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Competition and Bank Systemic Risk: New Evidence from Japan's Regional Banking

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Abstract

Bank competition and financial stability is a recurrent research issue, and researchers have begun to shed light on the competition effect on systemic-risk. Japan is an interesting case in this venue since its regional banking system has confronted intensified competition and there is growing evidence that the competition has led the portfolio of Japan's regional banks to be more overlapped, an indication of increased systemic risk. In this paper, we first examine the empirical relationship between competition and systemic-risk for Japan's regional banks. We find that the bank mark-up is negatively associated with the level of systemic risk, indicating that competition undermines the system-wide financial stability in Japan. However, this result is at odds with existing studies. To this end, we perform a theoretical analysis focusing on bank's portfolio diversification. We demonstrate that Japan's regional banks tend to diversify toward alternative lending when the profitability of the core business declines. This diversification results in the build-up of systemic risk through higher common exposure, a form of indirect interconnectedness.

JEL classification: G11; G21; L51
keywords: competition, mark-up, systemic-risk, indirect interconnectedness.

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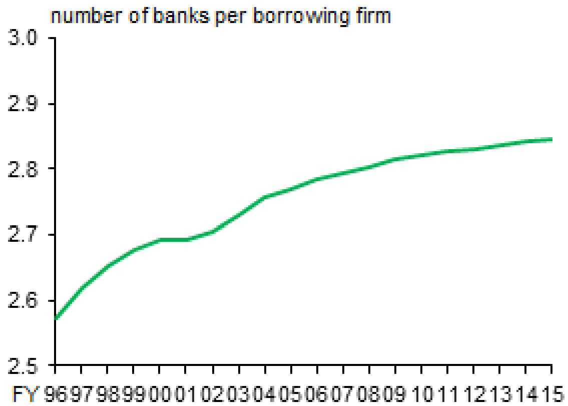
Figure 1: Average number of banks that each borrowing firm transact with



This figure displays the average number of banks that a given corporate borrower transacts with. It covers approximately 450 thousand firms for which data for entire observation period are available from fiscal year 1996.
Source: *The Financial System Report, October 2017,* the Bank of Japan and Teikoku Databank.

1 Introduction

The impact of competition on financial stability has drawn attention globally. For example, De Nicoló et al. (2012) and the International Monetary Fund (2013) discuss several channels through which competition destabilizes financial systems. One argument in these papers is that the relaxation of licensing and branching restriction, a pro-competitive policy, can lead to an erosion of lending standards because tougher competition and lower monopoly rent reduce bank's incentive to monitor borrowers. On this account, the IMF calls for the involvement of macroprudential authorities in designing and implementing competition policies to secure financial stability.

The competition-stability nexus is also a relevant topic in Japan. There has been a structural decline in traditional loan demand as population and the number of firms decreased in Japan. At the same instance, the non-financial corporates became net creditors, due in part to scarcity in profitable investment opportunities under low growth. On the contrary, the number of banks in Japan has more or less remained flat in past ten years, and cutbacks in bank branches lagged behind the contraction in customer base. As a result, competition in the banking sector has intensified, which is witnessed by an increase in the number of banks that lend to a given borrower. (See Figure 1.)

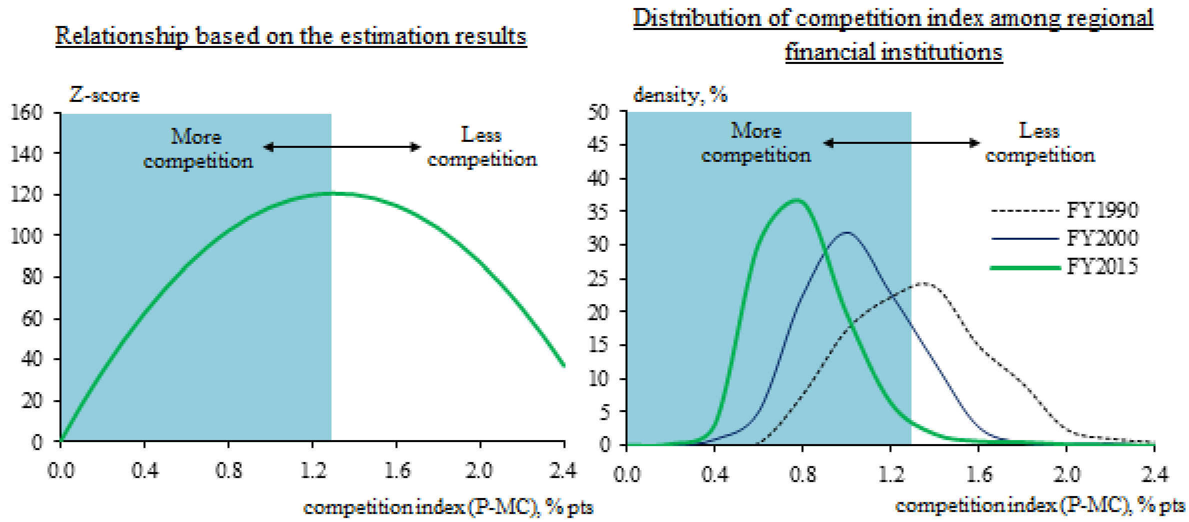
Researchers are not ignorant about this area of research.[1] In Japan, the Bank of Japan (2017a) and Ojima (2017) show that the relationship between bank competition and bank stability is non-linear, and has an inverse U-shaped form as shown in the left panel of Figure 2. Furthermore, they finds that the competition-stability paradigm, under which tougher competition fosters financial stability, applies to Japan's regional banking system in the early 1990s before the regime shifts to the competition-fragility paradigm in the 2000s, under which competition undermines financial stability. However, their novel finding does not fully answer whether the fragility in recent years is a microprudential or a macroprudential issue. She focuses on the impact of competition on Z-score, a measure of stand-alone bank stability, hence it remains to answer whether competition poses significant threats to the stability of the entire financial system.

In this paper, we examine the relationship between competition and systemic risk taking the case of Japan's regional banking system. More precisely, the focus of this paper goes beyond the impact of competition on stand-alone bank stability, and we perform an empirical analysis on the relationship between the banks' mark-up and CoVaR, a systemic risk measure developed by Adrian and Brunnermeier (2016). Then we discuss our empirical result by constructing a stylized model of portfolio choice *a la* Wagner (2010), focusing on banks' diversification motive and resulting change in the overlap of portfolios between banks.

Systemic risk can arise from market failures which are often time associated with negative externalities given constraints in the operational environment of financial industry.

[1]See section 2 for literature review.

Figure 2: Competition and individual bank stability in Japan



The left panel displays the empirical relationship between the level of mark-up and Z-score for Japan's regional banks. The right panel displays the probability density of Japan's regional banks with respect to their mark-up. The density at FY1990, FY2000 and FY2015 is drawn separately.
Source: *The Financial System Report, April 2017,* the Bank of Japan.

