Contagious Expectations and Malfunctions of Markets: Some Lessons from Japanese Financial Institution Failures of 1997*

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Abstract

This paper discusses contagious effects of expectation in financial markets. We first review developments of Japanese financial markets towards the end of 1997 when a number of financial institutions collapsed. We then consider a simple model and study conditions under which contagious expectation triggers a financial crisis. Finally, based upon these, we derive some policy implications regarding the role of central bank lending.

1 Introduction

Successive failures of the major Japanese banks and securities companies in November 1997 provoked a sharp increase in market awareness of credit risk and liquidity risk. At one point, the overnight uncollateralized call rate, which is usually lower than the official discount rate, exceeded it. Term rates in the money markets and yields on corporate bonds also rose, while yields on risk-free assets such as government bonds declined.

In response to the rapid rise in short-term interest rates, the Bank of Japan provided ample funds to the market in an effort to stabilize them, creating excess reserves. As a result, the overnight call rate regained stability at the end of November. Interest rates on term instruments such as CD rates, however, did not show any sign of declining immediately. They finally began to decline in Febru-

* The views expressed here are those of the authors. They do not necessarily reflect those of the Bank of Japan.

ary 1998 reflecting the substantial increase in the Bank's provision of funds.

From a theoretical viewpoint, this paper tries to explain how the financial institution failures triggered a sharp increase in market awareness of risk in terms of changes in people's expectations. We are especially interested in why some financial institutions' failures drastically changed market participants' behavior toward other financial institutions, whose information was not directly provided by the failed institutions.

We consider a simple game in which players decide whether or not to supply funds to a fund-raiser. We study conditions under which players choose not to supply funds and then demonstrate that failures of other fund-raisers can make players withdraw funds from the fund-raiser contagiously. We also discuss how the contagious withdrawal of funds can be prevented, stressing the role of central bank lending.

Our model is a variant of that of Morris and Shin (1998) who studied self-fulfilling currency attacks. They investigated the role of expectation of market participants with asymmetric information and studied when financial crises occur. Pursuing and developing their arguments, we study when financial crises more likely and contagiously occur, and apply the results to explain what happened in Japan.

This paper is organized as follows. Section 2 briefly reviews what happened in the Japanese financial markets from the end of 1997 to the beginning of 1998. Section 3 studies the model. Section 4 discusses policy implications. Section 5 concludes the paper.

2 Developments in Japanese financial markets

This section briefly reviews some of the individual failures and the subsequent rises in interest rates.

2.1 Successive failures of financial institutions

Since the bursting of the bubble in the early 90's, Japanese financial institutions have had to deal with increasing non-performing loans. From October to December in 1997, three banks and three securities companies failed (see Tables 1, 2, 3, and 4 for more details) due to solvency problems.

Among these failures, the cases of Sanyo Securities Co., Hokkaido Takushoku Bank, and Yamaichi Securities Co. are considered to have had a large impact on financial markets. Let us take a closer look at them.

Sanyo's failure

Sanyo Securities Co., a second-tier securities firm in Japan, had a solvency problem caused by a loss from writing off non-performing loans. Thus, it strongly depended upon subordinated loans to meet regulatory capital requirements. Life

insurance companies, which provided the loans, finally rejected Sanyo's request for suspending maturity, which led Sanyo to file for corporate reorganization on November 3. After the decision, Sanyo defaulted in the inter-bank markets, which had never happened before in Japan.

Hokkaido Takushoku's failure

Hokkaido Takushoku Bank, one of Japan's top 21 banks, also had a solvency problem caused by a loss from writing off non-performing loans. The failure was triggered by a liquidity crisis due to deposit withdrawals, which became widespread when its rating was downgraded to speculative. Due to these events, Hokkaido Takushoku Bank decided to transfer its business to Hokuyo Bank on November 17. It was the first of Japan's top 21 banks, which the government had suggested would never fail, that required a bail-out.

Yamaichi's failure

Yamaichi Securities Co., the 4th largest securities firm in Japan, had a solvency problem and a liquidity shortage, which became serious when its rating was downgraded to speculative.The solvency problem arose when an investigation uncovered previously undisclosed losses. Against these backgrounds, on November 24, Yamaichi decided to close all of its branches and overseas affiliates. It was the largest business failure in Japan since World War II at that time.

Yamaichi had illegally covered up losses, and such scandals repeatedly took place in Japan, which is considered to reduce the credibility of information disclosed by Japanese financial institutions.

2.2 Developments in market interest rates

These failures, together with the sluggishness of the Japanese economy and the spreading instability of Asian financial systems and Asian economy, provoked a sharp rise in market awareness of credit risk and liquidity risk. To see this, we will briefly review developments of market interest rates following the Bank of Japan (1998).

At one point in mid-November, the overnight uncollateralized call rate exceeded the official discount rate, when large financial institutions successively failed, due to mounting uncertainty about fund availability and growing concern about credit risk. Term instrument rates such as CD rates (3-month) and Euro-yen TIBOR (3-month) also rose sharply in mid-November (Figure 1). In addition to the rise in their average rates, the differential between rates offered to banks also expanded during the same period (Figure 2), reflecting market awareness of risk.

In response to the rapid rise in these interest rates, the Bank of Japan provided ample funds to the market in an effort to stabilize interest rates from late November, and clearly established its policy stance by expanding the "excess reserves as of the morning" to over 1 trillion yen (Figure 3). In supplying these funds, the

Bank actively utilized new bond-borrowing ("repo") operations introduced in late November, and also substantially increased commercial paper purchase operations, in trying to assist firms in raising funds.

As a result, the overnight call rate regained stability at the end of November. Interest rates on term instruments such as CDs, however, did not show any signs of declining. This is because financial institutions and firms were less willing to supply funds and more eager to raise funds, reflecting their concern about liquidity risk at the end of the fiscal year. Consequently, there were many cases of significant rises for interest rates of term instruments which were to mature after the end of the fiscal year.

