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Competition among Regional Banks in Japan: Evidence from the Boone Indicator

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Abstract

In this study, we use the method of Boone et al. (2007, How (not) to measure competition, TILEC Discussion Paper, No. 2007 - 014), known as the Boone indicator, to estimate competition in the banking industry in Japan. Classical methods, for example, market share, price-cost margin, and the Herfindahl-Hirschman Index, are not monotonically related to competition, so they are inappropriate. On the other hand, as many studies by Boone suggest, the Boone indicator can capture precisely the degree of competition. Our results show that the banking industry in Japan has been more competitive in recent years.

Keywords: Degree of competition, Boone indicator, Japanese regional banks

JEL Classification: G21, L13

1. Introduction

Since 1980, financial markets around the world have changed surprisingly because of globalization and deregulation. In Japan too, deregulation and mergers and acquisitions have occurred in the banking, securities, and insurance industries, and have led to the formation of huge banks and financial conglomerates. Furthermore, for some decades, the Japanese economy has undergone big changes: the bubble economy in the late 1980s, long-term recession in the 1990s, the financial "big-bang" between 1996 and 2001, and the sub-prime mortgage crisis in 2008. These shifts in the financial environment have provided changes in the financial structure as well as the state of competition.

Recently, researchers have argued about whether deregulation makes the banking industry more competitive. Berger et al. (2004) insist that banks' concentration and competition affect financial stability and economic growth. This has revealed the importance of investigating the state of bank competition. Moreover, Claessens and Laeven (2004) and Boone (2008a, 2008b) suggest that some classical competition indexes, for instance, the Herndahl-Hirschman Index (HHI), cannot capture the state of competition precisely. From this result, Claessens and Laeven (2004) emphasize an approach that considers firms' entry to the market, that is, contestability.

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There are many studies on the state of competition in the Japanese banking industry. Uchida and Tsutsui (2005) extend the methodology of Bresnahan (1982) and Lau (1982) to investigate panel data for Japanese banks from 1974 to 2000. They show that the banking industry had become more competitive by the mid-1980s, and that regional banks were more competitive than major city banks. On the other hand, Tsutsui (2009) estimates the price-cost margin (PCM) and the *H*-statistic to investigate the state of competition among Japan's regional banks. His result suggests that the lending market among Shinkin banks, relatively small regional banks, became competitive gradually. Furthermore, Molyneux et al. (1996) estimate the *H*-statistic and conclude that in 1986 and 1988, the state of competitiveness among Japanese city and regional banks was rather less competitive. Niimi (1998) uses the *H*-statistic to investigate competitiveness among the city banks and long-term credit banks before and after the bubble economy in the late 1980s. He finds that the state changed from "monopoly/coalition" to "monopolistic competition."

Besides the banking industry, other financial institutions in Japan have been investigated from a competition viewpoint by researchers. Tsutsui and Kamesaka (2005) investigate the competitive condition of the Japanese securities industry over the period 1983-2002 using the *H*-statistic and find that the industry was monopolistic between 1991 and 1996. Kubota and Tsutsui (2009) use a questionnaire survey in 2006-2007 to demonstrate from the results of the *H*-statistic and the PCM that the market for consumer credit is monopolistic. Souma and Tsutsui (2010) examine the change in the degree of competition in the Japanese life insurance industry during the period 1986-2002. In order to obtain the degree of noncompetition and collusion, they estimate the first-order condition for profit-maximizing insurance oligopolies. Their result suggests that competition has increased since 1995 in the industry.

On the other hand, Claessens and Laeven (2004) and Delis (2012) study the factors that trigger bank competition. Claessens and Laeven (2004) regress the *H*-statistic on the variables for banking system structures and contestability. They find that those variables are correlated with banks' competitiveness. Using the Boone indicator, Delis (2012) shows that the variables for financial reform, law quality, and bureaucratic quality make banks competitive. In addition, Uchida and Tsutsui (2005) regress their index of bank competition on a variety of variables. Their result suggests that the trading amount of government bonds affects the degree of bank competition.

In this study, we estimate the Boone indicator, for the Japanese regional banking industry from 1989 to 2009. The Boone indicator, introduced by Boone et al. (2007) and Boone (2008a), is an index that outperforms other competitive measures. We investigate the competitiveness for regional banks, second-tier regional banks, Shinkin banks, and credit unions in each year.

The main results are as follows. Whereas the estimated Boone indicator differs across categories, it tends to increase gradually, that is, the Japanese regional banking industry has become more competitive. For comparative purposes, we estimate the HHI, PCM, and *H*-statistic. Surprisingly, these measures suggest a decrease in the competitiveness of the regional banking industry. Our sample is in the period when a variety of deregulations were promoted, and thus, our results of the Boone estimator are intuitive relative to the other indexes.

The remainder of this paper is as follows. Section 2 introduces the Boone indicator and explains the methodology of estimation and our data. Section 3 demonstrates the estimated Boone indicator. Section 4 compares the results with other measures of competition. Section 5 concludes.

2 The method

2.1 The Boone indicator

Boone et al. (2005, 2007) and Boone (2008a, 2008b) present some measures for competitiveness.

Their common feature is that in a competitive market, more efficient firms obtain higher profits. These measures are called the "Boone indicator."[1] In this subsection, we explain the Boone indicator in the context of banking.

Bank i ($i = 1,\ldots, N$) maximizes profit

$$\pi_i = r_L L_i - C(D_i, L_i), \tag{1}$$

where L_i denotes loans, D_i is deposits, $r_L > 0$ is the interest rate of the loans, and $C(\cdot,\cdot)$ is the cost function. The balance sheet of bank i is $L_i = D_i$. For simplicity, we assume that each bank faces demand for bank lending,

$$r_L = a - bL_i - d\sum_{j\neq i} L_j, \tag{2}$$

and the cost function, $C(D_i, L_i) = c_{Di}\, D_i + c_{Li}\, L_i$. In addition, we assume there is an entry cost γ, so bank i enters the loan market when $\pi_i \geq \gamma$.

From these assumptions, we obtain

$$\pi_i = \left(a - bL_i - d\sum_{j\neq i} L_j\right) L_i - c_i L_i, \tag{3}$$

where $c_i = c_{Li} + c_{Di}$. The first-order condition is

$$a - 2bL_i - d\sum_{j\neq i} L_j - c_i = 0. \tag{4}$$

Using Eq. (4) for all banks, we solve for L_i as

$$L(c_i) = \frac{\left(\frac{2b}{d} - 1\right) a - \left(\frac{2b}{d} + N - 1\right) c_i + \sum_{j=1}^{N} c_j}{[2b + d(N-1)]\left(\frac{2b}{d} - 1\right)}. \tag{5}$$

From Eqs. (3), (4), and (5), we obtain

$$\pi_i = bL(c_i)^2. \tag{6}$$

So far, we have specified the functions. Generally, the profit function is written as a function of c_i, $\pi\ (c_i)$. In addition, higher marginal cost leads to lower profit, $\pi'(c_i) < 0$. Put differently, if we denote $z \equiv \partial\pi_i/\partial c_i$, then

$$z_i \equiv \frac{\partial \pi_i}{\partial c_i} < 0. \tag{7}$$

z_i is greater as the market becomes competitive. If we denote the parameters that ease the state of competition as $\theta = a, b, \gamma$ and the parameters that tighten the state of competition as $\phi = d, N$, we obtain

[1] To our knowledge, the first study that named these measures the Boone indicator is Van Leuvensteijn et al. (2011).

$$\frac{\partial z_i}{\partial \theta} = \frac{\partial^2 \pi_i}{\partial c_i \partial \theta} > 0, \qquad \frac{\partial z_i}{\partial \phi} = \frac{\partial^2 \pi_i}{\partial c_i \partial \phi} < 0. \tag{8}$$

These inequalities suggest that in a more competitive market, profits negatively react with marginal cost much more. Intuitively, in a competitive market, more effective firms outperform others, and thus, they should earn more profit. On the other hand, if firms are less effective, they should earn less profit.

Boone et al. (2007) propose a method to estimate the impact of marginal cost c_i on profit π_i. They estimate the marginal cost elasticity of profit

$$PE \equiv -\frac{c_i}{\pi_i}\frac{d\pi_i}{dc_i}. \tag{9}$$

Boone et al. (2007) call this profit elasticity (PE). Since firms with less costs have more profits, other things equal, PE is greater than zero. Competition makes efficient firms more profitable, and thus, the more competitive the sector is, the greater is PE. The earlier measures for competitiveness are criticized for several reasons. Suppose that there is a competitive market and that one of the firms came to be managed more efficiently. In other words, all firms in this market attempt as much as possible to earn more profit. Then, the firm that becomes effective earns more profit than others do. In this case, the Boone indicator indicates the more effective firm is more profitable, whereas the other measures do not. For instance, the HHI suggests that the market share of that firm is greater than before, and thus, the HHI indicates the firm is less competitive. For problems with the other measures, see Boone et al. (2005, 2007) and Boone (2008a).