One such a channel is the externality associated with interconnectedness between banks.[2] Interconnectedness in the banking industry arises when banks directly lend to and borrow from each other, and also when banks are exposed to the same type of risks. These can give rise to the spillover of the distress of one bank to another.

The interconnectedness in the form of common exposure, in other words indirect interconnectedness, is particularly a relevant phenomenon in Japan's regional banking system. In an effort to expand customer base and secure profits under intensified competition, regional banks in Japan have simultaneously increased lending to somewhat risky firms.[3] Importantly, many banks tend to herd in similar borrower classes in terms of geography and risk, a potential indication of increased indirect interconnectedness.

[2]This is articulated in De Nicoló et al. (2012) and the European Systemic Risk Board (2013). They also raise other types of externalities that give rise to systemic risk: fire-sale externalities and strategic complementarities.

[3]The Bank of Japan's *The Financial System Report* (2018a, 2018b) define those risky borrowers as "low-return borrowers."

The novel finding of this paper is that we apply the same empirical approach as Anginer et al. (2014), Leroy and Lucotte (2017) and Silva-Buston (2016), and yet find the opposite result to what was reported in the existing studies: we find that lower mark-up (tougher competition) is associated with higher level of systemic risk, indicating that competition destabilizes the financial system. Furthermore, our empirical strategy is designed to detect whether the competition affects systemic risk via shifts in the stand-alone risk of the banks, or in the comovement of the risk between banks. In this regard, we find a statistically significant impact of competition on the comovement of the risk. This finding is consistent with the maintained hypothesis in this paper, that is regional banks in Japan have increased common exposures when they faced tougher competition.

Several forms of common exposure can explain the build-up of the systemic risk in Japan. Hirakata et al. (2017) carefully examines the effect of common exposure to securities on the systemic risk. They find a bank that increases securities holdings contributes to the build-up of systemic risks in Japan, especially when other banks in the system are also highly exposed to them. We control this market exposure channel as they do, and still find the mark-up has an independent effect on systemic risk. We conjecture there are other risk taking channels through which competition affects the level of systemic risk, and our preferred explanation is the common exposure to credit risk which occurs through overlaps in lending portfolio. This is the same spirit as articulated in Cai et al. (2018) which examines the impact of the overlaps of syndicated loan portfolio on systemic risk.

Our paper goes one step further to provide potential explanation for the difference in empirical evidence between this paper and the existing studies, for example Leroy and Lucotte (2017) and Silva-Buston (2016) which utilize the data for large European banks. We perform an theoretical study built on Wagner (2010), focusing on the portfolio diversification effect on indirect interconnectedness. The main argument of Wagner is diversification, while mitigating the risk of individual failure, can give rise to an increase in the risk of joint failure due to the overlap in portfolio. We make one tweak to Wagner's model to account for the difference in the business model between regional banks in Japan and large European banks. A key parameter in our model is the degree of synergies/costs associated with portfolio diversification embedded in the business model of the banks in respective regions. We argue that synergies of pursuing different lending opportunities have been relatively limited for Japan's regional banks, and those banks are willing to diversify only when their core business becomes unprofitable. This indicates that common exposure is likely to develop when competition intensifies and when bank profitability declines.

The remaining structure of this paper is as follows. Section 2 offers a literature review on the relationship between competition and bank stability. Section 3 describes the sample and the data construction employed in our empirical analysis. Section 4 presents the empirical result. Section 5 establishes a theoretical model of Japan's regional banking and discusses our empirical result in conjunction with the model. Section 6 concludes.

2 Literature Review

Much of existing literature articulates the impact of competition on stability indices at individual banks level. From theoretical view point, the literature is divided into the competition-fragility view emphasizing the franchise value paradigm, and the competition-stability view emphasizing borrowers' risk-shifting behavior in response to changes in the level of competition. Jiménez et al. (2013) offers an excellent review of the literature, but we reiterate the argument first in this section.

The competition-fragility view stresses that the bank would take greater risks when their franchise value brought by monopoly rent is eroded due to competition, and this would lead to greater bank instability. The view is originally proposed by Marcus (1984), and re-established by Chan et al. (1986), Keeley (1990) and Allen and Gale (2004) under with or without government regulation.

In contrast, the competition-stability view emphasizes that borrowers' risk-shifting behavior in response to the changes in lending rates. Boyd and De Nicoló (2005) shows that a decline in lending rates as a result of competition alleviates the moral hazard problem of borrowers in that they shift to riskier projects when, on the contrary, interest charged rises under imperfect monitoring. This leads to lower credit risk for banks, resulting in bank stability.

Early empirical studies present mixed evidence on the relevance of the two conflicting view. Keeley (1990) and Saunders and Wilson (1996) support the competition-fragility view using U.S. banking data, and Salas and Saurina (2003) confirms this result using Spanish banking data. On the other hand, Boyd et al. (2006) presents evidence that supports the competition-stability view using the cross-sectional U.S. bank data and the panel data for 134 non-Western countries.

More recent studies reexamine the empirical relevance of the two conflicting views under the assumption that the both effects coexist, and that there can be non-linear relationship between the level of competition and bank risks. Berger et al. (2009), Jiménez et al. (2013) and Ojima (2017) test an inverse U-shaped relationship between competition and bank stability, and find that such a nonlinear relationship does exist. Ojima (2017), using Japan's regional banking data from fiscal year 1982 through 2015, finds that the competition-stability paradigm applies to the earlier years of the sample while the competition-fragility paradigm applies to more recent years when competition become more fierce.

The papers listed above mainly provide predictions on the effect of competition on the stability at individual bank level. However, the Global Financial Crisis of 2007-09 poses a renewed question regarding the effect of competition on the system-wide financial stability. For example, IMF (2013) lays out an argument that the competition-stability trade-off requires macroprudential consideration, illustrating that competition policies have the potential of creating system-wide instability including too-big-to-fail problems led by merger and acquisitions, and aggressive risk taking of local banks induced by the entry of foreign banking organizations.

From theoretical view point, Acharya and Yorulmazer (2007) and Wagner (2010) shed light on bank's herding incentive with or without government intervention, and show that systemic risks develop when such an incentive is present. Acharya and Yorulmazer (2007) focuses on government's ex-post optimal behavior when a numerous banks are failing. They show that governments may have an ex-post incentive to bail out failing banks as the mass bank failures incur enormous social costs. Recognizing this government's incentive, banks become ex-ante more risky in the sense that they are more likely to fail jointly. They call it a "too-many-to-fail" problem. Wagner (2010) shows a similar result without devising government intervention. Building on a portfolio diversification problem with the possibility of default, he shows that banks are prone to hold a socially inefficient level of common exposure that raises the possibility of systemic events (joint defaults). He claims that the failure of a bank in taking into account the impact of its portfolio choice on the risks of competing banks leads to the excess diversification that results in the increase in common exposure.