Interest rates on term instruments finally began to decline in late February 1998, reflecting the substantial increase in the Bank's provision of funds maturing after the end of the fiscal year (Figure 4), as well as the formulation of various financial stabilization measures by the government. Differentials in TIBOR between reference banks also slowly narrowed, in pace with the decline in average rates on term instruments.

3 Contagious expectation

3.1 A model

In order to study when market participants become less willing to supply funds, we consider a game in which 2 fund suppliers choose whether or not to lend funds to a fund-raiser. Mathematically, the model is a variant of that of Morris and Shin (1998).[1]

The set of players, or fund suppliers, is denoted by $I = \{1, 2\}$. The strategy set of player $i \in I$ is denoted by $A_i = \{S, N\}$ where S is to supply one unit of funds and N is not to supply it.

Let $\theta \in [0, 1]$ be a measure of credit risk of the fund-raiser, where larger θ implies lower credit risk. We assume that players cannot observe θ directly. Instead, player i observes his private signal x_i which is a random variable uniformly distributed on $[\theta - \varepsilon/2, \theta + \varepsilon/2]$ where $\varepsilon > 0$ is assumed to be very small.[2] Let $p(x_i|\theta)$ denote the conditional density function of x_i, i.e. $p(x_i|\theta) = 1/\varepsilon$ if $x_i \in [\theta - \varepsilon/2, \theta + \varepsilon/2]$ and $p(x_i|\theta) = 0$ otherwise. With respect to θ, both players have a common prior probability density $\mu(\theta)$.

There are 2 periods. At period 1, each player, who has one unit of funds, observes his private signal and chooses S or N. If a player chooses S, he lends one unit of funds to the fund-raiser with interest rate $r \neq 1$, which is exogenously

[1] These studies build on the incomplete information game analysis of Carlsson and van Damme (1993) and Morris, Rob and Shin (1995). This field is closely related to equilibrium refinement literature. See Kajii and Morris (1997a), Kajii and Morris (1997b), and Ui (1998).

[2] In addition to publicly disclosed information about the fund-raiser, players try to get further information individually, and/or they give their own interpretations. This is why players maintain private information about credit risk.

given.[3] If a player chooses *N*, he does nothing. When both players choose *S*, the fund-raiser borrows 2 units of funds. When one player chooses *S* and the other chooses *N*, the fund-raiser borrows 1 unit of funds. When both players choose *N*, the fund-raiser borrows no funds.

At period 2, a player choosing *S* receives $1 + r$ as long as the fund-raiser does not default. A player choosing *N* gets 1. Let $\rho(\theta, k)$ be a default probability when the fund-raiser borrows k units of funds. $\rho(\theta, k)$ depends upon k because a fund-raiser with less funds is more vulnerable to liquidity shocks. For the sake of simplicity, we assume that, for given $\underline{\theta}$ and $\overline{\theta}$, where $0 < \underline{\theta} < \overline{\theta} < 1$,

- $\rho(\theta, 2) = 1$ if $\theta \leq \underline{\theta}$ and $\rho(\theta, 2) = 0$ otherwise,
- $\rho(\theta, 1) = 1$ if $\theta \leq \overline{\theta}$ and $\rho(\theta, 1) = 0$ otherwise.

Note that $\rho(\theta, 2) \leq \rho(\theta, 1)$.[4]

Let $u_\mu(x_i, k)$ be such that

$$u_\mu(x_i, k) = (1 - E_\mu[\rho(\theta, k)|x_i])(1+r)$$

where $E_\mu[\rho(\theta, \mathrm{k})|x_i]$ is an expected value of $\rho(\theta, k)$ conditional on x_i under μ, i.e.

$$E_\mu[\rho(\theta,k)\,|\,x_i] = \frac{\int \rho(\theta,k)\,p(x_i\,|\,\theta)\mu(\theta)d\theta}{\int p(x_i\,|\,\theta)\mu(\theta)d\theta} = \frac{\int_{x_i-\varepsilon/2}^{x_i+\varepsilon/2} \rho(\theta,k)\mu(\theta)d\theta}{\int_{x_i-\varepsilon/2}^{x_i+\varepsilon/2} \mu(\theta)d\theta}.$$

Note that $u_\mu(x_i, k)$ is continuous in x_i. Then, the game has the following expected return matrix at period 1.

	S	*N*
S	$u_\mu(x_1, 2)$, $u_\mu(x_2, 2)$	$u_\mu(x_1, 1)$, 1
N	1, $u_\mu(x_2, 1)$	1, 1

3.2 Results

In this paper, we concentrate on symmetric equilibria. When $\varepsilon > 0$ and θ is uniformly distributed, a symmetric equilibrium is almost unique according to the following theorem, which is mathematically equivalent to Theorem 1 of Morris and Shin (1998):

[3] It is straightforward to extend the model in such a way that an interest rate depends upon credit risk.

[4] As far as $\rho(\theta, 2) \leq \rho(\theta, 1)$, we can relax these assumptions.

