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Abstract

Using the statistical relationships between market values of banks' assets and their volatilities that are implied from banks' shareholders' values of publicly held banks and their financial statement-based variables, which are used to compute banks' probabilities of default, we conduct out of sample predictions for these two variables for the sample of privately held *shinkin* banks. We, then, use estimates of these two variables to compute *shinkin* banks' probabilities of default. We find that estimated probabilities of default complement the regulatory capital adequacy ratio in identifying banks to fail in the near future.

Keywords: probability of default, privately held bank

JEL classification: G21, G22

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1. Introduction

A large number of banks worldwide are privately held. Falkenheim and Pennacchi (2003) point out that the majority of banks in the United States are privately held (their shares are not traded in stock markets), although the majority of bank assets are owned by publicly held banks (their shares are traded in stock markets). In Japan the corporate finance in one of the largest economies in the world is dominated by bank lending; according to the Nikkei NEEDS databank and the Japanese Bankers' Association,as of June, 2018, 8 of 115 banks that are licensed under the Banking Act and operate with standard branches with human employees, which are regarded as commercial banks, (we will refer to as traditional Banking Act banks), are neither publicly held nor owned by publicly held bank holding companies. The share of publicly held banks may sound small, but the Japanese banking system consists not only of banks that are stock companies but also of a large number of cooperative banks including *shinkin* banks and credit cooperatives. To be precise, there are 261 *shinkin* banks (as of January, 2018, according to the Shinkin Central Bank Research Institute) and 151 credit cooperatives (as of March, 2017, according to the Japanese Credit Cooperative Association). They are non-profit cooperative institutions whose shares are owned by their members who are individuals and businesses of their respective communities, but their business model of taking deposits to finance lending and securities investment is no different from that of commercial banks. Therefore, only 107 of 527 traditional banks based in Japan are publicly held. As privately held traditional Banking Act banks tend to be smaller than publicly held traditional Banking Act banks and *shinkin* banks and credit cooperatives tend to be smaller than traditional Banking Act banks, as of March, 2017, these 420 privately held banks constitute only 14.5 percent of total bank assets in Japan, which is not large but still non-negligible.[1] If one knows that the total sum of assets held by those privately held banks is 181 trillion yen, one's perception that these banks are a non-negligible part of the large banking sector in Japan should only grow.

Because of its large presence in the Japanese banking sector, in the literature, cooperative banks including *shinkin* banks are scrutinized from the prudential point of view. Murata and Hori (2006) discuss the way cooperative banks are subject to the depositors' market discipline. *Shinkin* banks saw massive merger waves in the 1990s and 2000s. Hosono et al. (2006, 2009) examine the effects of mergers on ex-post financial variables for banks including *shinkin* banks.

In this study, we shed light on this oft-overlooked portion of the Japanese banking sector; namely privately held banks, particularly *shinkin* banks, which are a type of banks that dominate privately held banks in Japan. Hundred fifty-one trillion yen of assets held by 261 *shinkin* banks constitute 83 percent of assets held by privately held banks in Japan as of March, 2017.

In particular, we propose measures to assess failure risks of *shinkin* banks, namely, the estimates of probability of default (PD) and the (hypothetical actuarially fair) insurance premium per dollar of deposits (IPP), which is an insurance premium per dollar of deposits on a bank's balance sheet that the bank would purchase from a hypothetical private insurer

[1] Bank assets held by privately held Banking Act banks, *shinkin* banks and credit cooperatives sum to 181 trillion yen. Total bank assets in Japan are 1,246 trillion yen. Note that total bank assets include small amounts of assets held by non-traditional banks such as internet banks and foreign based banks.

to insure depositors against the bank's failure.[2] [3] In doing so, we employ a two-stage-approach, where, in the first stage, statistical relationships between stochastic characteristics of bank assets and financial statement based variables are estimated for listed regional banks, and in the second stage, stochastic characteristics of privately owned *shinkin* banks are predicted based on relationships estimated for regional banks using the data about financial statements available for *shinkin* banks. The PD and the IPP for *shinkin* banks are computed based on these predicted stochastic characteristics of bank assets. Our approach rests on the premise that statistical relationships that hold for listed regional banks do also for *shinkin* banks that are relatively similar to regional banks in business model, size and regulatory environments.[4]

To the best of our knowledge, we are the first to examine the predictive power of the PD for failures of privately held banks. What is remarkable about our empirical strategy is that

[2] The concept of the IPP is proposed by a seminal study of Merton (1977) and the formula for the IPP is developed for applying to the actual data of banks by Ronn and Verma (1986) and Duan et al. (1992). Guizani and Watanabe (2016) utilize this methodology to examine the effects of public capital infusions on banks' risk taking.

[3] The real-world equivalent of the IPP is a premium rate for CDS a bank purchases to insure against its debts. In Japan, trading of CDSs started only in 1999 and for the largest firms including largest banks and bank holding companies. Thus, we need to reverse engineer the data of IPP for the sample of smaller regional banks for our sample period starting in FY 1989.

[4] Although Banking Act licensed regional banks and cooperative banks including *shinkin* banks are not licensed under the same law, they are the regulators' policy subjects under an integrated principle, which large Banking Act banks are not, as they are collectively grouped as regional financial institutions. Government organizations in charge of operating on-site and off-site monitoring, however, are separate as the Financial Services Agency directly handles the former, whereas Regional Finance Bureaus do the latter under the delegation of the FSA's authority.

our estimated PDs, computed on the basis of stochastic characteristics of bank assets that would be, in theory, implied by banks' shareholders' values, are obtained for *shinkin* banks, whose shareholders' values are unavailable, and nonetheless, predict their ex-post failures fairly well. For 15 out of 19 *shinkin* banks that failed during our sample period of FY 1989 through FY 2016, the estimated PD reaches 1 (100 percent failure probability) shortly before their actual failures.

The remainder of the paper is organized as follows: Section 2 discusses the empirical methodology. Section 3 introduces the data. Section 4 presents and interprets the results. Section 5 concludes.