A few recent studies address the impact of competition on the systemic risk empirically. Anginer et al. (2014), utilizing bank data for 63 countries over 1997-2009, and Leroy and Lucotte (2017), utilizing data for listed banks in Europe over 2004-2013, estimate the relationship between the newly developed systemic risk measures, such as CoVaR or SRISK[4], and the Lerner index, a representative measure of pricing power. These studies

[4] CoVaR is developed by Adrian and Brunnermeier (2016) and SRISK is developed by Acharya et al. (2012)

find the positive relationship between the mark-up and systemic risk. In other words, they find evidence that competition enhances the stability of financial system.

In explaining the empirical result, Leroy and Lucotte (2017) suggests that banks' common exposure is likely to play a role, siting the above mentioned theoretical studies. The notion of common exposure catches the attention of policy practitioners as well. For example, Bernanke (2010) states that the Federal Reserve is making effort to capture "*concentrations of risk that may arise through common exposures or sensitivity to common shocks*."

Echoing this argument, empirical studies on the relationship between systemic risk and common market factors have emerged recently. Brunnermeier et al. (2012) finds that banks with higher non-interest income accrued from market-oriented business have a larger contribution to systemic risk. Similarly, Hirakata et al. (2017), using the Japan's regional banking data, finds that banks with larger exposure to common market factors have larger contributions to systemic risk. These two papers display that banks' exposures to common market factors are likely to play a key role in the development of systemic risk.

The relevance of common exposure on the effect of systemic risk is not limited to market-oriented factors. Cai et al. (2018), using data on syndicated loans originated for U.S. firms, shows that banks have a high propensity to hold common exposure in the bank loans as well. Moreover, they find that the interconnectedness measures based on the level of common exposure in syndicated loans are positively correlated with the level of systemic risk.

3 Data and Empirical Methodology

This section documents the data and the empirical methodology employed in our study. Our sample covers 56 listed regional banks in Japan for which stock price data are available from fiscal year 1996 through 2017. These banks have no record of merger and acquisition during this period, thus there is neither discontinuities nor discrete jumps in stock prices arising from changes in corporate structure. We obtain detailed accounting data for Japan's regional banks from the Bank of Japan's supervisory data. Finally, we obtain a small set of macroeconomic control variables including output gap from either the Bank of Japan or Bloomberg. We summarize the data used in our empirical analysis in Appendix B.

3.1 Systemic risk measures

We first compute CoVaR using daily stock returns of individual banks and the regional banking system.[5] CoVaR, developed by Adrian and Brunnermeier (2016), is a widely employed systemic risk measure in financial research, and it measures the systemic risk that comoves with the risk of individual banks. Adrian and Brunnermeier (2016) proposes an estimate of CoVaR by applying quantile regression of $Y_{sys,t}$, the stock returns of the regional banking system at time t, on $Y_{i,t}$, the stock return of individual bank i, controlling for a number of state variables, M_t. We use TOPIX stock return as a state variable following Hirakata et al. (2017):[6]

$$Y^q_{sys,t} = \alpha^q_{sys|i} + \delta^q_{sys|i} Y_{i,t} + \gamma^q_{sys|i} M_t, \tag{1}$$

[5] The stock return of the regional banking system is the stock market value weighted average of individual bank's stock returns.

[6] As for the selection of the state variable, adding state variables does not have major impacts on the measurement of CoVaR.

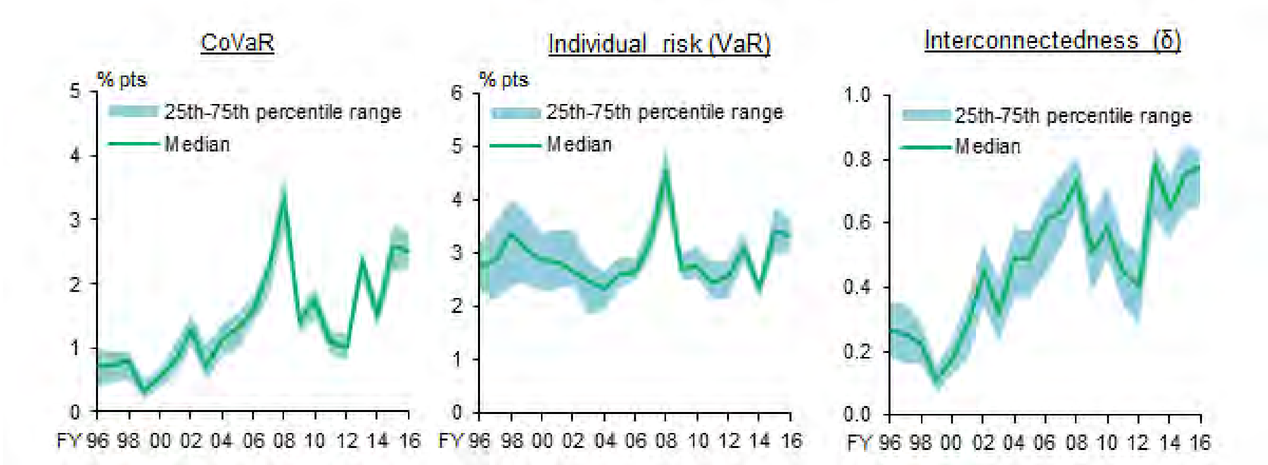
where $\alpha^q_{sys|i}$, $\delta^q_{sys|i}$ and $\gamma^q_{sys|i}$ are the parameters that gauge the impact of bank-specific and state variables on the q percent quantile of the aggregate bank stock return. In our case, we estimate the impact at the fifth quantile. Then we compute ΔCoVaR which is the distance between the aggregate loss of the banking system when bank i's loss is at the fifth quantile and that when bank i's loss is at the median state:

$$\Delta CoVaR^q_{i,t} = \delta^q_{sys|i}\left(VaR^q_{i,t} - VaR^{50}_{i,t}\right). \tag{2}$$

As we can see from (2), $\Delta CoVaR^q_{i,t}$ can be divided into the magnitude of the individual bank's risk, $VaR^q_{i,t} - VaR^{50}_{i,t} \equiv \Delta VaR^q_{i,t}$, and the correlation of the risk between individual bank and the aggregate banking system, $\delta^q_{sys|i}$. This correlation can be interpreted as the degree of interconnectedness either in the form of direct linkage (*e.g.* lending and borrowing in the interbank markets) or indirect interconnectedness (*e.g.* common exposure).

Figure 3 displays the time series of the median value and the interquartile range for $\Delta CoVaR^5_{i,t}$ and its components for 56 regional banks in Japan. We compute the predicted value of an aggregate regional bank loss conditional on the given loss of bank i for the fifth percentile, $q = 5$. There are significant time variations in $\Delta CoVaR$, yet it exhibits general an upward trend. Looking at the components, the interconnectedness parameter δ exhibits a clearer upward trend over time, whereas the individual risk component has remained relatively flat except for one-time spike at the height of the global financial crisis. This clear upward trend in the interconnectedness parameter is likely to be driven by the increase in the common exposure of Japan's regional banks, as articulated in Bank of Japan (2017b) and Hirakata et al. (2017).