There is criticism that the estimation of PE needs data for profits, which often comprises significant errors and that is why the PCM tends to be preferred. However, since the numerator of the PCM is price minus marginal cost, we obtain

$$PCM = \frac{p-c}{p} = \frac{(p-c)q}{pq} = \frac{\pi}{pq}. \tag{10}$$

That is, Eq. (10) is rewritten as the ratio of profit to income. Therefore, the PCM substantively uses data for profits, and thus, the problem of some errors is inevitable. On the other hand, the estimation of PE contains an error term, which alleviates the problem of profit errors.

Moreover, Boone (2008a, 2008b) proves that under a moderate condition, a more competitive market brings a stronger effect of firms' efficiency on their profits, and the authors propose two indicators: relative profits (RP) and relative profit differences (RPD).[2] Any types of the Boone indicator monotonically change against a change in competitiveness.

2.2 The estimation method

Following Boone et al. (2007), we estimate PE as follows. First, from the problem of firms' profit maximization, we obtain a profit function of marginal cost, $\pi(c_i)$. We take $\ln \pi(c_i)$ as a first-order Taylor approximation with respect to $\ln c_i$,

$$\ln \pi_i = \alpha + \beta \ln c_i. \tag{11}$$

[2] Boone et al. (2005) conduct a simulation, in which RP outperforms the other measures for competitiveness.

To estimate this equation, we add a vector of control variables, X_i', and an error term with mean zero, ε_i,

$$\ln \pi_i = \alpha + \beta \ln \hat{c}_i + X_i' \zeta + \varepsilon_i. \tag{12}$$

Since the marginal cost is unobservable, we estimate the translog cost function to obtain the estimate of marginal cost, $\hat{c}_i$.[3] Then, we obtain the estimate of the coefficient, $\hat{\beta}$, so that

$$\widehat{PE} = -\hat{\beta}, \tag{13}$$

is the estimate of PE. For the estimation, we use the ordinary least squares (OLS) estimator. While we estimate marginal costs by the translog cost function, the estimates can contain a measurement error, which could lead to endogeneity in the PE regression. To solve the errors-in-variable problem, we apply the two-stage least squares (2SLS) estimator.

It is important to note that the Boone indicator implicitly assumes that firms' profit is non-negative. Boone (2008b, p. 1248, Definition 1) assumes firms' profit is greater than the entry cost γ_i, that is, $\pi_i \geq \gamma_i$. Since $\gamma_i > 0$, profit should be positive.

2.3 Other estimation methods

Several researchers propose methods to estimate the Boone indicator. There are two methods to estimate PE. Schaeck and Cihak (2010) use the model,

$$\frac{\pi_i}{TA_i} = \alpha + \beta \ln c_i + \varepsilon_i, \tag{14}$$

where TA_i is total assets and π_i / TA_i is return on assets (ROA). However, the authors do not clearly explain the reason why the dependent variable is ROA instead of profit. ROA consists of total assets, and thus, β presents the effect of marginal cost not only on profit, but also on TA. This leads to estimation bias.

Next, Van Leuvensteijn et al. (2011) estimate the model,

$$\ln s_i = \alpha + \beta \ln c_i + \varepsilon_i, \tag{15}$$

where s_i is the share of products. Originally, Boone et al. (2007) criticize the share measures, and thus, the estimate of β is not the Boone indicator. In fact, Boone et al. (2005) compare the share measure with the Boone indicator, and conclude that the share measure can fail to capture the change in competitiveness. Therefore, the estimation by Van Leuvensteijn et al. (2011) is not reliable.

On the other hand, CPB Netherlands Bureau for Economic Policy Analysis (2000) presents an estimate of β in the model,

$$\frac{\pi_i}{\pi_0} = \alpha + \beta \frac{c_i}{c_0} + \varepsilon_i, \tag{16}$$

to obtain RP. Eq. (16) is assumed a linear relation between relative profit and relative cost. Taking the logarithms for these variables yields

$$\ln \frac{\pi_i}{\pi_0} = \alpha + \beta \ln \frac{c_i}{c_0} + \varepsilon_i. \tag{17}$$

In this case, as Boone et al. (2005) suggest, the estimate of β is equivalent to that in Eq. (12).

[3] For the detailed estimation, see the Appendix.

3 Results

3.1 Data

We use the Boone (2007) competition indicator approach to assess the degree of competition in the Japanese regional banking industry. The Boone indicator, that is, PE, is calculated by the marginal cost elasticity of bank profit. We estimate the impact of marginal cost on profit of banks, where the coefficient $\hat{\beta}$ is obtained, so that $\hat{\beta}$ is the estimate of PE. The larger is PE, the more intense is competition. This indicator monotonically changes with a change in competitiveness. We use the two estimators, OLS and 2SLS. Furthermore, to compare the results, we present results using three alternative measures of competition: HHI, PCM, and Panzar and Rosse's (1987) *H*-statistic.

We select regional banks, including second-tier regional banks, Shinkin banks, and credit unions. We use bank-level data from the Nikkei NEEDS Financial Quest, the Zenkoku Shinyo Kinko Zaimu Syohyo, and the Zenkoku Shinyo Kumiai Zaimu Syohyo, databases containing bank financial statements. The estimation period is from fiscal year 1989 to 2009. We use data from unconsolidated accounts to avoid double counting. The actual estimated Eq. (12) requires data on profit π_i and marginal cost $\hat{c}_i$. π_i, which is the profit obtained by the bank from its lending operations, is defined as interest income minus interest expenses, personnel expenses, and equipment expenses. Since we study the lending market, our definition of bank profits should incorporate the costs of lending operations, that is, we subtract the lending losses from the profits. However, our dataset has few observations of lending losses.[4] As marginal cost cannot be observed, the estimation $\hat{c}_i$, obtained by estimating the translog cost function, was used (see the appendix for an explanation of the estimations). The variable used to estimate the translog cost function is as follows. Cost C is defined as the sum of interest on deposits, personnel expenses, and equipment expenses. The input factor w_1 is the interest rate for fundraising, defined as the ratio of interest on deposits to total amount of deposits. w_2 is the wage rate, defined as the ratio of personnel expenses to the number of employees. The share of input factor s_j is the ratio of interest on deposits to cost C. The output factor q is the total financial assets, defined as the total amount of loans. We use the 2SLS approach with the instrumental variable being the deposit-cost rate of the explanatory variable, marginal costs.[5]

X_i is the control variable vector. We use the capital adequacy ratios to control for differences in the soundness of the bank management, the ratio of securities to total assets to control for the differences in the amounts of securities held, the number of employees per branch to control for differences in the size of financial institutions, and the loan-to-deposit ratio to control for economies of scope. After considering that there is heterogeneity in the behavior between the business categories, we use a Shinkin banks dummy, credit unions dummy, share-listing dummy, and second-tier regional banks dummy. However, for estimates using only Shinkin banks and credit unions, the number of members is added.

At the stage prior to the analysis, to exclude the influence of outliers, values outside of the range of the mean value of profit and marginal cost, ± the standard deviation × 2.58, are excluded in each fiscal year for each business category. Moreover, the data set used for the estimates excludes banks that cannot be used for the necessary variables. In addition, financial institutions are excluded where data on profit and marginal cost cannot be used.

[4] In Japan, moreover, during our sample period, a number of banks lent to bad firms, which is called "zombie lending." This implies that even if we could utilize lending losses, the results would not necessarily reflect the actual profits of banks.

[5] The deposit-cost rate is defined as (interest paid for deposit) / (total amount of deposits) + (personnel expenses + equipment expenses) / (ordinary income).

Table 1. Descriptive statistics of the variables

	All financial institutions					Regional banks				
	Mean	Std. Dev.	Median	Min.	Max.	Mean	Std. Dev.	Median	Min.	Max.
π (log)	6.503	1.644	6.467	-1.580	10.722	8.808	0.949	8.906	5.024	10.722
c (log)	-3.314	0.530	-3.432	-4.978	-1.738	-3.651	0.598	-3.854	-4.735	-2.412
w_1 (log)	-0.008	0.294	-0.017	-1.693	4.526	-0.007	0.280	-0.012	-1.159	1.312
w_2 (log)	-0.003	0.166	-0.004	-4.039	2.414	-0.004	0.152	0.003	-0.696	0.394
The total amount of loans (log)	11.295	1.703	11.211	5.076	15.642	13.837	0.814	13.955	11.358	15.642
The total amount of deposits (log)	11.733	1.601	11.627	5.829	15.839	14.099	0.837	14.211	11.590	15.839
Interest on loans (log)	8.054	1.616	7.982	2.187	12.930	10.401	0.798	10.430	8.074	12.930
Interest on deposits (log)	6.758	1.881	6.717	0.388	12.799	8.854	1.584	8.872	4.466	12.799
Bank loan interest rate (%)	4.266	1.806	3.617	-0.082	36.099	3.560	1.713	2.798	1.494	8.341
Bank deposit interest rate (%)	1.546	1.645	0.603	0.018	30.253	1.307	1.543	0.449	0.018	5.750
Total assets (log)	11.857	1.589	11.746	6.021	16.018	14.212	0.846	14.327	11.684	16.018
Ordinary income (log)	8.496	1.555	8.381	2.750	13.377	10.827	0.847	10.873	8.382	13.377
Capital ratio (%)	5.089	2.886	4.720	-58.535	161.124	4.012	2.366	3.937	-48.015	8.840
Ratio of securities (log)	16.612	11.650	15.144	0.000	173.877	19.042	6.440	17.896	0.517	46.129
Employees per branch (log)	2.627	0.345	2.639	0.100	6.879	2.768	0.238	2.775	1.382	3.562
Loan-to-deposit ratio (%)	67.019	52.585	68.319	7.252	6177.899	77.346	8.000	77.478	53.652	170.241
Ratio of non-performing loans (%)	7.830	6.731	6.533	0.000	81.228	4.700	4.023	4.017	0.038	53.191
Deposit-cost rate (%)	4.275	1.886	3.586	0.676	32.486	3.350	1.654	2.596	1.311	7.825
Average cost (log)	-3.140	0.515	-3.263	-4.998	-1.294	-3.462	0.518	-3.647	-4.375	-2.345
Debt ratio (log)	2.996	0.436	3.003	-0.653	7.320	3.187	0.325	3.193	2.333	6.632
Branches	29	36	15	1	284	97	42	91	20	284
Employees	469	704	203	2	24296	1647	912	1484	285	5110
Members	17341	18251	12037	45	361219					
N	14701					2352				