2. Empirical Methodology

In order to compute the failure risk measures for unlisted *shinkin* banks, we employ a two-stage empirical strategy, where in the first stage, we estimate the statistical relationships between the stochastic characteristics of a regional bank's asset value and its financial statement based variables. In the second stage, we conduct out of sample predictions of stochastic characteristics variables for *shinkin* banks using the data of their financial statement based variables. We, then, compute the DD, the PD and the IPP using the compiled data about stochastic characteristics variables for both regional and *shinkin* banks.

PD is calculated as a function of the value of the DD, which can be referred to as a z-score.

Here are more detailed descriptions of our methodology to compute DDs, PDs and IPPs, which follows Bharath and Shumway (2008).

In the first stage, we follow a seminal methodology developed by Merton (1974). First, we solve a system of two non-linear equations for V and σ_V, numerically. The first of the two equations expresses a bank's shareholders' value, E, as follows.

$$E = V\mathcal{N}(d_1) - e^{-rT}B\mathcal{N}(d_2) \tag{1}$$

Where B is the face value of a bank's debt, r is the instantaneous risk-free rate, T is the time-to-maturity of the corporate/bank debt in Black-Scholes-Merton analysis, $\mathcal{N}(.)$ is the cumulative standard normal distribution and d_1 is given by the following expression:

$$d_1 = \frac{ln\left(\frac{V}{B}\right)+\left(r+0.5\sigma_V^2\right)T}{\sigma_V\sqrt{T}} \tag{2}$$

and

$$d_2 = d_1 - \sigma_V\sqrt{T}$$

The second equation is the Ito's lemma that describes the relationship between the volatilities of the bank's market value σ_V and of its equity value σ_E, as follows.

$$\sigma_E = \left(\frac{V}{E}\right)\mathcal{N}(d_1)\sigma_V \tag{3}$$

In practice, we construct shareholders' values-based variables, E and σ_E for listed banks as a product of the bank's stock price and the number of its shares and the annual volatility of its daily stock returns, respectively, and use total liabilities for B. Following the literature, we assume $T = 1$.[5] Using the data compiled as such, we solve the system of equations (2) and (3) numerically for each bank-fiscal year observation and compute V and σ_V for that observation, accordingly.

Following Falkenheim and Pennacchi (2003) in sprit, in the second stage , we use the numerically computed data of V and σ_V to estimate two statistical relationships relating logarithms of $\frac{V}{B}$ (hereafter, x) and σ_V derived in the first stage to a set of financial statement-based variables for the sample of regional banks.[6]

We run the following regressions year by year for regional banks over the sample period from FY1989 through FY2016.

$$ln(x_{it}) = c_1 Y_{it} + \varepsilon_{1it} \qquad (4a)$$

$$ln(\sigma_{Vit}) = c_2 Y_{it} + \varepsilon_{2it} \qquad (4b)$$

Where Y_{it} is an m by 1 vector of financial statement-based independent variables with i being an index for a bank m and t being an index for time (fiscal year). c_1 and c_2 are 1 by m coefficient vectors and ε_{1i} and ε_{2i} are i.i.d. mean zero error terms. We employ the ordinary

[5] See Ronn and Verma (1986), Giammarino et al. (1989), Duan et al.(1992) and Guizani and Watanabe (2016).

[6] In addition to Falkenheim and Pennacchi (2003), Anginer et al. (2014) use their methodology to examine the default risks of privately held foreign bank subsidiaries operating in developing economies.

least square technique when estimating coefficient vectors, c_1 and c_2. The estimated coefficient vectors, $\hat{c}_1$ and $\hat{c}_2$ are then used to predict $\ln(x_k)$ and $\ln(\sigma_{Vk})$ for $k = 1, \ldots, M_t$, where k and M_t are an index for, and the number of, *shinkin* banks for fiscal year t.

The (logarithms of) x and σ_V predicted for *shinkin* banks are given by the following equations:

$$ln(\hat{x}_{kt}) = \hat{c}_1 Y_{kt} \tag{5a}$$

$$ln(\widehat{\sigma_{Vkt}}) = \hat{c}_2 Y_{kt} \tag{5b}$$

The independent variables included in Y_{it}, and Y_{kt}, are primarily the variables used by Falkenheim and Pennacchi (2003), the variables they think are important to and closely watched by investors and securities analysts when assessing a bank's net worth and risk profile. The first variable is the book value of the assets to liabilities ratio, A/L. This ratio represents the bank's leverage or alternatively its net worth. Three variables involving the net income to liabilities ratio, NI/L, its square $\left(\frac{NI}{L}\right)^2$ and its square multiplied by a dummy variable to indicate a negative value for $\frac{NI}{L}$ (Dum), Dum $\times \left(\frac{NI}{L}\right)^2$ are meant to measure a bank's profitability, where the latter two are meant to capture the possible non-linear relationships between the ratio and the dependent variables.[7] The loan loss provisions to liabilities ratio, PL/L, is meant to measure the loan risk a bank is exposed to. The total loans to total assets ratio, TL/A, is meant to measure a bank's lending intensity and the logarithm of book-value of total assets, LNA, is a measure for bank size. Table 1 describes the

[7] According to Beatty et al. (2002), banks manage the discretionary provisions for loan losses in order to manipulate earnings and transform small earnings decline into small earnings increases. This is consistent with the discontinuity in investors' assessment of these banks when earnings are negative.

independent variables used in regression equations (4a) and (4b).