Figure 3: $\Delta CoVaR$ and its components



This figure displays the estimated $\Delta CoVaR$ and its component at 5th percentile: individual VaR and the interconnectedness parameter (δ) for 56 regional banks in Japan over fiscal year 1996-2016. The solid line represents median and the shaded area represents interquartile range.

3.2 Mark-up measure

A large body of literature on bank competition uses the Lerner index as the measure of mark-up. It is defined as the difference between the output price, p, and the marginal cost, mc, of banking divided by the output price:

$$lerner = \frac{p - mc}{p}.$$

The Lerner index can be interpreted as a theoretical measure of mark-up that coincides with the inverse of the elasticity of substitution in demand. This has been the rationale of using the Lerner index as the measure of competition since it takes into account the demand structure and the cost structure specific to individual banks. However, in order to relate the Lerner index with the theoretical mark-up, we must assume a restrictive form of demand function: the elasticity of substitution is constant at all prices. This implies, for example, a decline in loan interest rates from 10 percent to 5 percent would stimulate loan demand by the same percentage as in the case of a decline from 1 percent to 0.5 percent. This argument may not hold for loan demand; a decline in loan interest rates in absolute term might be more closely tied to shift in loan demand. For the case of the above example, the loan demand might be stimulated by more when loan interest rates decline by 5 percentage point than when they decline by 0.5 percentage point.[7]

Reflecting this consideration, we use the adjusted Lerner index defined below as the measure of the mark-up for each bank i and each year t:

$$mark\text{-}up_{i,t} = p_{i,t} - mc_{i,t}. \tag{3}$$

This measure also has an practical advantage over the traditional Lerner index when p reaches close to zero: even a small change in p causes a sharp move in the Lerner index in such an environment because a small number is divided by a small number. This may generate unnecessary noises in the Lerner index, or making it too volatile. Since our sample mostly spans the low interest rate era which has pushed down p toward the low end of the single digit, we consider (3) a more robust measure of the mark-up.

In constructing the mark-up, we choose p to be the ratio of gross operating profits (the sum of interest income, non-interest income, and other operating income) to total assets. We follow existing literature, such as Berger et al. (2009) and Ojima (2017), in

[7] This argument can be justified if we assume semi-log demand function, *i.e.* $logY = \beta P + C$, where Y is demand and P is price. In this case, the elasticity of demand will be βP: demand is stimulated more when the absolute level of the price is higher holding price change in percentage term constant. For more detail, see Genesove and Mullin (1998).

estimating the marginal cost. we first estimate a translog cost function as follows:

$$
\begin{aligned}
TC_{i,t} = \quad & \alpha_i + \sum_{j=1}^{3} \beta_j \ln w_{i,j,t} + \frac{1}{2} \sum_{j=1}^{3} \sum_{k=1}^{3} \gamma_{j,k} \ln w_{i,j,t} \cdot \ln w_{i,k,t} \\
& + \sum_{j=1}^{3} \gamma_{j,a} \ln w_{i,j,t} \cdot \ln TA_{i,t} + \beta_a \ln TA_{i,t} + \frac{1}{2} \gamma_{a,a} \left(\ln TA_{i,t}\right)^2 \\
& + \theta \cdot Timedummies,
\end{aligned} \tag{4}
$$

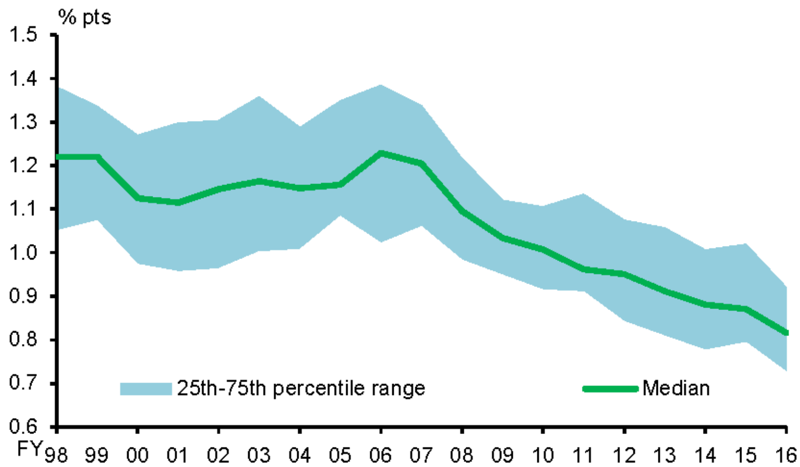
where TC is the sum of funding costs, personnel expenses and non-personnel expenses. $w_{i,j,t}$ for $j = 1,\ 2,\ 3$ represent the corresponding factor prices for bank i at time t: the ratio of funding costs to total funding, the ratio of personnel expenses to the number of personnel, and the ratio of non-personnel expenses to total assets. TA is the total output of banking service and we use total assets as the measure of output. We also include bank fixed effect α_i and year fixed effects denoted by $Timedummies$.

Using (4), we can show that the marginal cost has the following form:

$$
mc_{i,t} = \frac{TC_{i,t}}{TA_{i,t}} \left[\sum_{j=1}^{3} \gamma_{j,a} \ln w_{i,j,t} + \beta_a + \gamma_{a,a} \ln TA_{i,t} \right]. \tag{5}
$$

Figure 4 displays the derived mark-ups for Japan's regional banks. They have been relatively stable until the mid of the 2000s and then exhibit a marked decline during the latter half of the sample period. The sustained monetary easing during this period should account for the decline, at least to some extent. However, the Bank of Japan's Financial System Report (2017a) shows that structural factors such as the decline in the population and the number of firms, which determine the demand for financial services, are also attributable to the decline in the mark-ups. With the sticky supply in the banking services, the banks have been involved in the intensified competition to attract a shrunken customer base.

Figure 4: Estimated mark-up



This figure displays the estimated mark-ups for 56 regional banks in Japan over fiscal year 1996-2016. The solid line represents median and the shaded area represents interquartile range.

3.3 Control Variables

In estimating the impact of the mark-up on the development of systemic risk, we control a number of bank specific factors and macroeconomic factors following Anginer et al. (2014) and Berger et al. (2009) among others. We choose bank size, measured as the log of total assets, the share of loans in total assets, and the share of non-interest income in total revenue as the bank-specific factors. We also control business cycles using the output gap constructed by the Bank of Japan, and aggregate financial factors using the yield on 3-month treasury discount bills and the volatility of stock returns.

