Predicting the Probabilities of Default for Privately Held Banks: The Case of *Shinkin* Banks in Japan

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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 estimate *shinkin* banks' probabilities of default. We find that estimated probabilities of default predict *shinkin* banks' ex-post failures that are not predicted based on such financial statement-based variables as the regulatory capital adequacy ratio well.

Keywords: probability of default, privately held bank

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1. Introduction

A large number of banks worldwide are privately held. Falkenheim and Pennacchi (2003) point out that majority of banks in the United States are privately held (their shares are not traded in stock markets), although majority of bank assets are held by publicly held banks (their shares are traded in stock markets). In Japan, where bank lending dominates the corporate finance, as of June, 2018, according to the Nikkei NEEDS databank and the Japanese Bankers' Association, 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, which we now 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 Japan's 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 identical with 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 banking sector, privately held banks active in Japan. In particular, we focus on *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 credit 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 to insure depositors against the bank's failure.[2] The concept of the IPP is proposed by a seminal study of Merton (1977) and the formula for the IPP is developed

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[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 1246 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.

[2] The real-world equivalent of the IPP is a premium rate for CDS a bank purchases to insure against their 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.

for applying to the actual data of banks by Ronn and Verma (1986) and Duan et al. (1992). In doing so, we employ the following two step approach. At the first step, we select a sample of publicly held regional banks, which are relatively similar to *shinkin* banks in business model, size and regulatory environments and compute the IPP and the PD for these publicly held banks. When computing the IPP for a bank, we employ the formula developed by Duan et al. (1992). When computing the PD for a bank, we employ the formula based on a bank's distance to default (DD) developed by Bharath and Shumway (2008).[3] More precisely, we compute 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. We. then, apply formulae for the IPP and the PD to the data of these publicly held banks to obtain the values for these two variables. 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 market-based leverage as defined by the market value of bank assets divided by the book value of bank liabilities and the market-based asset volatility on a set of financial statement-based variables as employed by Falkenheim and Pennacchi (2003). Then, as Falkenheim and Pennacchi do for privately held banks in the United States, we conduct 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, assuming that the relationship between market-based variables and financial statement-based variables we observe for publicly held banks hold true for *shinkin* banks.[4]

[3] The probability of default is computed based on the distance to default model developed by Merton (1974). Bharath and Shumway (2008) provides the detailed survey of various attempts to compute PD based on the Merton's DD model.
[4] In addition to Falkenheim and Pennacchi (2003) themselves, Anginer et al. (2014) use their

To the best of our knowledge, we are the first to examine the predictive power of PD for failures of privately held banks. What is remarkable about our empirical strategy is that PD estimated for *shinkin* banks based on a bold assumption that the relationships between (implied) market-based variables, which are of course unobservable for privately held *shinkin* banks, and financial statement-based variables are the same between publicly held reginal banks and *shinkin* banks that are not only privately held but are cooperative institutions that are not even stock companies, the estimated PD predicts a failure of a *shinkin* bank 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 indirectly the risk characteristics, as they would be predicted by the financial market, of the non-listed *shinkin* banks in Japan, we use a two-stage empirical strategy. In the first stage of this approach and on the basis of Merton (1973) model, we will estimate the market-derived risk characteristics of the Japanese listed regional banks; namely the market value of each bank's total assets, and its standard deviation (volatility). A statistical relationship is then estimated between these generated

methodology to examine the default risks of privately held foreign bank subsidiaries operating in developing economies.

market-based data and several regional banks' financial statement-based variables. The second stage of this approach consists of using the statistical relationships determined in the first stage of the non-listed *shinkin* banks to predict their "pseudo" market-based risk characteristics on the basis of their financial statements data.

On the basis of Merton (1974) model, as described by Bharath and Shumway (2008), we estimate the distance to default, DD, and the probability of default, PD, for the sample of Japanese regional banks and *shinkin* banks. PD is calculated on the basis of the value of the DD, which can be referred to as *z-scores*.

The DD is determined by dividing the difference between the firm's debt face value and its estimated market value by the volatility of the latter; i.e., the firm's market value. The computed DD values are then put into a cumulative distribution function to produce the corresponding probabilities of default PDs.