Theorem 1 *Suppose that* $\mu(\theta) = 1$ *for* $\theta \in [0,1]$. *In any symmetric equilibrium of this game, there exists* x^* *such that a player observing* $x_i < x^*$ *chooses N and a player observing* $x_i > x^*$ *chooses S.*

Proof. For a symmetric equilibrium, let $\pi(x)$ be the probability of choosing *S* when observing *x*, which hereafter we simply call an equilibrium. The expected payoff of player 1 when choosing *S* is

$$F_\mu(x_1, \pi) = E_\mu[\pi(x_2) \mid x_1]\, u_\mu(x_1, 2) + (1 - E_\mu[\pi(x_2) \mid x_1])\, u_\mu(x_1, 1)$$

where

$$E_\mu[\pi(x_2) \mid x_1] = \frac{\int\int \pi(x_2)\, p(x_1 \mid \theta)\, p(x_2 \mid \theta)\mu(\theta)\, d\theta dx_2}{\int p(x_1 \mid \theta)\, p(x_2 \mid \theta)\mu(\theta)\, d\theta dx_2}.$$

Note that $F_\mu(x_1, \pi)$ is continuous in x_1. Note also that if $\pi_1 \le \pi_2$ then $F_\mu(x_1, \pi_1) \le F_\mu(x_1, \pi_2)$ since $E_\mu[\pi_1(x_2)|x_1] \le E_\mu[\pi_2(x_2)|x_1]$ and $u_\mu(x_1, 2) \ge u_\mu(x_1, 1)$.

In order for π to be an equilibrium, it must be true that if $F_\mu(x_1, \pi) > 1$ then $\pi(x_1) = 1$ and if $F_\mu(x_1, \pi) < 1$ then $\pi(x_1) = 0$.

Let $s_x(x_2)$ be such that $s_x(x_2) = 0$ if $x_2 \le x$ and $s_x(x_2) = 1$ if $x_2 > x$. Note that $E_\mu[s_x(x_2)|x_1] = 1/2$. Let $f_\mu(x) = F_\mu(x, s_x)$. Then

$$\begin{aligned} f_\mu(x) &= \frac{1}{2} u_\mu(x, 2) + \frac{1}{2} u_\mu(x, 1) \\ &= (2 - E_\mu[\rho(\theta, 1) + \rho(\theta, 2) \mid x])(1 + r)/2. \end{aligned}$$

It is straightforward to see that $E_\mu[\rho(\theta, 1) + \rho(\theta, 2)|x]$ is continuous and decreasing in x. If $x \in [\underline{\theta} - \varepsilon/2, \underline{\theta} + \varepsilon/2]$ or $x \in [\bar{\theta} - \varepsilon/2, \bar{\theta} + \varepsilon/2]$ then $E_\mu[\rho(\theta, 1) + \rho(\theta, 2)|x]$ is strictly decreasing in x. Otherwise $E_\mu[\rho(\theta, 1) + \rho(\theta, 2)|x] = 2$ or 1 or 0. These imply that $f_\mu(x)$ is continuous, increasing, and strictly increasing if $f_\mu(x) \ne 0$ or $f_\mu(x) \ne (1 + r)/2$ or $f_\mu(x) \ne 1 + r$. Thus, $f_\mu(x)$ is strictly increasing when $f_\mu(x) = 1$ and there exists unique x^* such that $f_\mu(x^*) = 1$.

We show that, in any equilibrium, a player observing $x_i < x^*$ chooses *N* and a player observing $x_i > x^*$ chooses *S*. Define

$$\bar{x} = \sup\{x \mid \pi(x) < 1\},$$

$$\underline{x} = \inf\{x \mid \pi(x) > 0\}.$$

First, compare π and $s_{\bar{x}}$. Since $\pi(x) \ge s_{\bar{x}}(x)$ for all x,

$$F_\mu(x, \pi) \geq F_\mu(x, s_{\bar{x}}).$$

Since $F_\mu(\bar{x}, \pi) = 1$, $f_\mu(\bar{x}) = F_\mu(\bar{x}, s_{\bar{x}}) \leq 1$. This implies that $\bar{x} \leq x^*$. Next, compare π and $s_{\underline{x}}$. Since $\pi(x) \leq s_{\underline{x}}(x)$ for all x,

$$F_\mu(x, \pi) \leq F_\mu(x, s_{\underline{x}}).$$

Since $F_\mu(\underline{x}, \pi) = 1$, $f_\mu(\underline{x}) = F_\mu(\underline{x}, s_{\underline{x}}) \geq 1$. This implies that $\underline{x} \geq x^*$.

By definition, $\underline{x} \leq \bar{x}$. Therefore, $\underline{x} = \bar{x}$. This implies that, in any equilibrium, a player observing $x_i < x^*$ chooses N and a player observing $x_i > x^*$ chooses S. •

The intuition of the result is as follows. Player 2 observing any signal below $\underline{\theta} - \varepsilon/2$ chooses N because he knows that the fund-raiser will default with probability 1. Knowing this, player 1 observing x^1 that is slightly greater than $\underline{\theta} - \varepsilon/2$ chooses N because he believes that player 2 will choose N with a reasonably high probability. Knowing this, player 2 observing x^2 that is slightly greater than x^1 chooses N because he believes that player 1 will choose N with a reasonably high probability. Knowing this, player 1 observing x^3 that is slightly greater than x^2 chooses N because he believes that player 2 will choose N with a reasonably high probability. If we repeat this argument, we obtain $x^* = \lim_{n\to\infty} x^n$ such that a player observing $x < x^*$ always chooses N. A similar argument is also possible by starting from $\bar{\theta} + \varepsilon/2$.

The point is that player 1 considers what player 2 considers and vice versa, and that they have slightly different information. Due to this, a "grain of doubt" about credit risk expands contagiously as described above, and the game has a unique equilibrium.

According to the theorem, both players supply funds when $\theta \geq x^* + \varepsilon/2$, but no players supply funds when $\theta \leq x^* - \varepsilon/2$. Thus, the threshold x^* plays a very important role. If the threshold increases, players are less likely to supply funds, triggering another liquidity crisis. The following two theorems consider when this happens.

Suppose that players observe defaults in other fund-raisers. Then it is natural to assume that they will change their prior distribution for θ to a more pessimistic one in which more probability is put on a smaller θ. The next theorem shows that a pessimistic prior distribution implies a larger threshold and less willingness of players to supply funds.