The last step of the second stage is to compute the market-based risk measures, namely the insurance premium per unit of deposits, the IPP, the DD and the PD for each *shinkin* bank k at time $t = 1989, \ldots, 2015$, according to the following formulas. [8]

$$IPP_{kt} = \mathcal{N}(\widehat{y_{kt}} + \widehat{\sigma_{Vkt}}) - \frac{\widehat{V_{kt}}}{B_{kt}}\mathcal{N}(y_{kt}) \quad (6)$$

Where $\widehat{y_{kt}} = \frac{ln\left(\frac{B_{kt}}{\widehat{V_{kt}}}\right) - 0.5\widehat{\sigma_{vkt}}^2}{\widehat{\sigma_{Vt}}}$

$$DD_{kt} = \frac{ln\left(\frac{\widehat{V_{kt}}}{B_{kt}}\right) + (\mu_{kt} - 0.5\widehat{\sigma_{Vkt}}^2)}{\widehat{\sigma_{Vkt}}} \quad (7)$$

Where the annual expected return on bank assets is given by $\mu_{kt} = \frac{\widehat{V_{kt}}}{\widehat{V_{kt-1}}} - 1$

$$PD_{kt} = \mathcal{N}(-DD_{kt}) \quad (8)$$

3. Data

We have four major sources of the bank level data. The first source of the data is the Nikkei NEEDS databank, which itself consists of the daily stock market data and the annual financial data of traditional Banking Act banks and bank holding companies. The second source is the Analysis of Financial Statements of Japanese Banks that collect the financial data of individual banks annually and are available in electronic format from the website of

[8] The formula is similar to the one employed by Guizani and Watanabe (2016) but is consistent with the methodology of Bharath and Shumway (2008).

the Japanese Bankers' Association (JBA) after FY1997 and in hard copy periodicals throughout our sample period. The third source is the Financial Statements of *Shinkin* Banks in Japan that collect financial data of *shinkin* banks that are published by *Kinyutoshokonsarutantosha* and are available in hard copy periodicals and are partially converted into electronic format under Keio University's government funded GCOE program that are now maintained by Keio University's Institute of Economic Studies. The fourth source is the Bureau Van Dijk's ORBIS Bank Focus formerly known as Bankscope that collect financial data of traditional Banking Act banks and *shinkin* banks.

We first collect the daily data about shareholders' values of all regional banks and bank holding companies holding primarily regional banks from the Nikkei NEEDS databank and compile the bank – fiscal year observations of E and σ_E. For the data about E, we use the end of fiscal year shareholders' value for each bank-fiscal year. For σ_E, we compute the annualized standard error of returns on shareholders' value for each bank-fiscal year.[9] As for necessary financial data of regional banks, we extract the data about financial variables primarily from Nikkei NEEDS data bank, but we make up for missing values by collecting the data from the Analysis of Financial Statements of Japanese Banks and individual banks' annual reports. As for necessary financial data of *shinkin* banks, we extract the data about financial variables for the period of FY1989 through FY2009 from the Analysis of *Shinkin* Banks' Financial Statements and for the period of FY2010 through FY2016 from the ORBIS Bank Focus. We measure the instantaneous risk-free rate by the average of a one-year

[9] More precisely, σ_E is calculated using the following formula. $\sigma_E = \sqrt{252 var\left(\frac{E_t}{E_{t-1}}\right)}$
, where E_t is a bank's shareholders' value at date *t*.

Japanese Government Bond yield over a corresponding fiscal year.

When running the cross-section year by year regressions of logarithms of leverage (x) and of the volatility of the market value of total assets (σ_V) , bank-year observations where either any of A/L, LNA, NI/L, TL/A, PL/A, x and σ_V is above the 99 percentile or below the 1 percentile are dropped as outliers.

Table 2 presents the descriptive statistics of independent variables used for the regressions of logarithms of x and σ_V. Panel A shows those for the sample of regional banks (the regional bank sample) for which regressions are actually run. Panel B shows those for the sample of *shinkin* banks (the *shinkin* bank sample) for which out of sample predictions based on the regressions run on the regional bank sample are conducted. Looking at both means and medians, non-profit *shinkin* banks are smaller in size than for-profit regional banks and also outperform them. More precisely, *shinkin* banks are more profitable (larger net income relative to size) and need to provide for less loan losses (lower loan loss provisions to liabilities ratio) than regional banks are. *Shinkin* banks also depend less on lending than regional banks do presumably because the Shinkin Central Bank (SCB) serves as a central financial institution that takes deposits from individual *shinkin* banks to finance its lending and securities investment.

Table 3 presents the sample size and the R-squared for every fiscal year in our sample period of FY1989 through FY2016.[10] For each year, the first row, the second row and the third row display the R squared for the regression of the logarithm of x (leverage), the R squared for the regression of the logarithm of σ_V (volatility) and the sample size that is

[10] The detailed regression results are available from the authors on request.

common to both volatility and leverage regressions. The fit is generally good, as 28 of 56 regressions are accompanied by the R-squared above 0.30. Unfortunately, the fit is sometimes very low and can reach as low as below 0.1 but we cannot attribute such breaks of the stable relationship between stock market-based variables and financial statement-based variables to any macroeconomic or financial episodes.[11]

4. Results

4.1. Overall results

Table 4 shows descriptive statistics of x, σ_V, PD and IPP for listed regional banks (Panel A) and for *shinkin* banks (Panel B). Regional banks as a group are better capitalized than *shinkin* banks when measured by the market leverage as shown in means and medians but the two groups of banks are almost equally distributed in leverage as shown in standard errors. Regional banks are much more volatile in and have a more dispersed distribution of assets than *shinkin* banks. *Shinkin* banks are predicted to be more likely to fail than regional banks are as shown in means and medians of PD and IPP. The PD and the IPP are more dispersedly distributed for *shinkin* banks than for regional banks as well. Overall, the descriptive statistics for pseudo market-based measures for *shinkin* banks are not anomalous when compared to corresponding statistics for regional banks for which these measures are directly

[11] We suspected that during periods of financial turmoil, the stable relationships between stock market-based and financial statement-based variables may break as stock markets reflect fundamentals less than at normal times, but this is not the case. The fit is small neither at the peak of the domestic crisis in FY 1997 nor at the peak of the global crisis in FY 2008 and FY 2009.

implied from their shareholders' values.

Figures 1.1, 1.2 and 1.3 depict year by year aggregate trends of PD, IPP and x (leverage), respectively. In each figure, a solid curve represents that for *shinkin* banks and a dashed curve represents that for regional banks. Values represented by these curves are weighted values where each of them is a weighted average with V, the market value of a bank's assets in a corresponding fiscal year, as an weight. These figures show that *shinkin* banks tend to be closer to default (higher PD as seen in Figure 1.1), would incur greater costs of insuring liabilities (higher IPP as seen in Figure 1.2) and are more greatly leveraged (more poorly capitalized as seen in Figure 1.3) than regional banks.

