounted profits, which can be expressed recursively as

(10)

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

where β is a discount factor. The first three terms represent the current dividend, profits minus investment spending, and financing costs. The last term is the expected next-period value; if the firm decides to exit and sells all its capital. We focus on the stationary equilibria, where all prices, aggregate quantities, and the distribution of firms across states are constant. Thus we assume that the wage rate is constant: $w'=w$.

Gomes (2001) shows that there is a unique value function $v(k,z;w)$ and that it is continuous and increasing in (k,z) and continuous and decreasing in w. Solving for Equation (10) results in the policy functions of the next-period capital and stay/exit decision. The capital accumulation decision is described as

(11)

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

In case the maximizer in Equation (10) is not unique, the firm chooses the minimum

[7] The U.S. plant-level evidence shows the existence of lumpy investment (e.g., Cooper et al., 1999; Cooper and Hultiwanger, 2006). We see the lumpiness of Japanese firm-level investment in Section 5.

value to avoid external financing costs if possible. The firm decides to exit if and only if

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

This exit decision implies a threshold value of the idiosyncratic shock z, below which the firm exits.

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

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

Finally, we describe the entry decision of potential entrants; they enter as long as the expected value of discounted profits is nonnegative. The free-entry condition is thus

(15) $\int v(0, z; w) \varphi(dz) \le 0$,

with equality if entry is positive.

Aggregation

We now characterize aggregate variables. Let $\mu(k, z)$ denote the mass of firms in the state (k, z) and B denote the mass of new entrants. For any set $\Theta = (K, Z)$, the law of motion for μ is given by

(16) $\mu'(\Theta) = \int T(\Theta, (k, z)) \mu(dk, dz) + B \int \mathrm{X}(K) \varphi(dz) Q(dz' | z)$,

where

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

and

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

The first term on the right hand side of Equation (16) represents the mass of incumbent firms that move from (k, z) to Θ. The last term represents the mass of new entrants, who have no capital at the time of entry. Equation (17) states that the transition must be conditional on the firm's staying in the market.

Given the mass of firms μ in each state (k, w) and the mass of new entrants, B, we can define the aggregate output, demand for labor, total profits, investment, financial costs, operating costs, and productivity, respectively as

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

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

cash flow: (21) $\Pi(\mu, B; w) = \int \pi(k,z;w)\mu(dk,dz) - Bf$,

investment: (22) $I(\mu, B; w) = \int (i(k(k,z;w),k)\mu(dk,dz) + B\int k(0,z;w)\varphi(dz)$,

financial costs: (23)

$$\Lambda(\mu, B; w) = \int (\lambda(k,k(k,z;w),z;w)\mu(dk,dz) + B\int \lambda(0,k(0,z;w),z;w)\varphi(dz)$$

fixed operating costs: (24) $\Phi(\mu, B; w) = \int f\mu(dk,dz) + Bf$

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

To derive Equations (19)-(25), we used the fact that new entrants who have no capital do not hire labor or produce anything, and hence incur the loss of f in the period of their entry.

Households

Households are represented by a single agent who maximizes lifetime utility from consumption c and leisure $1-l$. Household income consists of wages and dividends. Denoting the discount factor by $\tilde{\beta}$, the household problem can be written as

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

s.t.

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

where $\tilde{v}_t(k,z)$, $d_t(k,z)$, and $s_t(k,z)$ denote the price, dividends and the fraction of shares owned by the household, respectively. We assume that dividends are paid just after shares are bought. Because we focus on the stationary equilibrium described below, the assumption of a stationary equilibrium is implicit in this formulation. In the stationary equilibrium, the firm discount factor is equal to the household discount factor and the share price is equal to the firm value: $\tilde{\beta} = \beta$ and $\tilde{v}(k,z) = v(k,z)$ (Proposition 4 in Gomes, 2001). Since all the aggregate quantities and prices are constant in the stationary equilibrium, the consumer problem can be simplified into the following static problem,

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

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

We specify the momentary utility function following Hansen (1985):

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

where H is a positive constant. Then, solving for Equation (28), we get the optimal consumption and labor supply as

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

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

Stationary Competitive Equilibrium

In a 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. The labor market and goods market clearing conditions are

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

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

There exists a unique stationary competitive equilibrium with positive entry (Proposition 5 in Gomes 2001).

3. Calibration

We calibrate the model to the Japanese economy. Though bank nonperforming loans began to increase in the early 1990s when land prices dropped sharply, the banking crisis did not become severe until after some regional and major banks failed in the middle of the 1990s (Hyogo Bank, Taiheiyo Bank and Hanwa Bank failed in 1995, 1996 and 1997, respectively.) The financial crisis culminated in late 1997 and 1998 when Sanyo Securities, a large securities company, defaulted in the interbank market and one major bank (Hokkaido Takushoku Bank), one large securities company (Yamauchi Securities) and two long-term credit banks (Nippon

Credit Bank and Long-Term Credit Bank), as well as some regional banks, all failed. The financial crisis continued until the banks' nonperforming loans began to decrease in 2002.

Considering these changes in bank health, we divide the period into the pre-crisis period of 1980-1995 and the crisis period of 1996-2002. One may want to divide the sample period before and after 1990 or 1991, given that stock and land prices fell sharply and the Japanese economy turned downward in the early 1990s. However, we divided our period to focus on effects of the banking crisis on the aggregate economy. We follow the procedure below.

First, we calibrate the model to the pre-crisis aggregate data. The calibrated model economy is referred to as the benchmark economy.

Next, we change the financial intermediation cost parameters to be consistent either with the micro evidence on the proportion of financially constrained firms or with the nonperforming loan losses incurred by the banks during the crisis period. The calibrated model economies with high financial intermediation costs are referred to as the constrained economies.

Finally, we see whether the constrained economies can match the aggregate data in the crisis period, and how different the constrained economies are from the benchmark economy.

Preference

The marginal utility of leisure, H, is determined by the fraction of workers in the population. The share of labor force in the working age population (i.e., aged 15 and over) was 60 percent in Japan during the 1990s (*Labor Force Survey*), which we choose for H. The intertemporal discount factor, β, is set to $1/1.03$ so that the annual real interest rate is 0.03, roughly consistent with the Japanese economy from the 1980s to the 2000s.

Technology

To determine the output elasticity to labor, α_L, and capital, α_K, we have to consider the returns to scale. Miyagawa et al. (2006) estimates returns to scale for thirty-seven industries and found that a large number of industries show constant returns to scale. Considering their results, we set $\alpha_L + \alpha_K = 0.95$. The average capital share in the 1990s and 2000s is 30 percent (*JIP Database 2008*), which we use as the value of α_K. Consequently, we set $\alpha_L = 0.65$.

The fixed operating cost, f, mainly affects the firm turnover rate. Figure 2 shows that the share of entry firms decreased from 6.1 percent in the pre-crisis period to 4.4 percent in the crisis period. Therefore, we set f so that the turnover ratio becomes about 6 percent in the benchmark economy.

For incumbents, the stochastic process for the logarithm of the productivity, z, is assumed to follow

$$(33) \quad z' = \rho z + \varepsilon',$$

where ε' follows a (truncated) normal distribution with mean zero and standard deviation σ. In practice, we follow Tauchen and Hussey's (1991) method for optimal state space approximations to normal random variables. If appropriate data is available, the parameters ρ and σ could be calibrated to the serial correlation and standard error of the investment ratio, I/K. Unfortunately, we could not obtain micro evidence for the serial correlation of I/K that would cover a sufficiently long period and large sample of firms to calibrate ρ. Therefore, we borrow the parameter that is consistent with the U.S. firm dataset of Compustat (Gomes, 2001). In particular, we set $\rho = 0.6$. We calibrate σ to match the standard deviation of I/K for listed firms as reported in Hosono and Watanabe (2002), setting $\sigma = 0.05$. For new entrants, the initial level of technology is assumed to follow a uniform distribution over the range that is the same as the incumbents.

Financial Intermediation Costs

How to calibrate financial intermediation costs plays a key role in this model.

Figure 7 shows the interest rate margins between bank loans and deposits for Japanese banks. For the benchmark economy, we set the proportional financing cost (λ_1) to 2.2 percent, which is the average interest rate margin over the pre-crisis period.

The fixed financing cost mainly affects the proportion of financially constrained firms. The investment literature has studied a number of indicators to identify a financially constrained firm, including dividend payment ratio (Fazzari et al., 1988), the existence of a bond rating (Whited, 1992; Erickson and Whited, 2000), firm size and age, and membership in a Japanese business group, *keiretsu* (Hoshi et al., 1991).[8] However, most preceding studies classify firms into financially

[8] For example, Erickson and Whited (2000) uses the criteria of a Standard & Poor's bond rating and find that among 737 manufacturing firms from the Compustat

constrained firms and unconstrained firms a priori using those criteria, and do not estimate the proportion of financially constrained firms. One important exception is Gomes (2001), who reports that among U.S. listed firms (in the Compustat universe), 63 percent is estimated to be financially constrained. Given no counterpart number for the Japanese firms, we set the value of λ_0 so that the proportion of financially constrained firms becomes close to 63 percent in the benchmark economy. Later, we change the financial cost parameters to see how the economy is affected by high financial intermediation costs.

