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Were regulatory interventions effective in lowering systemic risk during the financial crisis in Japan? ☆

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Abstract

This study empirically examines the effectiveness of various regulatory interventions on systemic risk during the financial crisis in Japan. Our findings generally show that the regulatory interventions worked effectively through the liquidity provision. That is, the public fund injection programs, the prompt corrective actions, and the blanket guarantee reduced systemic risk. The simple government intervention package to bail out distressed "too-big-to-fail" banks stabilized the banking system via the external channel whereas the massive bailout scheme suffered the "too-many-to-fail" problem in the sense that it increased systemic risk through both direct spillover and external channels. This study suggests that the effective government intervention should be restricted to a limited number of bailouts to reduce systemic risk.

Keywords: financial crisis, systemic risk, deposit insurance, public fund injection, bank failure

JEL classification: G21; G28; G18; G14; G32

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Were regulatory interventions effective in lowering systemic risk during the financial crisis in Japan? ☆

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Contents

1. Introduction

The 2007 global financial crisis highlighted the absence of established crisis resolution mechanisms and thus is changing the perception of the role of financial regulations around the world. Regulators are now widely considered responsible for managing crises and proposing optimal bailout policies in a manner that does not aggravate systemic risk. It is necessary and urgent to evaluate the impacts of bail-out guarantees taken by governments for the purpose of preventing the future collapse of the banking system. This paper, therefore, examines whether regulatory interventions had a significantly ameliorating effect on the spillover from a distressed bank to the financial market.

What can we learn from Japanese financial crisis in the 1990s and the early 2000s? Our study on how regulatory interventions affect systemic risk in Japan is important for a few reasons. First, Hoshi and Kashyap (2010) witnessed that almost the policy reactions to the crisis employed by the U.S. government during the global financial crisis that were borne from Japan. Different from the financial crisis 2007-2009 in the U.S., the Japanese financial system experienced a longer period of continuing crisis, therefore providing rich evidence that can be a good stage for analyzing regulatory interventions for managing a crisis. Consequently, this study focuses on four types of interventions: public fund injection (abbreviated as PFI) programs; prompt corrective actions (PCA); failure resolution scheme (FRS); and deposit insurance reforms (DIR) act. To analyze regulatory interventions during the crisis, we use manually collected Japanese bank-level data to create an original comprehensive dataset on crisis resolution.

Second, recently, the post–global financial crisis has highlighted the need to analyze how financial intermediaries' behaviors are affected by financial regulation systematically, therefore, several systemic risk indexes have been proposed in the literature (Adrian and Brunnermeier 2016, Acharya et al. 2017, Huang et al. 2009, Lehar 2005, Billio et al. 2012, De Jonghe 2010). The characteristics of regulatory regimes are the predominant reasons behind a surge in global systemic risk, hence, we add to the scarce literature on how government bailout plans for the future crisis should be arranged.

Finally, Liu (2014) attracts the attention on the existence of systemic risk in Japan since extreme downside risk of the Japanese market is transmitted to the majority of Asian-Pacific markets when such a regionally dominant stock market switches into high volatility periods. In such a concern, understanding systemic risk in Japan is of importance for risk management and policy implications to prevent the possibility of extreme losses in Asia-Pacific markets and reduce the instability in the economy.

This paper makes contributions to different strands of literature. First, the literature provides a prediction that the regulatory interventions work primarily through liquidity provision to the financial system (Allen and Gale 2000, Freixas et al. 2000, Diamond and Rajan 2005). Our evidence that PFI, PCA, and DIR reduce systemic risk mostly complements this theoretical hypothesis that the liquidity provision works, contributing to the growing literature on systemic risk (Reboredo and Ugolini 2015, Girardi and Ergün 2013, Lopez-Espinosa et al. 2012).

Second, confirming the conjecture on moral hazard in government guarantee literature (Cordella and Yeyati 2003, Acharya and Yorulmazer 2007, 2008), we demonstrate that simple and intuitive rescue schemes outperform massive scheme in preventing systemic risk. Our findings show that the simple regulatory policy reduced systemic risk whereas the massive rescue package for the fifteen largest banks increased it. In line with the argument of Acharya and Yorulmazer (2007, 2008), our analysis provides the insight that the Japanese regulators suffered from a "too-many-to-fail" problem in their attempts of avoiding the continuation of bank losses in the 1990s.

Third, our study is the first to provide a novel finding that the government bailout has external effects on systemic risk. As suggested by Allen and Gale (2000), capital infusion has a direct spillover effect on the recipient and external effect on other banks given that there is an interbank linkage in the bank-centred system. With an attempt of investigating these two channels in PFI, we find that the simple government bailout package enhanced financial stability via the external channel but not the direct spillover channel. In other words, the external ameliorating effect on non-recipient banks exists, but no greater effect does on the recipient bank itself than that of non-recipient banks. In contrast, the massive PFI program increased systemic risk, adding a clearer evidence on too-many-to-fail literature that the banking system would be in a danger of further systemic disruption through direct exposure and interbank linkage.

Fourth, we contribute Japanese evidence to the literature on PCA (Chernykh and Cole 2015, Aggarwal and Jacques 2001, Benston and Kaufman 1997). The regulatory responses should provide a better move towards liquidity provision and thus prevent systemic disruption in the country characterized as a bank-centred financial system like Japan.

Section 2 reviews the characteristics of the financial crisis in Japan and relates them to the literature on regulatory policies and systemic risk. Section 3 describes the empirical methodology for systemic risk estimation and data sample. Section 4 provides the empirical results. Section 5 concludes the paper.