4.2. Estimated PD, IPP and leverage for ex-post failed *shinkin* banks

One way to justify our estimates of PD, IPP and leverage for privately held *shinkin* banks, which are obtained as out-of-sample predictions based on the results of the regressions of stock market data-derived stochastic characteristics variables on financial statement-based variables, is to see whether these variables predict ex-post failures of *shinkin* banks. The Deposit Insurance Corporation of Japan (DICJ) and the Small and Medium Enterprise Agency (SME Agency) jointly publish the list of 20 failed *shinkin* banks on their websites.[12]

[12] We identify a failed bank if either the DICJ or the SME Agency lists it as a failed bank. To be precise, 17 *shinkin* banks received financial assistance and were assumed by other banks (see https://www.dic.go.jp/content/000025772.pdf) and for one bank, the DICJ operated as a financial administrator for its resolution (see https://www.dic.go.jp/english/e_katsudo/page_000268.html.). The SME Agency lists 15 failed *shinkin* banks (http://www.chusho.meti.go.jp/kinyu/download/130404.pdf in Japanese) and two of these 15 banks are not included into 18 failed *shinkin* banks listed by the DICJ. Thus, in total, 20 *shinkin* banks are identified as failed banks.

The list of such failed *shinkin* banks are summarized in Table 4. These failed banks are relatively small as all but two among them are smaller as the last available amount of total assets is less than the average as reported in Panel B of Table 2.

Table 5 shows the values for DD, PD, IPP, leverage as well the risk-based capital adequacy ratio, for three consecutive fiscal years ending in the last year, for which at least IPP and leverage are available, leading to years of failures of 19 *shinkin* banks that eventually failed and also are included in our sample. The first four variables are those estimated based on our "pseud" market-based variable approach. We add the capital adequacy ratio, the most widely used regulatory measure for a bank's financial strength as a reference variable.

As it turns out, for 12 of 19 failed *shinkin* banks, the estimated PD is 1 in the last (pre-failure) fiscal year for which PD can be estimated, and for additional three banks, the estimated PD is one in the second to the last fiscal year for which PD can be estimated . In total, for 15 out of 19 failed *shinkin* banks that are included in our sample, the estimated PD is 1 at least once in the last two pre-failure fiscal years for which the PD can be estimated.[13] We also recognize that the level of the regulatory capital adequacy ratio does not appear to alert a bank's failure in advance. After the risk-based capital adequacy ratio was adopted as a numerical standard for the Prompt Corrective Action framework in FY1997, among 18 bank-fiscal years from abovementioned three consecutive fiscal years for which the predicted PD equals 1, only 2 bank-fiscal years are associated with banks being undercapitalized by the capital adequacy ratio standard (the ratio is reported as missing when a bank's capital

[13] In the Japanese context, Harada et al. (2013) discuss that the Merton's distance to default predicts failures of Japanese publicly held banks.

adequacy is negative) and an additional one bank-fiscal year is associated with a bank not meeting the regulatory minimum standard of 4 percent. Conversely, for 4 bank-fiscal years for which the capital adequacy ratio is less than the regulatory minimum standard of 4 percent, three are associated with a PD equaling 1. These facts suggest that our PD not only has a good predictive power for a bank's future failure and identify banks that would fail in the near future but also are considered well capitalized by the regulatory capital adequacy ratio. Hence, the PD we present in this study would complement the regulatory capital adequacy ratio as a policy metric.[14]

A caveat is that an estimated PD equaling one for a bank does not necessarily mean that that bank will eventually fail. Indeed, for 793 of 8825 bank-year observations for *shinkin* banks, the estimated PD equals one and 19 ex-post failed banks account for only 36 of 793 observations. This means that vast majority of *shinkin* banks whose estimated PD rose to one in any year over our sample period survived[15].

One explanation for this fact is that, in contrast to non-cooperative banks, cooperative banks of various types have their central organizations that function as their safety net. In

[14] It may be overstatement to claim that the PD is a (statistically) better predictor of bank failure than the regulatory capital adequacy but it, nonetheless, is a metric less confusing than the capital adequacy ratio. Carefully watching Table 6, we see that the capital adequacy ratios of ex-post failed banks follow the declining trends toward their respective failures, which may be trends that identify these ex-post failed banks from surviving banks whose capital adequacy ratios may not show the similar downward trends. The PD being 1 is an unambiguous alert to any observer but the declining capital adequacy that remains above the regulatory minimum is not.

[15] The financial statement-based data for *shinkin* banks are available for only a single bank for FY 2016. Thus, practically speaking, the sample period for *shinkin* banks begins in FY1989 and ends in FY2015.

this regard, as a safety net, *shinkin* banks have the SCB besides the government framework covering all deposit taking banks. The SCB had provided individual *shinkin* banks with special deposit accounts at which they were required to maintain certain levels of balances so that it could provide emergency funding to distressed *shinkin* banks. In 2001 this deposit-based emergency funding was replaced by a new safety net framework built on capital infusions into distressed *shinkin* banks by the SCB. Recall that the SCB is majority-owned by *shinkin* banks themselves. This system of cross bank assistance with the SCB as a facilitator reflects the nature of *shinkin* banks as non-profit cooperative banks.

The IPP and the leverage are not as powerful in predicting a *shinkin* bank's failure as the PD is. As for the IPP, if we arbitrarily choose the threshold for a high IPP at 0.01 (1 percent cost of insuring a bank's liabilities), for only three ex-post failed banks, the IPP is in excess of 0.01 in the last fiscal year for which IPP can be estimated and, for four banks, IPP is in excess of 0.01 at least once in the last two pre-failure fiscal years for which the PD can be estimated. As for leverage, for six ex-post failed banks, the leverage is less than 1 and thus undercapitalized in the last fiscal year for which the leverage can be estimated and, for nine ex-post failed banks, leverage is less than 1 at least once in the last two pre-failure fiscal years for which the leverage can be estimated.