Theorem 2 *Let $\mu'(\theta)$ be a prior probability density of θ and suppose that $\mu'(\theta)$ is decreasing. In any symmetric equilibrium of this game, there exists x^{**} such that a player observing $x_i < x^{**}$ chooses N. In addition, $x^{**} \geq x^*$.*

Proof. Define $f_{\mu'}(x)$ as in the proof of the previous theorem. Then

$$f_{\mu'}(x) = E_{\mu'}[s_x(x')|x]u_{\mu'}(x, 2) + (1 - E_{\mu'}[s_x(x')|x])u_{\mu'}(x, 1).$$

It is straightforward to see that

$$E_{\mu'}[s_x(x')|x] \le E_{\mu}[s_x(x')|x],$$

$$u_{\mu'}(x, 2) \le u_{\mu}(x, 2),\ u_{\mu'}(x, 1) \le u_{\mu}(x, 1),$$

$$u_{\mu'}(x, 2) \ge u_{\mu'}(x, 1),\ u_{\mu}(x, 2) \ge u_{\mu}(x, 1).$$

Thus, we have $f_{\mu'}(x) \le f_{\mu}(x)$ for all x. This implies that

$$x^{**} \equiv \inf\{x|f_{\mu'}(x) \ge 1\} \ge \inf\{x|f_{\mu}(x) \ge 1\} = x^{*}.$$

Let π be an equilibrium. Define

$$\underline{x} = \inf\{x|\pi(x) > 0\}.$$

Compare π and $s_{\underline{x}}$. Since $\pi(x) \le s_{\underline{x}}(x)$ for all x, $F_{\mu'}(x, \pi) \le F_{\mu'}(x, s_{\underline{x}})$. Since $F_{\mu'}(\underline{x}, \pi) = 1$, $f_{\mu'}(\underline{x}) = F_{\mu'}(\underline{x}, s_{\underline{x}}) \ge 1$. This implies that $\underline{x} \ge x^{**}$. Therefore, $\pi(x) = 0$ for any $x < x^{**}$. •

Suppose players find that disclosed information of another fund-raiser is not completely reliable. Then it is natural that they think their private signals also include more noise than previously thought. The next theorem shows that this leads to a larger threshold when players have a pessimistic prior distribution for θ and the initial uncertainty is small enough.

Theorem 3 *Let $\mu'(\theta)$ be a prior probability density of θ and suppose that $\mu'(\theta)$ is continuously differentiable and decreasing. Let $x^{**}(\varepsilon)$ be as given in the previous theorem. Let $x^{**} = \lim_{\varepsilon \to 0} x^{**}(\varepsilon)$. Then $x^{**} \le x^{**}(\varepsilon')$ for any ε' such that $0 < \varepsilon' < \min\{(x^{**} - \underline{\theta})/2, (\overline{\theta} - x^{**})/2\}$.*

Proof. Define $f^{\varepsilon}_{\mu'}(x)$ as in the proof of the previous theorem. Thus

$$f^{\varepsilon}_{\mu'}(x) = E^{\varepsilon}_{\mu'}[s_x(x')|x]u^{\varepsilon}_{\mu'}(x, 2) + (1 - E^{\varepsilon}_{\mu'}[s_x(x')|x])u^{\varepsilon}_{\mu'}(x, 1).$$

Let ε' be such that $0 < \varepsilon' < \min\{(x^{**} - \underline{\theta})/2, (\overline{\theta} - x^{**})/2\}$. Then it is straightforward to see that

$$\lim_{\varepsilon \to 0} u^{\varepsilon}_{\mu'}(x, 2) = u^{\varepsilon'}_{\mu'}(x, 2) \ge \lim_{\varepsilon \to 0} u^{\varepsilon}_{\mu'}(x, 1) = u^{\varepsilon'}_{\mu'}(x, 1).$$

In addition, we can calculate that $\lim_{\varepsilon \to 0} E^{\varepsilon}_{\mu'}[s_x(x')|x] = 1/2 \ge E^{\varepsilon'}_{\mu'}[s_x(x')|x]$. Since $u^{\varepsilon}_{\mu'}(x, 2) \ge u^{\varepsilon}_{\mu'}(x, 1)$, $\lim_{\varepsilon \to 0} f^{\varepsilon}_{\mu'}(x) \ge f^{\varepsilon'}_{\mu'}(x)$. This implies that

$$\lim_{\varepsilon\to 0} x^{**}(\varepsilon) = \lim_{\varepsilon\to 0} \inf\{x \mid f^{\varepsilon}_{\mu'}(x) \geq 1\} \leq \inf\{x \mid f^{\varepsilon'}_{\mu'}(x) \geq 1\} = x^{**}(\varepsilon').$$ ∎

The final theorem is about how to recover the equilibrium with the original threshold.

Theorem 4 *Let $\mu'(\theta)$ be a prior probability density of θ and suppose that $\mu'(\theta)$ is decreasing. Let $\rho'(\theta, k)$ be such that $\rho'(\theta, 1) = \rho(\theta, 2)$ for $\theta \in [x^* - \varepsilon/2, x^* + \varepsilon]$ and $\rho'(\theta, k) = \rho(\theta, k)$ otherwise. If the default probability is given by ρ', then in any equilibrium, a player observing $x_i > x^*$ chooses S.*

Proof. For $x \geq x^* + \varepsilon$, let $t_x(x_1)$ be such that $t_x(x_1) = 1$ if $x^* \leq x_1 \leq x$ and $t_x(x_1) = 0$ otherwise. Define $g_{\mu'}(x) = F_{\mu'}(x, t_x)$. Then

$$g_{\mu'}(x) = E_{\mu'}[t_x(x')|x]u_{\mu'}(x, 2) + (1 - E_{\mu'}[t_x(x')|x])u_{\mu'}(x, 1).$$