2. A brief outline on the Japanese financial crisis and regulatory policies

To begin with, it is helpful to outline the Japanese financial crisis and what measures the government has taken. The aim of this section is to smoothly lead the reader to the Japanese financial crisis and to relate the characteristics to the existing literature. The reader who is more interested in the Japanese financial crisis should refer to Hanazaki and Horiuchi (2003) and Shimizu (2006, 2009). Briefly speaking, the financial institutions suffered huge damages in the latter half of the 1990s and early 2000s. In 1993, the amount of nonperforming loans was 12.8 trillion yen, which was 3.5% of total loans. It increased to 42.0 trillion yen (8.9%)

by 2002, which was the highest record during the Japanese financial crisis. [1] The stock price index of banking industry became 20% in 2002 relative to 1995. The government paid 25 trillion yen to stabilize the financial system during the period from 1993 to 2004.

After the government took several types of measures quite frequently and intensively, the financial system finally recovered stability around 2004. As is well-known, the features of crisis such as successive bank failures and those of government interventions are in common with other crises like the global financial crisis in the U.S. and Europe. In our opinions, we can learn suggestive lessons from the Japanese financial crisis which provides the common resources for the research in this area together with those researches regarding the global financial crisis.

Japan is characterized as a bank-centred financial system because it has a weak bond market and firms are dependent on bank lending. The Japanese economy is considered as a world-beater in the 1980s and early 1990s. As problem loans dramatically mounted by the mid-1990s, many banks turned out to be undercapitalized or unhealthy (Hanazaki and Horiuchi 2003). Adequacy capitalization is a crucial condition for bank lending (Brei et al. 2013). Nevertheless, the bank-centred system does not have the strong capital market to immediately raise liquidity, hence, the regulatory intervention is a visible solution to stabilize the banking system.

Our research departs from the intersection of strands of literature on crisis resolution, liquidity provision, and systemic risk. As reasoned by Lopez-Espinosa et al. (2012), liquidity strains are regarded as the main contributor behind systemic risk. Being aware of the problems on an increasing amount of bank irrecoverable loans, in turn, capital shortages, a number of bailout policies were introduced in Japan during the 1990s and early 2000s. The following four subsections provide the information on regulatory interventions in the context of Japanese crisis, discussing the relation of each policy to the related literature.

[1] Compared to GDP, the nonperforming loans amounts to 8.2% in 2002.

2.1. Public fund injection (PFI)

The PFI programs allow banks to reinforce equity capital and provide liquidity to the financial system and the recipient bank. The regulator offered new PFI programs several times during our sample period. Among these programs, the largest program was introduced in 1999. In this program, the fifteen largest banks that were considered relatively healthy but that had substantial influence over the systemic risk applied for the reinforcement of equity capital. The second largest PFI program was introduced in September 1999. Four relatively weak regional banks reinforced their equity capital. Subsequently, one or a few banks applied simultaneously for the PFI program. The total numbers of approvals are thirteen during the sample period.

The previous literature on regulatory interventions argues that the measure of resolution works primarily through liquidity provision to the financial system. The provision of liquidity not only decreases a probability of default of the recipients of PFI, but also has an effect of decreasing a probability of bank runs and lowering systemic risk (Liu et al. 2013, Allen and Gale 2000, Freixas et al. 2000, Diamond and Rajan 2005). In addition, a bailout package provides the public with an implicit guarantee by certifying that the recipients are healthy, helps to reduce information asymmetries related to financial distress costs, and restores confidence (Bayazitova and Shivdasani 2012, Veronesi and Zingales 2010). Therefore, PFI aimed at rescuing distressed too-big-to-fail banks.

2.2. Prompt corrective actions (PCA)

The government introduced a rule-based PCA scheme in 1998, which requires early intervention on a timely basis when a bank's capitalization is still positive but under-capitalized. For example, the regulator orders banks to recapitalize, suspend dividends, restrict asset growth, and prohibit some or all activities (Benston and Kaufman 1997). [2] These amend-

[2] The scheme of PCA in Japan is similar to that of U.S., which was reviewed by Benston and Kaufman (1997).

ments decrease a probability of bank default and lower systemic risk. Under an announcement of PCA, a bank tends to recapitalize quickly under threat of early closure (Dahl and Spivey 1995). Aggarwal and Jacques (2001) document that banks significantly reduce their level of credit risk in response to PCA. Strengthened capital base indeed reduces systemic risk. Thus, we predict that the PCA has the same role of stabilizing financial system as the PFI.

2.3. Failure resolution scheme (FRS)

When a bank finally fails, deposit insurance resolves the failure, because the private-sector resolution is not always feasible. The regulator usually takes P&A-like resolution policy rather than deposit payoffs. In such rescue package, the failed bank is sold to another healthy bank. This rescuing bank usually purchases or assumes the assets and liabilities of the failed banks with the aid of a subsidy provided by deposit insurance. The subsidy usually covers the difference between the market values of the assets and liabilities. Deposit insurance sometimes purchases part of assets and deposits of the failed bank. Regulators seek a rescuing bank among candidate banks whose operating area is the same as or adjacent to the failed bank. Similarly to PCA, the FRS also ameliorates systemic risk if it succeeds in preventing spillover, provides liquidity, and eventually to isolate banks at default from the market (Cordella and Yeyati 2003).

2.4. Deposit insurance reforms (DIR)

Deposit insurance is an optimal policy under the circumstance of bank runs as in the classic work of Diamond and Dybvig (1983). The Japanese government reformed the deposit insurance act several times during the crisis. When the blanket guarantee was introduced in 1996, it was scheduled to end in March 2001. In the DIR Act of 2000, its period was extended.[3] It finally ended in March 2002 except for settlement accounts. The reform of 2002 enacted this measure as permanent. During the period of blanket guarantee, the Deposit Insurance

[3]See Kane and Klingebiel (2004) for the blanket guarantee in the world.

Corporation of Japan provided the rescuing bank with the amount of funds over the amount required for deposit payoffs. [4] When insurance coverage extends to all liabilities, the market expects that creditors do not incur losses when banks fail at the cost of the regulator and taxpayers, increasing financial stability.