	Shinkin banks					Credit unions				
	Mean	Std. Dev.	Median	Min.	Max.	Mean	Std. Dev.	Median	Min.	Max.
π (log)	6.626	1.079	6.667	-1.580	9.026	5.281	1.316	5.440	-1.339	8.044
c (log)	-3.300	0.500	-3.481	-4.341	-2.079	-3.180	0.469	-3.240	-4.978	-1.738
w_1 (log)	-0.005	0.205	-0.012	-0.865	4.526	-0.013	0.390	-0.031	-1.693	2.192
w_2 (log)	-0.003	0.136	-0.003	-4.039	2.414	-0.002	0.206	-0.009	-2.944	2.380
The total amount of loans (log)	11.453	0.971	11.420	8.166	14.531	9.916	1.331	10.089	5.076	13.453
The total amount of deposits (log)	11.911	0.956	11.862	7.888	14.982	10.407	1.167	10.523	5.829	13.493
Interest on loans (log)	8.188	0.936	8.132	4.873	11.589	6.798	1.348	6.982	2.187	10.563
Interest on deposits (log)	6.834	1.520	6.853	2.357	11.421	5.696	1.605	5.710	0.388	10.225
Bank loan interest rate (%)	4.129	1.685	3.380	1.432	10.185	4.780	1.866	4.515	-0.082	36.099
Bank deposit interest rate (%)	1.463	1.644	0.502	0.025	30.253	1.771	1.666	0.929	0.020	10.273
Total assets (log)	12.031	0.937	11.986	8.784	15.041	10.541	1.159	10.650	6.021	13.766
Ordinary income(log)	8.636	0.906	8.596	5.465	11.877	7.238	1.153	7.312	2.750	10.806
Capital ratio (%)	5.391	2.133	5.220	-55.927	48.142	5.159	3.766	4.435	-58.535	161.124
Ratio of securities (log)	18.295	9.399	16.792	0.122	173.877	13.160	15.037	8.114	0.000	76.697
Employees per branch (log)	2.690	0.285	2.671	0.201	6.879	2.475	0.403	2.485	0.100	5.354
Loan-to-deposit ratio (%)	65.083	72.962	64.483	19.982	6177.899	65.009	19.392	68.290	7.252	369.939
Ratio of non-performing loans (%)	7.956	5.301	7.258	0.000	81.228	9.944	9.258	8.513	0.000	67.310
Deposit-cost rate (%)	4.228	1.767	3.462	1.452	32.486	4.763	1.977	4.263	0.676	17.594
Average cost (log)	-3.138	0.477	-3.308	-4.192	-1.918	-2.995	0.500	-3.042	-4.998	-1.294
Debt ratio (log)	2.918	0.373	2.898	0.687	5.426	3.017	0.523	3.068	-0.653	7.320
Branches	21	15	17	1	113	8	8	6	1	78
Employees	343	411	245	11	24296	108	117	74	2	846
Members	20790	19703	14927	379	361219	12537	14721	7829	45	129926
N	7188					5161				

The descriptive statistics in Table 1 show the sample averages of the main variables over the entire period by business category. Table 2 shows the profit and marginal costs during the period. The sample size for the entire period is largest for Shinkin banks, at 7,188; followed by credit unions, at 5,161; and then regional banks, at 2,352.

Table 2. Profit and marginal cost

	All financial institutions			Regional banks				
	Profit	Marginal cost	*N*	Profit	Marginal cost	*N*	Listing	Second -tier
1989	6.186	-2.795	918	8.500	-2.891	123	71	24
1990	6.057	-2.556	880	8.102	-2.585	114	65	24
1991	6.196	-2.499	860	8.420	-2.568	123	71	25
1992	6.229	-2.655	864	8.671	-2.808	120	71	25
1993	6.106	-2.799	844	8.499	-2.993	121	72	25
1994	6.668	-3.013	845	9.079	-3.213	119	71	24
1995	6.632	-3.211	840	9.030	-3.454	124	74	25
1996	6.691	-3.431	824	8.985	-3.689	120	71	25
1997	6.603	-3.525	793	8.903	-3.782	119	71	25
1998	6.558	-3.585	760	8.887	-3.860	116	71	25
1999	6.625	-3.638	724	8.988	-3.951	118	72	24
2000	6.474	-3.632	679	8.937	-3.989	109	71	23
2001	6.447	-3.701	599	8.895	-4.087	108	71	24
2002	6.520	-3.769	587	8.893	-4.183	110	73	25
2003	6.638	-3.819	554	8.969	-4.228	106	74	25
2004	6.749	-3.841	540	9.016	-4.252	103	74	25
2005	6.854	-3.874	539	9.007	-4.274	103	74	25
2006	6.937	-3.833	530	9.030	-4.210	100	73	24
2007	6.797	-3.714	516	8.884	-4.080	102	74	25
2008	6.644	-3.713	504	8.723	-4.104	98	72	25
2009	6.692	-3.761	501	8.633	-4.182	96	72	25
Mean	6.503	-3.314		8.808	-3.651			
Sum			14701			2352	1508	517

	Shinkin banks			Credit unions		
	Profit	Marginal cost	*N*	Profit	Marginal cost	*N*
1989	6.505	-2.762	428	5.038	-2.800	367
1990	6.421	-2.523	413	4.972	-2.586	353
1991	6.512	-2.462	403	4.995	-2.518	334
1992	6.417	-2.604	406	5.137	-2.661	338
1993	6.257	-2.747	392	5.052	-2.790	331
1994	6.922	-2.970	392	5.512	-2.994	334
1995	6.878	-3.179	391	5.420	-3.156	325
1996	6.947	-3.404	385	5.520	-3.367	319
1997	6.849	-3.512	379	5.359	-3.439	295
1998	6.759	-3.581	369	5.307	-3.473	275
1999	6.697	-3.620	362	5.375	-3.514	244
2000	6.532	-3.628	345	5.192	-3.465	225
2001	6.347	-3.665	312	5.145	-3.531	179
2002	6.405	-3.733	306	5.200	-3.568	171
2003	6.466	-3.783	288	5.402	-3.614	160
2004	6.638	-3.801	279	5.466	-3.643	158
2005	6.794	-3.850	278	5.554	-3.656	158
2006	6.914	-3.809	274	5.635	-3.631	156
2007	6.698	-3.665	267	5.530	-3.549	147
2008	6.579	-3.655	261	5.356	-3.552	145
2009	6.662	-3.710	258	5.477	-3.578	147
Mean	6.626	-3.300		5.281	-3.180	
Sum			7188			5161

3.2 Estimation results of the Boone indicator

We estimate the following four Boone indicators for regional banking industries for each year: (1) financial institutions in all three business categories (all financial institutions), (2) regional banks, (3) Shinkin banks, and (4) credit unions. From Eq. (12), the coefficient of the marginal cost, obtained from the estimates using OLS and 2SLS, is defined as the PE. After multiplying the value of the coefficient obtained by -1, the results could be interpreted as showing that the larger the value is, the more competitive is the market.