For $x > x^* + \varepsilon$, $E_{\mu'}[t_x(x')|x] \geq 1/2$, $u_{\mu'}(x, 1) \geq u_{\mu}(x - \varepsilon, 1)$, $u_{\mu'}(x, 2) \geq u_{\mu}(x - \varepsilon, 2)$. Thus

$$\begin{aligned} g_{\mu'}(x) \geq \frac{1}{2}u_{\mu'}(x, 2) + \frac{1}{2}u_{\mu'}(x, 1) &\geq \frac{1}{2}u_{\mu}(x - \varepsilon, 2) + \frac{1}{2}u_{\mu}(x - \varepsilon, 1) \\ &= f_{\mu}(x - \varepsilon) > f_{\mu}(x^*) = 1. \end{aligned}$$

This implies that $g_{\mu'}(x) > 1$ for $x > x^* + \varepsilon$.

Let π be an equilibrium. It is straightforward to see that for any $x \in [x^*, x^* + \varepsilon]$ $\pi(x) = 1$ because $\rho'(\theta, 1) = \rho(\theta, 2) = 0$ for $\theta \in [x^* - \varepsilon/2, x^* + \varepsilon]$. Suppose that

$$\bar{x}' \equiv \inf\{x | x \geq x^*, \pi(x) < 1\} < 1.$$

Due to the continuity of $u_{\mu'}(x, k)$, $\bar{x}' > x^* + \varepsilon$. Compare π and $t_{\bar{x}'}$. Since $\pi(x) \geq t_{\bar{x}'}(x)$ for all x,

$$F_{\mu'}(x, \pi) \geq F_{\mu'}(x, t_{\bar{x}'}).$$

However, $F_{\mu'}(\bar{x}', \pi) = 1$ and $F_{\mu'}(\bar{x}', t_{\bar{x}'}) = g_{\mu'}(\bar{x}') > 1$, which is a contradiction. Therefore, $\bar{x}' < 1$ is not true, and $\pi(x) = 1$ for any $x \geq x^*$. •

Suppose that the threshold has increased from x^* to x^{**} and that ε is very small compared to $x^{**} - x^*$. Then fund-raisers with $\theta \in [x^* + \varepsilon/2, x^{**} - \varepsilon/2]$, who were able to borrow funds when the threshold was x^*, cannot borrow funds any more. If the threshold x^{**} is considered temporary, then it can be economically justified for authorities to provide funds to any fund-raisers with $\theta \in [x^* + \varepsilon/2, x^{**} - \varepsilon/2]$.

Is this the only way for authorities to recover the original equilibrium by providing funds? Theorem 4 says no and proposes another method. Namely, it is enough for authorities to provide funds to fund-raisers with $\theta \in [x^* - \varepsilon/2, x^* + \varepsilon]$, and to make everyone believe this as common knowledge.[5] If ε is very small compared to $x^{**} - x^*$, this method is very efficient in the sense that the amount of funds for authorities to supply is reduced.

4 Discussions

What can we learn from the theoretical results in light of Japan's experience? First, they provide one explanation of how successive financial institution failures triggered a sharp rise in market awareness of risk.

As discussed in Section 2, market participants observing the financial institution failures learned the following:

- Defaults are possible in the inter-bank market, even though there were no prior defaults.
- Even top 21 banks can default, despite the government's suggestion that they would never fail.
- Disclosed information of financial institutions might not be absolutely reliable.

These lessons are enough for market participants to change their expectations, i.e. they thought that financial institutions were more likely to default and that information about credit risk contained more noise than previously thought.

Using the terms of our model, we can say that they adopted μ' instead of μ and ε' instead of very small ε. Theorem 2 and Theorem 3 suggest that these changes in expectation increased the threshold of private signals x^*. As a result of the increase, private signals of some fund suppliers became below the new

[5] Something is said to be common knowledge if one knows it, one knows that another knows it, one knows that another knows that another knows it, one knows that another knows that another knows that another knows that another knows it, and similar statements with any number of hierarchies are true.

threshold, and a portion of fund-raisers emitting those private signals found it difficult to borrow new funds.

If it is possible for authorities to control the expectations of market participants, the spreading difficulty in raising funds can be prevented. Namely, the following may work to decrease the threshold:

- Make market participants less pessimistic.
- Provide market participants with more accurate information.

The former does not seem so easy. The latter seems feasible. There is, however, little evidence that financial institutions or the authorities actually provided the information, though the authorities have been stressing its importance. These may explain one of the settings in which a rise in market awareness of risk remained for a long time.

Second, the theoretical results explain the role of central bank lending when there is a sharp rise in market awareness of risk. If the sharp rise can be regarded as a temporary phenomenon, it can be economically justified to provide funds publicly to those who find difficulties in raising funds after the sharp rise. Central bank lending can fill this role. The Bank of Japan actually provided ample funds, expanding excess reserves, as discussed in Section 2. The Bank of Japan also released a statement in which it ensured smooth inter-bank transactions by providing necessary funds with a view to ensuring the stability of the financial system.

Theorem 4 indicates there is a more efficient way to provide funds and obtain the same results. Namely, the following can reduce the amount of funds a central bank needs to provide:

- Make a commitment to provide funds to financial institutions with credit risk measures within a pre-specified range.
- Make market participants believe this is common knowledge.

This does not necessarily coincide with what the Bank of Japan did. In that sense, although what the Bank did was necessary and economically justified, it may not have been the most efficient way if Theorem 4 is true.

5 Concluding remarks

This paper has set out to explain what happened in Japanese financial markets when a number of financial institutions failed. Our model provided one possible explanation and demonstrated the mechanism in which contagious effects of expectation can trigger another liquidity crisis, shedding light on another aspect of systemic risk. Based on the model, we derived policy implications, which is a first step in the study of optimal announcements from authorities.