2.5. Limitations of regulatory interventions

However, there are many articles that argue the limitations of regulatory interventions. Among them, the most relevant to our analysis is "too-many-to-fail" problem that induces banks to herd and thus results in an increased number of failed banks being bailed out (Acharya and Yorulmazer 2007, 2008). In addition, an ex-post bailout policy may not be ex-ante optimal, an incidental provision of private information may make market responses more accentuated to reduce financial stability, a moral hazard may arise from additional risk-taking because of higher bailout expectation (Acharya and Yorulmazer 2007, Dam and Koetter 2012).

Similarly, other measures are also subject to criticism. As argued by Chernykh and Cole (2015), there is skepticism on the effectiveness of PCA. Peek and Rosengren (1996) find that the PCA guidelines on the U.S. banks fail to provide a timely indication of distressed banks. The FRS scheme may also face the too-many-to-fail issue. The blanket guarantee may also have adverse effect on systemic risk, because creditors lose incentives to monitor banks and banks can shift risk onto the insurer (Hovakimian et al. 2003). Deposit insurance increases a likelihood of banking crisis and government interventions have a negative impact on banking sector stability (Demirguc-Kunt and Detragiache 2002, Hryckiewicz 2014).

[4] The reform of 1997 was somewhat minor. The framework for new mergers and assistance was introduced but only used for one resolution. The reform of 1998 introduced the receivership of the failed banks, the establishment of a bridge bank, and the temporary nationalization of failed banks.

3. Research design

3.1. Methodology

In this subsection, we first describe the overall methodology for conducting our analyses. The next subsection briefly explains the methodology for estimating CoVaR.[5]

We measure our systemic risk by delta Conditional Value-at-Risk (CoVaR), which is the extended notion of value-at-risk (VaR) frequently and intensively used by financial institutions (Girardi and Ergün 2013, Adrian and Brunnermeier 2016, Lopez-Espinosa et al. 2012, Reboredo and Ugolini 2015, 2016).[6]

The CoVaR on financial system measures the maximal loss rate of the financial system conditional on the event that certain bank suffers severe losses beyond the VaR. The delta CoVaR is the systemic risk contribution of distressed banks, which is defined as the standardized difference of the CoVaR between the distress and the normal state. Intuitively, it captures the risk spillover effects from a distressed bank to the overall financial system. Following Girardi and Ergün (2013), the delta CoVaR of the j-th bank at date t is defined as

$$\Delta \text{CoVaR}_t^{Sj} = 100 \times (\text{CoVaR}_t^{Sj} - \text{CoVaR}_{B,t}^{Sj})/\text{CoVaR}_{B,t}^{Sj}, \tag{1}$$

where S denotes financial system, CoVaR_t^{Sj} is the CoVaR of the j-th bank in distress, $\text{CoVaR}_{B,t}^{Sj}$ is the CoVaR of the j-th bank in the bench mark state. The delta CoVaR repre-

[5]There are several estimation methods to calculate CoVaR. Adrian and Brunnermeier (2016) used quantile regression method, Girardi and Ergün (2013) used the maximum likelihood in DCC GARCH model, Reboredo and Ugolini (2015) proposed CoVaR-copula approach. Among them, we use the maximum likelihood method in DCC GARCH model.

[6]Many candidates exist for the systemic risk index. Acharya et al. (2017) propose the systemic expected shortfall (SES) and marginal expected shortfall (MES). Lopez et al. (2014) propose the CoMargin, which systematically adjusts collateral requirements on the basis of the CoVaR concept. Huang et al. (2009) propose the "distress insurance premium" indicator, which measures the expected portfolio loss above the total liabilities. Lehar (2005) proposes the systemic risk index on the assets and the number of banks measured as the probability of a systemic crisis. Billio et al. (2012) propose the interconnectedness measure using the principal component analysis. De Jonghe (2010) proposes tail-β measure using extreme value analysis. Each of these measures has advantages and disadvantages. The advantage of CoVaR is that it requires only stock price data. To save the space, we leave the more detailed overview of systemic risk to articles cited above.

sents the systemic risk contribution of the distressed bank relative to that of the benchmark state.

We employ daily data on equity prices from the Nikkei Needs Database. Book value data are collected from the EoL database and the Nikkei Needs Database. Our baseline regression equation is defined as

$$\Delta \text{CoVaR}_t^{Sj} = x_{jt}\beta + D_{jt}\theta + u_j + v_{jt}, \quad (2)$$

where x_{jt} is a vector of covariates for bank j on date t, u_j is an individual error term, and v_{jt} is an idiosyncratic error term. Following Adrian and Brunnermeier (2016) and Lopez-Espinosa et al. (2012), we examine volatility in the stock market (Tokyo Stock Exchange), the change in the 10-year JGB rate, two yield spreads, the stock market return (TOPIX), the call rate, and the reserves on the Bank of Japan account. In addition to these covariate variables, we include VaR, log of asset size, and leverage of each bank, following Girardi and Ergün (2013).

The vector of the dummy variable D_{jt} is the set of dummies corresponding to each regulatory interventions. This variable takes the value of 1 during the corresponding period of measures taken and 0 otherwise. The event period is 30 days, which starts from the event date of announcement.

3.2. An estimation methodology for CoVaR

The delta CoVaR is estimated in three steps. In the first step, we calculate the daily market return of bank assets using the option pricing formula. In the second step, we estimate the parameters of the bivariate normal distribution of returns for the financial system and each bank by multivariate GARCH model with dynamic conditional correlation (DCC).[7] In

[7]Alternative assumption instead of bivariate normal distribution is the bivariate skewed–t distribution GARCH of Bauwens and Laurent (2005). We selected the bivariate normal for the following two reasons. First, unlike VaR, CoVaR conditions on a bad event as shown in Eq. (1). CoVaR focuses on the tail distribution and is more extreme than the unconditional VaR (see the former version of Adrian and Brunnermeier

the third step, we estimate VaR, CoVaR, and delta CoVaR using the estimated parameters in the second step.