In order to compute the above-mentioned estimated data of DDs and PDs for Japanese regional banks, we first need to estimate the market values of each bank's total assets (V) and their corresponding volatilities (σ_V). To do so, we follow Merton (1974) seminal methodology that was widely applied by many researchers and practitioners. V and $\sigma_V$are calculated numerically by solving a system of two non-linear equations; the first equation is the equity value equation as described by Bharath and Shumway (2008) based on the famous Black-Scholes-Merton formula where the market value of the bank's equity, E, is the following:

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

Where B is the bank's debt face value, 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:

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

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

The second equation in the system is the Ito's lemma that describes the relationship between the volatility of the bank's market value V and its equity value E as follows:

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

Our calculations are based on the following observable data of listed Japanese banks: the market value of bank's equity, E, is calculated by multiplying each bank's stock price by the number of its shares, the volatility of the bank's equity, σ_E, is determined by computing the annual volatility of its daily stock returns, banks's debt, B, is represented by the total liabilities, as in Guizani and Watanabe (2016) and Duan et al.(1992), the risk-free rate, r, is generated by computing the annual average of the daily interest rate on the one-year Japanese treasury bonds. And finally, following Guizani and Watanabe (2016) and some other literature[5] we assume $T = 1$. On the basis of the above compiled data, we solve the system of equations (2) and (3) numerically in order to obtain the Vs and $\sigma_V s$ of the listed Japanese regional banks.

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

The second stage of this strategy is to use the numerically computed data of the banks' market values, V, and their standard deviations, σ_V, to estimate two statistical relationships relating these variables to some of their financial statement-based variables. We then, on the basis of their book-based variables, use the results of these estimated regressions to predict the unobserved market-based risk characteristics of the Japanese non-listed *shinkin* banks.

As Falkenheim and Pennacchi (2003) do, we run the regressions of the logarithms of the generated $\frac{V}{B}$ (hereafter, *x*) and σ_V on some financial statement variables of the Japanese listed regional banks. The estimation of these regressions aims at determining the statistical relationships that exist between a bank's market-based risk characteristics and its book-based variables.

For each year of the sample period from FY1989 through 2016, the following two regressions are then estimated for a sample of listed regional banks data.

$$ln(x_i) = c_1 Y_i + \varepsilon_{1i} \quad (4a)$$

$$ln(\sigma_{V_i}) = c_2 Y_i + \varepsilon_{2i} \quad (4b)$$

Where i is an index for banks, $i = 1, \ldots 128$, $c_j, j = 1, 2$ is an 1 by m vector.m is the number of independent variable and the ε_{ji} is an idiosyncratic error term with mean zero and assumed to be independent across banks, Y_i is an m by 1 vector of financial statement-based independent variables. The ordinary least square method is then used to estimate the coefficients c_j for each year in the sample period.

The two vectors of the estimated coefficients, $\hat{c}_j$, are then used to predict $\ln(x_k)$ and $\ln(\sigma_{Vk})$ for $k = 1, \ldots, M_t$.

Where M_t is the number of *shinkin* banks in fiscal year t.

The predicted market risk characteristics are given by the following equations:

$$ln(\hat{x}_k) = \hat{c}_1 Y_k \quad (5a)$$

$$ln(\widehat{\sigma_V}_k) = \hat{c}_2 Y_k \quad (5b)$$

Where Y_k is the vector of the book-based independent variables.

The independent variable vectors, Y_i, and Y_k, are mostly inspired from Falkenheim and Pennacchi (2003). The variables chosen by these authors are those judged to be important and closely eyed by market participants; namely investors and security analysts, to assess bank's net worth and risk profile. The first variable is the ratio of the book values of the assets to liabilities, A/L. This ratio represents the bank's leverage or net worth. Three variables of net income to liabilities ratios are also included in the regressions. These variables are expected to represent bank's present discounted value of its future earnings; namely a linear term, NI/L, a quadratic term, $(NI/L)^2$ and a quadratic term multiplied by a dummy variable that is equal to one when the net income is negative and zero otherwise, Dum × $(NI/L)^{22}$. These quadratic terms are included in order to capture the possible non-linearity that might exist between the net income ratio and the dependent variables; i.e., the x and the σ_V. The bank provision for loan losses to liabilities, PL/L, is included in the equations on order to count for the bank's level of loan risk.[6] Two more variables are also included; namely the total loans to assets ratio, TL/A, to represent lending intensity of the bank and the natural logarithm of book value of total assets, LNA, to count for the bank i's size.