Table 1 summarizes our calibration procedure for the benchmark economy.

4. The Benchmark Economy

We numerically compute the stationary competitive equilibrium given the parameters in Table 1, following the procedure described in Appendix 3. Before investigating the impacts of high financial intermediation costs, we check the performance of our model by comparing the benchmark economy and the Japanese economy during the pre-crisis period of 1980-1995.

Aggregate Quantities

Table 2 provides some aggregate statistics of the benchmark economy. These are reasonably consistent with the Japanese economy during the pre-crisis period. The investment-to-capital ratio and the firm turnover ratio almost coincide, which is not surprising given our calibration of the parameters δ and f, respectively. The highly nonlinear property of the model prevents us from exactly matching those quantities. In the benchmark economy, aggregate cash flow is larger than aggregate investment, just as it is in the Japanese economy. The share of financial intermediation costs in the benchmark economy is lower than the Japanese economy, which is not surprising given that we do not consider any other financial services but financial intermediation. The average Tobin's Q of the benchmark economy is lower than that of Japanese listed firms, either because we do not consider any investment adjustment costs or intangible assets, because the actual data of Tobin's Q is measured only for listed firms, or because the stock market overpriced firm values during the pre-crisis period.

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database covering the years 1992-95, 459 firms are identified as constrained firms and 278 firms as unconstrained. For Japanese listed firms, Nagahata and Sekine (2005) uses the criterion of whether a firm has ever issued a corporate bond, and finds that about a quarter of total firms has never issued a corporate bond. It should be noted that those studies focus on publicly listed firms.

Optimal Firm Behavior and Classification of Firm Types

Because we look at the differential impacts of financial intermediation costs among heterogeneous firms, it is useful to classify the different firm types to see how their investment and exit decisions depend on firm type.

Without financial intermediation costs, optimal firm behavior depends only on the current productivity shock, a signal of future profitability, and not on the current capital stock. However, with financial intermediation costs, optimal firm behavior depends on both. Current capital stock matters because it affects current cash flow. Figure 8 depicts the optimal next-period capital stock against the current capital stock. The upper lines show high levels of current productivity shocks and the lower lines show low levels of current productivity shocks. Depending on the optimal firm behavior, we can classify firms into four types.

Firms belonging to the first type make negative gross investment and do not borrow, but they stay in the market. We label them as "unconstrained" firms.[9] Firms with sufficiently large current capital and with relatively low productivity shocks tend to be unconstrained.

Firms of the second type make positive gross investment within their cash flow and do not borrow. We call them "constrained" firms. Firms with less capital stock and with lower productivity shocks are likely to be constrained. The constrained firms are severely affected by financial intermediation costs and tend to invest just enough to replenish depreciated capital.

Firms of the third type make positive gross investment beyond their cash flow and borrow from financial intermediaries. We call them "external financing" firms. Firms with less capital stock but with higher productivity shocks are likely to finance externally. Their investment is lumpy: a small positive shock to productivity induces a large jump of investment due to the fixed cost of financing.

Firms belonging to the final type of firms sell out their capital stock and choose to exit; we label them as "exit" firms. Firms with very low productivity shocks are likely to exit.

Financing, Size, and Productivity

Table 3 presents some key statistics for each of the four firm categories. It is a

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[9] Even unconstrained firms are actually affected by the existence of financial intermediation costs; they over-accumulate the capital compared to the economy, without financial costs, in order to save the financial costs that they may incur in the future.

benefit of our model to see which firms are financially constrained. The share of financially constrained firms is 61.8 percent, close to our target in calibrating the fixed financial cost parameter to match the U.S. counterpart. Though the share of firms that raise external funds is as small as 1.2 percent, they account for a dominant proportion of aggregate investment. Many of the new entrants are classified in this category.[10]

One of the most interesting cross-sectional implications of this model is that externally financed firms are the most productive, followed by financially constrained firms and then unconstrained firms, in terms of total factor productivity (TFP) and Tobin's Q. The order of firm size in terms of capital stock is in the reverse direction: unconstrained firms are the largest, followed by financially constrained firms and then externally financed firms. The implication that small firms are more likely to be financially constrained than large firms is consistent with the estimation result based on the Corporate Financial Survey (Table A2) and most of the empirical evidence from Japanese firms.

The exit firms are the least productive and their Tobin's Q is lower than unity. Though there are some competing empirical evidence concerning whether exit firms were actually the least productive or not during the 1990s in Japan, our result is consistent with some empirical results showing that less productive firms were more likely to exit.[11]

5. Constrained Economies

5.1 Setting Financial Intermediation Cost Parameters

As we see in Figure 7, the interest rate margins did not increase during the crisis period. The average interest margins were 2.23 percent and 2.05 percent for

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[10] Financial Statistics of Corporations, the second quarter of 2008, published by the Ministry of Finance, which covers corporations capitalized at 10 million yen and more, report the proportion of firms that did not increase fixed assets. According to these statistics, the proportion of firms that did not increase their fixed assets during the second quarter of 2008 was 74.5 percent. Considering that this statistic does not cover small firms capitalized with less than 10 million yen, our result for the small proportion of externally financed firms seems to be reasonable.

[11] Griliches and Regev (1995) and Bellone et al. (2005) find that less productive firms were more likely to exit in Israel and France. For Japanese firms, some researches show that less productive firms were more likely to exit (Matsuura and Motonishi, 2005; Kiyota and Takizawa, 2006), though others find the opposite (Sekine et al., 2003; Nishimura et al., 2005; Fukao and Kwon, 2006). Different industries as well as different data sources seem to result in such a disparity. Unfortunately, we cannot estimate firm-level productivity using our dataset described in Appendix 2 due to lack of data that is necessary to estimate TFP.

the pre-crisis and crisis period, respectively.

Nonetheless, the proportion of financially constrained firms seems to have increased during the crisis period. Actually, firms whose applications for loans were rejected by banks increased. The Small and Medium Enterprise Agency conducted a survey in December 2001 (*Corporate Finance Survey*)[12] and asked whether firms' applications for loans had been rejected by their main bank and other financial institutions over the preceding three years. According to the Survey results, among 4,258 small- and medium-sized firms, 7.4 percent of firms, on average, were rejected by their main bank and could not find alternative financing sources during 1999-2001.

Worsening financial conditions on the part of firms or decreasing collateral values may have at least partially caused the increase in financially constrained firms. However, because we want to focus on the effects of the deterioration of bank balance sheets, not firm balance sheets, we estimated the determinants of the loan rejection. Our estimation results show that the deterioration of bank capital increased the number of loan rejections by 17 percent to 23 percent (Appendix 2). It is reasonable to assume that the deterioration of bank capital increased financial intermediation costs and thus the number of financially constrained firms.

There are some possible channels through which deteriorating bank health raises the financial intermediation costs. As vast empirical literature on credit crunches (e.g., Gibson 1995, 1997) suggests, poorly capitalized banks tend to tighten screening standards to meet the capital adequacy requirements. Firms have to spend more time, effort and resources to persuade banks to accept their loan applications. They may also have to engage in a costly search for alternative sources of funds. These costs are likely to increase fixed financial costs. In addition, banks that have to allocate their managerial resources to the management of nonperforming loans may spend fewer resources on processing borrower information on creditworthiness. In this case, banks may raise variable financial costs to cover larger potential losses due to lower quality of borrowers by raising interest rates and noninterest fees, or tighten financing conditions such as collateral or covenants. Instead of distinguishing these various channels, we simply raise fixed costs or variable costs of financial intermediation so as to be consistent with the micro data evidence of borrowing firms and banks to see their impacts on the aggregate economy.

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[12] The Corporate Finance Survey for the Japanese firms is similar to the NSSBF1993 (National Survey of Small Business Finance) for the U.S. firms.

Specifically, we adopt the following two alternative approaches to account for the stable interest rate margins and the increase in the number of financially constrained firms,

In one method, we increase *the fixed cost* so as to increase the financially constrained firms by about 20 percent based on the estimates using the Corporate Finance Survey. We label this economy as *the financially constrained economy A*.

The other method is to raise unit costs utilizing the nonperforming loan losses incurred by the Japanese banks. This experiment is reasonable given that in our model financial intermediaries are competitive and do not incur losses, while actual banks reported huge losses from nonperforming loans during the crisis period. For the period covering fiscal years 1997-2001 when aggregate loan loss data is available, the Japanese banks incurred 1.7 percent in loan losses per total loans on average. We raise λ_1 from 2.2 percent to 3.9 percent. This economy is referred to as *the financially constrained economy B* below.

By comparing the financially constrained economies A and B with the benchmark economy, we can find the effects of banking crises on aggregate productivity and other macroeconomic performance.