In the first step, we calculate market value of asset because the asset VaR is more relevant when we study the systemic risk. When we use equity VaR, the put option value of deposit insurance is ignored. Since regulator's intervention affects this put option value in various points, we use asset VaR instead of equity VaR. The specific procedure of the first step is as follows; The gross return of the bank j at date $t = (1, \cdots T)$ is defined as $R_{jt} = \ln P_{jt} - \ln P_{j,t-1}$, where P_{jt} is the stock price. We calculate market value of asset V_A and asset return X_{jt} on the daily basis using Black-Scholes-Merton formula (Merton 1974, 1977). [8] Asset return is defined as $X_{jt} = \ln V_{Ajt} - \ln V_{A,j,t-1}$. We also define the asset return of financial system as $X_{St} = \ln \sum_j V_{Ajt} - \ln \sum_j V_{Aj,t-1}$.

The second step is as follows; We assume that each pair of individual asset return and system return follows bivariate GARCH model with DCC, $X_t^j = \mu_t^j + \epsilon_t^j$, where $X_t^j = (X_{St}, X_{jt})'$ is the j-th pair of asset return vector, $\mu_t^j = \alpha_0^j + \alpha_1^j X_{t-1}^j$ is the conditional drift term, ϵ_t^j is the error term. This error term follows $\epsilon_t^j = (H_t^j)^{1/2} \nu_t^j$, where ν_t^j follows bivariate *i.i.d.* joint normal distribution $N(0, I)$. The conditional covariance matrix of ϵ_t^j defined as $H_t = E_{t-1}(\epsilon_t^j \epsilon_t^{j\prime})$ is decomposed into $H_t = D_t^{1/2} R_t D_t^{1/2}$, following Engle (2002). D_t is a diagonal matrix with element being conditional variance of j-th return σ_{jt}^2. R_t is time-varying correlation coefficient matrix with 1 on the diagonal and $\rho_{jS,t}$ off the diagonal.

The variance-covariance matrix of ϵ_t^j is modeled as $R_t = diag(Q_t)^{-1/2} Q_t \, diag(Q_t)^{-1/2}$ and $Q_t = (1 - \lambda_1 - \lambda_2)R + \lambda_1 \left(\hat{\epsilon}_{t-1}\hat{\epsilon}'_{t-1}\right) + \lambda_2 Q_{t-1}$. The typical element of Q_t is $q_{jS,t}$ satisfying

(2016)). Second, according to Adrian and Brunnermeier (2016), a bivariate diagonal Gaussian GARCH model produces CoVaR quite similar to the quantile regression method.

[8] Our method follows the approach used in Vassalou and Xing (2004). Define risk-free discount rate as r and the volatility of asset value as σ_A. The method consists of the following six steps. (1): we estimate σ_{Et}, standard deviation of $R_{j\tau}$ ($\tau = t - 250, \cdots, t$) for each t, (2): Substituting this σ_{Et} as initial value, we compute V_{At} using the formula for past 12 months, (3): We estimate σ_{At} using daily data V_{At} in (2) for the past 12 months, (4): Using σ_{At} in (3), compute V_{At} using the formula for the past 12 months, (5): We repeat (3) and (4) until σ_{At} from two consecutive iterations converge, (6): Using converged σ_{At}, compute daily V_{At} from the formula.

$\rho_{jS,t} = q_{jSt}/\sqrt{q_{jjt}q_{SSt}}$. $\hat{\epsilon}_{t-1}$ is the standardized error defined as $D_t^{-1/2}\epsilon_t$. R is quasi-correlation matrix. λ_1 and λ_2 are nonnegative parameters satisfying $0 \leq \lambda_1 + \lambda_2 < 1$. The estimates of μ_t^j and variance covariance matrix H_t are obtained by maximal likelihood estimation method.

The third step is as follows; The CoVaR is defined as

$$Pr\left(X_{St} \leq \text{CoVaR}_t^{Sj} \mid X_{jt} \leq \text{VaR}_t^j \right) = q \tag{3}$$

, where q is the confidence level. Following Girardi and Ergün (2013), this conditional bivariate normal probability is transformed into joint probability $Pr\left(X_{St} \leq \text{CoVaR}_t^{Sj}\ ,\ X_{jt} \leq \text{VaR}_t^j \right) = q^2$. The benchmark state is defined as the one sigma region around the conditional mean $\{\mu_{jt} - \sigma_{jt} \leq X_{jt} \leq \mu_{jt} + \sigma_{jt}\}$. The benchmark CoVaR is defined as

$$Pr\left(X_{St} \leq \text{CoVaR}_t^{BSj}\ ,\ \mu_{jt} - \sigma_{jt} \leq X_{jt} \leq \mu_{jt} + \sigma_{jt} \right) = p_t^j q \tag{4}$$

with p_t^j defined as $Pr\left(\mu_{jt} - \sigma_{jt} \leq X_{jt} \leq \mu_{jt} + \sigma_{jt} \right) = p_t^j$. Finally, delta CoVaR is defined as in Eq. (1).

3.3. Sample description

Our data sample includes listed banks during the period from April 1995 to March 2004. In December 2003, the last failure occurred during the Japanese financial crisis. Our observed period between 1995 and 2004 was the peak of Japanese financial crisis with the subsequent failures and continuous regulatory interventions were announced, therefore, it is meaningful to study systemic risk issue during this period.

In Table 1, we provide the orderly events of regulatory interventions taken by the regulator for our sample banks. These events are available in the annual report of the deposit insurance and are also documented in Shimizu (2009).

Table 1

4. Empirical analyses on systemic risk and regulatory interventions

4.1. Four types of regulatory interventions and systemic risk

Table 2 provides descriptive statistics for ΔCoVaR at the 5% tolerance level by year and type of regulatory interventions. The sample mean over the full period is 22.6%. The 5 and 95 percentiles are 7.3 and 50.2, respectively. The mean was the highest in 1997. The lower panel compares the summary statistics by type of interventions. The subsample mean of interventions is not statistically different from that of no interventions. Among each policy, only the subsample mean of FRS is significantly smaller than that of no interventions.