Table 1 represents the summary statistics for the variables we use in our estimation. The variation of ΔCoVaR is lower than those reported in Anginer et al. (2014). Perhaps, this reflects the fact that their sample covers much more diverse banks than ours both in terms of business model and size. The properties of bank controls are quite similar to those reported in Hirakata et al. (2017): loan-to-total assets is on average greater than 60

Table 1: Descriptive Statistics for bank-specific variables

variable	N	P10	Median	Mean	P90	Stdev
ΔCoVaR	1176	0.315	1.217	1.331	2.558	0.872
ΔVaR	1176	1.942	2.821	2.912	4.000	0.908
Interconnectedness (δ)	1176	0.113	0.459	0.454	0.800	0.290
Mark-up	1176	0.820	1.074	1.110	1.443	0.256
Log(total assets)	1176	13.513	14.689	14.654	15.554	0.724
Loan-to-assets ratio	1176	56.100	65.440	65.111	73.840	6.649
Non-interest income share	1176	14.250	22.200	22.452	30.820	6.497

All variables are denoted in percentage term except for $log(totalassets)$. N indicates the number of observations. P10, P90 and Stdev indicate 10 percentile, 90 percentile and standard deviation respectively.

percent and non-interest income share is generally low, just above 20 percent on average. These are the typical patterns observed in Japan's regional baking system; their business is concentrated on deposit taking and loan making, and they only earn limited amount from fee-based business. Nonetheless, the loan-to-asset ratio has edged down and the non-interest income share has tilted up toward the end of our sample period.

3.4 Estimated Equation

We estimate the following panel regression model:

$$risk_{i,t} = \alpha + \alpha_i + \beta_1 mark\text{-}up_{i,t-1} + \sum_{j=2}^{n} \beta_j X_{i,t-1} + \sum_{j=1}^{m} \gamma_j Y_{t-1} + u_{i,t}, \tag{6}$$

where $risk$ is one of the measures of systemic risk defined in the section 3.1, and $X_{i,t-1}$ and Y_{t-1} are the vector of bank-specific controls and the macroeconomic controls respectively. The βs and γs are the parameters regarding the effect of bank-specific and the macroeconomic variables. Of those, our primary focus is β_1, the marginal effect of the mark-up on the systemic risk. For the all time-variant regressors including the mark-up, we use one-year lag. We employ the fixed-effect approach to explicitly account for the bank-specific unobserved heterogeneity: $\alpha + \alpha_i$ is time-invariant bank-specific effect where α is the mean of the bank specific effect. Lastly, $u_{i,t}$ represents the residual term.

4 Empirical Results

We first estimate the equation (6) using ΔCoVaR as the dependent variable and evaluate the impact of the mark-up on contribution to the systemic risk. Then we estimate the same equation using ΔVaR and δ, the components of ΔCoVaR, as the dependents. The latter exercise would provide a clearer interpretation on the relationship between mark-up and systemic risk: a statistically significant relationship between ΔVaR and the mark-up, if detected, would indicate that competition would affect systemic risk through changes in the contribution of standalone risk of individual banks. On the other hand, a statistically significant relationship between δ, the interconnectedness parameter, and the mark-up would indicate that competition would affect systemic risk through the shift in banks' common risk exposure.

Table 2 presents the estimation result using ΔCoVaR as the measure of systemic risk. we estimate various specifications, with or without macroeconomic and bank-specific factors. Column (1) presents the estimation result when considering the mark-up only. Column (2) and (3) present the results that control macroeconomic factors, and both macroeconomic and bank-specific factors respectively.

For all specifications, we find negative and statistically significant relationship between the mark-up and ΔCoVaR.[8] In light of the Japan's experience displayed in Figure 3 and 4, our result suggests that the secular decline in the mark-up has contributed to gradual increase in the systemic risk. Note, however, that our empirical result contrasts sharply

[8]This result is mostly robust to the inclusion of additional bank control variables such as leverage and credit costs.

Table 2: Mark-up and systemic risk: ΔCoVaR as the dependent variable

Independent variable	(1)	(2)	(3)
Mark-up	-0.821^{***}	-0.671^{***}	-0.374^{**}
	(0.149)	(0.137)	(0.168)
log(total assets)			2.671^{***}
			(0.273)
Loan-to-asset ratio			-0.018^{**}
			(0.008)
Non-interst income share			0.036^{***}
			(0.006)
Output gap		0.188^{***}	0.082^{***}
		(0.009)	(0.010)
3-month TB yield		-1.012^{***}	1.268^{***}
		(0.098)	(0.127)
Stock return volatility		1.853^{***}	-0.179^{***}
		(0.072)	(0.045)
Bank fixed effect	Yes	Yes	Yes
Observations	1120	1120	1120
R-squared	0.41	0.61	0.59

$***$ and $**$ indicate statistical significance at 1% and 5% respectively. Robust standard errors adjusted for heteroskedasticity and clustered at bank level are reported in parentheses below the coefficient estimates.

with the result of Anginer et al. (2014) and Leroy and Lucotte (2017): they report positive relationship between mark-up and systemic risk. This issue is worth noting and we will discuss more in the next section.

Macroeconomic and bank-specific factors are also statistically significant. As for the effect of bank-specific factors, we find that, consistent with Anginer et al. (2014) and Hirakata et al. (2017), the larger banks in terms of total assets are more systemically important. Moreover, banks with lower loan-to-assets ratio and higher non-interest income share are found to be more systemic. As discussed in Hirakata et al. (2017), those variables capture Japan's regional banks' exposure to market-oriented business: lower loan-to-assets ratio is associated with larger share in securities holdings; higher non-interest income is likely to driven by increased fees earned from selling investment trusts and other market-

Table 3: Mark-up and systemic risk: ΔVaR and δ as the dependents

	ΔVaR		δ: interconnectedness	
Independent variable	(1)	(2)	(3)	(4)
Mark-up	-0.103	0.246	-0.281^{***}	-0.119^{**}
	(0.136)	(0.206)	(0.047)	(0.052)
log(total assets)		0.970^{***}		0.787^{***}
		(0.372)		(0.085)
Loan-to-asset ratio		-0.010		-0.005^{**}
		(0.010)		(0.003)
Non-interst income share		-0.002		0.010^{***}
		(0.006)		(0.002)
Output gap	0.111^{***}	0.082^{***}	0.050^{***}	0.010^{***}
	(0.013)	(0.017)	(0.003)	(0.004)
3-month TB yield	1.282^{***}	1.596^{***}	-0.356^{***}	0.125^{***}
	(0.147)	(0.178)	(0.038)	(0.040)
Stock return volatility	-0.156^{**}	-0.261^{***}	0.137^{***}	-0.011
	(0.063)	(0.067)	(0.016)	(0.016)
Bank fixed effect	Yes	Yes	Yes	Yes
Observations	1120	1120	1120	1120
R-squared	0.33	0.34	0.37	0.57

$***$ and $**$ indicate statistical significance at 1% and 5% respectively. Robust standard errors adjusted for heteroskedasticity and clustered at bank level are reported in parentheses below the coefficient estimates.

oriented products. Thus the risks of banks with lower loan-to-assets ratio and/or higher non-interest income are more apt to common market factors, contributing to the elevation of systemic risk.

