Effect of Firm Age in Credit Scoring Model for Small Sized Firms

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Abstract. Since the 2000s, a number of Japanese banks have utilized credit scoring models to manage their debtors' credit risk. There are various types of credit scoring models. It is common to utilize the logistic regression model in order to calculate credit scores of small sized firms with 20 or less employees, linked to the correlations between financial indicators and default occurrence. However, such correlations of small sized firms are lower than those of medium or large sized firms, since the most of small sized firms are run by owner's family members, and deficits incurred from their businesses are compensated with the private assets of the family, which are not described in the companies' financial statements. Hibiki, Ogi and Toshiro (2010) suggested "Firm Age" as the proxy variable in the model, and analyzed the correlation between firm age and default occurrence calculated using a data set of more than 480,000 Japanese small sized firms for the period from 2004 to 2007, owned by Japan Finance Corporation. However, the robustness of the model was not sufficiently confirmed owing to the short span of data being analyzed. In this paper, we extend the data period from 2004 to 2011, and analyze the correlation calculated from the data set of more than 1,000,000 Japanese small sized firms to validate the robustness of the logistic regression model from a practical perspective. In accordance with Hibiki, Ogi and Toshiro (2010), the results show that i) the default occurrence rate can be expressed by the cubic function of the firm age, and ii) the introduction of cubic function of the firm age into the model as a variable improves the accuracy ratio for small sized firms. Moreover, we confirm that the model is robust, and we can enhance the potential for practical use of the model on sound banking.

Keywords: credit scoring model, firm age, logistic regression model, small sized firms, credit risk

1. INTRODUCTION

Since the 2000s, a number of Japanese banks have utilized credit scoring models to manage their debtors' credit risk. Micro Business and Individual Unit of Japan Finance Corporation (JFC-Micro), a policy-based financial institution that aims to contribute to the promotion of small sized firms and solo proprietors, also have utilized the credit scoring model in order to control its customers' credit risk. There are various types of credit scoring models. It is common to utilize the logistic regression model in order to calculate the credit score of small sized firms with 20 or less employees, linked to the correlations between financial indicators and default occurrence rate (DR).

However, the levels of the correlations brought by the small sized firm models are lower than those of medium or large sized firms. Hence, the accuracy of the credit scoring model for small sized firms is not as high as expected.

In order to evaluate the accuracy of the credit scoring model, the accuracy ratio (AR) is commonly used as a measure. The AR is equivalent to the portion under the receiver operating characteristic (ROC) curve. Yamashita and Miura (2011) show that the AR of the logistic regression model is between 60% and 70% for medium or large sized firms, while Hibiki, Ogi and Toshiro (2010) reveal that it is between 35% and 45% for small sized firms. The reason of the difference between the percentages is that most of small sized firms are run by their owners' family members, and the deficits incurred from their businesses are compensated with the private assets of the families, which are not described in the companies' financial statements. Hence, the use of private assets of the owner family as a variable in the model may improve the AR, however, such information is not available easily and accurately.

A number of previous studies examine the relationship between the firm age and its performance indexes such as firm growth, firm size, borrowing cost, and so on. Evans (1987) shows that the default occurrence of U.S. small sized firms is negatively correlated with the firm age. Sakai, Uesugi and Watanabe (2008) reveal that the borrowing cost is also negatively correlated with the firm age according to a unique data set of more than 200,000 small sized firms for the period from 1997 to 2002. Loderer and Waelchli (2009) investigate how age affects a corporation's performance, and show that age progressively impairs performance, defined as ROA and Tobin's Q. However, most of the previous studies do not utilized the firm age as a control variable for their credit scoring models except for Hibiki, Ogi and Toshiro (2010). The paper utilizes "Firm Age" as the proxy variable in the model, and analyzes the correlation between the firm age and the DR using a JFC-Micro data set of more than 480,000 Japanese small sized firms for the period from 2004 to 2007. In accordance with Hibiki, Ogi and Toshiro (2010), the results show that i) DR can be expressed by the cubic function of the firm age, and ii) the introduction of cubic function of the firm age into the model as a variable improves AR for small sized firms. However, the robustness of the model is not sufficiently confirmed, because only four years of the data period are employed.