Table 2

Table 3 shows the estimation results of equation (2) in four specifications when four dummies are used. In these four specifications, we use restricted data where overlapping observations are dropped. [9] In model (i) and (ii), the fixed effects models are estimated and the heteroscedastic robust standard errors are reported. In model (iii), the estimates are OLS and the robust standard errors with respect to bank clustering are reported. As a robustness check to potential endogeneity issue, we estimate the regression equation by GMM in (iv).[10] From these four columns, the coefficients of PFI, PCA, and DIR are significantly

[9]There are events whose windows were overlapped. Since the numbers of overlapping dates are relatively small, we simply drop those observations. There are six days overlapping for PFI and PCA, five days for PFI and FRS, 31 days for PCA and FRS, three days for PCA and DIR, and 14 days for FRS and DIR. This appendix table is available upon request from the authors.

[10]The regulatory intervention is generally considered endogenous. To address this issue, we employ the instrument variables method of GMM. However, we should point out that the government did not observe the systemic risk which is the dependent variable, in the past of our sample. The government decides to

negative. The systemic risk contribution of the distress of a particular bank declines when the regulator announced PFI, PCA or DIR. In this respect, government capital infusions lower systemic risk through the provision of liquidity, tend to certify that the recipient banks are healthy and restore confidence. Under PCA announcement, the banks' quick reaction in response to regulatory announcement could avoid possible systemic disruption. DIR scheme also promotes financial stability. However, the coefficients of FRS are insignificant. The possible explanation put forward by Acharya and Yorulmazer (2008) is that it is not optimal to let surviving banks to purchase failed banks' assets when facing misallocation cost from liquidation. [11]

Table 3

Among the control variables, volatility, yield slope for long maturity, and log of assets have significantly positive impacts on ΔCoVaR. The coefficients for short maturity yield spread, VaR, call rate, and log of reserves are significantly negative. These signs are mostly consistent with the intuition and the results in Adrian and Brunnermeier (2011), Lopez-Espinosa et al. (2012), and Girardi and Ergün (2013). As a robustness check, we conducted year-by-year estimations, including daily time effects. [12] Although not reported, we found significantly negative coefficient for PFI in 1999, for PCA in 1999 and 2002, for FRS in 1996 and 2003, and for DIR in 1996 and 1998. This appendix table is available upon request from the authors.

take a policy, observing only the health of an individual bank. Hence, we considered that the endogeneity issue is weaker than the usual case where the government decides to intervene by examining the systemic risk (dependent variable). Nevertheless, this endogeneity issue may be an empirical limitation of our study if it exists.

[11]Frankly speaking, the government usually announced the failure and their rescue program simultaneously in Japan. This explains why the result of FRS is different from others. The market participants simultaneously received bad news that the bank failed and good news that the bank would be rescued.

[12]We are grateful for this suggestion made by an anonymous referee.

4.2. Individual measures of PFIs and systemic risk

The too-many-to-fail guarantees focus on a choice of a group of banks rather than individual choices that demonstrate individual too-big-to-fail policy. The fact that banks with different systemic impacts received guarantee or bailout at the same time casts doubt on the effectiveness of such a bailout policy. Among four policies, some PFI programs had multiple recipients. Therefore, it is interesting to investigate such heterogeneous effects of PFI to contrast the effectiveness of too-many-to-fail and individual too-big-to-fail policy.

Table 4 shows the fixed effects estimation results with heteroscedastic-robust standard errors when thirteen individual event dummies are used. There are five events where the recipients are multiple (#15, #22, #28, #32, #34). We group three events, #31, #32, and #33, into one event because their dates are very close. Seven PFI events have significantly negative impacts on the systemic risk contribution, consistent with the fact that the efficient government intervention can succeed if the government focuses on a small number of too-big-to-fail banks.

However, we find that event #15 fails to mitigate systemic risk, indicating that the government bailout policy had a drawback in practice. In this program, the fifteen largest banks that were considered relatively healthy but that had substantial influence over the systemic risk applied for the reinforcement of equity capital. [13] This result stresses the too-many-to-fail problem faced by the Japanese government that the massive bailout induces other banks to herd and increase the risk that many banks fail together.

Table 4

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[13]The recipients were Daiichi-Kangyo, Fuji, Industrial Bank of Japan, Sanwa, Tokai, Sumitomo, Sakura, Asahi, Daiwa, Yokohama, and five trust banks.

4.3. Spillover effect channels of the PFI

As suggested by Allen and Gale (2000), capital infusion has a direct spillover effect on the recipient and external effect on other banks, as shown in Figure 1. Direct spillover effect comes from the fact that capital infusion deters insolvency of the recipient directly whereas external effect arises because the capital infusion deters a contagion of recipient ’s failure to non-recipients. The contagion occurs because banks are interdependent through interbank market transactions (Eisenberg and Noe 2001). In addition, under the multiple lending relationships prevalent in Japan, the default of large borrower simultaneously damages multiple banks. Thus, when the government provides liquidity to the recipient, the external effect occurs between the financial system and non-recipients. It is argued that the results in the previous section can be driven by either direct spillover effect, external effect channels, or both. The last analysis, therefore, aims at detecting these two effect channels in PFI.

Figure 1

Table 5 reports the results. In the first two columns, the recipient dummy c_{jt} which takes the value of 1 if j-th bank is the recipient of capital injection program and 0 otherwise is added to equation (2). This dummy measures the liquidity provision/capital infusion effect, which is a direct spillover specific to the recipient. The non-recipient dummy D_{jt} measures an external spillover effect common to all banks. In the last two columns, we disentangle the event #15 from other PFI events by using dummies specific to this event in the model.

Table 5

According to the column (i) and (ii) of Table 5, we find that the direct spillover effect of PFI is significantly positive whereas external effect is significantly negative; indicating that liquidity provision of PFI enhances financial stability via the external effect channel decreasing a probability of runs, but not via the direct channel.