Table 1: Events in October 1997

10/3 Fri	The ex-vice president of Yamaichi was arrested on charges of illegally paying off *Sokai-ya* corporate racketeers and compensating them for investment losses.
6 Mon	Tokyo-Mitsubishi Bank, Daiwa Bank, and Nippon Credit Bank provided emergency loans and Nomura Securities announced that it was discussing the acceptance of capital injection to Sanyo. These actions were planned in order to support Sanyo in the negotiations with the life insurance companies about suspending the maturity of subordinated loans.
8 Wed	Echigo Securities was liquidated, affected by misappropriation of customers' funds.
14 Tue	**Kyoto Kyoei Bank decided to transfer its assets to Kofuku bank.** MOF began the examination of Hokkaido Takushoku Bank (HTB) to support HTB in the negotiations for capital increase by reducing ambiguity in its financial condition.
15 Wed	The executive director of Japan Life Insurance announced that they would not accept Sanyo's offer for suspending the maturity of subordinated loans. S&P downgraded the rating of HTB and Hokkaido Bank to speculative grade.
16 Thu	The former president of Yamaichi was indicted on charges of illegally paying off *Sokai-ya* and compensating them for investment losses.
19 Sun	The big four securities companies were expected to announce losses in September 1997 as their interim settlement. Yamaichi's ordinary P&L fell into the red.
21 Tue	Shareholders of Yamaichi filed suit against Yamaichi for the charge of illegally paying off *Sokai-ya* as shareholders' derivative action. The Supervisors Committee of Security Markets accused the former executives of Nikko Securities.
22 Wed	The former executives of Nikko Securities were arrested and prosecutors conducted search and seizure on the headquarters of Nikko Securities.
23 Thu	The former president of Yamaichi was re-arrested on suspicion of covering losses of Showa Lease. The big securities firms in the second tier fell into the red in September 1997 as their interim settlement.
24 Fri	Yamaichi's loss amounted to 2.7 billion.
29 Wed	Moody's interviewed Yamaichi. Four of the former executives of Daiwa Securities were arrested on suspicion of illegally paying off *Sokai-ya*. The big four securities firms were expected to receive administrative action.
30 Sun	The cumulative volume of deposit withdrawals from HTB since February reached 1,200 billion, which amounted to 10% of the outstanding amount at the end of last October. Zenshinren Bank provided a loan to Hokkaido prefecture as a substitute for HTB. S&P downgraded the rating of Sumitomo Bank.

Table 2: Events before and after the shocks of Sanyo and Hokkaido Takushoku Bank

11/1 Sat	Concerned life insurance companies announced their reservation for the issue of subordinated loans.
3 Mon	**Sanyo Securities filed for corporate reorganization.**
4 Tue	The main banks provided 15 billion in bridging loans to the Deposited Securities Insurance Fund. A default in the inter-bank call market occurred for the first time. Newspapers reported that the life insurance companies were about to write off the subordinated loans.
6 Thu	Trading of JGBs in London became inactive as market participants avoided holding JGBs registered in Sanyo's name. Moody's announced Yamaichi's rating under investigation for downgrading to speculative grade.
7 Fri	The Nikkei Index fell below 16,000. Yen declined to 124 ¥/$. Long-term interest rate reached 1.570%, a historical low. Japan premium increased to 0.1%. The ex-vice president and executives of Daiwa Securities were arrested on suspicion of illegally paying off *Sokai-ya*. The number of arrested people from the big four securities firms and DKB amounted to 36. Yamaichi's stock price suddenly plunged and the Nikkei Index dipped below 16,000 during day-time trading.
13 Thu	IBCA downgraded the rating of IBJ.
14 Fri	IBCA downgraded the ratings of Asahi, Tokai, and Yokohama Bank. Nikkei Index reached a new low for the year. Stock prices of the bank sector fell to the lowest since the bubble burst.
17 Mon	**Hokkaido Takushoku Bank transferred its assets to Hokuyo Bank**, and asked the DIC to purchase its non-performing loans. BOJ supplied 600 billion of special loans to HTB. The five city banks in Korea faced settlement problems caused by reluctance of foreign financial institutions to provide credit to Korean banks. Japan premium reached 0.5%
18 Tue	MOF began examination of Hokkaido Bank. Korean Won and Taiwanese dollar suddenly plunged.
19 Wed	BOJ supplied additional 150 billion of special loans. Moody's announced that downgrading of Fuji Bank was under consideration. S&P announced that downgrading of DKB, Sakura, and Sanwa Bank was under consideration. The Nikkei Index plunged 884, the largest decline in the year.
20 Thu	The DIC announced that it would purchase sound assets as well as non-performing assets in the process of winding up HTB.

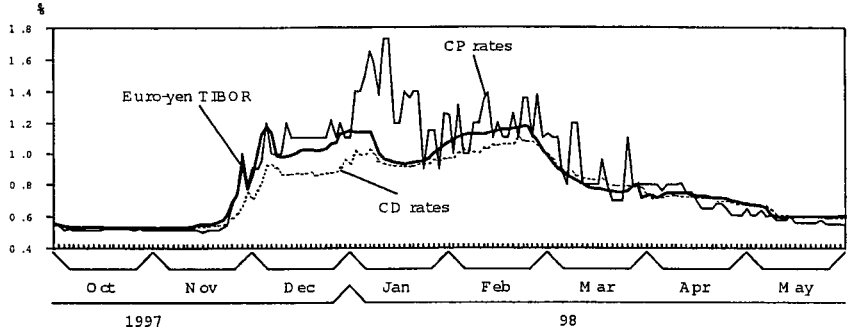
Table 3: Events in November 1997, before and after the Yamaichi Shock