In this paper, we extend the data period from 2004 to 2011, and analyze the correlation calculated from the data set of more than 1,000,000 Japanese small sized firms to validate the robustness of the logistic regression model from a practical perspective. In this study, iii) we reveal that the AR of the model with the cubic function of the firm age is stable over time, and then confirm that the model is robust, enhancing the potential for practical use of the model on sound banking.

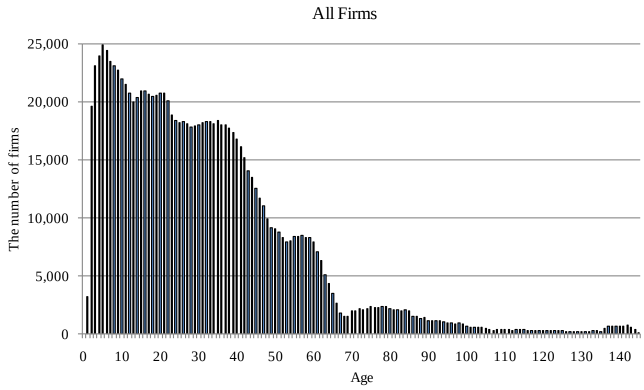

Figure 1: The number of firms by age bracket

This paper is organized as follows. Section 2 presents the relationship between the firm age and DR. Section 3 explains the framework of using the cubic function of the firm age. Section 4 empirically examines robustness of the cubic function. Section 5 shows AR is improved by utilizing the cubic function of the firm age as one of the independent variables of the credit scoring model. Section 6 provides our conclusion.

2. DATA

The reason we focus on the firm age is that it is one of important factors to assess the credit risk of debtors in the traditional screening process of loans by experienced bankers. The DR of small sized firm decreases as the firm becomes older, because the private assets of owner's family and the management know-how of the owner used as performance related indexes, are accumulated year by year.

In this section, we examine the relationship between the firm age and the DR. For this study, we use a data set of more than 1,000,000 Japanese small sized firms for the period from 2004 to 2011, owned by JFC-Micro, which provides business loans to micro/small sized firms. Approximately 90% of borrowers run the business with nine or less employees. About a quarter of all small sized firms in Japan have loans outstanding. We need to pay attention that the sample consists of only firms to which JFC-Micro made loans.

Figure 1 shows each number of firms by age in the sample. There is a data set of more than 10,000 firms for each firm age until 47 years of the firm age except one year. The number of firms is approximately 8,000 even as 60 years of the firm age.

Figure 2 shows the DR of small sized firms by age bracket. We calculate mean and standard deviation using the data set of about 990,000 firms of 60 years or less of the firm age. The bold line is the moving average of five years (t-2,t-1, t, t+1, t+2). In this paper, we define that the firm becomes default when its loan payment delays three