However, regarding the largest injection program (#15), both coefficients for the direct and external spillover are significantly positive, consistent with the view that a complete guaranteed bailout generated moral hazard. A surge in the systemic risk of these rescued banks triggered an overall increase in systemic risk of their counterparts. This result provides a deeper understanding for our finding in the previous section that #15 event was different from other rescue packages of PFI in terms of the too-many-to-fail problem due to its direct and external spillover effect channels. Our evidence strengthens the fact that PFI bailout of fifteen unhealthy banks was beyond the adequacy of regulatory interventions in Japan.

5. Conclusion

In summary, our analyses mostly provide supportive evidence for the liquidity provision/capital infusion by the government. The results are summarized as follows: (i) the three types of regulatory interventions (PFI, PCA and DIR) played an important role in stabilizing systemic risk during the Japanese financial crisis, (ii) seven individual PFI events have mitigated systemic risk while one largest PFI event failed, (iii) PFI mostly had a positive direct spillover effect, but a negative external effect, (iv) however, the largest PFI event had a positive direct/external spillover effect.

Our paper provides the regulators with the following policy implications. Regarding the result (i), we should take into account its costs. The bottom line is whether the amount 25 trillion yen that the government paid was worth the price of mitigating systemic risk or not.

The result (ii) warns the way how to provide liquidity to the banks during the financial crisis. Given too–big–to–fail concern, the government has to decide at least the timing of liquidity provision, the amount of liquidity provided, and the number of banks that the government provides liquidity. This result has a policy implication that the efficient government intervention can succeed if the government focuses on a small number of too-big-to-fail banks. In other words, the massive bailout induces other banks to herd and increase the risk that many banks fail together.

The third result means that the PFI works through decreasing a probability of bank runs rather than through directly decreasing a probability of default of the PFI recipients. Therefore, this result has an implication that the government should care how to manage a surge in the direct spillover effect that ameliorates the systemic risk contribution of the recipient bank when it provides the liquidity. Practically, this implies that the government needs devices other than PFI just when it decides to provide liquidity to the recipient.

Basel III revisions proposed the reforms to ensure that all classes of capital instruments fully absorb losses at the point of non-viability before taxpayers are exposed to loss. Non-viability becomes a trigger event of a written off of non-common Tier 1 and Tier 2 instruments. Although such a scheme will protect taxpayers' money, it is uncertain whether such a scheme contributes to stabilizing a financial system. Our analyses suggest that it is necessary for the government to aim at calming down systemic risk by a simple regulatory policy rather than at rescuing all distressed bank.

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Appendix A

Table A1

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Table 1: Events of regulatory interventions during financial crisis in Japan

Event id	Year	Event date	Category	Institutions	Notes
1	1995	19950830	FRS	Regional bank (Hyogo)	
2	1996	19960330	FRS	Regional bank (Taiheyo)	
3		19960619	DIR		Special assistance (Blanket guarantee), Special insurance fee, Repurchase of deposittory claims
4		19961121	FRS	Regional bank (Hanwa)	Order of suspending operation
5	1997	19970906	FRS	City bank (Hokkaido Takushoku)	Merger cancellation
6		19971009	FRS	Regional bank (Fukutoku and Naniwa)	Merger
7		19971014	FRS	Regional bank (Kyoto Kyoei)	Operation transderred
8		19971117	FRS	City bank (Hokkaido Takushoku)	
9		19971126	FRS	Regional bank (Tokuyo City)	
10		19971213	DIR		Assistance for special merger
11	1998	19980515	FRS	Regional bank (Hanshin Midori)	Merger
12		19981003	DIR		Receiver, bridge bank, and special public management (temporary nationalization)
13		19981023	FRS	Long-term bank (Long-Term Credit Bank of Japan)	Nationalized
14		19981212	FRS	Long-term bank (Nippon Credit Bank)	Nationalized
15	1999	19990313	PFI	fifteen institutions	
16		19990408	FRS	Regional bank (Kokumin)	
17		19990412	PCA	Regional bank (Kofuku)	
18		19990522	PCA	Regional bank (Hokkaido)	
19		19990601	PCA	Regional bank (Tokyo Sowa)	
20		19990629	PCA	Regional bank (Namihaya)	

Table 1 (Continued)

Event id	Year	Event date	Category	Institutions	Notes
21		19990705	PCA	Regional bank (Niigata Chuo)	
22		19990914	PFI	four institutions	
23		19991126	PFI	Regional bank (Kumamoto Family)	
24	2000	20000210	PFI	Long-term bank (Long-Term Credit Bank of Japan)	
25		20000225	PFI	Regional bank (Hokkaido)	
26		20000428	PCA	Regional bank (Chiba Kogyo)	
27		20000524	DIR		Extending the period of blanket guarantee
28		20000901	PFI	two Regional banks (Chiba Kogyo, Yachiyo)	
29		20000906	PFI	Long-term bank (Nippon Credit Bank)	
30		20000928	PCA	Regional bank (Senshu)	
31	2001	20010302	PFI	Regional bank (Kansai Sawayaka)	
32		20010309	PFI	two Regional banks (Kinki Osaka, Higashi Nihon)	
33		20010323	PFI	Regional bank (Gifu)	
34		20011127	PFI	three Regional banks (Fukuoka City, Kyushu, Wakayama)	
35		20011228	FRS	Regional bank (Ishikawa)	
36	2002	20020104	PCA	Regional bank (Chubu)	
37		20021212	DIR		Blanket guarantee of account for settlement
38	2003	20030220	FRS	Regional bank (Chubu)	
39		20030401	PFI	Regional bank (Kanto Tsukuba)	
40		20030517	FRS	City bank (Resona)	Nationalized
41		20030611	PFI	City bank (Resona)	
42		20031206	FRS	Regional bank (Ashikaga)	Nationalized

(Note): PFI (public fund injection program), PCA (prompt corrective action), FRS (failure resolution scheme), DIR(deposit insurance act reform). Sample period : Apr. 3rd, 1995-Mar. 31, 2004. Event day is identified by Nikkei Shimbun. (Source): Annual report of Deposit Insurance Corporation in Japan.