Table 3. Estimation result of the Boone indicator: OLS

	All financial institutions						Regional banks					
	Boone indicator	CI (upper)	CI (lower)		N	R^2	Boone indicator	CI (upper)	CI (lower)		N	R^2
1989	2.4216	3.295	1.548	[0.445]***	917	0.6701	3.7645	5.864	1.665	[1.060]***	123	0.5906
1990	0.6090	1.694	-0.476	[0.553]	880	0.5886	4.9938	7.778	2.209	[1.404]***	114	0.4810
1991	0.3809	1.390	-0.628	[0.514]	859	0.6511	4.8127	7.030	2.595	[1.120]***	123	0.6814
1992	1.6126	2.452	0.773	[0.428]***	862	0.6653	5.7689	7.667	3.871	[0.958]***	120	0.6956
1993	1.4804	2.367	0.593	[0.452]***	841	0.5850	4.5664	6.732	2.401	[1.093]***	121	0.5742
1994	1.2392	2.021	0.458	[0.398]***	844	0.6909	4.2390	5.831	2.647	[0.803]***	119	0.6818
1995	1.2785	2.013	0.544	[0.374]***	838	0.6584	2.9179	4.453	1.383	[0.775]***	123	0.6323
1996	0.6794	1.200	0.159	[0.265]**	822	0.6893	2.1367	3.361	0.912	[0.618]***	119	0.5435
1997	0.8405	1.319	0.362	[0.244]***	779	0.6785	1.6264	2.849	0.404	[0.617]***	117	0.5440
1998	1.0978	1.578	0.618	[0.244]***	749	0.6758	2.4190	3.875	0.963	[0.734]***	113	0.6179
1999	1.4657	1.983	0.949	[0.263]***	711	0.6990	4.1917	5.418	2.966	[0.618]***	114	0.6889
2000	1.6668	2.298	1.035	[0.322]***	673	0.6877	2.4201	3.824	1.016	[0.708]***	109	0.6248
2001	1.8901	2.541	1.239	[0.331]***	596	0.6656	2.7966	4.067	1.526	[0.640]***	107	0.6605
2002	1.6629	2.306	1.020	[0.327]***	587	0.6396	3.3261	4.520	2.132	[0.602]***	110	0.6691
2003	1.8841	2.410	1.358	[0.268]***	554	0.6931	2.5363	3.172	1.901	[0.320]***	106	0.7599
2004	1.7538	2.325	1.183	[0.291]***	539	0.7112	3.1622	3.837	2.487	[0.340]***	102	0.7579
2005	1.8745	2.434	1.315	[0.285]***	539	0.7114	2.9162	3.680	2.152	[0.385]***	103	0.6758
2006	1.8870	2.461	1.313	[0.292]***	530	0.7032	2.9213	3.834	2.009	[0.459]***	100	0.6665
2007	2.6967	3.446	1.947	[0.382]***	516	0.7027	3.4962	4.544	2.449	[0.528]***	102	0.7297
2008	2.7598	3.455	2.064	[0.354]***	503	0.6513	4.4443	5.507	3.382	[0.535]***	98	0.7324
2009	1.9409	2.673	1.209	[0.373]***	500	0.6641	3.9830	4.878	3.088	[0.450]***	95	0.7157
	Shinkin banks						Credit unions					
	Boone indicator	CI (upper)	CI (lower)		N	R^2	Boone indicator	CI (upper)	CI (lower)		N	R^2
1989	4.9114	5.997	3.826	[0.552]***	428	0.7669	3.6173	4.658	2.577	[0.529]***	366	0.5655
1990	5.2970	6.677	3.917	[0.702]***	413	0.7159	1.0355	2.952	-0.881	[0.974]	353	0.5254
1991	3.1392	4.776	1.502	[0.833]***	403	0.7264	1.1117	2.682	-0.458	[0.798]	333	0.5192
1992	3.5879	4.593	2.583	[0.511]***	406	0.7388	2.9214	4.150	1.692	[0.625]***	336	0.5087
1993	2.8260	4.285	1.367	[0.742]***	392	0.5094	2.6649	3.872	1.458	[0.614]***	328	0.4388
1994	2.0657	2.799	1.333	[0.373]***	392	0.8063	2.6868	3.605	1.769	[0.467]***	333	0.5752
1995	3.1900	4.157	2.223	[0.492]***	391	0.7703	1.8382	2.500	1.177	[0.336]***	324	0.4927
1996	1.8575	2.377	1.338	[0.264]***	385	0.8221	0.7894	1.257	0.322	[0.238]***	318	0.5256
1997	2.1479	2.597	1.699	[0.228]***	379	0.7903	0.8269	1.297	0.357	[0.239]***	283	0.4753
1998	2.1254	2.576	1.675	[0.229]***	367	0.7899	0.7881	1.261	0.315	[0.240]***	269	0.5043
1999	1.4208	2.085	0.756	[0.338]***	354	0.7749	0.6118	1.071	0.153	[0.233]***	243	0.5914
2000	1.7337	2.343	1.125	[0.310]***	345	0.7438	0.7727	1.458	0.088	[0.348]**	219	0.5049
2001	1.7995	2.453	1.145	[0.332]***	312	0.6717	0.8430	1.515	0.172	[0.340]**	177	0.5081
2002	1.7718	2.464	1.080	[0.352]***	306	0.6795	0.5551	1.283	-0.173	[0.369]	171	0.4252
2003	2.1873	2.814	1.561	[0.318]***	288	0.6933	0.4489	0.954	-0.056	[0.256]*	160	0.5044
2004	2.0797	2.625	1.535	[0.277]***	279	0.7730	0.1341	0.803	-0.535	[0.339]	158	0.4729
2005	1.9646	2.491	1.438	[0.267]***	278	0.7027	0.4434	0.998	-0.112	[0.281]	158	0.5524
2006	1.4687	1.930	1.007	[0.234]***	274	0.7806	0.8711	1.539	0.203	[0.338]**	156	0.5733
2007	2.5122	3.457	1.567	[0.480]***	267	0.7438	1.4769	2.558	0.395	[0.547]***	147	0.5294
2008	2.5324	3.478	1.587	[0.480]***	260	0.6840	1.2186	2.040	0.397	[0.416]***	145	0.5685
2009	1.8850	2.829	0.941	[0.479]***	258	0.7245	0.5707	1.271	-0.130	[0.354]	147	0.6268

Note: Robust standard errors in parentheses. Asterisks indicate significance at the following levels: $*$ significance 10%, $**$ significance 5%, $***$ significance 1%.

Table 4. Estimation result of the Boone indicator: 2SLS

	All financial institutions						Regional banks					
	Boone indicator	CI (upper)	CI (lower)		N	R^2	Boone indicator	CI (upper)	CI (lower)		N	R^2
1989	6.2053	7.376	5.034	[0.597]***	917	0.6325	7.6837	10.331	5.036	[1.351]***	123	0.5358
1990	6.7534	9.060	4.447	[1.177]***	880	0.5034	7.2818	10.075	4.489	[1.425]***	114	0.4707
1991	6.7125	8.587	4.838	[0.956]***	859	0.5680	4.8802	6.907	2.853	[1.034]***	123	0.6813
1992	5.7600	7.212	4.308	[0.741]***	862	0.6140	5.7469	7.425	4.068	[0.856]***	120	0.6956
1993	4.7099	6.110	3.310	[0.714]***	841	0.5433	4.8796	6.788	2.971	[0.974]***	121	0.5737
1994	4.3459	5.503	3.188	[0.591]***	844	0.6477	6.4140	8.242	4.586	[0.933]***	119	0.6619
1995	4.1939	5.426	2.962	[0.629]***	838	0.6106	5.8738	7.819	3.929	[0.992]***	123	0.5779
1996	2.9526	3.738	2.168	[0.401]***	822	0.6386	4.5361	5.931	3.141	[0.712]***	119	0.4857
1997	3.0315	3.763	2.300	[0.373]***	779	0.6313	3.7614	4.934	2.589	[0.598]***	117	0.4869
1998	2.8996	3.680	2.120	[0.398]***	749	0.6417	4.3919	5.573	3.211	[0.603]***	113	0.5784
1999	3.3566	4.109	2.604	[0.384]***	711	0.6654	5.4405	6.524	4.357	[0.553]***	114	0.6741
2000	3.7337	4.524	2.943	[0.403]***	673	0.6514	4.8000	6.181	3.419	[0.705]***	109	0.5643
2001	4.0854	5.023	3.148	[0.478]***	596	0.6307	4.7502	6.126	3.374	[0.702]***	107	0.6259
2002	3.1084	3.842	2.375	[0.374]***	587	0.6201	3.8496	4.993	2.706	[0.584]***	110	0.6656
2003	2.6700	3.339	2.001	[0.341]***	554	0.6862	2.2638	2.862	1.666	[0.305]***	106	0.7582
2004	2.8857	3.574	2.197	[0.351]***	539	0.6981	3.0691	3.716	2.422	[0.330]***	102	0.7577
2005	2.8992	3.603	2.196	[0.359]***	539	0.7006	3.2294	3.998	2.461	[0.392]***	103	0.6733
2006	3.1143	3.922	2.306	[0.412]***	530	0.6890	3.3700	4.173	2.567	[0.410]***	100	0.6617
2007	3.8826	4.839	2.926	[0.488]***	516	0.6918	3.8087	4.679	2.938	[0.444]***	102	0.7280
2008	3.8530	4.684	3.022	[0.424]***	503	0.6409	4.7806	5.778	3.784	[0.509]***	98	0.7311
2009	3.1449	4.033	2.257	[0.453]***	500	0.6495	4.1220	5.079	3.165	[0.488]***	95	0.7154