These findings suggest that the estimated ex-ante PD is the most powerful predictor of a *shinkin* bank's failure among three "pseudo market based" default risk measures . It could tell a bank to fail even when the level of the regulatory capital adequacy ratio does not. Clearly, our estimated ex-ante PD outperforms the capital ratio in predicting shrink bank's risk of failure. Admittedly, our three bank failure risk measures are the variables that merely summarize multiple financial statement based variables such that, for a privately held *shinkin* bank, these variables are associated with the hypothetical market value of the bank's assets (or more precisely the leverage based on the market value of the bank's assets) and its volatility that are non-existent in the real world in the same way as they are with the market value of a bank's assets and its volatility that are observable (implied from a bank's shareholders' values) for publicly held regional banks. Thus, this pseud market-based approach for measuring a bank's default risk allows us to detect the default risks that are hard to find by looking at multiple financial statement-based variables separately.

5. Conclusion

In this paper, we proposed to measure credit risks of privately held *shinkin* banks by pseudo market-based measures such as the PD. When computing the PD for a bank, we employed the formula based on a bank's DD developed by Bharath and Shumway (2008). We computed the market value of assets and its volatility for each bank - fiscal year observation implied from the data about the shareholders' values that are observed daily within that fiscal year for publicly held banks. Since the shareholders' values are not observable for privately held *shinkin* banks, we estimate the hypothetical market value of assets and its volatility for these banks. We, first, run the regressions of logarithms of the market-based leverage and the market-based asset volatility on a set of financial statement-based variables. Then, we conducted the out of sample predictions for the market value of a bank's assets and the leverage using values of financial statement-based variables available for *shinkin* banks.

We found that estimated PDs predict ex-post failures of *shinkin* banks that the levels of their regulatory capital adequacy ratios would tell are adequately capitalized. We believe that our measures for a privately held bank's failure risks provide the regulators with a simple and intelligible numerical metric for their early warning system, which they could use to assess a bank's financial health based on various quantitative metrics. By introducing our estimated PDs into practice, the regulators' assessments and resulting decisions would certainly become more rule based and less discrete.

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Table 1. Independent Variables for Regressions of Logarithms of x (Leverage) and σ_V (Volatility of the Market Value of Assets) and Their Definitions.

Variable	Definition
A/L	The ratio of the book-based values of bank's assets to liabilities.
LNA	The natural logarithm of the total book value of bank assets.
NI/L	The ratio of net income to the book value of liabilities.
TL/A	The ratio of total loans to total assets.
PL/L	The ratio of loan loss provisions to total liabilities
Dum*$(NI/L)^2$	The square of the NI/L ratio multiplied by a dummy variable equal to one when the net income is negative and zero otherwise.
$(NI/L)^2$	The square of the NI/L ratio.

Table 2. Descriptive Statistics of Stock Market Based Variables and Independent Variables Used for the Regressions of Logarithms of x (Leverage) and σ_V (Volatility of the Market Value of Assets) for Listed Regional Banks

Panel A. Listed Regional Banks, Stock Market-Based Variables and Independent Variables

Variable	N	Mean	Median	Standard error	Min	Max
E	2,160	118,379,667	99,594	209,388,547	6,502	42,729,193,782
σ_E	2,177	0.310	0.296	0.161	0.002	3.400
A/L	2,177	1.049	1.047	0.013	1.019	1.097
LNA	2,177	14.642	14.666	0.810	12.509	16.740
A (million yen)	2,177	3,115,253	2,340,586	2,604,387	270,741	18,624,972
NI/A	2,177	0.002	0.002	0.002	-0.009	0.011
TL/A	2,177	0.662	0.664	0.063	0.449	0.773
PL/L	2,177	0.002	0.001	0.003	0	0.018

Panel B. *Shinkin* Banks, Independent Variables

Variable	N	Mean	Median	Standard error	Min	Max
A/L	8,825	1.057	1.055	0.019	1.019	1.117
LNA	8,825	12.183	12.099	1.030	8.576	15.428
A (million yen)	8,825	342,530.3	179,646.1	465,372.1	5304	5,016,126
NI/A	8,825	0.003	0.002	0.002	-0.009	0.016
TL/A	8,825	0.550	0.556	0.094	0.297	0.773
PL/L	8,825	0.001	0.000	0.002	0.000	0.018

Table 3. The Sample Size and the R-squared for Every Fiscal Year in the Sample Period of FY1989 through FY2016

FY		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
R squared	$\ln(x)$	0.2691	0.3545	0.2496	0.3209	0.3236	0.3003	0.3251	0.3553	0.3556	0.2199	0.6516
	$\ln(\sigma_V)$	0.2285	0.1553	0.1638	0.2721	0.2486	0.1727	0.1871	0.2766	0.2962	0.2021	0.1225
N		72	79	82	82	81	82	72	73	67	70	79

FY		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
R squared	$\ln(x)$	0.1085	0.1877	0.0616	0.3552	0.5328	0.5718	0.7744	0.6916	0.5645	0.5722
	$\ln(\sigma_V)$	0.1016	0.1986	0.3973	0.4265	0.6231	0.2511	0.6167	0.7096	0.1962	0.0977
N		81	73	74	78	80	81	75	77	72	82

FY		2010	2011	2012	2013	2014	2015	2016
R squared	$\ln(x)$	0.6182	0.5696	0.7015	0.6017	0.6218	0.581	0.3677
	$\ln(\sigma_V)$	0.112	0.0622	0.1229	0.1285	0.5848	0.1551	0.1745
N		79	80	81	82	81	82	80

Table 4. Descriptive Statistics of Shareholder Value Implied Variables and Failure Risk Measures

Listed Regional Banks

Variable	N	Mean	Median	Standard error	Min	Max
x	2,177	1.036	1.034	0.021	0.929	1.113
σ_V	2,177	0.014	0.012	0.010	0.000	0.091
PD	1,968	0.069	0.000	0.209	0	1
IPP	2,177	0.001	0.000	0.004	0	0.071