Table 2: Summary statistics of delta CoVaR

				Cross sectional average of Delta CoVaR for each year						
Year	Mean		S.D.	5%		Median		95%		Number of days
1995	23.5		6.4	15.5		22.8		35.4		81
1996	26.9		18.1	12.2		23.6		45.8		244
1997	43.7		24.2	18.3		36.2		95.4		242
1998	27.7		11.9	14.8		25.4		48.0		244
1999	16.3		16.4	-8.9		16.0		45.3		242
2000	24.5		16.7	7.5		21.3		61.1		245
2001	18.4		12.7	5.1		16.2		45.2		243
2002	21.2		23.7	2.9		15.8		70.7		243
2003	9.7		7.1	0.3		8.6		21.6		242
2004	14.3		7.3	5.6		13.1		33.0		58
Full sample period	22.6		14.4	7.3		19.9		50.2		208.4
Regulatory interventions	Mean		S.D.	5%		Median		95%		Number of days
None	23.2		19.5	4.5		18.9		61.374		1641
Four types	23.6		17.5	-2.4	***	22.4	***	47.934	**	443
PFI (public fund injection)	30.0		17.2	13.4	**	26.8		52.211		188
PCA (prompt corrective action)	26.6	***	7.9	17.2	***	23.9	***	41.329		77
FRS (failure resolution scheme)	20.2	***	14.8	7.8	***	15.8	***	45.149		110
DIR (deposit insurance reform)	8.1		19.7	-13.1	***	1.4	***	45.647		68

(Note) Sample period : Apr. 3, 1995- Mar. 31, 2004. Table shows mean, standard deviation (S.D.), 5 percentile, median, 95 percentile. Number of days is on operating basis. The results of significance test on the difference of means, 5%, 50%, and 95% are reported. *, **, *** denotes the significance level of 10%, 5%, 1%, respectively.

Table 3 : Delta CoVaR and four types of regulatory interventions: Panel data estimation

Dep. Var.	Delta CoVaR			
Model	(i) fixed effects	(ii) fixed effects	(iii) OLS (clustering robust)	(iv) GMM
Regulatory intervention variables				
PFI (public fund injection)	-4.860***	-6.473***	-6.621***	-4.662***
	(1.164)	(1.221)	(1.232)	(0.903)
PCA (prompt corrective action)	-17.276***	-18.564***	-19.027***	-15.149***
	(3.261)	(3.636)	(3.691)	(1.535)
FRS (failure resolution scheme)	-0.952	-0.570	-0.424	-2.419
	(0.957)	(1.129)	(1.186)	(1.885)
DIR (deposit insurance reform)	-2.482*	-3.567**	-3.467**	-3.344***
	(1.399)	(1.615)	(1.615)	(1.185)
Market variables				
Volatility	5.460***	4.550***	4.489***	4.241***
	(0.769)	(0.899)	(0.907)	(0.405)
Change in JGB rate	-11.475	-1.702	-1.668	
	(8.150)	(2.794)	(2.693)	
Yield spread (Long)	4.487***	4.451***	5.725**	
	(0.967)	(1.408)	(2.466)	
Yield spread (Short)	-1.891	-9.297**	-8.787**	
	(3.158)	(3.734)	(4.175)	
Market return	13.257	10.753	11.970	
	(8.342)	(8.800)	(9.002)	
Call rate		-7.320***	-6.227*	
		(2.630)	(3.214)	
Log of Reserve		-5.033***	-4.719***	
		(1.279)	(1.257)	
Bank variables				
VaR		-99.140***	-127.623***	
		(25.880)	(29.763)	
Log of asset		19.070	11.653***	22.430***
		(13.013)	(2.111)	(2.371)
Leverage		41.778	75.869	
		(51.611)	(83.625)	
Constant	10.741***	-261.787	-186.484**	-323.5985***
	(2.016)	(206.097)	(87.200)	(35.827)
Observations	134,485	106,617	106,617	106,617
Number of bank	80	63	63	63
R-squared (within)	0.007	0.014	0.065	
F (zero coeffs)	19.09	12.36	22.48	
p-value	0.000	0.000	0.000	
Hausman test	23.79	71.87		
p-value	0.005	0.000		
Overidentifying restriction tests				61.3422
p-value				0.29

(Notes) This table reports the empirical analysis of four regulatory interventions on systemic risk. The fixed effects panel data models are estimated in model (i) and (ii). Robust standard errors are reported in parentheses. In model (iii), the OLS estimate with bank clustering-robust standard error are reported. In model (iv), GMM estimates are reported. Systemic risk is measured by delta CoVaR. Four interventions are PFI (public fund injection program), PCA (prompt corrective action), FRS (failure resolution scheme), DIR(deposit insurance act reform). Market variables are volatility in the stock market (Tokyo Stock Exchange), the change in the 10-year JGB rate, the short-maturity yield spread between the overnight call rate and the three-month CD rate, the long-maturity yield spread between the three-month CD rate and the 10-year JGB rate, the market return (TOPIX), the call rate, and the reserves on the Bank of Japan account.. Bank-specific variables are VaR, log of asset size, and leverage of each bank. *, **, or *** denotes 10%, 5%, 1% significance level, respectively.