5.2 Comparison of Financially Constrained Economies and the Benchmark Economy

Table 4 compares the financially constrained economies A and B with the benchmark economy. We first focus on the constrained economy A.

The share of financially constrained firms increases to 73.7 percent from 68.8 percent in the benchmark economy, with a 19.3 percent rate of increase (19.3% = (73.7-61.8)/61.8), which is close to the target of 20 percent derived from our estimates using the Corporate Finance Survey. The firm turnover ratio, which is equal to the share of entry firms or exit firms in the stationary equilibrium, decreases from 5.8 percent to 4.0 percent. This decrease is consistent with the actual decline in the entry rate from 6.1 percent to 4.4 percent, though we do not calibrate the financial cost parameters to match the turnover ratio.

Figure 9 compares the distribution of the firm-level investment-to-capital ratios of small and medium-sized enterprises (SMEs) in Japan's manufacturing sector during the crisis period[13] to that of the financially constrained economy A.

[13] JADE, compiled by Bureau van Dijk from the Teikoku Databank database, is used to construct firm-level investment ratios. Jade contains financial statements of unlisted firms only from 1998. The sample covers 27,017 firm-year observations from 1999 to 2002. For the details of the construction of the investment-to-capital ratio, see Hosono

Unfortunately, the data for the pre-crisis period was not available. The model economy captures a distinguishing feature of the data: a large proportion of firms are inactive, and when a firm invests, it invests a lot. That is, investment is lumpy.

Looking at the aggregate variables, we see that neither the investment-to-capital ratio nor the investment-to-output ratio changes significantly from the benchmark economy. This result suggests that the aggregate investment ratios are not informative with respect to the proportion of financially constrained firms. The actual investment ratios slightly decreased from the pre-crisis period to the crisis period. The aggregate productivity (TFP) of the constrained economy A decreases by 0.4 percent from the benchmark economy. As a counterpart of the Japanese economy, we linearly de-trended the logarithm of aggregate TFP and found that TFP dropped by 1.9 percent from the pre-crisis period to the crisis period. High financial intermediation costs account for about 20 percent of the actual decline in the de-trended TFP.

Why is the aggregate productivity of the constrained economy lower than the benchmark economy? Entrants and productive firms incur losses from high financial intermediation costs because they are more willing to raise capital through external financing. As a result, the real wage decreases so as to make the entrant's firm value nonnegative (See the free-entry condition of Equation 15). The real wage is lower in the constrained economy A than in the benchmark economy by 0.2 percent. On the other hand, less productive firms gain from the low real wage while they do not incur losses from high financial intermediation costs because they are less willing to raise capital through external financing. Consequently, less productive firms are more likely to stay in the market. The survival of less productive firms lowers the aggregate productivity and the firm turnover ratio. In sum, financial intermediation costs have differential impacts between more and less productive firms: they are harmful to more productive firms and beneficial to less productive firms.

The actual de-trended real wage did not decrease but rather increased by 1.3 percent during the crisis period from the pre-crisis period. However, the real wage often deviates from marginal labor productivity for various reasons. In Japan, a rising trend in the proportion of middle-aged workers contributed to widen the gap between the real wage and marginal labor productivity.[14]

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and Masuda (2005).

[14] Hosono and Makino (2007) confirm this using industry-level data over the period 1973-2002.

Having explained how financial constraints have negative impacts on aggregate productivity in our model, we briefly compare our results with some relevant existing studies. Caballero et al. (2008) show that "zombie lending," or loans to almost insolvent firms, raised factor prices and lowered factor mobility, which was harmful to productive firms. Tomura (2007) analyzes a collateral-constrained economy and finds that a tightening of collateral constraints lowers the price of land (collateral and production factor) and thus enables low-productivity firms to survive. Though exact mechanisms through which financial sector problems transmit to aggregate productivity are different among those two models and ours, all share a general equilibrium impact: financial market imperfections affect factor prices in such a way that high-productivity firms are negatively affected while low-productivity firms benefit.

Next we compare the constrained economy B with the benchmark economy. The share of financially constrained firms increases to 83.5 percent and the firm turnover ratio decreases to 2.9 percent. The changes from the benchmark economy are somewhat larger than those of the constrained economy A. The other aggregate variables, including the investment ratio and the cash flow ratio, are almost identical to those of the constrained economy A. The aggregate productivity (TFP) decreases by 0.6 percent from the benchmark economy, which accounts for about 30 percent of the actual decline in TFP. Though the quantitative effects on TFP are somewhat different between constrained economies A and B, both results suggest that a high financial intermediation cost results in a significant decrease in TFP without a significant change in the aggregate investment ratio.

6. Differential Financial Costs between Entrants and Incumbents

So far we have assumed that external financing costs are identical between entrants and incumbents. However, entrants may incur higher financing costs than incumbents, especially during the crisis period, for several reasons. First, banks may have to allocate more resources to the management of nonperforming loans and less to information processing concerning new borrowers' creditworthiness. Second, banks may apply lenient screening standards to poorly performing incumbents and continue to lend to them in order to prevent reporting an increase in nonperforming loans by bank managers who are allowed to exert discretion in reporting nonperforming loans. Discretionary accounting practices seem to have been prevalent during the crisis in Japan (e.g., Peek and Rosengren, 2005).

In this section, we allow for differential financial costs between entrants and incumbents in two ways. First, we increase fixed financial costs only for entrants so as to increase the number of financially constrained firms by about 20 percent from the benchmark economy based on estimates using the Corporate Finance Survey. We label this economy as *financially constrained economy C*. We find that this target for the proportion of financially constrained firms can be achieved when we set fixed financial costs for entrants to 0.04, the same level as the constrained economy A, where both entrants and incumbents incur the same financial costs. Second we increase variable financial costs for entrants by 1.7 percent based on the average loan losses as a percentage of total loans, assuming that banks transfer losses from nonperforming loans only to entrants. We label this economy as *financially constrained economy D*.

Table 5 shows the summary statistics of constrained economies C and D as well as the benchmark economy.

In the case of constrained economy C, both cross-sectional and aggregate results are identical with those of constrained economy A. In particular, the decline in TFP accounts for about 20 percent of the actual de-trended decline during the crisis period. These results suggest that the impacts of a high fixed-financial cost on entrants tend to dominate those on incumbents.[15]

On the other hand, the cross-sectional and aggregate results of constrained economy D are different from constrained economy B. Notably, while the proportion of financially constrained firms in constrained economy D is slightly smaller than that of constrained economy B (D: 83.3 vs. B: 83.5 percent), the decrease in TFP from the benchmark economy is larger in constrained economy D than in constrained economy B (D: 0.8 vs. B: 0.7 percent). The decline in TFP is associated with the decline in firm turnover ratio and not necessarily with the increase in financially constrained firms. Actually, the firm turnover ratio of constrained economy D is smaller than that of constrained economy B (D: 2.0 vs. B: 2.9 percent). The decline in TFP in constrained economy D accounts for about 40 percent of the actual decline in the de-trended TFP during the crisis period. However, it may somewhat overestimate the impacts of financial intermediation costs on aggregate productivity given such a drastic decrease in the firm turnover ratio.

7. Conclusion

[15] It is not always the case that the economy with a fixed financial cost only on entrants coincides with the economy with the same fixed financial cost on both entrants and incumbents.

We quantitatively assessed the effects of the deterioration in the health of banks during the Japanese banking crisis on aggregate productivity through firm dynamics. Our results suggest that high financial intermediation costs significantly decrease aggregate productivity through depressed firm turnover and distorted investment decision making, while they do not decrease aggregate investment share.

Though our model with intermediation costs could account for a significant part of the decline in aggregate productivity during the crisis period in Japan, there may be some other factors that raised firms' financial costs, including the deterioration of firms' balance sheets and the declining value of collateral. Analyzing those factors would reveal other sources of the TFP decline. A natural extension, therefore, is to extend the model to explicitly incorporate collateral constraints arising from imperfect contract enforcement and calibrate it to the Japanese economy.

Our model can also be extended to allow for other distortions as well as financial frictions. Given the significant labor wedge in the 1990s' Japanese economy that has been reported by some business cycle accounting studies (e.g., Kobayashi and Inaba, 2006; Inaba, 2007; Otsu, 2008), introducing labor market frictions may be a useful extension that could help explain the decline in aggregate productivity during the crisis period.

Despite these limitations, this paper has the following general implications. Differential impacts of financial intermediation costs between more and less productive firms or between entrants and incumbents are essential to quantitatively understand their aggregate consequences. Because high financial intermediation costs are harmful to entrants and highly productive firms while they are beneficial to relatively unproductive incumbents, they decrease aggregate productivity through depressed firm turnover and distorted investment decisions.

Appendix 1. Data

Aggregate Data

Aggregate output, investment, capital, labor and TFP are available in the JIP Database 2008. All these variables exclude public and housing sectors (i.e., "market economy").