Even after accounting for those controls, the estimation result implies that the economic impact of the mark-up on the systemic risk is non-negligible. Using the coefficient estimates in column (3) and the summary statistics in Table 1, one can compute that one standard deviation (0.26 percentage point) decline in the mark-up raises ΔCoVaR by approximately 0.1 percentage point, or approximately 11 percent of the standard deviation of ΔCoVaR. This magnitude is similar to the finding in Anginer et al. (2014) though the direction of the effect is opposite in our study.

We now turn to the result of using the individual risk component and the interconnectedness component of ΔCoVaR as the dependents. Table 3 presents the results. There is no statistically significant relationship between the mark-up and ΔVaR, the individual risk component. On the other hand, we find a negative and statistically significant relationship between the mark-up and δ, the interconnectedness parameter.[9]

This result suggests that there exists an important channel on the build-up of systemic risk for the case of Japan's regional banking: the decline in the mark-up has led Japan's regional banking system to be more systemic through increased correlations in the risk between Japan's regional banks. Given the features of the banks' behavior observed in recent years, we conjecture that overlaps in loan portfolio between the banks are attributable to the increased level of the systemic risk. We will discuss this aspect more in detail in the next section.

5 Discussion

Our empirical study shows a novel finding that banks' correlated risk-taking behavior is an empirically plausible channel behind the negative relationship between the mark-up and the systemic risk for Japan's regional banking. However, our result sharply contrasts with existing findings, *e.g.* Anginer et al. (2014) and Leroy and Lucotte (2017), which found that lower mark-ups are associated with less systemic risk using cross-country banking data, which contains information on the largest banks in Europe.

In this section, we discuss the difference paying attention to the business model of Japan's regional banks. In doing so, we first demonstrate a stylized model of portfolio choice in view of Japan's regional banking, and then we discuss our empirical finding in

[9]This result is robust to the inclusion of additional bank control variables such as leverage and credit costs.

conjunction with the model.

5.1 A Stylized Model

The model that we demonstrate sheds light on banks' common exposure to credit risks that develops through portfolio diversification. Wagner (2010) shows that diversification, while lowers the standalone risk of individual banks, entails a cost via increased likelihood of systemic crisis. We make use of Wagner's framework but make one simple departure to demonstrate that an exogenous change in mark-up affects the likelihood of systemic crisis.

Assume there are two banks, bank 1 and bank 2. They allocate their funds into two distinct investment projects whose returns are denoted by x and y respectively. Both projects require one unit of funds. Each bank collects $d < 1$ units of deposits from depositors and raises $1 - d$ units of capital from shareholders, thus there is no shortage in funds in aggregate to finance the two investment projects.

The returns of the investment projects are stochastic. They are independent, identically and uniformly distributed with a support $[0, s]$. Let ω_1 be the portion of bank 1's funds allocated to the project y, and ω_2 be the portion of bank 2's funds allocated to the project x. The gross returns of the investment, denoted by v_1 and v_2, are then expressed as:

$$\begin{aligned} v_1 &= (1 - \omega_1)\, x + \omega_1 y, \\ v_2 &= \omega_2 x + (1 - \omega_2)\, y. \end{aligned} \tag{7}$$

The actual return of each project becomes known before the project matures. If v_1 (v_2) falls short of d, bank 1's (bank 2's) depositors run, and the bank has to liquidate its assets. If, say, only bank 1 fails, we assume bank 1 sells its assets to bank 2 with the amount of discount c, *i.e.* one unit of assets is sold at a price $v_1 - c$. If the two banks fail simultaneously, their assets are sold to outside investors with deeper discount qc, where $q > 1$. We can justify this deeper discount as an outcome of the asset fire-sales. When the liquidity supplied by the outsiders under such a systemic event was insufficient, the failing banks would be forced to sale their assets with significant discounts.

In addition to those default costs, we consider the operational cost of diversification. We assume bank 1 has specialized management skill in investing in the project x and bank 2 in the project y. When bank 1 starts to diversify its portfolio by reducing the amount of exposure to x, it must bear additional operational costs. The same is true for bank 2 when it reduces portfolio share in y. We assume the operational cost is increasing and convex in ω_i, the portfolio share of the assets for which bank i has no specialized skill.

This operational cost can be born from, for example, an elevated cost of monitoring due to a lack of management skills. In the context of Japan's regional banking, the project with specialized management skill can be thought of relationship lending to borrowers in local economy. In contrast, the project with which the bank has no specialized management skill can be thought of lending to new borrowers located distant from the bank's home ground.

We assume that depositors and shareholders are risk neutral. In order to maximize the returns for them, banks maximize the expected return from the investment net of the expected default cost and the operational cost of diversification. The expected default cost is the multiple of the probability of default, π, and the cost at default. The former is divided into two parts: the probability of individual default, π_i for $i \in \{1, 2\}$, and the probability of simultaneous default, π_s. The cost at default is the discount that banks have to accept at the asset sales. As for the operational cost of diversification, the exact functional form is assumed to be $\frac{\omega_i}{1-\omega_i}b$, where b represents the scale of the cost. This formula guarantees the existence of a unique analytical solution for the portfolio share. With that, banks' payoff function can be expressed as:

$$
\begin{aligned}
R_1 &= E\left(v_1\right) - c\left(\pi_1 + q\pi_s\right) - \tfrac{\omega_1}{1-\omega_1}b, \\
R_2 &= E\left(v_2\right) - c\left(\pi_2 + q\pi_s\right) - \tfrac{\omega_2}{1-\omega_2}b.
\end{aligned} \tag{8}
$$

The expected returns, the first term in the right hand side of (8), are constant regardless of the degree of diversification under the *i.i.d.* assumption on x and y. Hence banks minimize the sum of the costs by choosing the right degree of diversification and the following optimality conditions apply to bank 1 and bank 2:

$$
\begin{aligned}
c\left(\tfrac{\partial\pi_1}{\partial\omega_1} + q\tfrac{\partial\pi_s}{\partial\omega_1}\right) + \tfrac{b}{(1-\omega_1)^2} &= 0, \\
c\left(\tfrac{\partial\pi_2}{\partial\omega_2} + q\tfrac{\partial\pi_s}{\partial\omega_2}\right) + \tfrac{b}{(1-\omega_2)^2} &= 0.
\end{aligned} \tag{9}
$$

(9) indicates that the banks balance the marginal operational cost associated with diversification, the second term in the left hand sides, and the marginal reduction in the default costs, which is the sum of the changes in the cost of individual default and simultaneous default. Note the marginal operational cost is always positive under $b > 0$, implying the marginal default costs are always negative in equilibrium. In other words, absent the operational cost, banks would further diversify, reduce the portfolio risk, and save the default costs.[10]