Table 4 :Delta CoVaR and individual PFIs

Dep. Var.: Delta CoVaR

Event / Var.	Coef.	Event / Var.	Coef.
15	9.932***	Volatility	3.486***
	(3.500)		(0.908)
22	-18.664***	Change in jgb rate	-3.983
	(3.070)		(2.989)
23	-5.162**	Yield spread (Long)	3.583**
	(1.955)		(1.494)
24	-1.773	Yield spread (Short)	-13.158***
	(2.495)		(4.348)
25	-17.045***	Market return	11.545
	(2.648)		(7.367)
28	-7.267	VaR	-95.178***
	(4.689)		(24.827)
29	-8.023**	Log of asset	20.270
	(3.239)		(13.379)
31, 32, 33	0.300	Leverage	32.410
	(4.060)		(53.450)
34	-8.357***	Call rate	-6.308**
	(1.974)		(2.477)
39	-6.281***	Reserve	-4.738***
	(2.278)		(1.350)
41	-6.223***	Constant	-271.831
	(1.377)		(209.141)
		Observations	106,617
		R squared	0.024
		F (zero coeffs)	24.97
		p-value	0.000

(Notes) This table presents the fixed effects panel estimation of individual packages on systemic risk. Systemic risk is measured by delta CoVaR. Individual packages in PFI (public fund injection program) can be found in Table 1. Market variables are volatility in the stock market (Tokyo Stock Exchange), the change in the 10-year JGB rate, the short-maturity yield spread between the overnight call rate and the three-month CD rate, the long-maturity yield spread between the three-month CD rate and the 10-year JGB rate, the market return (TOPIX), the call rate, and the reserves on the Bank of Japan account. Bank-specific variables are VaR, log of asset size, and leverage of each bank. Reported in parentheses are heteroscedastic-robust standard errors. *, **, or *** denotes 10%, 5%, 1% significance level, respectively.

Table 5 : Delta CoVaR and direct/external spillover effect channels

Dep. Var.	Delta CoVaR			
Model	(i) fixed effects	(ii) OLS (clustering robust)	(iii) fixed effects	(iv) OLS (clustering robust)
Regulatory intervention variables				
PFI non-recipient dummy	-9.880***	-10.01***	-12.816***	-12.84***
	(1.755)	(1.769)	(1.793)	(1.809)
PFI recipient dummy	17.993**	14.62*	1.260	-4.973
	(7.262)	(7.318)	(3.611)	(5.939)
#15 non-recipient dummy			7.118*	6.285*
			(3.717)	(3.734)
#15 recipient dummy			17.703**	17.73**
			(8.542)	(8.271)
Market variables				
Volatility	3.761***	3.676***	3.762***	3.677***
	(0.869)	(0.856)	(0.869)	(0.855)
Change in JGB rate	-5.573*	-5.598*	-4.190	-4.227
	(2.972)	(2.942)	(2.948)	(2.921)
Yield spread (Long)	3.543**	4.960*	3.279**	4.697*
	(1.445)	(2.617)	(1.445)	(2.623)
Yield spread (Short)	-13.655***	-13.14***	-14.770***	-14.28***
	(4.270)	(4.740)	(4.272)	(4.761)
Market return	17.346**	18.23**	11.215	12.16
	(7.206)	(7.336)	(7.226)	(7.367)
Call rate	-6.414**	-5.239	-5.954**	-4.797
	(2.580)	(3.175)	(2.611)	(3.191)
Log of Reserve	-5.277***	-4.950***	-5.296***	-4.981***
	(1.368)	(1.349)	(1.366)	(1.348)
Bank variables				
VaR	-96.994***	-125.6***	-95.239***	-123.9***
	(25.123)	(28.97)	(24.581)	(28.51)
Log of asset	20.894	11.66***	20.716	11.61***
	(13.333)	(2.107)	(13.358)	(2.117)
Leverage	35.577	73.72	34.486	73.67
	(52.941)	(84.36)	(52.476)	(84.40)
Constant	-278.836	-180.0**	-274.443	-178.5**
	(209.970)	(88.39)	(210.633)	(88.54)
Observations	106,617	106,617	106,617	106,617
Number of bank	63	63	63	63
R-squared (within)	0.023	0.072	0.024	0.073
F (zero coeffs)	15.28	51.7	24.68	93.2
p-value	0.000	0.000	0.000	0.00
Hausman test	150.66		146.19	
p-value	0.000		0.000	
Overidentifying restriction tests				
p-value				

(Notes) This table reports the empirical analysis of the direct and external spillover effect channels of PFI (public fund injection program) on systemic risk. Systemic risk is measured by delta CoVaR. The fixed effects panel data models with heteroscedastic-robust standard errors are estimated in model (i) and (iii), OLS model with bank clustering-robust standard erroris in (ii) and (iv). Market variables are volatility in the stock market (Tokyo Stock Exchange), the change in the 10-year JGB rate, the short-maturity yield spread between the overnight call rate and the three-month CD rate, the long-maturity yield spread between the three-month CD rate and the 10-year JGB rate, the market return (TOPIX), the call rate, and the reserves on the Bank of Japan account. Bank-specific variables are VaR, log of asset size, and leverage of each bank. Robust-standard errors are reported in parentheses. *, **, or *** denotes 10%, 5%, 1% significance level, respectively.

Table A1: Summary statistics

	Variables	Mean	Std. Dev.
Market variables			
	Volatility	1.181	-0.535
	Change in JGB rate	-0.001	-0.038
	Yield spread (Long)	1.519	-0.568
	Yield spread (Short)	0.101	-0.129
	Market return	-0.00009	-0.013
	Call rate	0.210	-0.269
	Log of Reserve	10.970	-0.719
Bank variables			
	VaR	-0.005	-0.021
	Log of asset	15.280	-0.981
	Leverage	0.952	-0.022
Observations		111,784	

Definition of variables: Volalitility: return standard deviation in the stock market (Tokyo Stock Exchange), Change in JGB rate: the change in the 10-year Japanese Government Bonds rate, Yield spread(short): the short-maturity yield spread between the overnight call rate and the three-month CD rate, Yield spread (Long): the long-maturity yield spread between the three-month CD rate and the 10-year JGB rate, Market return: TOPIX return, VaR: value-at-risk of each bank, Log of asset: Book asset value of each bank, Leverage: leverage of each bank. Call rate: interbank rate (one day), Log of reserves: log of aggregate reserve on the Bank of Japan account.

Figure 1: Direct spillover effect and external effect