Y = Real Output - Real Intermediate Input,

K = Real Net Capital Stock,

I = Real Investment Flow, and

L = Divisia Index of Labor.

To derive the de-trended natural log function of the TFP series, we first construct the TFP level series by consecutively multiplying the TFP growth rates from the 1980 level, which we normalize to be unity, to year 2005. Then we regress the logarithm of TFP level by regressing it on the time trend:

$$\ln(TFP) = 0.027 + 0.0102 * time\,trend\ .$$

We use the regression residuals as the de-trended ln(TFP).

Similarly, we obtained the de-trended ln(Y/L) by regressing the logarithm of labor productivity level (Y/L) on the time trend.

The share of financial services is derived from the JIP Database 2008 as

Λ / Y = The share of real value added by financial industries (*Industry 69*) in the market economy.

Cash flow is obtained from *Financial Statements Statistics of Corporations by Industry (FSSC)* published by the Ministry of Finance. We adjusted the effects of sample changes and sample selection lag for the small firms to maintain the consistency of the time series data. See Hosono (2004) for details.

CF/Y = (Operating income + Depreciation) / Value added.

The turnover ratio of firms with employees is from "Employment Insurance Annuals," published by the Ministry of Welfare and Labor.

Firm-level Data

For the descriptive statistics of the firm-level data of I/K and Q, we refer to Hosono and Watanabe (2002), whose sample consists of all the firms listed in the first and second sections of Tokyo Stock Exchange and other regional stock exchanges during 1971-99. Hosono and Masuda (2005) provide the SMEs' firm-level data of *I/K* for the period 1999-2003, which we use for the comparison between the distribution of *I/K* and the financially constrained economy (Figure 9).

Appendix 2. Estimation of the share of financially-constrained firms

Data

To estimate the share of financially-constrained firms, we use the *Corporate Finance Survey* published by the Small and Medium Enterprise Agency in December, 2001. This *Survey* is similar to the NSSBF1993 (National Survey of Small Business Finance) for U.S firms. The sample firms were randomly drawn from the TSR (Tokyo Shoko Research) database. In the *Survey*, firms were asked whether their applications for loans had been rejected by their main bank over the last three years. When their loan applications had been rejected, they were further asked whether they could obtain funds from other financial institutions.

We obtain information about the firms' financial statements and their main banks from the TSR database. The firms' main banks are identified as the first financial institutions listed in the TSR database.[16]

The *Survey* data is linked to the main banks' financial statements that are available in the Nikkei Needs database, and the bank stock prices from the Toyo Keizai Stock Price CD-ROM.

Our sample consists of the firms that satisfy the following three conditions. First, they are small or medium-sized enterprises as defined by the Small and Medium-sized Firm Fundamental Law.[17] Second, their main financial institutions are major banks, long-term credit banks, trust banks, first-tier regional banks, second-tier regional banks or credit banks (*shinkin*) whose data is available. Finally, we restrict our sample to those firms that did not change their main banks during the 1999-2001 three-year period. This criterion is necessary to correctly identify the firm's main bank. The number of firms satisfying these conditions is 4,258 and the total firm-year observations are 12.569.

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16 The Corporate Finance Survey does not contain the information on the firm's main bank. The first financial institution listed in the TSR database is regarded as the most important one by researchers of TSR, based on the information they acquire from the firm managers. As such, it should coincide with the most important one regarded by the firm managers. However, if the firm changes its main banks during the inquiry period, the researcher cannot track the past main bank. For this reason we exclude those firms that changed main banks during the inquiry period (Jan. 1999-Dec. 2001).

17 Large firms are included in the sample of the Survey so that they occupy 10 percent in each industry. We omitted these large firms because the actual share of the number of small and medium-sized enterprises (SMEs) is 99.7 percent (*White Paper on Small and Medium Enterprise,* Small and Medium Enterprise Agency, compiled from *Establishment and Enterprise Census of Japan, 2001,* Ministry of Public Management, Home Affairs, Posts and Telecommunications.)

Probit Estimation

We estimate the determinants of the rejections of loan applications using a Probit estimation.[18] We denote by R_{it} the dummy variable that takes the value of one if firm *i*'s loan application is rejected by its main bank and other financial institutions in year *t,* and zero if accepted[19]. R_{it} is determined by R^{*}_{it}, defined as

$$\text{(A1)}\quad R^{*}_{it} = \beta_0 + \beta_1 Firm_{it} + \beta_2 Bank_{it} + \beta_3 \mathrm{Re}lationship_{it} + u_{it},$$

where $Firm_{it}$ denotes the vector of firm *i*'s operational performance and other firm characteristics, $Bank_{it}$ the vector of the main bank's capital condition, and $\mathrm{Re}lationship_{it}$ the vector of the relationship variables between firm *i* and its main bank. u_{it} is a random variable drawn from a normal distribution with mean zero and variance σ^2. Whether the main bank rejects or accepts the firm's loan application is determined as

$$\text{(A2)}\quad R_{it} = \begin{cases} 1 & if\ R^{*}_{it} \geq 0 \\ 0 & if\ R^{*}_{it} < 0 \end{cases}$$

For the $Firm$ variables, we use (1) EBITDA: earnings before interests, taxes, depreciation, and amortization, (2) SALES: sales as a proportion of the book value of assets, (3) DEBT: debt as a proportion of the book value of assets, (4) SIZE: the logarithm of the number of employees, (5) AGE: firm age, and (6) BUSINESS: a dummy variable that takes unity if firm *i*'s business conditions are better or unchanged, and zero if they are worse. AGE serves as the degree of informational transparency (e.g., Petersen and Rajan, 1995). It is, however, strongly correlated with the bank-firm relationship years (the correlation coefficient is 0.628) and hence partly captures the degree of relationship with its main bank. We expect that the firm is likely to be rejected if EBITDA, SALES, SIZE, AGE, and BUSINESS are low and if DEBT is high,

As for the $Bank$ variables, we adopt (1) STOCK: rate of change in stock prices from March 1993, and (2) NPL: nonperforming loans outstanding as a share of total assets. Nonperforming loans are defined as the sum of loans to borrowers in

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[18] The specification is similar to Berkowitz and White (2002), Hosono et al. (2004) and Hosono and Xu (2009) though Berkowitz and White do not include the bank's capital conditions in the explanatory variables.

[19] Among those firms that were rejected by their main banks, about 20 percent of firms, on average, were able to find funds from other financial institutions during 1999-2001. We classified these firms as "accepted" firms.

legal bankruptcy, past due loans in arrears by six months or more, loans in arrears by three months or more and less than six months, and restructured loans. As the benchmark of stock prices, we choose March 1993 because the bank stock prices were relatively stable and nonperforming loans were not regarded as a severe problem at that time. A bank with a high STOCK is expected to be healthier, to extend more loans and hence to less frequently reject the client firm. NPL is expected to be correlated either negatively or positively with the probability of loan rejections. If a bank with a high NPL is poorly capitalized, it should be more cautious in screening loan applications. On the other hand, a bank with a high NPL may suggest that it has adopted a very lenient screening policy. It may also extend loans even to poorly capitalized borrowers ("zombies") to prevent reported loans from increasing. In these cases, NPL should be negatively correlated to the probability of loan rejections.

For the *Relationship* variables, we use (1) NUMBER: the number of financial institutions that the firm deals with, and (2) YEAR: the number of years for which the firm has been conducting business with its main bank. A smaller NUMBER and a longer YEAR suggest a closer relationship between the firm and its main bank, and hence is supposed to result in a lower frequency of loan rejection.

The sample statistics of the variables we use are summarized in Table A1.

Results

Table A2 presents the estimation results for the marginal effect evaluated at the mean value of each dependent variable. The first column shows the results when we use only STOCK for *Bank* variables. All the coefficients have expected signs with high significance levels except for AGE. AGE is strongly correlated with YEAR and it takes a negative and significant coefficient if we exclude YEAR from the explanatory variables. The second column shows the results when we add NPL for *Bank* variables. NPL has a significantly negative coefficient. The other explanatory variables have expected signs with high significance levels, except for AGE.

Our goal here is to estimate the share of firms that were financially constrained due to their main banks' unhealthy conditions. It is notable, however, that accounting measures of banks are not reliable and sometimes cause a perverse effect given the discretionary accounting practices prevalent among Japanese banks in the 1990s (Peek and Rosengren, 2005; Hosono and Sakuragawa, 2008). Thus, we focus on STOCK to estimate the share of financially constrained firms. By using the coefficient on STOCK (-0.0003) in the first column and multiplying it by the average value of STOCK (-35.9 percent), we find that among all sample firms, 1.08 percent of firms were rejected due to their main banks' financial condition. Given that the rejected firms occupy 7.42 percent of all firms, we estimate that the number of rejected firms increased by 17.1 percent (17.1% = 1.08/(7.42-1.08)) due to the deterioration of bank equity value. Using the coefficient of STOCK in column 2, we find that the number of rejected firms increased by 23.4 percent.