Table 1 describes in more details the independent variables used in the abovementioned regressions (4) and (5):

The last step of this second stage in our empirical strategy is to compute the

[6] 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.

market-based risk measures; namely the insurance premium per unit of deposits, IPP,[7] the DD and the PD for each *shinkin* bank k at time $t = 1989, \dots, 2015$, according to the following formulas.

$$IPP_{\,kt} = \mathcal{N}\left(y_{kt} + \widehat{\sigma_V}_{kt}\right) - \frac{\widehat{V_{kt}}}{B_{kt}} \mathcal{N}(y_{kt}) \tag{6}$$

Where $y_k = \frac{ln\left(\frac{B_k}{\widehat{V_k}}\right) - \widehat{\sigma_V}_k^{\,2} / 2}{\widehat{\sigma_V}}$

$$DD_{kt} = \frac{ln\left(\widehat{V_{kt}} / B_{kt}\right) + \left(\mu_{kt} - 0.5 \widehat{\sigma_V}_{kt}^{\,2}\right)}{\sigma_{V\,Kt}} \tag{7}$$

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

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

3. Data

We have four major sources of 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 the Japanese Bankers' Association (JBA) after FY1997 and in hard copy periodicals before and after FY 1996. 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

[7] As in Guizani and Watanabe (2016).

converted into electronic format under Keio Unviersity's government funded GCOE program that are now maintained by Keio Unviersity'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' value of all regional banks and bank holding companies holding primarily regional banks from the Nikkei NEEDS databank and compile the bank – 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 yea.[8] 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 if needed. As for necessary financial data of *shinkin* banks, we extract the data about financial variables for the period from FY1989 through FY2009 from the Analysis of *Shinkin* Banks' Financial Statements and the data from FY2010 through FY2016 from the ORBIS Bank Focus.

Regressions for logarithm of leverage and market-based value of total assets

When running the cross-section year by year regressions of logarithm of leverage (x) and the volatility of the market value of total assets (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 as outliers.

Table 2 presents the descriptive statistics of independent variables used for the

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

regressions of logarithms of x and σ_V for the sample of regional banks (the regional bank sample, Panel A) on which regressions are actually run and the sample of *shinkin* banks (the *shinkin* bank sample, Panel B) on which out of sample predictions based on the regressions run on the regional bank sample are conducted.[9] Looking at both means and medians, generally speaking, 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 (smaller loan loss provisions to liabilities ratio) than regional banks are. *Shinkin* banks also depend less on lending than regional banks do presumably because *shinkin* banks as a group have the Shinkin Central Bank as a central financial institution that takes deposits from individual *shinkin* banks to lend and invest into securities.

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 common to both leverage 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 associate such breaks of the stable relationship between stock market-based variables and financial statement-based variables with any macroeconomic or financial episodes.[11]

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[9] The descriptive statistics for (exponentials of) dependent variables, x and σ_V will be presented later along with the results for *shinkin* banks obtained by conducting out of sample predictions based on regression results on the regional bank sample for comparison purposes.

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

[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

4. Results

4.1. Overall results

Figure 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 *shinkin* banks and a dashed curve represents 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).

As for cross sectional year by year distributions of regional banks and *shinkin* banks for these three variables, *shinkin* banks tend to be more dispersed than regional banks as standard errors for PD, IPP and leverage tend to be higher for *shinkin* banks than for regional banks.

Table 4, Panels A, B and C and Panels D, E and F show year by year cross section descriptive statistics of PD, IPP and x (leverage) for regional banks and those for *shinkin* banks, respectively. Comparing standard errors of these variables between *shinkin* and regional banks, one cannot definitively say that the distribution is wider for one type of banks than for another, which also justifies our methodology of out of sample prediction-based estimates for *shinkin* banks, as predicted values for x and σ_V resulted in neither excessively dispersed distributions nor excessively concentrated distributions for *shinkin*

in FY 1997 nor at the peak of the global crisis in FY 2008 and FY 2009.