The derivation of the solution follows Wagner (2010) hence we relegate to the Appendix the derivation. Let us first focus on the equilibrium level of diversification. Since the problem of bank 1 and bank 2 are symmetric, there exists a unique equilibrium level of

[10] The negative marginal default costs are achieved by a negative marginal cost of individual default and a positive marginal cost of simultaneous default, where the absolute magnitude is larger for the former.

diversification, ω^{eq}, that applies to both bank 1 and bank 2:[11]

$$\omega^{eq} = \frac{1}{1 + \sqrt{q + \frac{2b}{c} \times \left(\frac{d}{s}\right)^{-2}}}. \tag{10}$$

When $b = 0$, the solution of our model exactly matches Wagner's solution. When $b > 0$, it starts to affect the equilibrium level of diversification through the direct impact on the cost of diversification. Moreover, it creates a room for other parameters to affect the equilibrium level of diversification. Intuitively, shifts in parameter s, d and c alter the balance between the marginal default costs and the marginal operational cost that leads banks to reconsider the degree of diversification. For example, banks face more imminent risk of default, *i.e.* the expected default costs increases, when s declines while such a shock does not change the operational cost at all. Then banks are incentivized to diversify further in order to mitigate the default risk while permitting an increase in the operational cost. This behavior occurs only when $b \neq 0$ because what matters is the balance between the marginal default costs and the marginal operational cost.

Of those parameters, s that governs the return on investment would draw attention when relating the implication of this model to our empirical finding. First, the decline in s is a primary shock that Japan's regional banks have been facing. Due to persistent decline in population and the number of firms, there has been a secular decline in investment demand especially in the rural area of Japan.[12] This has translated into a secular decline in lending rates, which can be mimicked by the decline in s. Moreover, a shift in s has a direct consequence on the fluctuation of the mark-up employed in the empirical section.

[11] The market equilibrium is characterized by excess diversification compared with the social optimum. As Wagner (2010) points out, diversification by one bank increases the risk of simultaneous default whose costs fall onto both banks. However, each bank fails to internalize the costs that the competitor incurs. This results in excess diversification.

[12] See Bank of Japan's *Financial System Report* (2017a, 2017b) for details.

Recall that the mark-up defined in the empirical section is the rate of return of assets net of the marginal cost of maintaining the assets, the latter consisting of funding costs and other operational costs. In light of this definition, it is obvious that the decline in s has a direct negative impact on the mark-up in our model set-up. Hence we focus on the prediction of our model regarding the shift in s in what follows.

Our model predicts that an exogenous decline in s encourages banks to diversify more when $b > 0$. This results in higher ω^{eq} in light of (10).

The resulting diversification leads to elevated systemic risk via an increase in the banks' common exposure. We can confirm this by observing the equilibrium level of the probability of simultaneous default, π_s^{eq}:[13]

$$\pi_s^{eq} = \frac{d^2}{(1-\omega^{eq})\, s^2} \Rightarrow \frac{\partial \pi_s^{eq}}{\partial s} < 0, \tag{11}$$

5.2 The Business Model of Japan's Regional Bank And the Empirical Result

The model that we demonstrate above intends to capture the typical behavior of Japan's regional banks under declining profitability. Japan's regional banks tend to specialize in local lending business, and they typically do not diversify their income source widely toward fee-earning business. Under such a business model, an option to Japan's regional banks which face declining profitability would be to expand the customer base of loan business. Actually, some banks expanded geographical locale of loan supply and others entered into markets of different customer segments even in the same local area. Since incumbent banks prevailed in almost all customer segments under the matured loan

[13] In deriving this property, note $\frac{\partial \omega^{eq}}{\partial s} < 0$. Under this condition, a decrease of s has an effect of reducing $1-\omega^{eq}$. Hence the change in π_s^{eq} is unambiguously positive to a decline in s.

market in Japan, these moves inevitably increase the level of indirect interconnectedness between banks. According to our model, it entails increased risk of joint failure.[14]

Consistent with the model prediction, our empirical study on Japan's regional banking system indicates that the decline in the mark-up is associated with the increase in systemic risk.

According to our model, the key economic concept that explains our empirical result is the limited degree of synergy in diversifying portfolio. As described above, the diversification for Japan's regional banks typically takes the form of selling similar loan products to different customers whose business profiles vary considerably. Although this contributes to a safer portfolio, this form of diversification often times entails costs, such as information acquisition costs and the overhead costs of opening new branches in order to approach new customers. Then the banks are prone to diversify only when the profitability of core business, *e.g.* relationship lending to local business, declines. Hence, the degree of interconnectedness and systemic risk are likely to increase when the profitability of core business declines, and when banks find the risk mitigating effect of diversification outweighs its cost.

When considering universal banks, such as large European banks, different outcomes could arise. They have a variety of income sources, including non-interesting income business, and there suppose to be synergies in offering a variety of financial services. One form of synergies would be savings in the information acquisition costs when cross-selling multiple financial products. We conjecture that those banks tend to expand and diversify when competition is not fierce and when there is enough room to enter into new business

[14] The diversification also takes the form of investing in marketable securities. This is also considered to increase the systemic risk according to Hirakata et al. (2017). Indeed, a small change in our model would be able to capture this effect. Instead of assuming that the two banks competes in the lending market, we may assume that the banks' alternative option to lending is securities investment. Then again in response to a decline in lending rates, we could draw a model that the both banks shift to securities investment that results in increased common exposure in marketable securities.

segments. In such a case, banks can secure large profits from offering new products to existing clients without incurring significant additional costs.[15] This behavior would generate a positive relationship between mark-up and systemic risk.

In view of the synergy regarding diversification, we can reconcile the contrast between our empirical result and existing empirical results. While our study covers small-to-medium sized banks whose focus is traditional lending business, Anginer et al. (2014) and Leroy and Lucotte (2017) cover large banks that are globally active and offer a variety of financial products. Many of them, especially those located in Europe, offer a wider range of financial services compared with Japan's regional banks.[16] Thus it is likely that the difference in the empirical results arises from the difference in the business models.

Indeed, we can explain the difference in the empirical results using our theoretical model. We can assume $b < 0$ instead of $b > 0$, in which case there exists synergy between the two different investment opportunities. In this setup, all the model properties discussed in the section 5.1 can be overturned: the degree of diversification is increasing in s, hence the decline in s can mitigate the likelihood of systemic crisis. At the same time, the decline in s is likely to reduce the mark-up, implying the positive relationship between the mark-up and the systemic risk. Note, however, that our model has certain limits in explaining the behavior of universal banks: our model has a forced assumption that banks must use their balance sheet in doing business. The business models of universal banks are broader and often time they rely on fee-earning business that does not use balance sheet. Admitting the limitation, we conjecture that the mechanism in our model would still apply to the case of diversification to fee-based business. Banks would be more

[15]The advantage of the cross-sale is that banks can save costs for processing information of customers.