	Shinkin banks						Credit unions					
	Boone indicator	CI (upper)	CI (lower)		N	R^2	Boone indicator	CI (upper)	CI (lower)		N	R^2
1989	5.8114	6.863	4.760	[0.537]***	428	0.7644	6.0424	7.285	4.800	[0.634]***	366	0.5344
1990	7.4345	9.015	5.854	[0.807]***	413	0.7078	5.5030	8.653	2.353	[1.607]***	353	0.4521
1991	4.9863	7.247	2.726	[1.153]***	403	0.7200	7.0050	9.558	4.452	[1.303]***	333	0.4225
1992	4.3728	5.831	2.915	[0.744]***	406	0.7374	6.3339	8.109	4.559	[0.906]***	336	0.4466
1993	3.3860	5.992	0.780	[1.330]**	392	0.5083	5.2856	6.727	3.844	[0.735]***	328	0.3907
1994	3.4577	4.441	2.474	[0.502]***	392	0.7967	4.4571	5.453	3.461	[0.508]***	333	0.5423
1995	4.2892	5.466	3.113	[0.600]***	391	0.7642	3.5822	4.532	2.632	[0.485]***	324	0.4441
1996	2.4211	3.046	1.796	[0.319]***	385	0.8190	2.3667	3.085	1.649	[0.366]***	318	0.4490
1997	2.7646	3.302	2.227	[0.274]***	379	0.7865	2.4348	3.194	1.675	[0.388]***	283	0.3943
1998	2.5249	3.068	1.982	[0.277]***	367	0.7884	2.1087	2.853	1.365	[0.380]***	269	0.4434
1999	1.9696	2.817	1.122	[0.432]***	354	0.7716	2.1657	2.964	1.368	[0.407]***	243	0.5185
2000	2.5393	3.210	1.869	[0.342]***	345	0.7376	2.5810	3.581	1.581	[0.510]***	219	0.4196
2001	2.6517	3.403	1.900	[0.383]***	312	0.6656	2.9443	4.043	1.845	[0.561]***	177	0.4162
2002	2.4767	3.318	1.635	[0.429]***	306	0.6748	1.8898	2.640	1.140	[0.383]***	171	0.3719
2003	2.7743	3.497	2.051	[0.369]***	288	0.6896	1.2899	2.043	0.537	[0.384]***	160	0.4718
2004	2.5911	3.205	1.977	[0.313]***	279	0.7697	1.6613	2.474	0.849	[0.415]***	158	0.3991
2005	2.7068	3.354	2.060	[0.330]***	278	0.6954	1.6423	2.373	0.912	[0.373]***	158	0.5070
2006	2.0684	2.626	1.511	[0.285]***	274	0.7757	2.1782	3.133	1.223	[0.487]***	156	0.5343
2007	3.2209	4.117	2.324	[0.457]***	267	0.7386	2.7544	4.111	1.398	[0.692]***	147	0.5011
2008	2.7359	3.617	1.855	[0.450]***	260	0.6835	2.5808	3.727	1.434	[0.585]***	145	0.5334
2009	2.8535	4.172	1.535	[0.673]***	258	0.7123	1.9550	2.883	1.027	[0.473]***	147	0.5777

Note: Robust standard errors in parentheses. Asterisks indicate significance at the following levels: $*$ significance 10%, $**$ significance 5%, $***$ significance 1%.

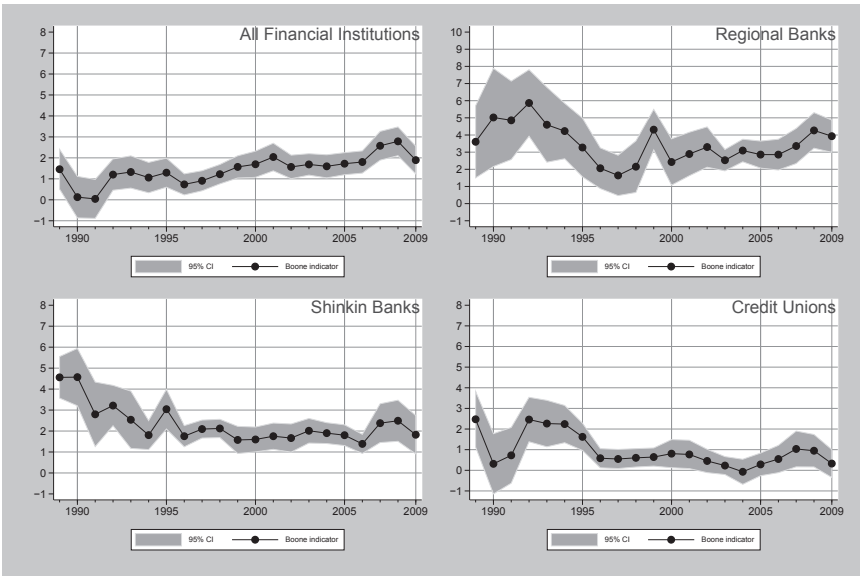

Figure 1. Estimates of Boone indicator using OLS

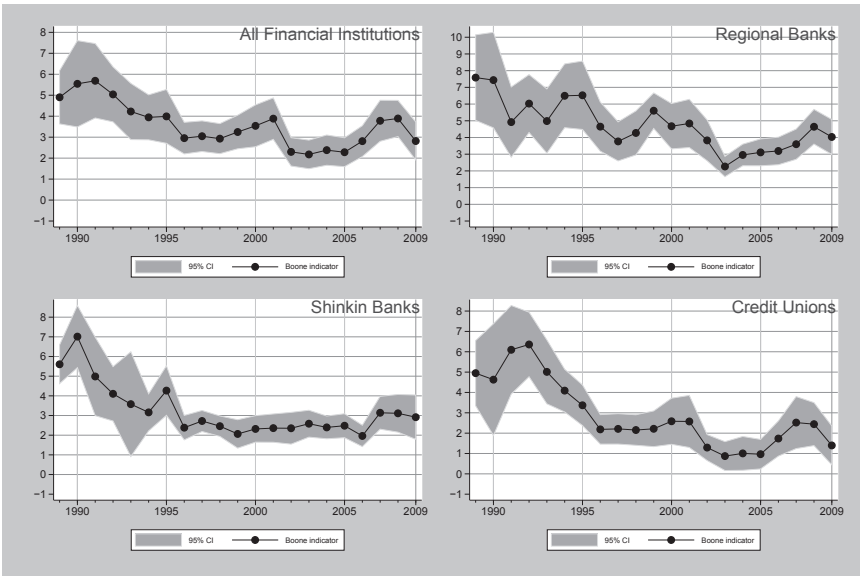

Figure 2. Estimates of Boone indicator using 2SLS

Table 3 shows the results of the estimations using OLS, and Table 4 the results using 2SLS. Starting from the left, these tables show the Boone indicator, confidence interval, robust standard error, and sample size. In addition, Figure 1 depicts the OLS result and Figure 2 the 2SLS result as well as the confidence intervals.

In the estimation results for the financial institutions from all three business categories, the PE values from the 2SLS estimator are larger than those from the OLS estimator. The results show that, in the period 1990 to 1992, the fluctuation in the level of competition was large for both estimators, and in both, their trends moved in opposite directions. Note that their confidence intervals are quite wide and these estimates are not statistically different. However, the p-value rule should not be overconfident. In fact, the point estimates seems to have a long-run trend, and thus, we interpret the long-run changes in the estimates as change in competition. In this period, Japan experienced a bubble economy, followed by its collapse. In other words, it is assumed a period when there was major turmoil in lending markets. After this period, it is confirmed that both estimators trended roughly in parallel. In particular, it is confirmed that in both estimators, after 2003, the level of competition trended upwards, and then in 2009, dramatically declined. The capital markets were dysfunctional at that time due to the sub-prime loan crisis, and as a result, firms had difficulties raising funds by issuing stocks and corporate bonds. It is thought that demand for borrowing increased from those Japanese financial institutions that had managed to maintain their soundness, and thereby there was an easing of inter-bank competition. From these results, in the period other than 1990 to 1992, it can be observed that the regional lending markets became moderately competitive, although there were some fluctuations.

Next, we consider the results of the Boone indicator estimates according to business category. We confirm that the degree of competition for regional banks, Shinkin banks, and credit unions trended generally about the same. First, the degree of competition trended downward until the first half of the 1990s. However, caution is necessary when evaluating this period, because the width of the confidence interval is large. In the second half of the 1990s, we observe that the degree of competition levels off or increases moderately, while still fluctuating. We identify the following characteristics when we include the results of the Boone indicator estimates for the three business categories. First, considering the period as a whole, we observe that, while fluctuations were severe in the 1990s, on entering the 2000s, the degree of competition moderately increased. One reason for this is considered as follows: owing to the effects of the financial big bang that began in 1996, the markets became competitive in stages in each of the business categories. Moreover, it is possible that due to the effects of such events as banking mergers, the financial crisis, and the sub-prime loan problem, inefficient financial institutions left the market, which may have contributed to the increase in the degree of competition. Second, when we compare the averages for the degree of competition over the period, we find that for both estimators, the order is as follows: regional banks > Shinkin banks > credit unions. From 1989 to 1999, there were hardly any differences in the degree of competition between business categories, but these differences became large from 2000 onwards. In 1998, the Japanese government legalized financial holding companies. This led to a wave of big financial groups, including banks, insurance companies, and security companies, especially among city banks and regional banks. On the other hand, a number of relatively small financial institutions, that is, Shinkin banks and credit unions, failed to merge in these periods. This surge is evident in the figures indicating differences of competition among business categories after 2000. Third, we observe decreases in the degree of competition in the period after the collapse of the bubble, in the first half of the 1990s, and in 2009 immediately after the global financial crisis. It is considered that these were periods of turmoil in the regional financial markets and that this had an impact on the lending market.