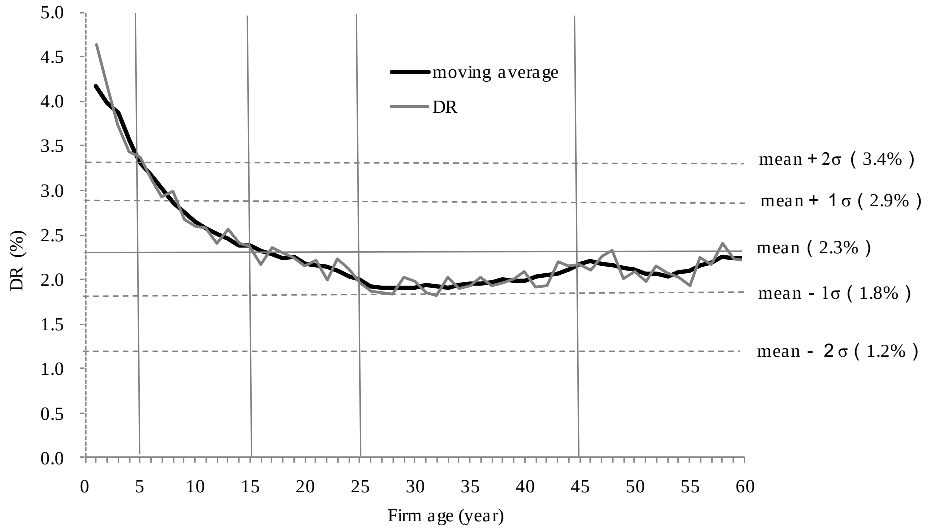

Figure 2: DR measured by the firm age bracket

Table 1: Estimation results of the *n*-th order polynomial functions

	n=1	n=2	n=3	n=4	n=5	n=6	n=7	n=8
β0	0.029	0.038	0.043	0.046	0.047	0.051	0.052	0.051
	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(0.010)	(< 0.001)	(< 0.001)	(< 0.001)
β1	-0.200	-1.048	-2.004	-2.759	-3.547	-5.639	-6.053	-5.162
[×10^-3]	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)
β2		1.390	5.273	10.737	19.483	52.105	60.628	37.345
[×10^-5]		(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(0.166)
β3			-0.424	-5.580	-26.520	-26.520	-34.040	-7.270
[×10^-6]			(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(0.004)	(0.800)
β4				1.140	8.070	71.800	105.000	-55.500
[×10^-8]				(< 0.001)	(0.003)	(< 0.001)	(0.036)	(0.737)
β5					-0.455	-9.620	-17.400	36.700
[×10^-9]					(0.010)	(< 0.001)	(0.126)	(0.500)
β6						0.501	1.420	-8.850
[×10^-10]						(< 0.001)	(0.283)	(0.385)
β7							-0.432	9.850
[×10^-12]							(0.484)	(0.332)
β8								-4.220
[×10^-14]								(0.310)
adjusted R2	0.379	0.833	0.932	0.948	0.971	0.970	0.969	0.969
AR	39.7%	42.0%	42.7%	42.8%	42.9%	43.0%	43.0%	43.0%

Note: P-values are shown in parentheses.

months or more. The DR at time t is calculated as follows:

$$DR_t = \frac{D_t}{ND_{t-1}} \qquad (1)$$

where ND_{t-1} is the number of the non-default firms at time t-1, and D_t is the number of the default firms at time t.

According to the function of the DR with respect to the firm age, we infer a business lifecycle of small sized firms as below.

First, when the firm age is five or less, the DR is higher than 3.4%, which is equal to the mean plus twice the standard deviations. It is considered that the high DR for the first five years of the business is caused by a number of business owners who are not capable to run their business.

Second, the DR decreases gradually for more than five years of the firm age, and becomes almost equal to the mean at 15 years. Then, it continues to decrease until around 25 years. The reason is that the business owners of such firms that survive long years accumulate management know-how to run their business.

Third, the DR begins to rise slowly for more than 35 years of the firm age, and it fluctuates in the range between 2.0% and 2.5% for more than 45 years. The business owners are from 70s to 80s when their firm age is 40s, if they are not retired, as most of the business owners start the business in their 30s. It is considered that the rise of DR after 35 years is caused by the lack of the successors.

Table 2: Estimation results of the *n*-th order polynomial functions of each year

	2004	2005	2006	2007	2008	2009	2010	2011
n=3	○	○	○	○	×	○	○	○
n=4	×	×	×	×	×	○	○	○
n=5	×	×	×	×	×	○	○	○
n=6	×	×	×	○	×	○	○	×

Note: ○ represents statistical significance at the 5 percent on all variables.