Shinkin Banks

Variable	N	Mean	Median	Standard error	Min	Max
x	8,825	1.017	1.021	0.023	0.777	1.046
σ_V	8,825	0.003	0.002	0.002	0.000	0.012
PD	8,207	0.116	0.000	0.315	0	1
IPP	8,825	0.003	0.000	0.017	0	0.223

Table 5. The List of Failed *Shinkin* Banks

Bank name	Date of failure	Last available total assets	FY
Toyo Shinkin	June 1, 1992	418502	1991
Kamaishi Shinkin	October 1, 1993	99372	1992
Nichinan Shinkin	November 19, 1999	31906	1999
Fudo Shinkin	November 29, 1999	73970	1997
Tamano Shinkin	March 31, 2000	141352	1998
Ogawa Shinkin	November 10, 2000	561240	1999
Wakaba Shinkin	November 11, 2000	95281	1999
Utsunomiya Shinkin	February 25, 2002	201990	2000
Usuki Shinkin	February 26, 2002	37732	2000
Okinawa Shinkin	March 18, 2002	45604	2000
Osaka Daiichi Shinkin	March 25, 2002	56708	2000
Kansai Nishinomiya Shinkin	March 26, 2002	331367	2000
Nakatsu Shinkin	March 27, 2002	83588	2000
Sagaseki Shinkin	March 28, 2002	14453	2000
Sinei Shinkin	May 20, 2002	38235	2000
Nagashima Shinkin	June 2, 2002	14619	2000
Saeki Shinkin	June 10, 2002	76406	1999
Sougo Shinkin	June 11, 2002	605001	2000
Funabashi Shinkin	June 17, 2002	219904	2000
Ishioka Shinkin	September 24, 2002	356374	2000

Note: Among these banks, Toyo Shinkin Bank is the only one that is not included in our sample.

Table 6. The values for the DD, the PD, the IPP, Leverage and the Capital Adequacy Ratio for Three Consecutive Fiscal Years Ending in the Last Year, for Which at Least IPP and Leverage Are Available, Leading to A Year of A Bank's Failure: 19 Failed *Shinkin* Banks

Kamaishi

FY	PD	IPP	x	capital adequacy
1990	0.000	0.000	1.006	-
1991	0.000	0.000	1.001	-
1992	1.000	0.000	1.000	-

Nichinan

FY	PD	IPP	x	capital adequacy
1996	0.000	0.000	1.020	-
1997	0.000	0.000	1.018	6.68
1998	0.000	0.000	1.015	7.67

Fudo

FY	PD	IPP	x	capital adequacy
1994	0.000	0.000	1.026	-
1995	1.000	0.000	1.027	-
1996	1.000	0.000	1.015	-

Tamano

FY	PD	IPP	x	capital adequacy
1994	0.000	0.000	1.027	-
1995	0.000	0.000	1.025	-
1996	1.000	0.000	1.010	-

Ogawa

FY	PD	IPP	x	capital adequacy
1996	0.000	0.000	1.015	-
1997	-	-	-	4.60
1998	-	0.019	0.981	4.00

Wakaba

FY	PD	IPP	x	capital adequacy
1996	1.000	0.000	1.010	-
1997	0.000	0.006	0.994	5.63
1998	1.000	0.000	1.004	5.00

Utsunomiya

FY	PD	IPP	x	capital adequacy
1997	1.000	0.007	0.993	5.58
1998	1.000	0.003	0.997	6.00
1999	1.000	0.000	1.008	6.03

Usuki

FY	PD	IPP	x	capital adequacy
1998	0.000	0.000	1.010	6.73
1999	0.000	0.000	1.024	9.97
2000	1.000	0.003	0.997	7.95

Okinawa

FY	PD	IPP	x	capital adequacy
1996	0.000	0.000	1.015	-
1997	1.000	0.000	1.014	5.00
1998	0.000	0.000	1.004	4.55

Osaka Daiichi

FY	PD	IPP	x	capital adequacy
1998	0.000	0.000	1.016	6.83
1999	-	-	-	5.86
2000	1.000	0.000	1.011	5.86

Kansai Ninishinomiya

FY	PD	IPP	x	capital adequacy
1998	1.000	0.007	0.993	-
1999	-	-	-	-
2000	-	0.060	0.940	4.42

Nakatsu

FY	PD	IPP	x	capital adequacy
1998	1.000	0.000	1.004	5.51
1999	1.000	0.064	0.936	4.52
2000	0.000	0.000	1.015	4.66

Sagaseki

FY	PD	IPP	x	capital adequacy
1998	1.000	0.046	0.954	8.94
1999	-	-	-	9.97
2000	-	0.000	1.000	5.62

Shin-ei

FY	PD	IPP	x	capital adequacy
1997	1.000	0.000	1.018	7.15
1998	1.000	0.000	1.008	-
1999	1.000	0.000	1.014	7.70

Nagashima

FY	PD	IPP	x	capital adequacy
1998	0.000	0.009	0.991	11.26
1999	0.000	0.000	1.018	11.27
2000	1.000	0.136	0.864	9.64

Saeki

FY	PD	IPP	x	capital adequacy
1996	0.000	0.004	0.996	-
1997	0.000	0.000	1.026	8.28
1998	0.000	0.000	1.005	8.30

Sougo

FY	PD	IPP	x	capital adequacy
1998	-	0.009	0.991	5.50
1999	-	-	-	5.24
2000	-	0.002	0.998	6.21