3.3 Robustness checks of basic results

In this subsection, we provide a check on the robustness of the results in the previous subsection. To do so, we replace the explanatory and/or instrumental variables in Eq. (12) with alternative variables.

First, the estimates are carried out by adding the ratio of non-performing loans to the control variable of the estimation equation in Eq. (12). Figure 3 shows the results of the estimations using OLS, while Figure 4 shows the results of the estimations using 2SLS. The estimation period used is 1998 to 2009 owing to the availability of the data.

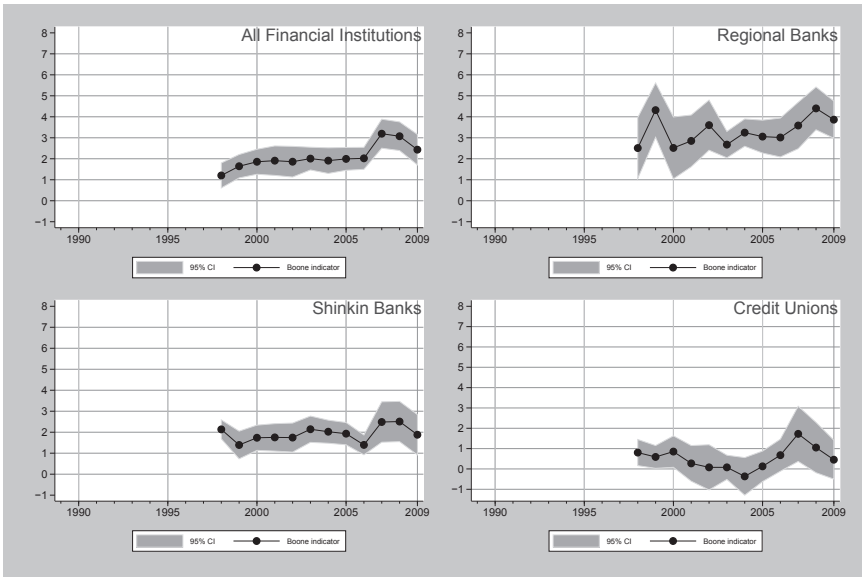

Figure 3. Estimates of Boone indicator using OLS

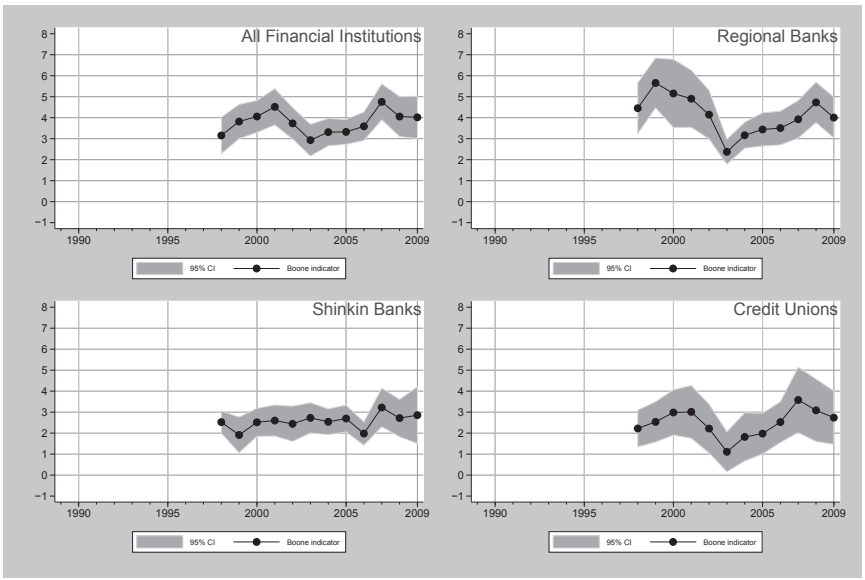

Figure 4. Estimates of Boone indicator using 2SLS

Second, the 2SLS estimates are carried out using the deposit-cost rate and the debt ratio as the instrumental variables. These results are shown in Figure 5. Third, the 2SLS estimates are carried out using the average cost as the instrumental variable. These results are shown in Figure 6.

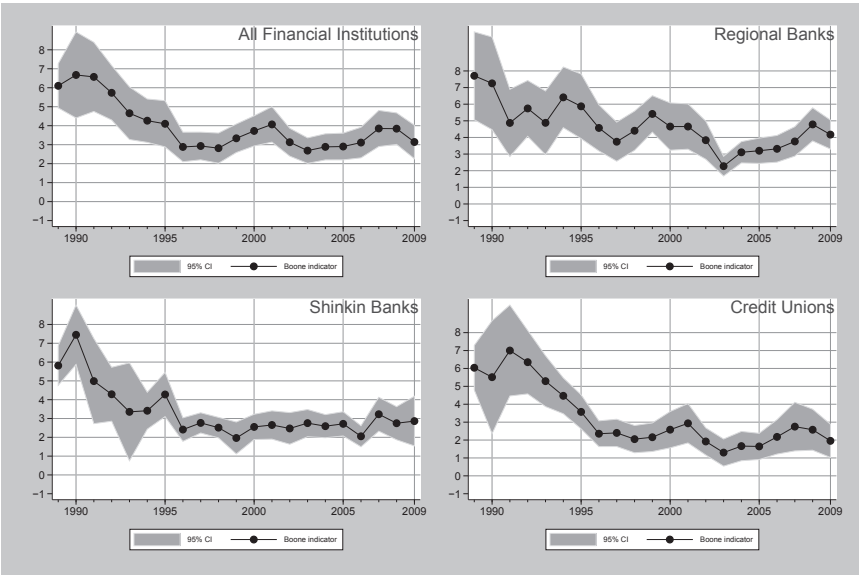

Figure 5. Estimates of Boone indicator using 2SLS

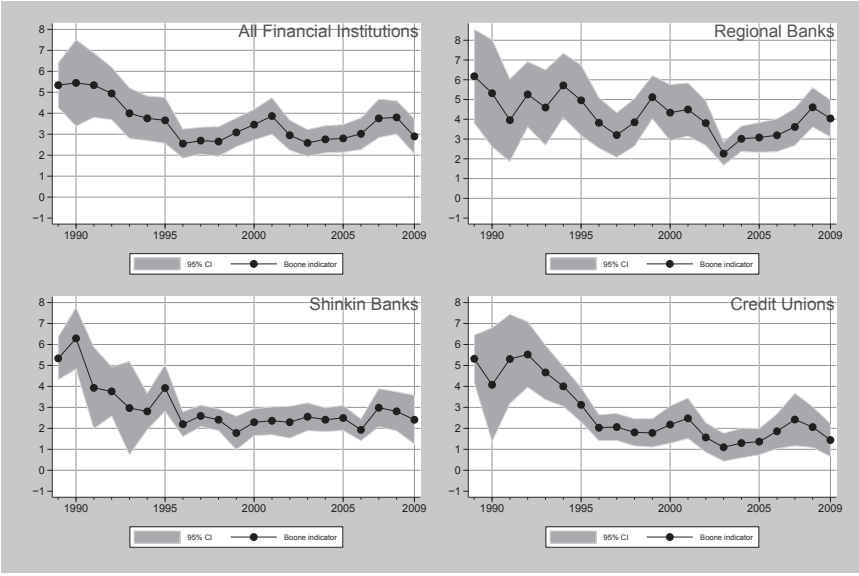

Figure 6. Estimates of Boone indicator using 2SLS

Fourth, the estimates are carried out using the average cost instead of the marginal cost. The results of the estimates using OLS are shown in Figure 7, while the results using 2SLS are shown in Figure 8.