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 obtained as out of sample predictions for these variables based on the results of the regressions of stock market-based variables on financial statement based variables is to see whether these variables predict ex-post failures of *shinkin* banks. The Deposit Corporation of Japan (DICJ) and the Small and Medium Enterprise Agency (SME Agency) jointly publish the list of 20 failed banks including failed *shinkin* banks on its websites.[12] The list of such failed *shinkin* banks are summarized in Table 4. These failed banks are relatively small as every but two such banks is smaller as measured by the last available total assets 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. As the PD is computed as a standard normal cumulative distribution function of a negative of DD, a large negative value for the DD is associated with a very high PD. We add the capital adequacy ratio that is the most widely used regulatory measure for a bank's financial strength as a

[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.

reference.

As it turns out, for 12 of 19 failed *shinkin* banks that are included in our sample, 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 computed. In total, 15 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 regulatory capital adequacy ratio does not have good predictive power for a bank's failure that PD does. 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 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 PD equaling 1.

These facts suggest that our PD not only has a good predictive power for a bank's future failure but also is far superior to the regulatory measure in predicting bank failures. A caveat is that an estimated PD being 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 18 ex-post failed banks account for only

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

37 of 793 observations. This means that vast majority of *shinkin* banks whose estimated PD rose to one in any year over our sample period from FY1989 through FY2015 survived[14].

IPP and leverage are not as powerful in predicting a *shinkin* bank's failure as PD is. As for 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, 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 below 1 so that they are undercapitalized in the last fiscal year for which the leverage can be estimated and, for nine ex-post failed banks, leverage is below 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 "market comparable" measures for a *shinkin* bank's default risk and also outperforms financial statement-based variables such as the capital adequacy ratio in predicting a bank's ex-post failure. Admittedly, our three measures of bank default risk 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' value)

[14] The financial statement-based data for *shinkin* banks are available for only a single bank. Thus, practically speaking, the sample period for *shinkin* banks begins in FY1989 and ends in FY2015. The listed of failed shinkin banks is updated as of

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 financial statement-based variables only independently.

5. Conclusion

In this paper, we proposed to measure credit risks of privately held *shinkin* banks by the PD and the IPP. 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 as employed by Falkenheim and Pennacchi (2003). Then, as Falkenheim and Pennacchi do for privately held banks in the United States, 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 *shinkin* banks' ex-post failures that are not predicted based on such financial statement-based variables as the regulatory capital adequacy ratio that is a primary metric for a bank's financial health when regulators take actions for financially distressed banks. We believe that our measures for a privately held bank's credit risks provide the regulators with easy to interpret numerical standards for their early warning system that make their prudential regulations to prevent bank failures more rule based and less discrete.

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Table 1. Independent variables and 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 bank's provision for loan losses expense 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 Independent Variables Used for the Regressions of Logarithms of x (Leverage) and σ_V (Volatility of the Market Value of Assets)

Panel A. Publicly held regional banks

Variable	N	Mean	Median	Standard error	Min	Max
A/L	2507	1.048	1.047	0.013	1.019	1.097
LNA	2507	14.587	14.621	0.840	12.376	16.740
A (million yen)	2507	3013849	2237922	2593200	237142	18624972
NI/A	2507	0.002	0.002	0.002	-0.009	0.012
TL/A	2507	0.665	0.671	0.062	0.449	0.773
PL/L	2427	0.002	0.001	0.003	0.000	0.018

Panel B. Privately held *shinkin* banks

Variable	N	Mean	Median	Standard error	Min	Max
A/L	8825	1.057	1.055	0.019	1.019	1.117
LNA	8825	12.183	12.099	1.030	8.576	15.428
A (million yen)	8825	342530.3	179646.1	465372.1	5304	5016126
NI/A	8825	0.003	0.002	0.002	-0.009	0.016
TL/A	8825	0.550	0.556	0.094	0.297	0.773
PL/L	8825	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. 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 5. The values for DD, PD, 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'as Failure: 19 Failed *Shinkin* Bnks

Kamaishi Shinkin

FY	DD	PD	IPP	x	capital adequacy
1990	383.907	0.000	0.000	1.006	-
1991	892.880	0.000	0.000	1.001	-
1992	-69.484	1.000	0.000	1.000	-