Funabashi

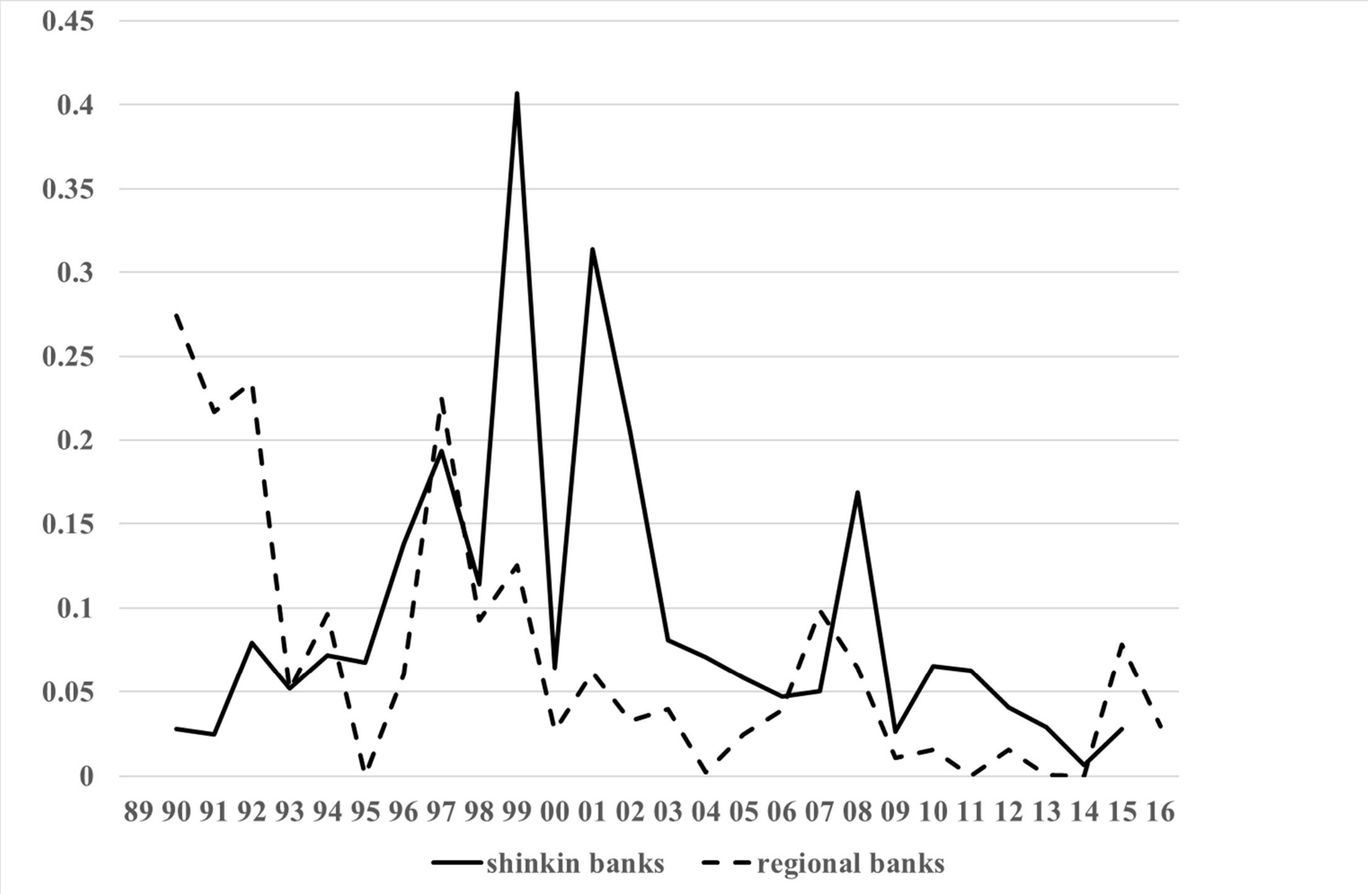
FY	PD	IPP	x	capital adequacy
1998	-	0.000	1.014	5.00
1999	1.000	0.012	0.988	3.53
2000	0.000	0.000	1.016	4.46

Ishioka

FY	PD	IPP	x	capital adequacy
1998	0.000	0.017	0.983	10.00
1999	1.000	0.000	1.007	10.95
2000	1.000	0.119	0.881	8.35

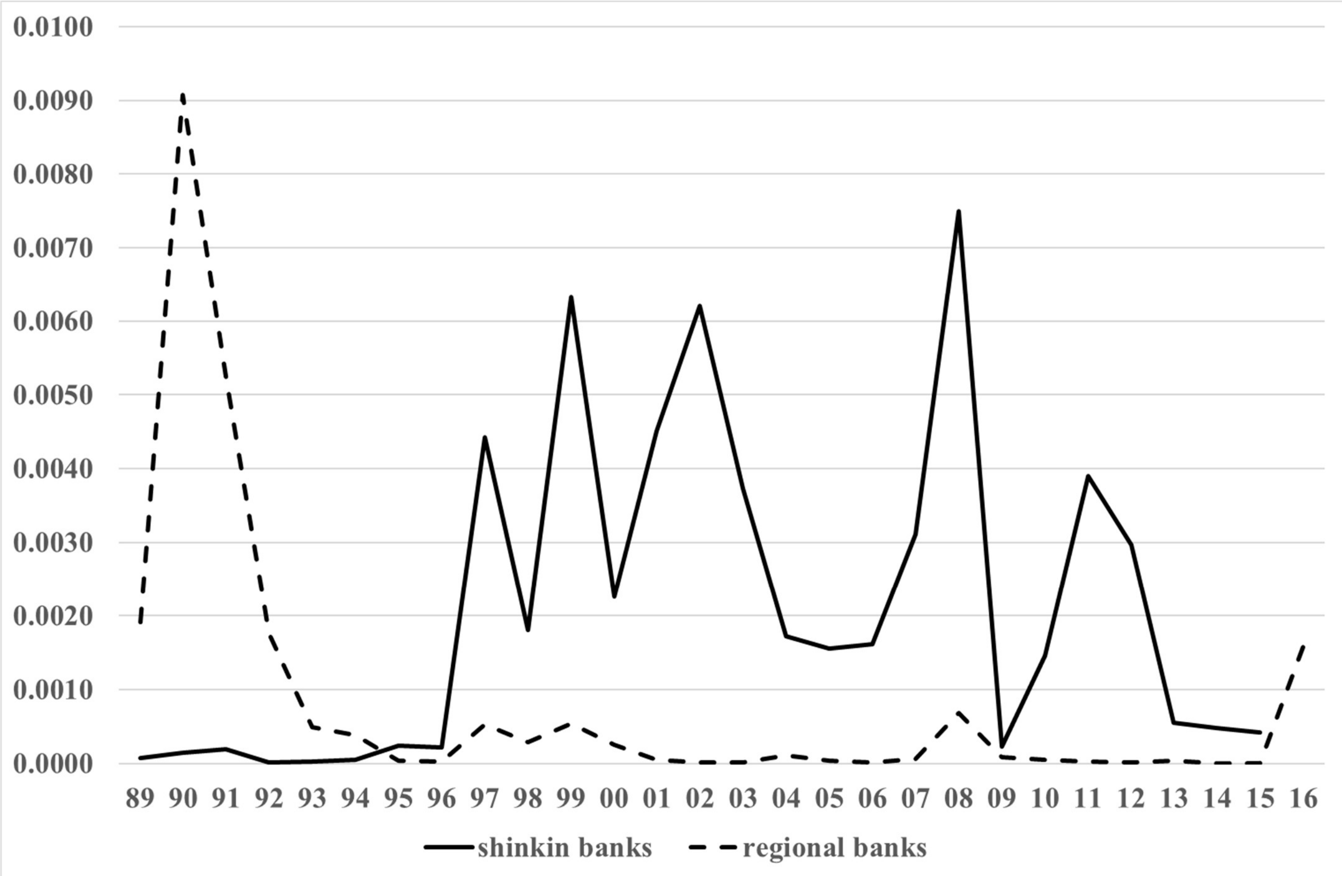
Note: Tables for failed *shinkin* banks are listed in chronological order of their failures.