11/14 Fri	S&P downgraded Yamaichi's rating to speculative. Yamaichi's stock price dipped below par value (100 yen). MOF and BOJ announced that subordinated loans to HTB would be secured.
16 Sun	Yamaichi announced plans for restructuring including separation of the company, the first time for a Japanese securities firm and a reduction of 2,500 employees.
19 Wed	Trading in Yamaichi stock was halted as the price reached 58 yen. The Nikkei Index suffered its largest fall of the year and anxiety about the Japanese financial system among the markets spread. The trading system of the Osaka Stock Exchange malfunctioned. Fuji Bank announced that it would consider supporting Yamaichi.
21 Fri	Moody's downgraded Yamaichi's rating to speculative. O/N interest rate in uncollateralized call market rose to 0.54% over the official discount rate. Japan premium increased and DJIA in NY fell because of the shock of Yamaichi.
22 Sat	The media reported that **Yamaichi** had decided to close down. The head of the Security Bureau of MOF revealed the existence of off-the-book loans of Yamaichi. The executive director of BOJ announced that "our first priority is to stabilize the financial markets." MOF and BOJ announced that all investors would be protected as a first priority and that subordinated loans to HTB would be secured. The authorities of Japan and England announced that they would collaborate in the operation.
23 Sun	The board of Yamaichi confirmed that it would close down.
24 Mon	BOJ announced "we are discussing liquidity support for Yamaichi Trust Bank since these loans will not be irrecoverable and Yamaichi is solvent," and that "we will ask FRB New York to supply dollars if necessary." The Prime Minister and Minister of Finance announced that they would accept the use of public funds. Stock markets in the U.S. and European countries declined.
25 Tue	The head of the Security Bureau of MOF suggested termination of Yamaichi's license. MOF could not find the off-the-book loans during its examination in 1993 and 1995. SCSM began a special examination. Fuji Bank announced that Yamaichi had reported the existence of off-the-book loans in October. TSE announced that they had examined whether the facts are claimed for default event. Trading in Yamaichi's CB was halted. An executive of BOJ announced that no default event had occurred because Yamaichi is solvent. BOJ supplied 800 billion of special loans. Yamaichi decided to close all of its branches and affiliates abroad. BOJ supplied unprecedented liquidity through Open Market Operation. Long-term yield suddenly declined reflecting the unexpected BOJ operation of outright purchasing of government bond. Yen (to ¥/$128) and Nikkei Index plunged. Trading in Nikkei 300 futures was halted by the circuit breaker. Most of the stock indexes in Asian countries simultaneously collapsed. Japan premium increased by 0.7%.

Table 4: Events and measures adopted by the authorities after the shocks

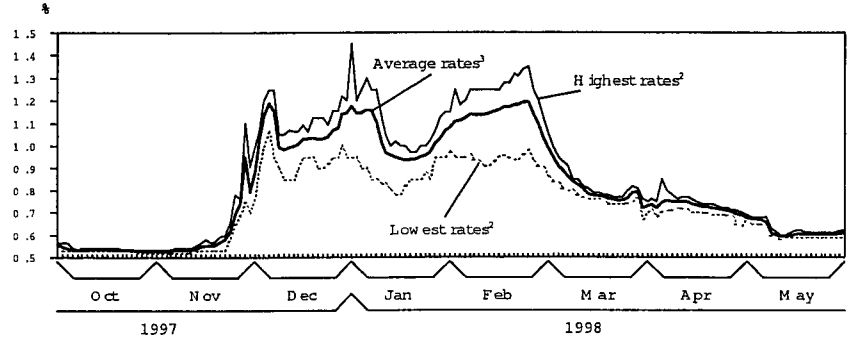
11/26 Wed	Minister of Finance and Governor of BOJ announced **a state of emergency**. **Tokuyo City Bank** transferred its assets to Sendai Bank. Kiyo Bank rejected the rumors of business problems, and MOF and BOJ announced their support. Moody's announced that most Japanese banks' ratings were under investigation.
27 Thu	BOJ announced that it would flexibly utilize loans and did not expect defaults to occur serially.
28 Fri	Yamaichi was prosecuted for the charge of false reporting.
12/1 Mon	LDP announced that public funds should be injected to the Deposited Securities Insurance Fund, which should be covered by the BOJ's special loan. Prime Minister announced plans for stabilizing the financial system.
3 Wed	MOF ordered security firms to investigate off-the-book liabilities. BOJ conducted unexpected bond purchasing operation.
6 Sat	Yamaichi announced that it had an off-the-book liability in an Australian affiliate amounting to 106.5 billion yen. MOF announced that foreign currency deposits and financial bonds are secured by deposit insurance.
9 Tue	Yamaichi insider alleged that the company had reported its *tobashi* to MOF. Prime Minister suggested that 10 trillion yen obtained by new type of government bonds should be utilized to stabilize the financial system.
10 Wed	HTB suggested the possibility of its insolvency at the Diet. LDP announced that it would investigate widening the coverage of the Resolution and Collection Bank's operation.
11 Thu	SCSM recommended administrative action against Daiwa and Nikko to MOF.
12 Fri	Amendment Deposit Insurance Act was passed.
16 Tue	MOF announced that it would flexibly implement the PCA, i.e., i) the PCA would not be activated against banks which adopted the domestic standard until 2001, ii) banks can choose either way of accounting for stock prices: original book method or lower price method. Nikko and Daiwa admitted they had illegally paid off *Sokai-ya*.
17 Wed	The limit of borrowing by the Deposit Insurance was increased to 10 trillion yen.
19 Fri	Toshoku Co. filed for corporate reorganization.
22 Mon	The Nikkei Index declined below 15,000.
23 Tue	**Maruso Securities Co.** filed for voluntary bankruptcy.
24 Wed	LDP and the government announced that of the 10 trillion fund for financial system stabilization, 3 trillion would be used for purchasing preferred stock, and 7 trillion for securing depositors and for delivering to the Special Account of the DIC. MOF announced that it had begun to investigate the feasibility of a new act in which the financial authorities would have the autonomy to file for liquidation of securities firms.
25 Thu	Orix Co. was reported to be merging with Yamaichi Trust. S&P downgraded the ratings of Sanwa and Sakura.
26 Fri	MOF disclosed the result of the HTB examination.
27 Sat	Outstanding amount of BOJ's CP purchasing operation increased.
29 Mon	MOF announced that the Deposited Securities Insurance Fund was secured by the government.