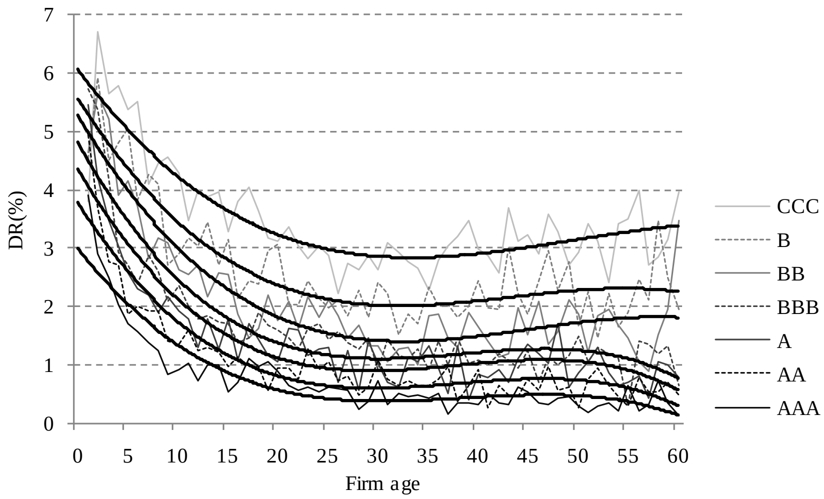

Figure 3 Default occurrence rate by age of firm with respect to each rating classification

3. STATISTICAL FRAMEWORK

This section outlines the estimation framework of the cubic function of the firm age. First, we formulate the DR of the *n*-th order polynomial function. By using ordinary least squares (OLS), the function is set as follows:

$$p_g = a_0 + \sum_{k=1}^{n} \beta_k g^k \quad (g = 1, \cdots, G), \qquad (2)$$

where g is the firm age, G is the maximum firm age, p_g is DR in g years, β_k is the OLS coefficient of the k-th power of the firm age, and a_0 is the constant term. Table 1 reports the coefficients of the regressions ($\beta_0 \sim \beta_8$) and adjusted R^2 for different-order polynomial functions.

The results show that each adjusted R^2 of the polynomial of *n=3* or more is about 0.1 percent higher than that of Hibiki, Ogi and Toshiro (2010). As for β_5 to β_7 of $n{=}7$ and β_2 to β_8 of $n{=}8$, p-values are higher than five percent. Adjusted R^2 do not increase as the higher polynomial than $n{=}3$ while p-values of $n{=}6$ or less are lower than 1 percent.

Moreover, Table 2 shows the results of the significance level of 5% in order to examine the robustness of the models between *n=3* and *n=6* from 2004 to 2011. As for the cubic function (*n=3*), all variables are significant except those of 2008. Hence, according to the analysis with time series data, we hereby confirm the robustness of the cubic function among the different polynomial functions.

4. STATISTICAL TESTS AND ESTIMATION RESULTS

It is possible that the cubic function forms vary according to the firm characteristics such as industry, firm size, and rating classification. We attempt to examine the robustness of the cubic functions with respect to some firm characteristics.

4.1 DR with Respect to Rating Classification

Figure 3 compares the DRs of each rating classification. The thick lines represent the moving averages and the thin lines represent the raw DRs. As the rating becomes higher from CCC to AAA, the DR becomes lower. For every subsample, the DRs tend to decrease with the firm ages, however, they tend to increase at more than 50 years of the firm ages.

It is supposed that the reason is they have no successor. Most founders may be more than 80 years old when the firms continue for more than 50 years. It is becoming more and more difficult to find successors among owners' family because the average income of the business owners is currently lower than that of office

Table 3: Estimation results with respect to each rating classification

	AAA	AA	A	BBB	BB	B	CCC
β0	0.030	0.038	0.044	0.048	0.053	0.056	0.061
	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)
β1	-2.204	-2.732	-2.996	-3.129	-2.930	-2.753	-2.330
[×10^-3]	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)
β2	5.995	7.558	8.339	8.528	7.028	6.804	5.274
[×10^-5]	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)
β3	-5.190	-6.620	-7.330	-7.390	-5.180	-5.230	-3.560
[×10^-6]	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(0.024)
Adjusted R2	0.839	0.848	0.826	0.836	0.817	0.790	0.726
Hibiki,et al.(2010)	0.707	0.738	0.734	0.656	0.682	0.476	0.417

Note: P-values are shown in parentheses.