[16]For international comparison of the source of income in banking, see The Financial System Report of the Bank of Japan (2017b). The report shows that bank's non-interest income share is smaller in Japan relative to the US and the Europe.

cautious about business line expansion that can exploit synergy between the lines, such as providing financial advisory or asset management service to existing loan customers when competition of such business is tight.

6 Conclusions

This paper studies the relationship between mark-up and systemic risk from an empirical and theoretical perspective. In this emerging area of research, we find new evidence of negative relationship between the two for Japan's regional banking system. This finding sharply contrasts with existing studies which utilize the cross-country bank data, calling for investigation on what distinguishes the positive or negative impact of mark-up on the build-up of systemic risk.

To reconcile the conflicting results, we focus on the business model of Japan's regional bank and present a theoretical model consistent with it. Japan's regional banks has specialized in local relationship lending without widely diversifying their business profiles like universal banks in Europe. Facing a secular decline in the mark-up though, they have been incentivized to diversify their lending portfolio by entering into markets that other banks are already dominant players. Such a diversification mitigates the individual default risk, hence it is individually rational behavior. However, we show that the simultaneous moves of banks are detrimental to the stability of banking system since they elevate systemic risk via increase in the level of indirect interconnectedness.

Our analysis has important policy implications to the stability of the banking system populated by a cluster of traditional lenders. First, in line with the analysis of Wagner (2010) and Acharya and Yorulmazer (2007), these banks, even if they are individually non-systemic, could pose a threat to banking system when they herd and hold common exposure. Hence supervisory authorities must watch the collective behavior of these banks in order to secure the stability of banking system. Second, there are needs for competition policies that well suit for regional banks whose focus is on traditional lending, given the effects of competition on such a banking system could differ considerably from those on banking system dominated by universal banks. Specifically, providing market power and alleviating competition could benefit such a banking system since they reduce banks' herding incentive.

The trade-off between competition and financial stability has attracted lots of researchers. Yet renewed interest on the effect of competition on systemic risk opens up a new area of research. Our study shows that the impact of competition on systemic risk could be unique depending upon the characteristics of banks in a system. To this end, further research on bank competition is warranted to design right competition policies that take into account the characteristics of banks in distinct banking systems.

A The Derivation of the Model Solution

In this appendix, we provide the derivation of the model described in Section 5. We begin with the equation (9) in the Section 5, the optimality condition regarding the banks' diversification:

$$c\left(\frac{\partial \pi_1}{\partial \omega_1} + q\frac{\partial \pi_s}{\partial \omega_1}\right) + \frac{b}{(1-\omega_1)^2} = 0, \tag{A.1}$$

$$c\left(\frac{\partial \pi_2}{\partial \omega_2} + q\frac{\partial \pi_s}{\partial \omega_2}\right) + \frac{b}{(1-\omega_2)^2} = 0.$$

To derive the analytical solution for the level of diversification, we must know the formula of π_i and π_s. In deriving the formulas, let us first return to (7) in Section 5, and express the minimum return y given x, $y(x)$, below which each bank fails and bank run occurs:

$$y_1(x) = \frac{d}{\omega_1} - \frac{(1-\omega_1)\,x}{\omega_1}, \tag{A.2}$$

$$y_2(x) = \frac{d}{1-\omega_2} - \frac{\omega_2 x}{(1-\omega_2)}.$$

Then for the case of bank 2, we can write the sum of the probability of the individual failure and the joint failure as follows (from what follows, we only consider the case of bank 2 *w.l.g.* because the problems are symmetric.):

$$\pi_2 + \pi_s = \frac{1}{s^2}\int_0^{\frac{d}{\omega_2}}\int_0^{y_2(x)} dydx, \tag{A.3}$$

where $1/s$ is the *p.d.f* of the gross return of the investment project x and y. Note if x is above $\frac{d}{\omega_2}$, then bank 2 will not fail for any positive realization in y. Taking the derivative of (A.3) with respect to ω_2, we obtain the marginal default probability of bank 2:

$$\frac{\partial(\pi_2+\pi_s)}{\partial\omega_2} = \frac{1}{s^2(1-\omega_2^2)}\left(\frac{d^2}{\omega_2} - \frac{d^2}{2\omega_2^2}\right). \tag{A.4}$$

Acknowledging that the simultaneous default occurs when $y < min\,(y_1(x), y_2(x))$ given x, and $y_2(x) < y_1(x)$ when $x < d$ and *vice versa*, we can write the probability of the simultaneous default, π_s, and the associated derivative as:

$$\pi_s = \frac{1}{s^2}\left(\int_0^{d}\int_0^{y_2(x)} dydx + \int_d^{\frac{d}{1-\omega_1}}\int_0^{y_1(x)} dydx\right), \tag{A.5}$$

$$\frac{\partial\pi_s}{\partial\omega_2} = \frac{1}{s^2(1-\omega_2^2)}\frac{d^2}{2}.$$

Combining (A.1), (A.4), and (A.5), we can write the exact form of the optimality condition as follows:

$$c\left(\frac{d}{s}\right)^2\left(\frac{1}{\omega_2}-\frac{1}{2\omega_2^2}+\frac{q-1}{2}\right)+b=0. \tag{A.6}$$

(A.6) can be seen as a quadratic function of ω_2. Then solving (A.6) and eliminating an infeasible solution, we obtain the solution for the equilibrium level of diversification as (10). And by plugging (10) into the (A.5) and simplifying, we obtain the equilibrium level of the probability of simultaneous default as (11).

B Data definition

The detailed description of the variables used in the estimation of the relationship between $CoVaR$ and the mark-up is listed in Table B1.

Table B1: Data definition

variable	**category**	**definition**
$CoVaR^q$	bank	q percent value-at-risk of the aggregate regional bank stock return conditional on the stock return of an individual bank. The aggregate regional bank stock return is the stock market value weighted average return of 56 regional banks.
VaR^q	bank	q percent value-at-risk of an individual bank stock return.
interconnectedness (δ)	bank	Estimated coefficient on the comovement of individual bank stock return and the aggregate regional bank stock return.
mark-up	bank	Difference between gross operating profits and the marginal cost normalized by total assets.
Log(total assets)	bank	Log value of total assets in millions of Japanese Yen.
Loan-to-assets ratio	bank	Total loans divided by total assets. In percentage term.
Non-interest income share	bank	Gross operating profits less interest income divided by gross operating profits. The numerator includes realized gains/losses on securities holdings. In percentage term.
Output gap	macro	Deviation of actual GDP from potential GDP for Japan. In percentage term.
3-month TB yield	macro	The average yield of Japan's 3-month Treasury Discount Bill for a given fiscal year. In percentage term.
Stock return volatility	macro	Historical volatility of the daily TOPIX return for a given fiscal year. In percentage term.

The variable category (the second column of the table B1) is divided into two pieces: "bank" represents a bank specific variable and "macro" represents a macroeconomic variable.

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