Figure 1.1. The Trends of Aggregate PD



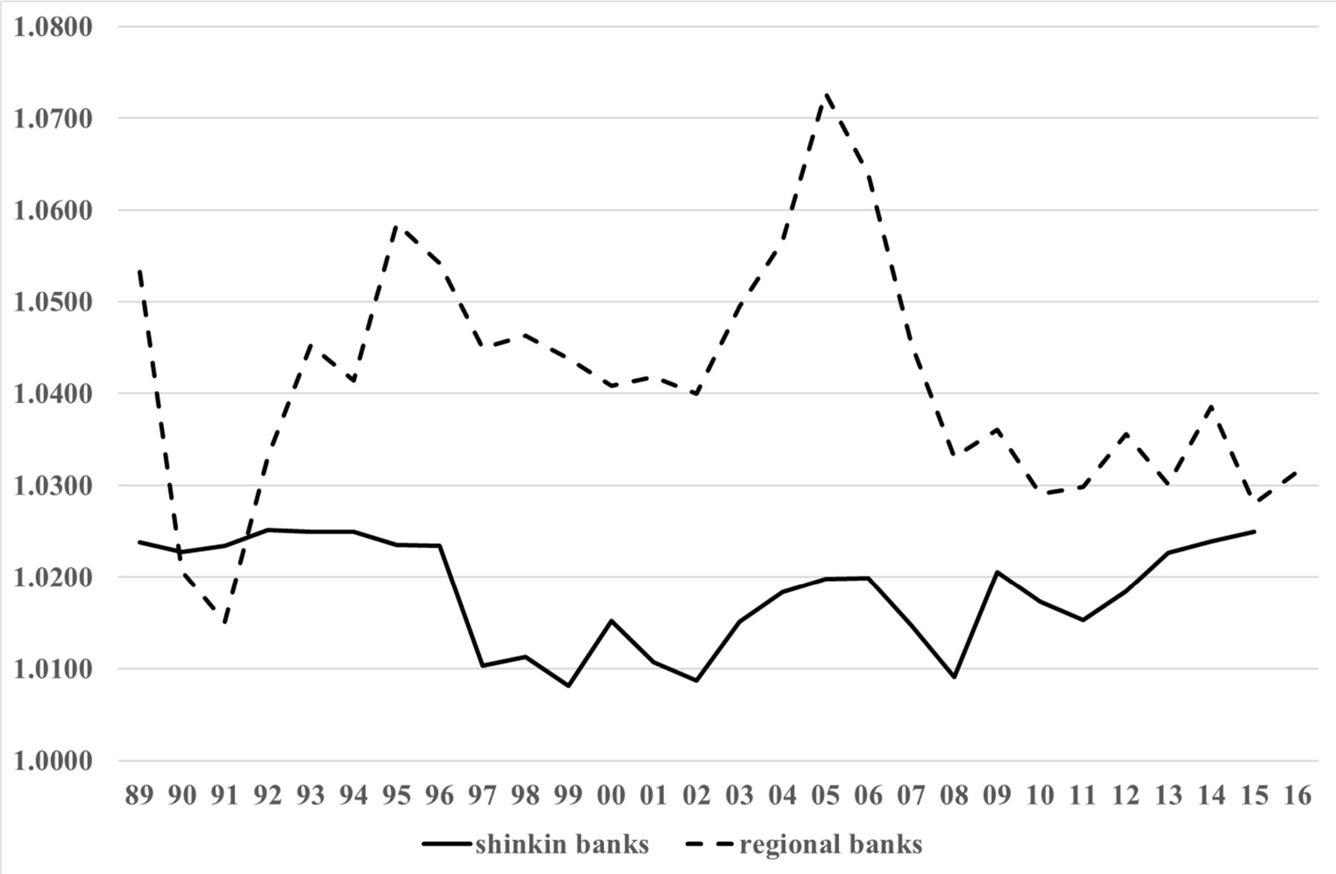
Note: Each variable is weighted with V, the market value of a bank's assets as a weight. Since computation of PD needs the lagged value for V, PD cannot be computed for FY1989, the first fiscal year in our sample period.

Figure 1.2. The Trends of Aggregate IPP



Note: Each variable is weighted with V, the market value of a bank's assets as a weight. Since computation of PD needs the lagged value for V, PD cannot be computed for FY1989, the first fiscal year in our sample period.

Figure 1.3. The Trends of Aggregate Leverage



Note: Each variable is weighted with V, the market value of a bank's assets as a weight. Since computation of PD needs the lagged value for V, PD cannot be computed for FY1989, the first fiscal year in our sample period.