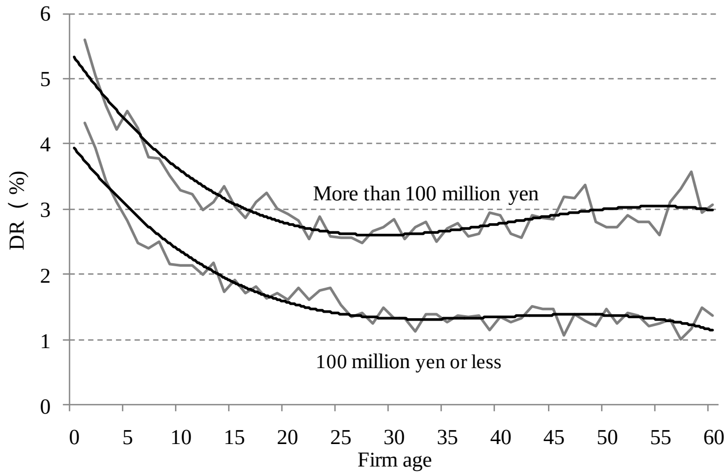

Figure 4: DR measured by age of firm with respect to each firm size

workers. It is also supposed that it becomes difficult to find successors when the rating becomes lower.

Table 3 reports regression coefficients, p-values and adjusted R^2s. Adjusted R^2s are between 0.726 and 0.848 which are higher than those of Hibiki, Ogi and Toshiro (2010). All p-values are less than 5 percent. The curves of cubic functions remain stable, because β_1 and β_3 are negative at all rating classifications. The results support our hypothesis that the cubic function model is robust.

4.2 DR with Respect to Firm Size

Figure 4 compares the DRs by firm age with respect to two firm size categories. The upper line represents the DR of the firms with annual sales of more than 100 million yen, and the lower line represents the other. Both curves are cubic functions.

Table 4 reports the coefficients and p-values of the two regressions. Adjusted R^2s are 0.887 and 0.924 which are higher than those of Hibiki, Ogi and Toshiro (2010), respectively. All p-values are less than 1 percent. The results also support our hypothesis that the cubic function model is robust.

Table 4: Estimation results with respect to each firm size

	More than 100	100 or less
β0	0.053	0.039
	(< 0.001)	(< 0.001)
β1	-2.302	-2.073
[×10^-3]	(< 0.001)	(< 0.001)
β2	6.116	5.341
[×10^-5]	(< 0.001)	(< 0.001)
β3	-4.880	-4.440
[×10^-6]	(< 0.001)	(< 0.001)
adjusted R2	0.887	0.924
Hibiki, et al.(2010)	0.757	0.775

Note: P-values are shown in parentheses.

4.3 DR with Respect to Industry

Figure 5 compares the DRs by age of firm with respect to each industry. The left figure represents the DRs of Wholesale/Retailing, Restaurant/Accommodation and Services. The right represents the DRs of Construction and Manufacturing. The three curves on the left are similar to cubic functions. On the other hand, the two curves on the right may look similar to quadratic functions, rather than cubic functions. We can confirm that the DRs of