Nichinan Shinkin

FY	DD	PD	IPP	x	capital adequacy
1996	9.956	0.000	0.000	1.020	-
1997	7.321	0.000	0.000	1.018	6.68
1998	36.511	0.000	0.000	1.015	7.67

Fudo Shinkin

FY	DD	PD	IPP	x	capital adequacy
1994	5.981	0.000	0.000	1.026	-
1995	-8.878	1.000	0.000	1.027	-
1996	-6.276	1.000	0.000	1.015	-

Tamano Shinkin

FY	DD	PD	IPP	x	capital adequacy
1994	18.504	0.000	0.000	1.027	-
1995	16.217	0.000	0.000	1.025	-
1996	-90.061	1.000	0.000	1.010	-

Ogawa Shinkin

FY	DD	PD	IPP	x	capital adequacy
1996	7.925	0.000	0.000	1.015	-
1997	-	-	-	-	4.60
1998	-	-	0.019	0.981	4.00

Wakaba Shinkin

FY	DD	PD	IPP	x	capital adequacy
1996	-45.966	1.000	0.000	1.010	-
1997	5107.048	0.000	0.006	0.994	5.63
1998	-79.831	1.000	0.000	1.004	5.00

Utusnomiya Shinkin

FY	DD	PD	IPP	x	capital adequacy
1997	-867.468	1.000	0.007	0.993	5.58
1998	-59.169	1.000	0.003	0.997	6.00
1999	-43.764	1.000	0.000	1.008	6.03

Usuki Shinkin

FY	DD	PD	IPP	x	capital adequacy
1998	165.834	0.000	0.000	1.010	6.73
1999	6.879	0.000	0.000	1.024	9.97
2000	-35.860	1.000	0.003	0.997	7.95

Okinawa Shinkin

FY	DD	PD	IPP	x	capital adequacy
1996	11.039	0.000	0.000	1.015	-
1997	-5.190	1.000	0.000	1.014	5.00
1998	5.655	0.000	0.000	1.004	4.55

Osaka Daiichi Shinkin

FY	DD	PD	IPP	x	capital adequacy

1998		48.712	0.000	0.000	1.016	6.83
1999	-	-	-	-		5.86
2000		-115.954	1.000	0.000	1.011	5.86

Kansai Ninishinomiya

DD	DD	PD	IPP	x	capital adequacy
1998	-457.115	1.000	0.007	0.993	-
1999	-	-	-	-	-
2000	-	-	0.060	0.940	4.42

Nakatsu Shinkin

FY	DD	PD	IPP	x	capital adequacy
1998	-6.769	1.000	0.000	1.004	5.51
1999	-10904135	1.000	0.064	0.936	4.52
2000	16.928	0.000	0.000	1.015	4.66

Sagaseki Shinkin

FY	DD	PD	IPP	x	capital adequacy
1998	-2815490	1.000	0.046	0.954	8.94
1999	-	-	-	-	9.97
2000	-	-	0.000	1.000	5.62

Shin-ei Shinkin

FY	DD	PD	IPP	x	capital adequacy
1997	-24.278	1.000	0.000	1.018	7.15
1998	-178.769	1.000	0.000	1.008	-
1999	-77.738	1.000	0.000	1.014	7.70

Nagashima Shinkin

FY	DD	PD	IPP	x	capital adequacy
1998	3327.361	0.000	0.009	0.991	11.26
1999	67.085	0.000	0.000	1.018	11.27
2000	-37632939655168	1.000	0.136	0.864	9.64

Saeki Shinkin

FY	DD	PD	IPP	x	capital adequacy

1996	85.704	0.000	0.004	0.996	-
1997	18.803	0.000	0.000	1.026	8.28
1998	90.989	0.000	0.000	1.005	8.30

Sougo Shinkin

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

Funabashi Shinkin

FY	DD	PD	IPP	x	capital adequacy
1998	-	-	0.000	1.014	5.00
1999	-2257.131	1.000	0.012	0.988	3.53
2000	13.706	0.000	0.000	1.016	4.46

Ishioka Shinkin

FY	DD	PD	IPP	x	capital adequacy
1998	1805.909	0.000	0.017	0.983	10.00
1999	-61.374	1.000	0.000	1.007	10.95
2000	-279016898560	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

