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Title	Efficiency of the Domestic and Foreign Banks in Russia
Author(s)	Ono, Shigeki
Citation	Economic Journal of Hokkaido University, 37, 29-43
Issue Date	2008-10
Doc URL	https://hdl.handle.net/2115/34900
Type	departmental bulletin paper
File Information	EconJ_vol37_p29-43.pdf



Efficiency of the Domestic and Foreign Banks in Russia[†]

Shigeki Ono

In this article, we examine the efficiency of domestic and foreign banks in Russia using Data Envelopment Analysis. The characteristics of this approach enable us to investigate the technical, pure technical, and scale efficiency without specifying assumptions regarding the production function. We also test whether domestic and foreign banks come from the same population. Furthermore, we calculate Malmquist Indices to measure bank productivity changes. Finally, using Tobit regression, we discuss the determinants of bank efficiency. The results indicate that foreign banks tend to be more technically efficient than domestic banks.

JEL Classification: C67, G21, G28

Keywords: Russian Banks, Foreign Banks, Data Envelopment Analysis, Efficiency

1. Introduction

The nonresident share of Russian bank charter capital tends to increase with the growing interest of foreign investors in the Russian banking system. From about 6 % at the beginning of 2005, it reached 15.9 % at the beginning of 2007 (Expert RA, 2007, p. 17). The share will continue to rise in the future, and foreign bank influence on the Russian economy will increase. Under these circumstances, the roles of foreign banks continue to be actively discussed in Russia. For example, Vernikov (2003) insists that, since Russian companies need inexpensive fund-raising sources and large banking structures for the execution of their projects, foreign investors are attracted to business in the Russian banking sector. Vernikov (2002) and Vernikov (2005) analyze the shares of foreign banks in the total asset, loans outstanding, deposits, and other indicators of all Russian banks. Vernikov (2004) and Tulin (2006) examine the influence of the entry of foreign bank direct branches into the Russian market; at this point, foreign banks are not permitted to open direct branches in Russia, but they can set up subsidiaries. Both researchers report that the impact of the entry of foreign bank branches on the Russian banking system is overestimated in debates held in Russia and that their influence on the Russian banking system will be small even after the direct branches of foreign banks are permitted to open.

[†] This work was supported by Grant-in-Aid for Young Scientists (B) (No. 20730174) from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

Since there have been studies focusing on the analysis of the current situation regarding the Russian banking sector, we seek to analyze the influence of foreign banks on the Russian banking system by measuring the efficiency scores of domestic and foreign banks in Russia.¹⁾ Before we begin the analysis of the efficiency of domestic and foreign banks in Russia, we survey former studies on a similar analogical subject. Berger et al. (2000) analyze bank efficiency in developed countries and report that foreign financial institutions had lower efficiency scores than domestic institutions, although foreign banks from certain countries were more efficient than domestic banks. On the other hand, Sturm and Williams (2004), considering the efficiency of Australian banks, found that foreign banks experienced superior scale efficiency, which resulted in increased efficiency, on average, to domestic banks. The research on developing and transition countries is in progress. Bhattacharyya et al. (1997), Isik and Hassan (2002), Grigorian and Manole (2002), Hassan and Marton (2003), and Harvrylchuk (2006) concluded that foreign banks in each analyzed country exhibited higher efficiency than domestic banks.

In this paper, we measure the efficiency scores of Russian and foreign banks, use Data Envelopment Analysis (DEA), and add findings from our analysis of Russian banks to the analyses of the efficiency of domestic and foreign banks in other countries. We conduct parametric and non-parametric tests in order to investigate whether or not it is appropriate to construct efficient frontiers by pooling data on domestic and foreign banks. Furthermore, we measure changes in bank productivity during the years analyzed by using Malmquist Indices, following Sturm and Williams (2004). Finally, we discuss the determinants of bank efficiency and conduct regression analysis. In this analysis, the correlation of technical efficiency scores with bank indicators, such as a logarithm of assets and several dummy variables representing banks' characteristics, is calculated. We conclude that foreign banks are more efficient than Russian domestic banks, in agreement with the results of previous studies on transition economies.

The outline of this paper is as follows. Section 2 is an explanation of the regulation of the entry of foreign banks into the Russian market and the characteristics of their activities in Russia. In Section 3, we describe the methodology used in this study, specify outputs and inputs for the banking sector, and describe the data for banks. Section 4 is a presentation of the empirical results of the efficiency analysis. The last section contains the conclusions.