Estimation of the proportion of financially constrained firms

Rejected firms can be safely regarded as financially constrained firms. But even among those who do not apply for loans, there must be some firms who wanted to borrow but are discouraged due to high financial intermediation costs (just like discouraged workers, who do not search for jobs anticipating a low likelihood of finding a job). We assume that the ratio of the number of "discouraged" firms to the number of rejected firms is constant over time. Then, the number of financially constrained firms should increase at the same rate as the number of rejected firms. Consequently, we estimate that the number of financially constrained firms increase by the range of 17 percent to 23 percent due to high financial intermediation costs during the crisis period.

Appendix 3. Solution Methods

We adopt the following numerical solution methods based on Gomes (2002).

1. Given an arbitrary initial value of w, we solve the Bellman equation for the firm, (10), and compute the optimal decision rule, using the value function iteration method. We divide the space for capital stock into 101 grid points between zero and the upper bound that is chosen so as to be non-binding. The space for productivity shocks is divided into 9 points.

2. Using the value function obtained in Step 1, we determine w that satisfies the free entry condition (15) for $B>0$.

3. Using the optimal decisions rules obtained in Step 1, we iterate the law of motion for μ, (16), to compute the stationary measure μ with $B = 1$.

4. Using the market clearing conditions (31) or (32), we determine the equilibrium level of entry B and the corresponding stationary measure μ.

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Table. 1 Calibration

Parameters	Benchmark Economy	Empirical Restrictions
Technology		
αk	0.3	Degree of returns to scale
αl	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		
$\lambda 0$	0.035	Share of financially constrained firms
$\lambda 1$	0.022	Interest rate margins between bank loans and deposits
Preferences		
β	1/1.03	Interest rate
H	0.6	Employment share

Table 2. Aggregate Results: Benchmark Economy

Variable	Japanese 1980–95	Benchmark Economy
Matched quantities		
Investment rate I/K	0.113	0.095
Firm turnover rate (Entry)	0.061	0.058
Other quantities		
Investment share I/Y	0.225	0.222
Cash flow / Y	0.341	0.323
Share of financing costs Λ/Y	0.039	0.013
Tobin's Q	2.058	1.092
	(1.443)	

Notes.
1. The Tobin's Q value in the parentheses is the average over the period exculding the "bubble" period (1987–92).
2. Firm turnover rate (Entry) is the average over 1981–1995.

Table 3. Cross-Sectional Results: 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	0.965	0.004	2.572	3.736	0.330	0.182	1.623	1.305	0.176	0.474
Financially Constrained	0.618	0.652	0.574	0.107	0.230	0.325	0.000	1.611	1.122	0.042	0.551
Unconstrained	0.312	−0.262	0.384	−0.064	−0.170	0.326	0.000	1.615	1.044	−0.026	0.730
Exit	0.058	−0.355	0.037	−0.900	−3.157	0.303	0.000	1.560	0.986	−0.116	0.485

Note. CF and Λ dnote cash flow and financial costs, respectively.

Table 4. Financially Constrained Economies

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	0.040	0.005	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	0.007	−0.005	0.005	−0.007		
Financially Constrained	0.618	0.737	0.119	0.835	0.217		
Unconstrained	0.312	0.216	−0.096	0.132	−0.181		
Exit	0.058	0.040	−0.018	0.029	−0.029		
C. Aggregate Results							
Investmetn Ratio (*I/K*)	0.095	0.096	0.002	0.097	0.002	0.113	0.092
Investment share (*I/Y*)	0.222	0.228	0.006	0.228	0.006	0.225	0.222
Cashflow share (*CF/Y*)	0.323	0.323	0.000	0.321	−0.003	0.341	0.295
Log (*Y/L*)	0.474	0.472	−0.002	0.464	−0.010	0.009	−0.009
Firm turnover rate (Entry)	0.058	0.040	−0.018	0.029	−0.029	0.061	0.044
Log(Real Wage) (log(*W*))	0.084	0.081	−0.003	0.078	−0.006	0.010	0.023
Log(*TFP*)	0.015	0.011	−0.004	0.009	−0.006	0.007	−0.012

Note:
1. Log(TFP) and Log(Real Wage) for the Japanese economy are the detrended average levels.
2. Log(TFP) s for the model economies are for incumbernt firms.

Table 5. Financially Constrained Economies with Differential Financial Costs between Entrants and Incumbents

Variable	Benchmark Economy	Constrained Economy C	Change from Benchmark	Constrained Economy D	Change from Benchmark	Japanese economy 1980-1995	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	0.040	0.005	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	0.007	−0.005	0.009	−0.002		
Financially Constrained	0.618	0.737	0.119	0.833	0.215		
Unconstrained	0.312	0.216	−0.096	0.138	−0.174		
Exit	0.058	0.040	−0.018	0.020	−0.039		
C. Aggregate Results							
Investmetn Ratio (I/K)	0.095	0.096	0.002	0.098	0.003	0.113	0.092
Investment share (I/Y)	0.222	0.228	0.006	0.231	0.009	0.225	0.222
Cashflow share (CF/Y)	0.323	0.323	0.000	0.320	−0.003	0.341	0.295
Log (Y/L)	0.474	0.472	−0.002	0.464	−0.010	0.009	−0.009
Firm turnover rate (Entry)	0.058	0.040	−0.018	0.020	−0.039	0.061	0.044
Log(Real Wage) (log(W))	0.084	0.081	−0.003	0.078	−0.006	0.010	0.023
Log(TFP)	0.015	0.011	−0.004	0.007	−0.008	0.007	−0.012

Note:
1. Log(TFP) and Log(Real Wage) for the Japanese economy are the detrended average levels.
2. Log(TFP) s for the model economies are for incumbernt firms.

Table A1. Variables in Coporate Finance Survey

Variable		No. of Obs.	Mean	Std. Dev.
Rejection of Loan Applications				
R	dummy that takes 1 if the loan application is rejected	12569	0.07423	0.262156
Firm				
EBITDA		12569	4.887	7.970
SALES	sales/ total assets	12569	1.493332	1.164877
DEBT	debt / total assets	12569	0.777794	0.231922
SIZE	logarithm of the number of workers	12569	3.692509	1.037867
AGE	firm age	12569	40.85257	21.80731
BUSINESS	business condition: better or unchagned=1, worse =0	12569	0.614448	0.486745
Main Bank				
STOCK	rate of change in stock prices from March, 1993	10519	−35.9448	23.79753
NPL	non−performing loans / total loans	12569	3.810169	1.861728
Firm−Bank Relationship				
NUMBER	number of financial institutions that the firm deals with	12569	4.333042	3.291917
YEAR	number of years for which the firm deals with the main bank	12569	30.46233	15.02379

Table A2. Probit estimates for loan rejection

A. Marginal Probability

Column	1	2
Firm		
EBITDA	−0.0011 **	−0.0011 **
	(0.0002)	(0.0002)
SALES	−0.0165 **	−0.0167 **
	(0.0024)	(0.0024)
DEBT	0.0955 **	0.0959 **
	(0.0079)	(0.0079)
SIZE	−0.0168 **	−0.0171 **
	(0.0022)	(0.0022)
AGE	−0.0001	−0.0002
	(0.0001)	(0.0001)
BUSINESS	−0.0521 **	−0.0523 **
	(0.0048)	(0.0048)
Bank		
STOCK	−0.0003 **	−0.0004 **
	(0.0001)	(0.0001)
NPL		−0.0030 *
		(0.0013)
Relationship		
NUMBER	0.0022 **	0.0022 **
	(0.0006)	(0.0006)
YEAR	−0.0007 **	−0.0007 **
	(0.0002)	(0.0002)
Psudo R2	0.130	0.131
No. of Obs.	10519	10519

B. Rate of increase in the number of rejected firms due to a decrease in bank stock price

	0.1712	0.2337

Notes

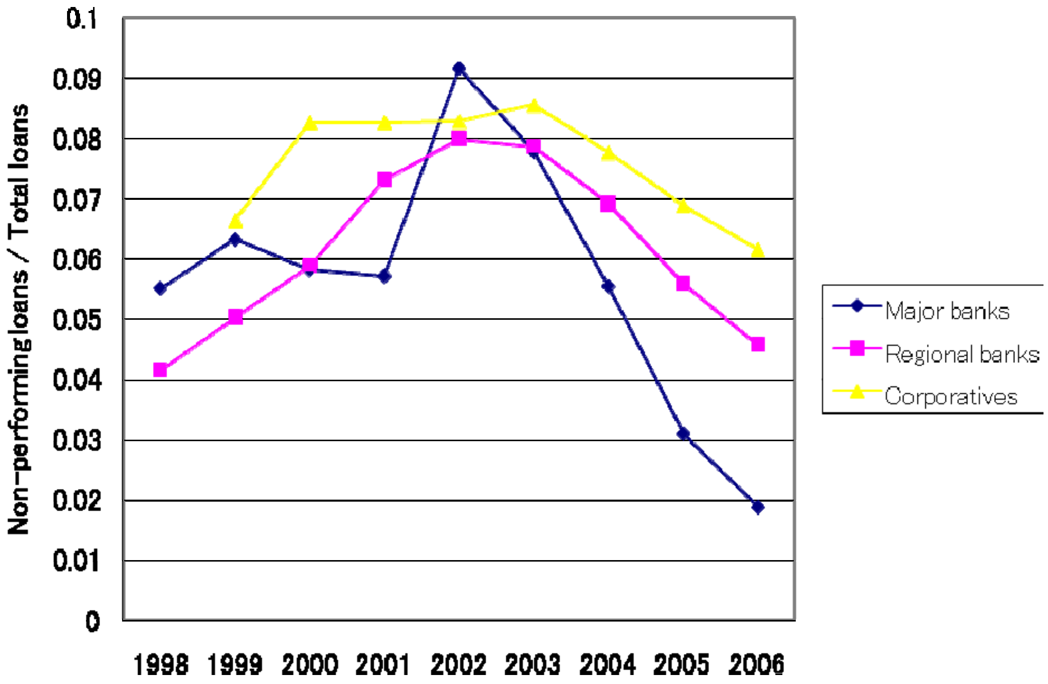
Panel A:

1. The dependent variable is a dummy that takes unity if the firm's loan application is rejected and zero otherwise.
2. The coefficients denote the marginal probability evaluated at the mean value of the explanatory variables
   For BUSINESS dummy, it is for discrete change from 0 to 1.
3. Numbers in theparentheses are standard errors.
4. ** and * denote the significance levels at 1% and 5%, respectively.

Panel B:

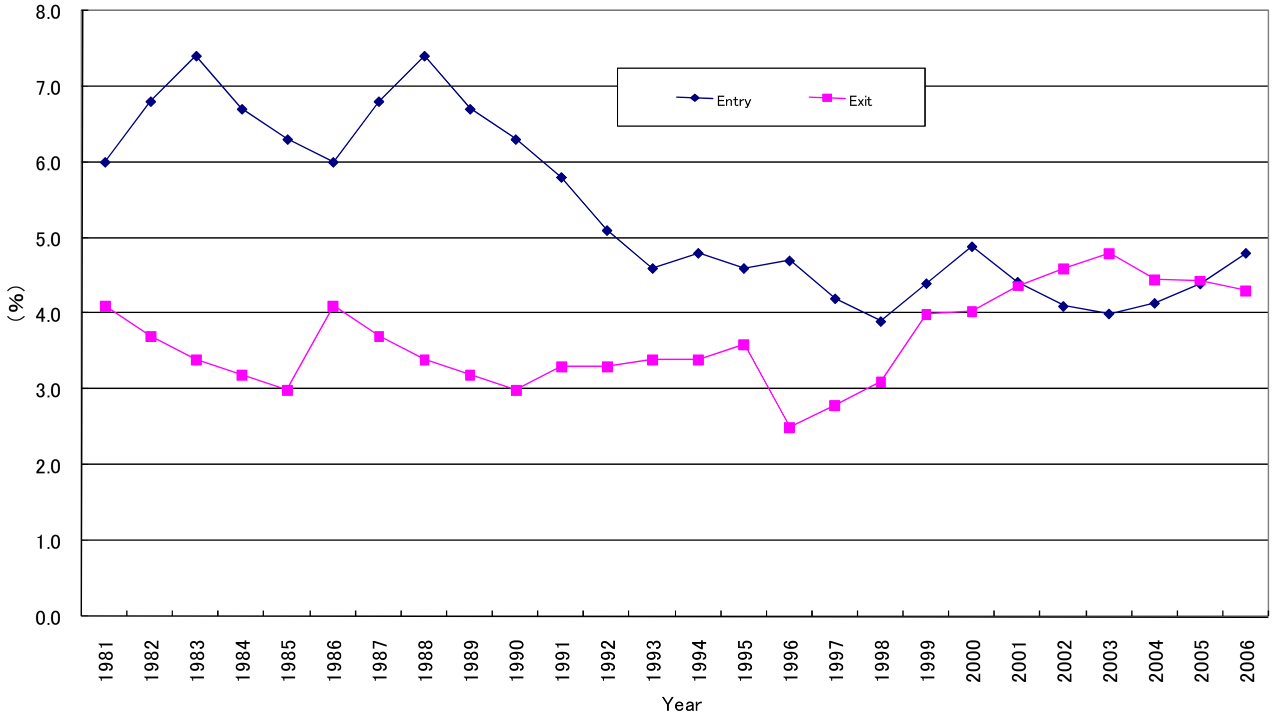
5. Rate of increase in the number of rejected firms due to a decrease in bank stock price
   = Coeffcieints on STOCK x Average STOCK
   / (Average proportion of loan rejections −Coefficient on STOCK x Average STOCK)

Figure 1. Non-performing loans of Japanese banks



Source: Financial Service Agency. The non-performing loan ratios are as of March of each year.

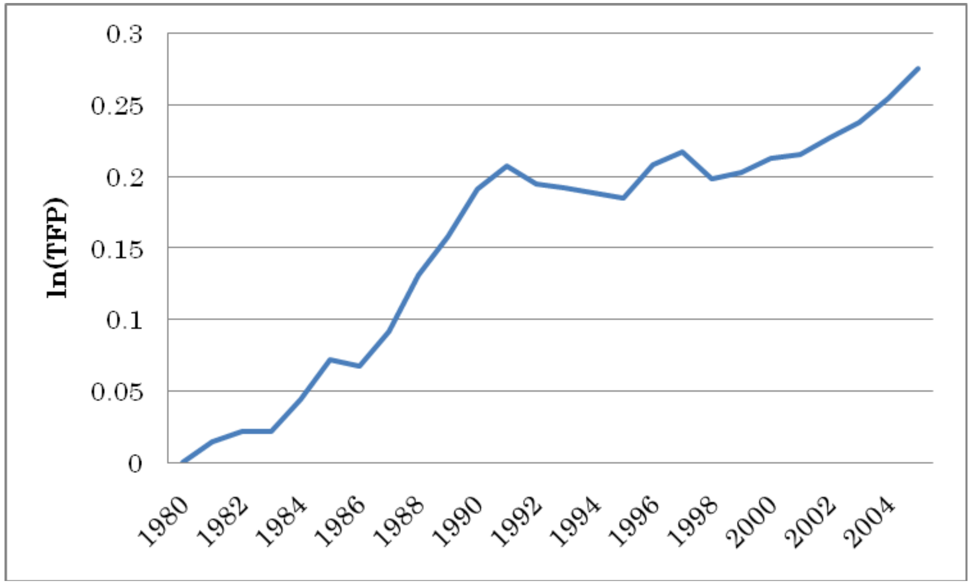
Figure 2. Turnover of Establishments



Note: Turnover ratio of establishments with emploees

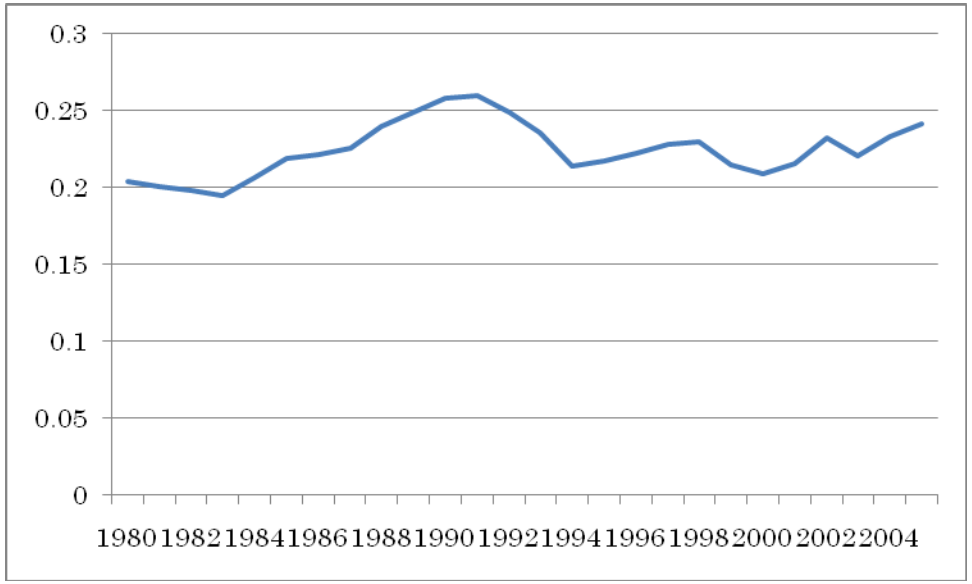
Source: Ministry of Welfare and Labor, "Employment Insurance Annuals."

Figure 3. TFP in Japan



Note: The market economy sector in JIP Database 2008. The TFP level in 1980 is normalized to unity.

Figure 4. Share of Investment in GDP



Note: The market economy sector in JIP Database 2008.