Figure 1: Interest rates on term instruments (3-month)[1]



Note : 1. The latest data are those for end-May 1998.
Source : Bank of Japan (1998).

Figure 2: Euro-yen TIBOR (3-month)[1]

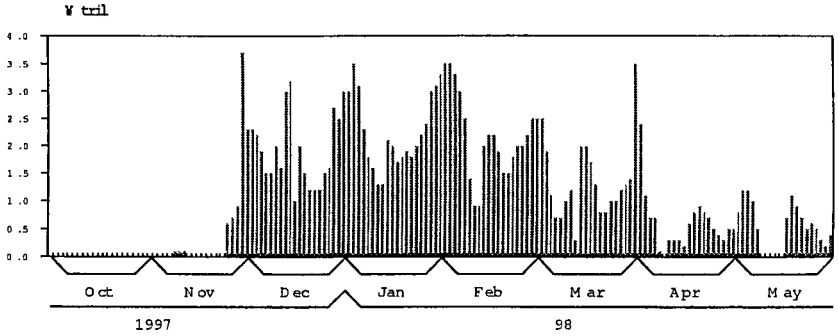


Notes : 1. The latest data are those for end-May 1998.
2. The highest and lowest rates are those quoted by 15 Japanese banks with a reference contract with the Quotation Information Center K. K. (QUICK) until February 1998 and those quoted by 16 Japanese banks with a reference contract with the Federation of Bankers Associations of Japan (Zenginkyo) from March 1998.
3. Average rates are arithmetic averages of those quoted by 15 Japanese banks with a reference contract with the Quotation information Center K. K. (QUICK) until February 1998 and those quoted by 16 Japanese banks with a reference contract with the Federation of Bankers Associations of Japan (Zenginkyo) from March 1998.

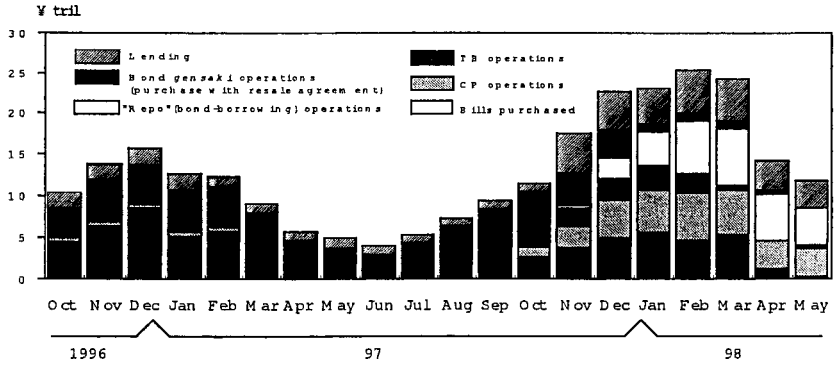
Source : Bank of Japan (1998).

Figure 3: Money market operations

(1) Excess reserves as of the morning[1]



(2) Supply of funds[2]

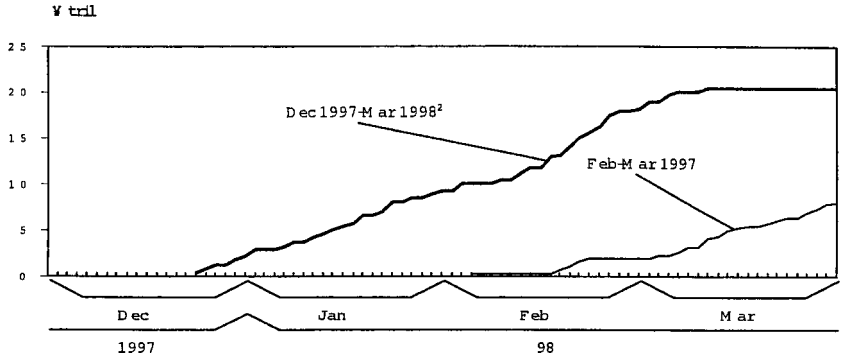


Notes : 1. The amount of "excess reserves" is calculated by subtracting the daily average of reserves to be deposited in the remaining reserve maintenance period from the current amount of reserves. The Bank of Japan conducts major market operations at 9:20 a.m. in principle. The resultant amount of excess reserves based on the operations announced at 9:20 a.m. is referred to as "excess reserves as of the morning." Data are for all business days in the period from the beginning of October 1997 to the end of May 1998.

2. Data are amounts outstanding at the end of each month.

Source : Bank of Japan (1998).

Figure 4: The Bank of Japan's supply of funds maturing after the fiscal year-end[1]



Notes : 1. Supply of funds refers to those supplied through the following measures: market lending operations (excluding those conducted pursuant to Article 25 of the former Bank of Japan Law); bill-purchasing operations; and funds through treasury bill (TB) operations, bond-borrowing ("repo") operations, bond *gensaki* operations (purchase with resale agreement), and commercial paper (CP) operations.

2. Data include funds offered on March 31, 1998.

Source : Bank of Japan (1998).

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