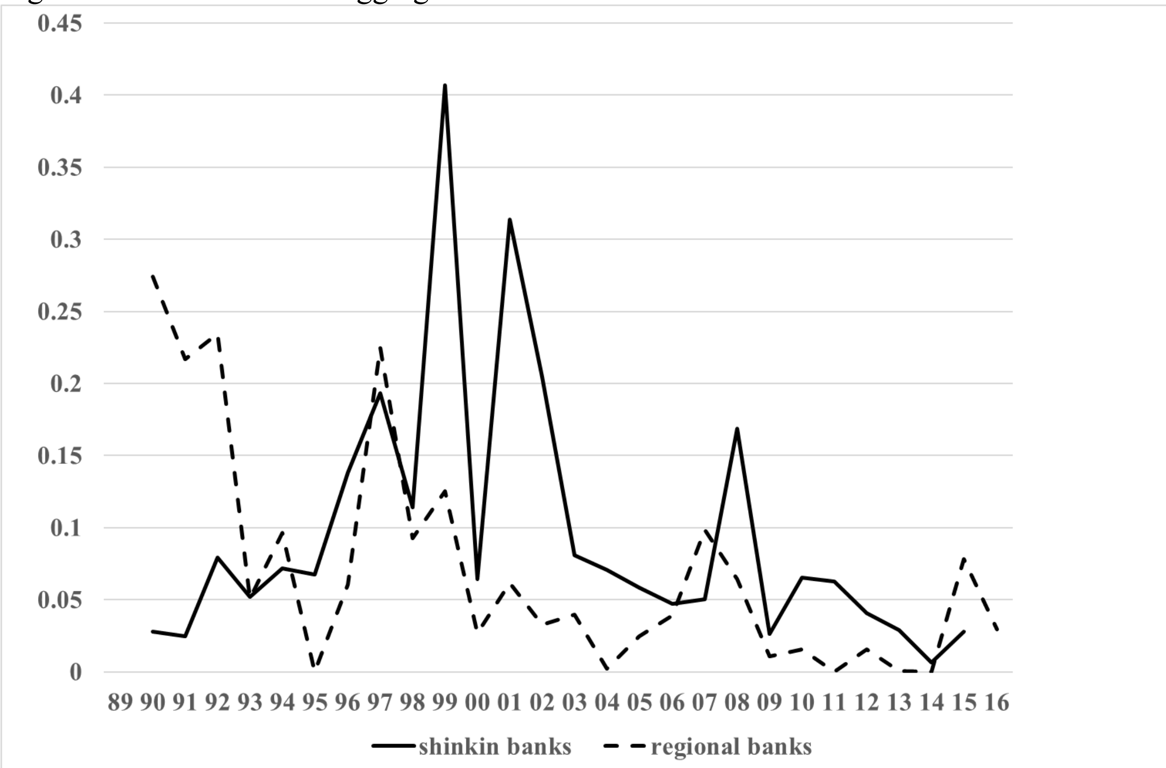


Figure 1.2. The Trends of Aggregate IPP

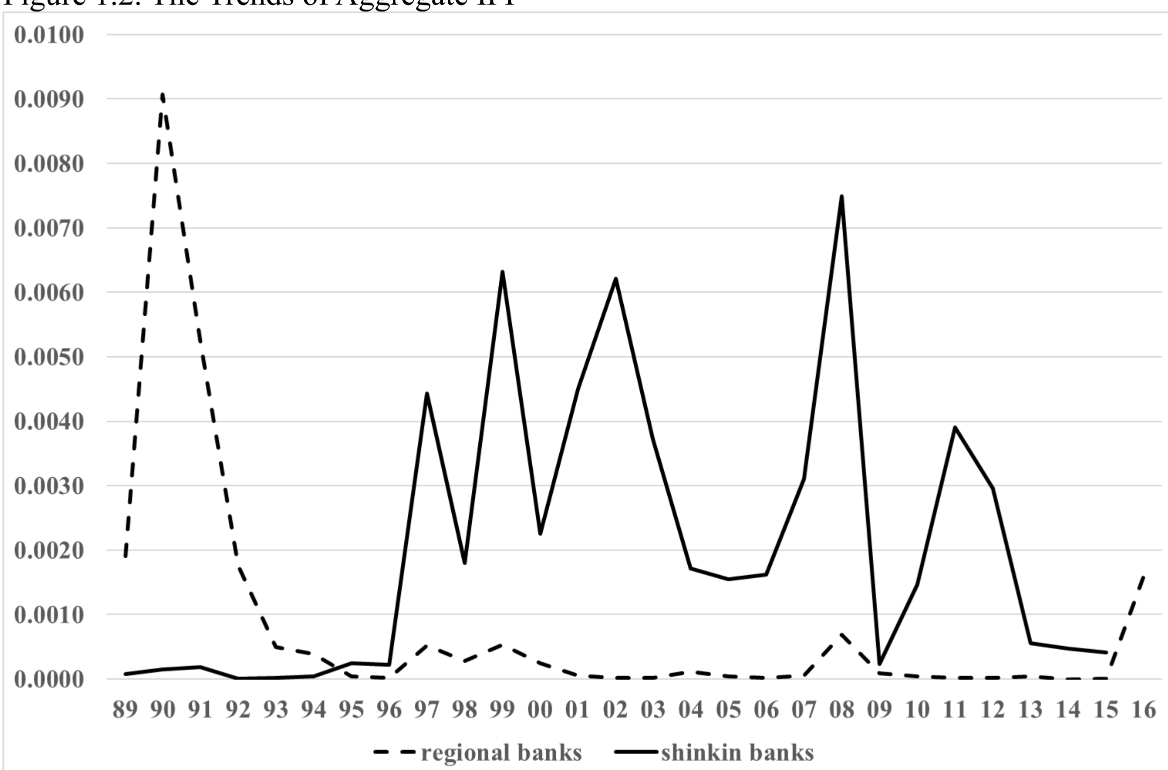