Figure 5. Sequence of Events

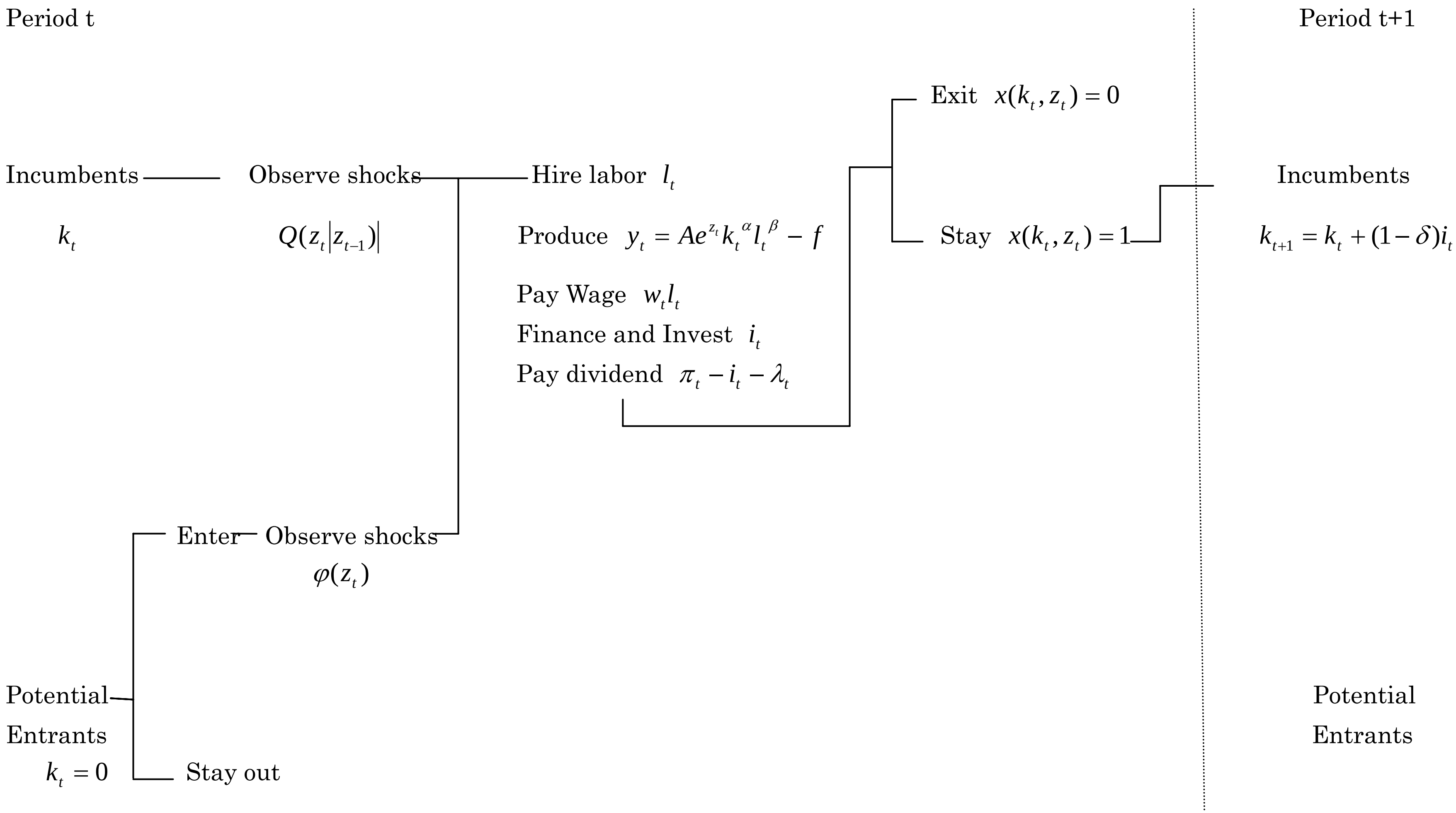


Figure 6. Financing Costs

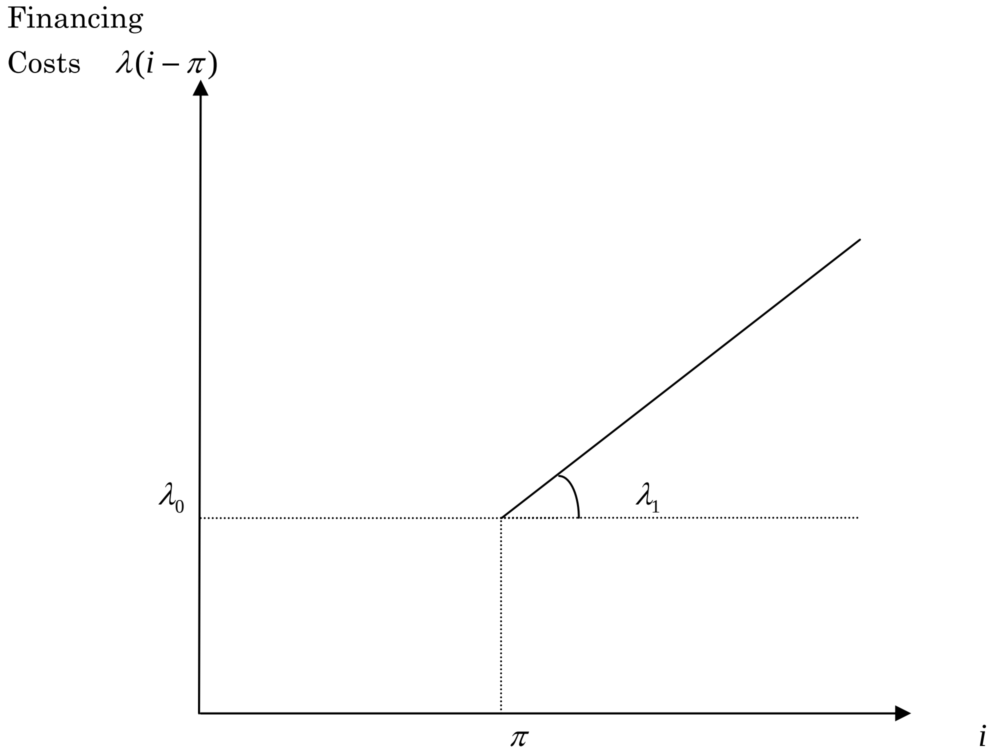
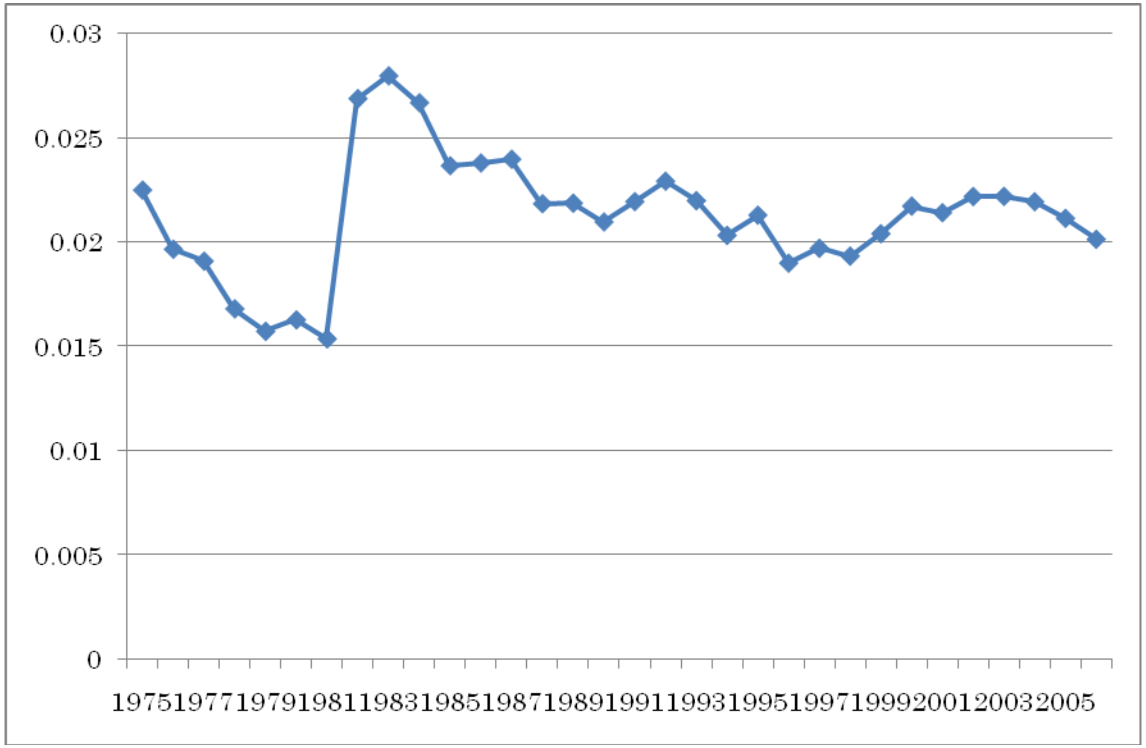