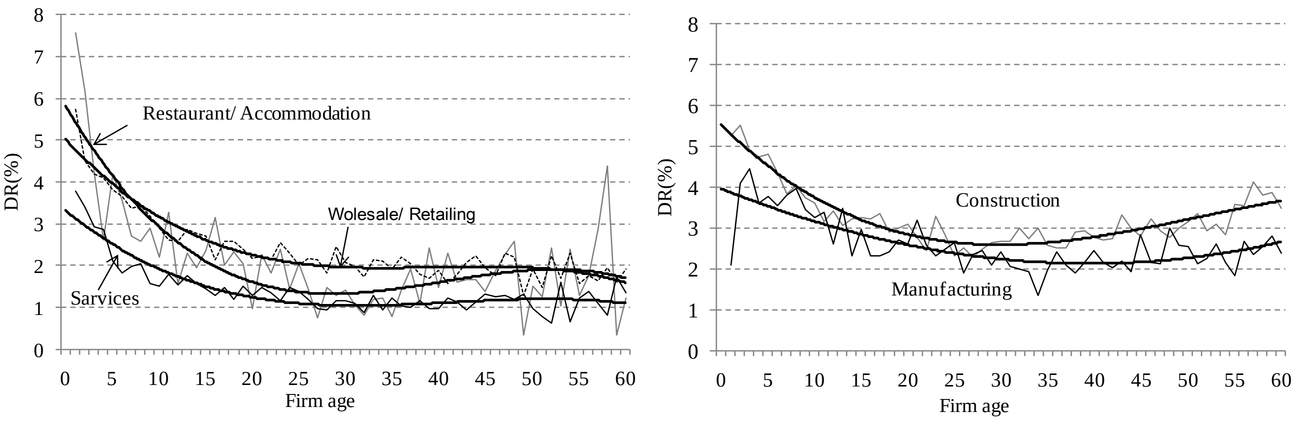

Figure 5: DR measured by age of firm with respect to each industry

Table 5: Estimation results with respect to each industry

	Construction	Manufacturing	Wholesale/ Retailing	Sarvices	Restaurant/ Accommodation
β0	0.055	0.040	0.050	0.033	0.058
	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)
β1	-2.280	-0.908	-2.427	-1.821	-3.842
[×10^-3]	(< 0.001)	(0.007)	(< 0.001)	(< 0.001)	(< 0.001)
β2	5.385	1.072	6.288	4.681	10.388
[×10^-5]	(< 0.001)	(0.388)	(< 0.001)	(< 0.001)	(< 0.001)
β3	-3.500	0.131	-5.320	-3.770	-8.550
[×10^-6]	(< 0.001)	(0.922)	(< 0.001)	(< 0.001)	(0.001)
adjusted R2	0.881	0.589	0.893	0.808	0.622
Hibiki,et al.(2010)	0.676	0.613	0.816	0.491	0.242

Note 1: P-values are shown in parentheses.

Note 2: Shaded areas are where the p-values are more than 5% in Hibiki, et al. (2010).

Construction and Manufacturing increase gradually as the firm age become large after 50 years.

Table 5 reports coefficients, p-values, and adjusted R^2 s of the regressions. All p-values except the Manufacturing industry are less than 5 percent. Compared with Hibiki, Ogi and Toshiro(2010), the results are improved because most of p-values of our previous study are more than 5 percent. They are indicated as shaded areas on the Table 5. The range of adjusted R^2 is between about 0.59 and 0.89. In particular, the adjusted R^2 of Services and Restaurant/Accommodation are substantially high. However, p-values of β_2 and β_3 of Manufacturing are more than 5 percent because the DR increases after 50 years of the firm age.

5. EVALUATION OF MODEL USING ACCURACY RATIO

First, this section outlines credit scoring models of small sized firms for which we utilized the cubic functions of the firm age. Second, we compare AR of the models with and without the cubic function.

5.1 Outline of the Model

We utilize a binominal logistic regression model. The score is calculated by the following regression equation:

$$p_i = \frac{1}{1+e^{z_i}}, z_i = ln\left(\frac{1-p_i}{p_i}\right) = \alpha_0 + \sum_{j=1}^{J} \alpha_j f_{ij} \ , \quad (3)$$

where i is each firm, p_i is the probability of the default of firm i, z_i is the score of firm i, α_0 is the constant, and $f_{ij}\,(i = 1,\cdots,n; j = 1,\cdots,J)$ is the financial indicator J of firm i. We estimate the parameter, $\alpha_j\,(j = 1,\cdots,J)$, using a maximum likelihood method. The score is converted into the rating categories from AAA to CCC.