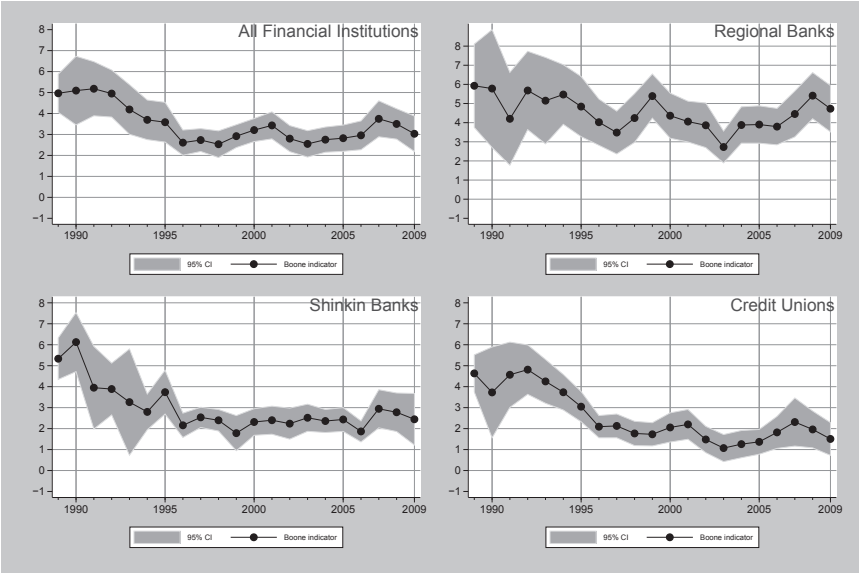

Figure 7. Estimates of Boone indicator using OLS (average cost)

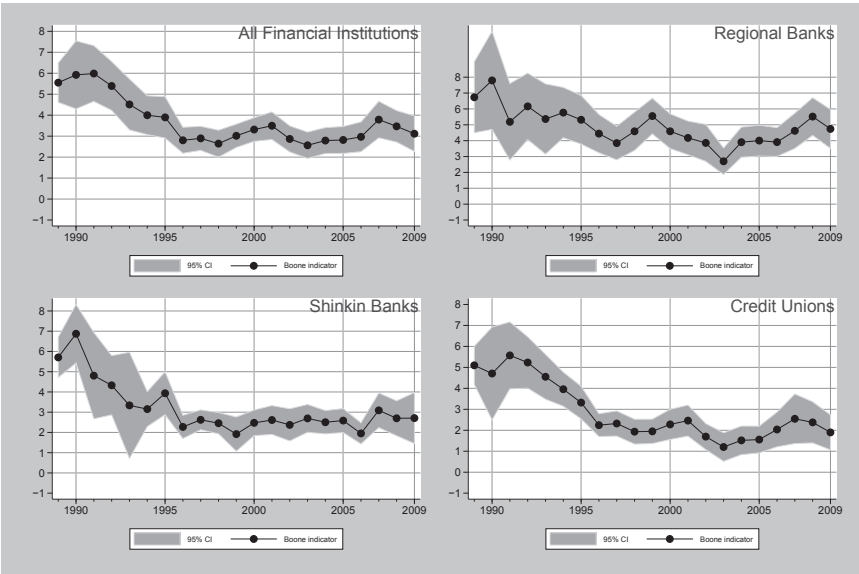

Figure 8. Estimates of Boone indicator using 2SLS (average cost)

When we compare these results with the results using OLS in Figure 1 and 2SLS in Figure 2, we observe that, while the values are different for some of the period, in terms of the overall trend, there are no differences for any of the variables used.

3.4 Other measures of competition

We now compare the results for the Boone indicator with those for other competition measures considered in the previous literature, namely the HHI, PCM, and *H*-statistic. The first indicator for market power is the HHI, which measures the degree of market concentration. This indicator is often used in the context of the "structure-conduct-performance" (SCP) model, which assumes that market structure affects banks' behavior, which in turn determines their performance. The idea is that a smaller number of banks makes collusion more likely. However, the HHI has a disadvantage in that concentration may be due to consolidation forced by intense competition. We calculate the HHI using the amount of loan data. This can be calculated as the sum of the squared market shares of all banks:

$$HHI = \sum_{i=1}^{N} \left(\frac{q_i}{Q}\right)^2,$$

where $Q = \sum_{i=1}^{N} q_i$ and q_i is the amount of bank loan. Figure 9 shows the time series of the HHI for each type of banking institution. Roughly speaking, the HHIs tended to increase gradually, which suggests that the concentration ratio was rising in the Japanese banking industry through the sample period. As long as a rise in concentration means a decline in competition, this trend turns out opposite to the result for the Boone indicator.

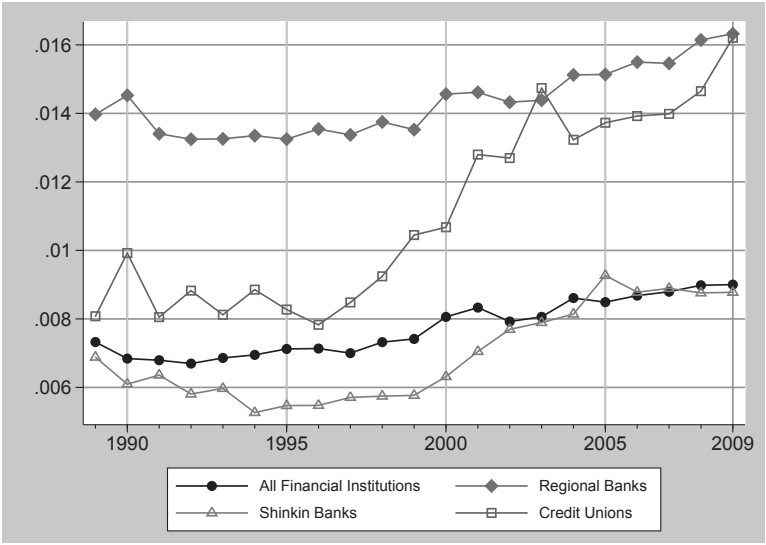

Figure 9. Estimates of the HHI

As discussed in subsection 2.1, market power may be related to banks' profit. Second, a traditional measure of profitability is the PCM, which is equal to the output price minus marginal cost (mark-up of price), divided by the output price. This indicates that significantly higher profits may point to weak competition. We calculate the PCM as follows:

$$PCM = \frac{p_i - c_i}{p_i},$$

where p_i is bank loan interest rate, defined as the ratio of the interest on loans to the total amount of loans. c_i is marginal cost, $\hat{c}_i$.

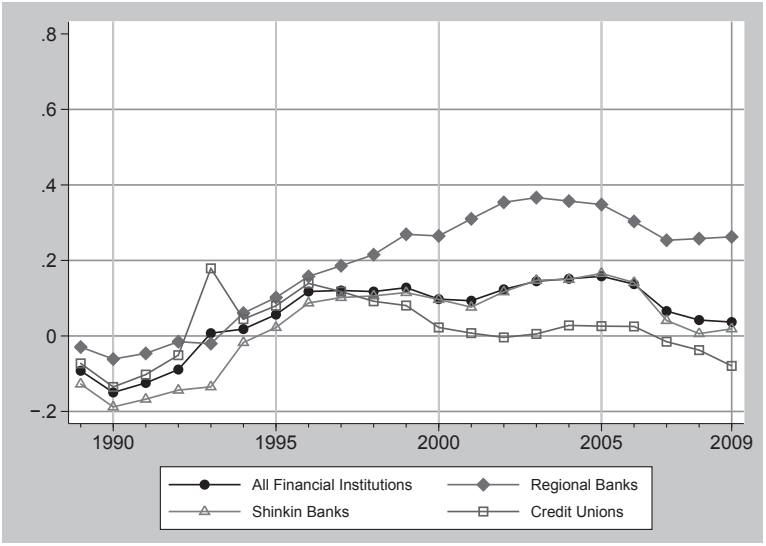

Figure 10. Estimates of the PCM

The results of the PCM are shown in Figure 10. The results of the PCM for all financial institutions show that it continues rising from 1989 through to the mid-2000s. Bank market power increases from 1989 through to the mid-2000s, but rebounds somewhat from 2005. The point at which competition improves from the mid-2000s is consistent with the results of the Boone indicator. Despite the Japanese regional banking industry experiencing a deep crisis and financial liberalization during our sample periods, the HHI and PCM do not seem able to capture those influences. This discrepancy might occur by the reallocation effect, named by Boone et al. (2007). An increase in competition seems to reduce firms' PCM. However, an increase in competition raises the market share of efficient firms with high PCM. Hence, attention should be paid to the results of PCM from the viewpoint of the reallocation effect.

Third, we estimate the *H*-statistic using Panzar and Rosse's (1987) methodology. The *H*-statistic is calculated from reduced-form bank revenue equations and measures the sum of the elasticities of the total revenue of the banks with respect to their input prices. The *H*-statistic is interpreted as follows. $H < 0$ indicates a monopoly; $H = 1$ indicates perfect competition; and $0 < H < 1$ indicates monopolistic competition. Moreover, under a certain assumption, a higher H means a higher degree of competition. To obtain the *H*-statistic, we estimate the following reduced-form revenue equation:

$$\ln R_i = \beta_0 + \beta_1 \ln w_{1i} + \beta_2 \ln w_{2i} + X_i' \zeta + \varepsilon_i,$$

where R_i denotes ordinary income, w_1 is the interest rate for fund-raising, defined as the ratio of interest on expenses to the total amount of deposits, and w_2 is the wage rate, defined as the ratio of personnel expenses to the number of employees. We add two control variables reflecting bank size effect, X_i, which is the number of branches and total assets. We take the natural logarithm of these variables. The *H*-statistic can be computed as

$$H = \hat{\beta}_1 + \hat{\beta}_2.$$

Therefore, *H* is the sum of the elasticities of the total interest revenue of the bank with respect to their factor input price.