Figure 7. Interest Margins of Japanese Banks



Note: Interest margins = average loan interest rate – average deposit interest rate

Source: Nikkei Financial Quest

Figure 8. Optimal Capital Accumulation in Benchmark Economy

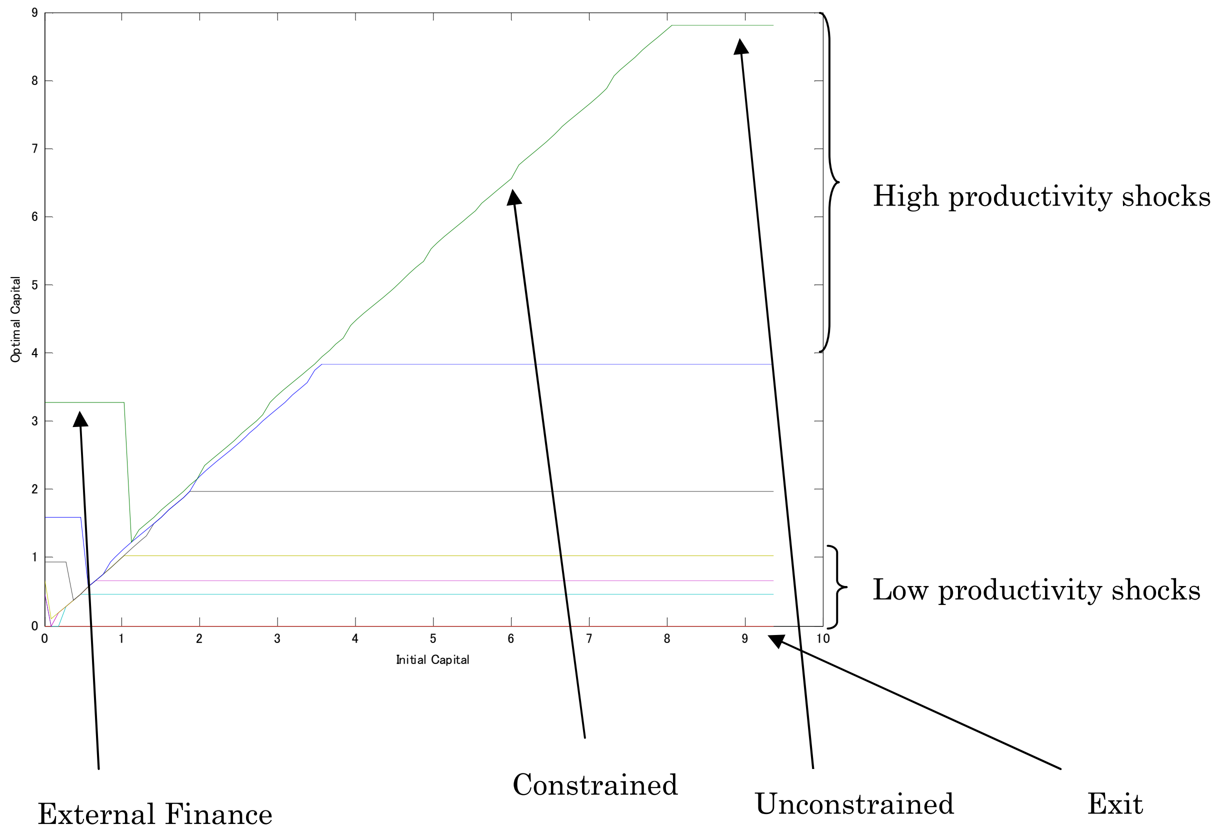
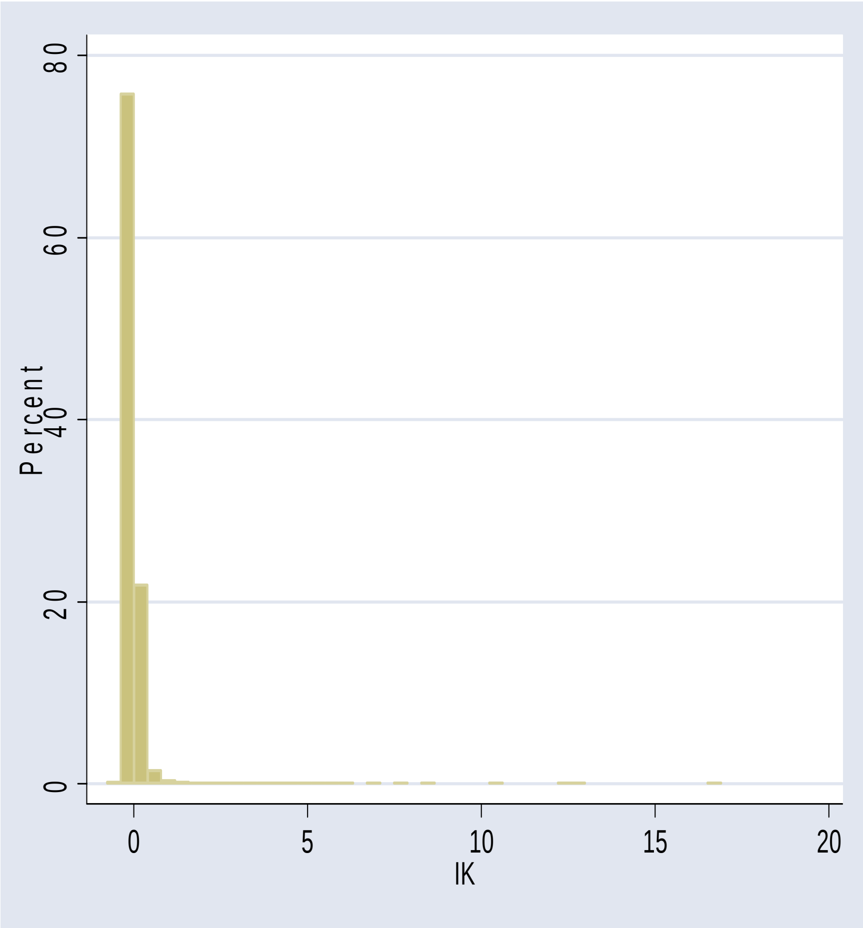
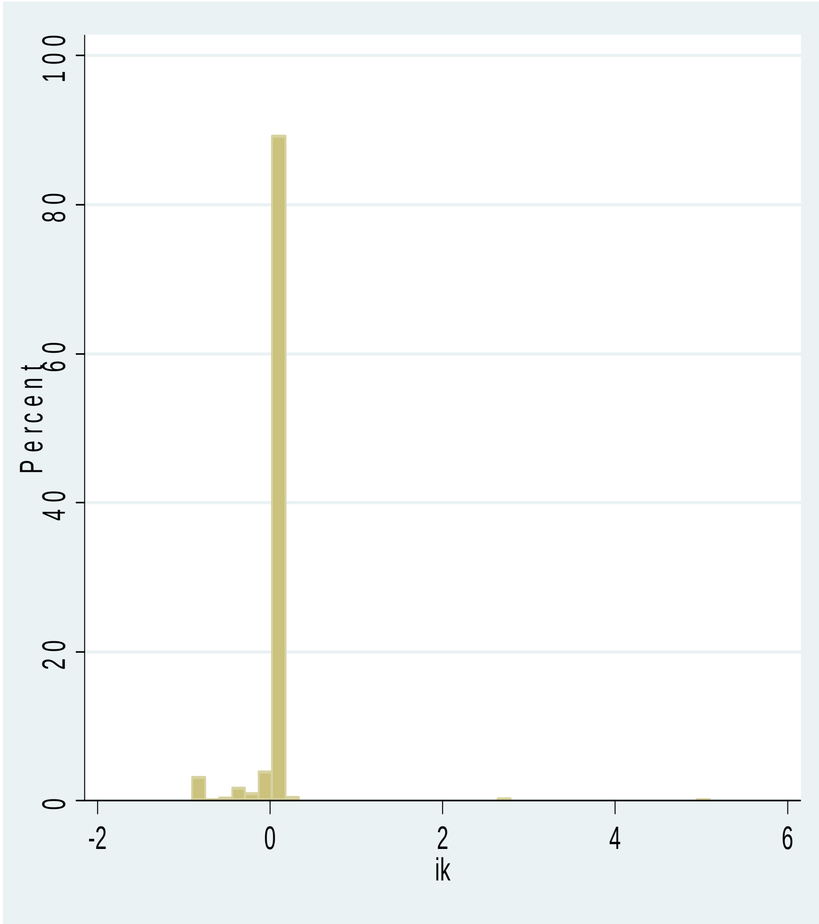


Figure 9. Distribution of Investment-to-Capital Ratio



A . SMEs in Japanese Manufacturing
Industries: 1999-2002



B. Financially Constrained Economy A