The credit scoring model which utilized the cubic function of the firm age represents as following,

$$p_i = \frac{1}{1+e^{z_i}}, z_i = ln\left(\frac{1-p_i}{p_i}\right)$$

$$= \alpha_0 + \sum_{j=1}^{J} \alpha_j f_{ij} + \sum_{k=1}^{3} \beta_k (g_i)^k \quad (i = 1,\cdots,n), \quad (4)$$

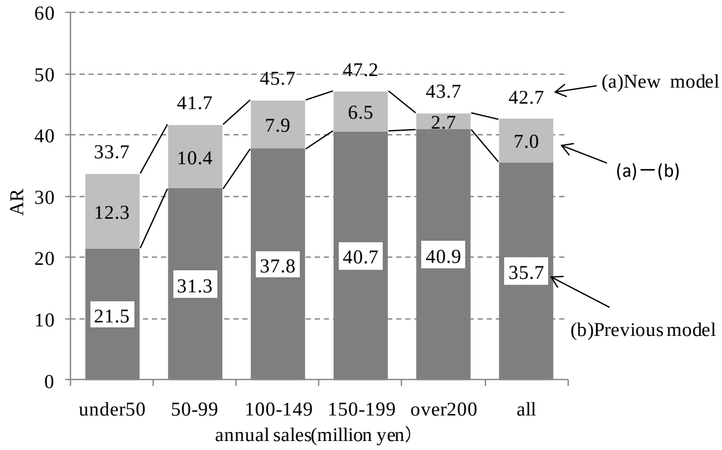

Figure 6: AR measured by size of firm

where g_i is the firm age (more than 60 years is treated as 60 years.), and $(g_i)^k (i = 1, \cdots, n; k = 1,2,3)$ is the cubic function of the firm age.

5.2 Estimation Results of AR

Figure 6 compares estimation results of AR by size of firm. The overall AR increases from 35.7 to 42.7 percent by using the cubic functions of the firm age. The AR of the "previous model" without the cubic function is positively related with the firm size. It is supposed that the reason is financial indicators are highly related with the DR as the firm size becomes large.

On the other hand, the difference of ARs between two models is negatively related with the firm size. It shows that effect of the firm age is higher for the firm with smaller size. This is because the value of cubic function of the firm age is highly related with the private assets of owner's family for the firm with smaller size.

5.3 Robustness Tests in Terms of Time Series

Hibiki, Ogi and Toshiro (2010) do not validate the robustness of the model in terms of the time series, because the time span of data set is not enough long to examine. In this paper, we extend the data period between 2004 and 2011, and validate the robustness of the model from a practical perspective.

First, we calculated that the AR of the score "HI_i", which is calculated only using the cubic function of the firm age as the independent variables of formula (4). HI_i is calculated as follows:

$$HI_i = \sum_{k=1}^{3} \beta_k (g_i)^k \; (i = 1, \cdots, n) \qquad (5)$$

Second, we calculated that AR of the score "CS_i^N", which is calculated only using financial indicators as the independent variables of formula (4). CS_i^N is calculated as follows:

$$CS_i^N = \sum_{j=1}^{J} \alpha_j f_{ij} \qquad (6)$$

Figure 7 shows the AR of HI_i and CS_i^N. The AR of CS_i^N decreases year by year. Notably, it was depressed when the economic depression is triggered by the bankruptcy of Lehman Brothers in 2008. The decrease in the AR could be caused by the macro factors in addition to the deterioration over time. However, the AR of HI_i is not affected by the macro factors or the deterioration over time. We conclude that we find the robustness of HI_i in terms of time series.