On the other hand, while for the *H*-statistic, the size values and degrees of competition are proportional under conditions of certainty, as pointed out by Matsumura (2005), there are various problems with their use. The first is that the size of the value does not necessarily signify the degree of competition. In previous studies using the *H*-statistic, the values are from 0 to 1, and, in most cases, it is assumed that the closer the value is to 1, the higher is the degree of competition. This is established based on certain conditions, but in general, these conditions are not observed. Second, even without perfect competition, a judgment of perfect competition can be made, or conversely, perfect competition can be dismissed even though the competition is actually perfect. This captures the fact that it is only proven that the *H*-statistic equals 1 under a simple condition. Third, the *H*-statistic can be negative in the case of a monopoly. In this case, it is difficult to judge the degree of competition. Fourth, as the findings of Panzar and Rosse (1987) are established only in the event of long-run equilibrium, they are not suitable for estimates using cross-sectional data. Even when using panel data, it is necessary to verify whether there is a state of long-run equilibrium. With these types of problems, the *H*-statistic is not suitable for verifying the degree of competition. However, we conduct estimations using the *H*-statistic with our data in order to carry out a comparison with the results from the previous subsection.

Figure 11 shows the time series of the *H*-statistic. The *H*-statistic fluctuates at a low level, and gradually decreases through the period. The estimated result shows that regional lending markets are monopolistically competitive.

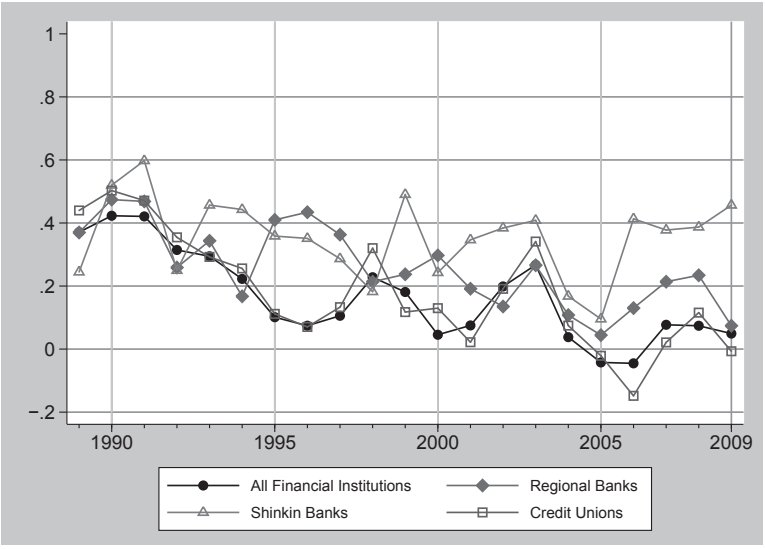

Figure 11. Estimates of the *H*-statistic

Unlike the results from the Boone indicator, in the time series for each *H*-statistic, competition declined until around 2005, while still fluctuating. The results are consistent in that the degree of competition increased in the period after 2006, but at a low level in each of the banking industries. As indicated by the HHI and PCM results, it is difficult to imagine that competition in all three banking industries eased during this period, considering the failure of many regional financial institutions due to the financial crisis along with the long-term economic recession beginning in the second half of the 1990s.

It seems that the estimated *H*-statistic does not capture the actual state of competitiveness in the Japanese regional banking industry during this period. Therefore, when viewed from this perspective, it can be said that our estimates using the Boone indicator offer extremely normal results.

4 Conclusion

In this study, we used the PE proposed by Boone et al. (2007) to verify the degree of competition in Japan's regional banking industries (regional banks, Shinkin banks, and credit unions) from 1989 to 2009. From the estimated Boone indicators, while we observed differences in the degree of competition according to business category, it was clarified that, over the long term, there was an upward trend, and Japan's regional lending markets have become more competitive. In order to confirm whether this trend would have been evident with the other indicators, we used the sample from the same period and recalculated the data using the HHI, PCM, and *H*-statistic. However, when using these indicators, the opposite trend was observed, and the degree of competition decreased.

Our estimation period coincided with a time in which the financial market was undergoing deregulation in various ways and therefore, intuitively, we consider the results obtained from the Boone indicators to be more consistent with reality.

Appendix: Estimation of Marginal Cost

Because marginal cost is not observable, we estimate the translog cost function, as in the Hayashi (2000) approach. The cost function is $C(q,w_1,w_2)$, where q is output and w_j is factor price $j = 1, 2$. Taking the second-order Taylor expansion of $\ln C(q,w_1,w_2)$ with respect to $\ln q = 0$ and $\ln w_j = 0$ ($j = 1, 2$), we obtain:

$$\ln C = \alpha_0 + \sum_{j=1}^{2} \alpha_j \widetilde{\ln w_j} + \frac{1}{2}\sum_{j=1}^{2}\sum_{k=1}^{2} \gamma_{jk} \widetilde{\ln w_j} \widetilde{\ln w_k}$$
$$+\alpha_q \widetilde{\ln q} + \frac{1}{2}\gamma_{qq}\left(\widetilde{\ln q}\right)^2 + \sum_{j=1}^{2} \gamma_{jq} \widetilde{\ln w_j} \widetilde{\ln q} + \varepsilon, \tag{A1}$$

where $\tilde{x}$ denotes the value that equals x minus its average. Note that we drop a subscript that denotes index, $i = 1,\ldots, n$. We use the symmetry assumption, $\gamma_{jk} = \gamma_{kj}$ ($j, k = 1, 2$). For $j = 1, 2$, share equations are

$$s_j = \alpha_j + \sum_{k=1}^{2} \gamma_{jk} \widetilde{\ln w_k} + \gamma_{jq} \widetilde{\ln q}, \tag{A2}$$

where s_j is the share of input factor j. Adding an error term to each share equation, we obtain

$$s_1 = \alpha_1 + \gamma_{11} \widetilde{\ln w_1} + \gamma_{12} \widetilde{\ln w_2} + \gamma_{1q} \widetilde{\ln q} + \varepsilon_1,$$
$$s_2 = \alpha_2 + \gamma_{21} \widetilde{\ln w_1} + \gamma_{22} \widetilde{\ln w_2} + \gamma_{2q} \widetilde{\ln q} + \varepsilon_2. \tag{A3}$$

Due to adding-up restrictions,

$$\begin{cases} \alpha_1 + \alpha_2 = 1 \\ \gamma_{11} + \gamma_{21} = 0 \\ \gamma_{12} + \gamma_{22} = 0 \\ \gamma_{1q} + \gamma_{2q} = 0 \end{cases} \tag{A4}$$

and the symmetry assumption, we rewrite the share equations as

$$\begin{aligned} s_1 &= \alpha_1 + \gamma_{11}\left(\widetilde{\ln w_1} - \widetilde{\ln w_2}\right) + \gamma_{1q}\,\widetilde{\ln q} + \varepsilon_1, \\ s_2 &= \alpha_2 + \gamma_{11}\left(\widetilde{\ln w_1} - \widetilde{\ln w_2}\right) + \gamma_{2q}\,\widetilde{\ln q} + \varepsilon_2. \end{aligned} \tag{A5}$$

We can estimate all of the parameters using only one share equation and the parameter restrictions. First, we estimate

$$s_1 = \alpha_1 + \gamma_{11}\left(\widetilde{\ln w_1} - \widetilde{\ln w_2}\right) + \gamma_{1q}\,\widetilde{\ln q} + \varepsilon_1,$$

by OLS to obtain three parameters, α_1, γ_{11}, and γ_{1q}. Then, using the restrictions, we obtain the other parameters, $\alpha_2 = 1-\alpha_1$, $\gamma_{12} = -\gamma_{11}$, $\gamma_{21} = \gamma_{12}$, $\gamma_{22} = -\gamma_{21}$ and $\gamma_{2q} = -\gamma_{1q}$. Substituting these parameters into the translog equation yields

$$Y^* = \alpha_0 + \alpha_q\,\widetilde{\ln q} + \frac{1}{2}\gamma_{qq}\left(\widetilde{\ln q}\right)^2 + \varepsilon, \tag{A6}$$

where

$$Y^* = \ln C - \sum_{j=1}^{2} \hat{\alpha}_j\,\widetilde{\ln w_j} - \frac{1}{2}\sum_{j=1}^{2}\sum_{k=1}^{2} \hat{\gamma}_{jk}\,\widetilde{\ln w_j}\,\widetilde{\ln w_k} - \sum_{j=1}^{2} \hat{\gamma}_{jq}\,\widetilde{\ln w_j}\,\widetilde{\ln q}. \tag{A7}$$

Because Eq. (A7) has no restrictions, we can estimate it by OLS to obtain α_0, α_q, and γ_{qq}.

Finally, differentiating the translog function with respect to output, we obtain marginal cost:

$$\begin{aligned} \hat{c}_i &= \frac{\partial C(q_i, w_1, w_2)}{\partial q_i} \\ &= \frac{C_i}{q_i}\frac{\partial \ln C_i}{\partial \ln q_i} \\ &= \frac{C_i}{q_i}\left(\hat{\alpha}_q + \hat{\gamma}_{qq}\,\widetilde{\ln q_i} + \hat{\gamma}_{1q}\,\widetilde{\ln w_{1i}} + \hat{\gamma}_{2q}\,\widetilde{\ln w_{2i}}\right). \end{aligned} \tag{A8}$$

From Eq. (A8), the marginal cost of bank output is $\hat{c}_i$.

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