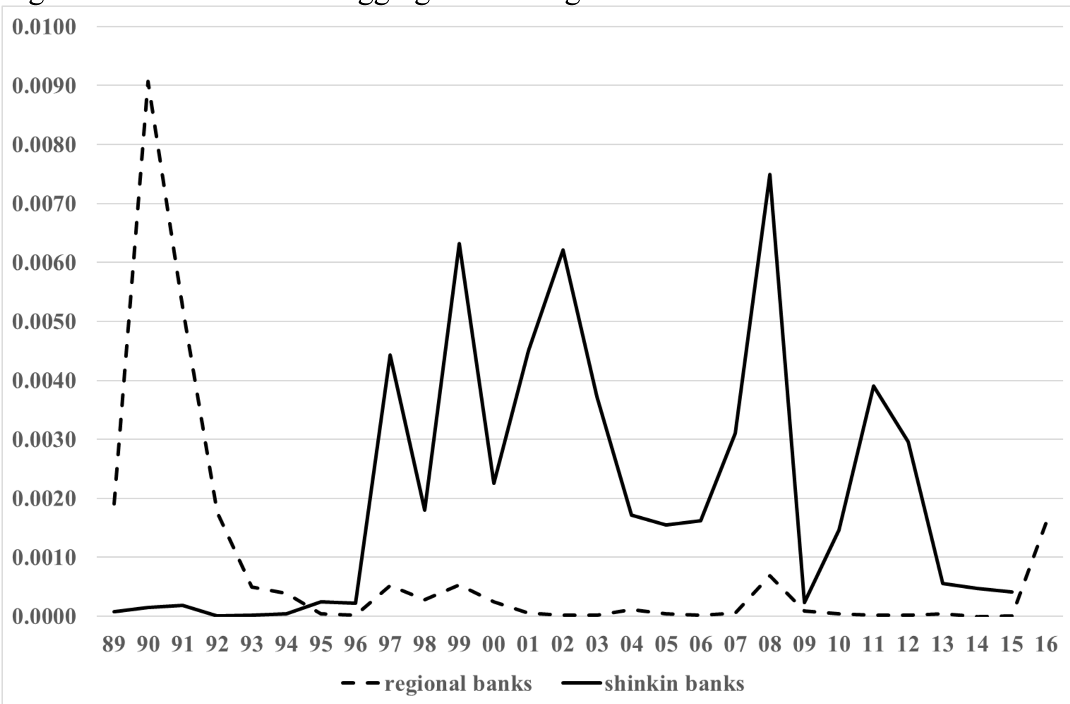


Figure 1.3. The Trends of Aggregate Leverage



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.