Figure 8 shows the AR of HI_i and CS_i^N by size of firm. Firm size defined by annual sales is divided into five ranges: under 50, 50-99, 100-149, 150-199, and over 200 (million yen). The AR of CS_i^N is positively related with the annual sales size, while the AR of HI_i is negatively related with it. We can infer that the correlation between AR and private assets of owner's family is higher than the correlation between AR and financial indicators as firm size becomes smaller.

6. CONCLUSION

The first key finding of this paper is that the firm age is the important factor of the default occurrence of small sized firms with 20 or less employees, and that the DR can be expressed by the cubic function of the firm age.

The second key finding is that the use of the cubic functions of the firm age as variables improves the AR of the credit scoring model for small sized firms. As for these points, our paper reconfirms the result of Hibiki, Ogi and

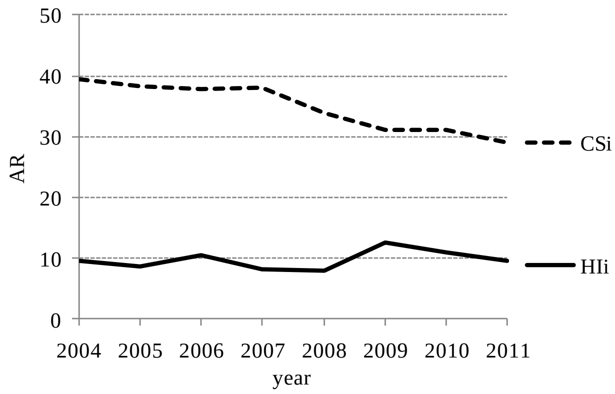

Figure 7: AR of HI_i and CS_i^N

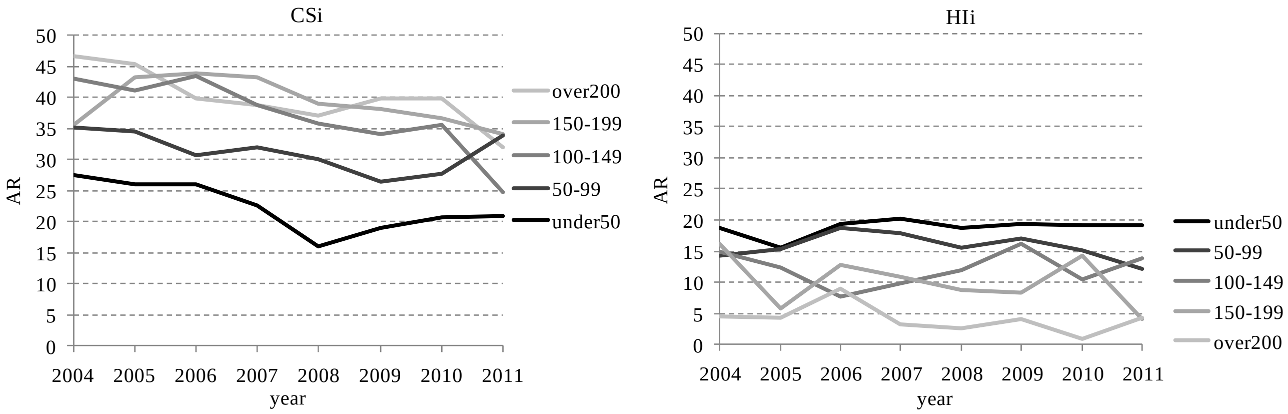

Figure 8: AR of HI_i and CS_i^N by size of firm

Toshiro (2010).

The third or the most important key finding is that we confirm the sufficient robustness of the model that is not examined in our previous paper. In this study, we extend the data period between 2004 and 2011, and analyze the data including more than 1,000,000 small sized firms in Japan in order to validate the robustness of the cubic function model from a practical perspective.

It is possible that these findings are weakly biased, because the data set consists of only the firms for which JFC financed. In order to improve the accuracy of the model, we might need to update the estimation using another more refined data set. Nevertheless, we can conclude that this study enhance the potential of the cubic function model for the practical use of the credit scoring model on sound banking.

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