2. Characteristics of foreign bank activities

The only way for a foreign bank to work in the Russian territory is to participate in the capital of a Russian bank (It is permitted for a foreign bank to set up a wholly-owned subsidiary), but it is prohibited for a foreign bank to open its direct branches in Russia. As reported above, while the nonresident

¹⁾ In this article, we define a foreign bank as a bank with 50 % or more participation of foreign capital in its charter capital.

share in Russian bank charter capital accounted for 6.2 % at the beginning of 2005, it increased to 11.2 % in the beginning of 2006 (Vedomosti, Feb. 22, 2006) (the share was limited to 12 % at the maximum). In March, 2006, the Russian government agreed to increase the limit to 50 % in the negotiation process of Russia's accession to the World Trade Organization (Vremia novostei, March 30, 2006), and the nonresident share in Russian bank charter capital reached 15.9 % at the beginning of 2007 (Expert RA, 2007, p. 17). The negotiating countries also required Russia to permit the entry of foreign banks into the Russian market by setting up direct branches, but the Russian government gave preference to the interest in the domestic banks and did not agree to permit foreign banks to open branches in Russia. Russia has an obligation to return to this problem in prospective negotiations on Russia's accession to the Organization for Economic Cooperation and Development.

There are 65 banks with more than 50 % participation of foreign capital in the charter capital in Russia at the beginning of 2007 (CBR, 2007, p. 86). In the current situation, foreign banks entered into the Russian banking sector and established subsidiaries. In general, leading foreign banks actively work in the field of corporate loans, and their main clients are subsidiaries of Western companies and Russian big businesses. The investment banking services provided by foreign banks to client companies are expanding, and they include the underwriting of bonds and shares. The retail sector also attracts foreign bank interests. They provide not only loans secured by real estate but also unsecured personal loans.

3. Methodology and data

Measuring the efficiency of banks with observed inputs and outputs can be achieved through the implementation of two alternative methodologies. One is parametric, and the other, non-parametric.²⁾ In this paper, we use a non-parametric approach to estimate the efficiency of each bank. This means that the approach requires the observed inputs and outputs to construct the best practice reference units in input-output space, without estimating parameters. There are several favorable characteristics with regard to this approach. First, there is no need to specify the estimated production function required by the parametric approach. Second, it provides efficiency scores for each individual bank without having data on input prices, in contrast to the parametric cost function estimation.³⁾ In the analysis, we computed the efficiency of input usage to produce a given level of outputs; therefore, the method can be referred to as an input-based method.⁴⁾ As for the methodology of efficiency estimation, see Appendix A.

²⁾ Lewin and Knox Lovell (1990) present general surveys on the two methodologies.

³⁾ We should also take into account the situation in which data on the number of employees are not available for many banks, which makes it impossible to calculate the price of labor.

⁴⁾ Of course, another aspect with regard to how efficient banks earn income to make a given level of expenses is referred to as the output-based method. However, it is impossible to determine on which aspect banking activities are based. Therefore, in this paper, we expediently assume that banking activities are input-based. This assumption does not exert the decisive influence on the efficiency estimation of banks.

Furthermore, we use Malmquist Indices to measure productivity changes in comparison with the base year.⁵⁾ As Sturm and Williams (2004) explain, changes in productivity can be decomposed into components due to changes in technical efficiency (catching up) and movements due to changes in technology (technological change). Changes in the efficiency of a firm's technical process can be decomposed into changes due to pure technical ability and changes due to scale efficiency.

Here, we discuss the specification of outputs and inputs and the meaning of the application of these outputs and inputs to the DEA analysis of Russian banking. Former studies on banking activity used various data as inputs and outputs. We broadly categorize the methods of analysis into three parts. One is the production approach. According to this, banks are considered to be producers of deposit accounts and loan services.⁶⁾ Therefore, outputs are measured by the number of accounts and loans. The second is the intermediation approach. According to this, banks are regarded as intermediators that transfer financial resources from units in surplus to units in deficit.⁷⁾ The third is the profit-oriented approach. The various revenue and cost elements in the profit and loss statement are used as inputs and outputs.⁸⁾

In this paper, we use a profit-oriented approach for the following reasons. As Berger and Mester (2003) report, the use of the profit approach helps take into account unmeasured changes in the quality of banking services by including higher revenues paid for by the improved quality and helps capture the profit maximization goal by including both the costs and revenues. Moreover, specific Russian banks raise the funds of local governments and government-related companies at a low interest rate, which is reflected not in the absolute amount of deposits but in the interest expenses. The increase in the commission income resulting from the activation of investment banking in Russia is also reflected in the profit and loss statement.

In the analysis, we chose interest expenses, non-interest expenses, and administrative expenses as inputs and interest income and non-interest income as outputs.⁹⁾ Other than these, we take into account an allowance for doubtful accounts and the reversal of allowance for doubtful accounts. The former is considered to be expenses, and the latter, income. Since both items do not appear simultaneously in the net terms, it is difficult to add them into independent input and/or output items. Therefore, we decided to add the former to interest expenses and the latter to interest income, considering that almost all of

⁵⁾ For relevant articles, see Berg et al. (1992), Färe et al. (1994), and Sturm and Williams (2004).

⁶⁾ Sherman and Gold (1985) and Ferrier and Lovell (1990) use this approach.

⁷⁾ Aly et al. (1990), Rangan et al. (1998), and Berger and Humphrey (1991) use this approach.

⁸⁾ Avkiran (1999), Sturm & Williams (2004), and Drake et al. (2006) use this approach.

⁹⁾ Interest expense mainly includes interest expense on deposits and issued bonds. The major components of non-interest expense are expenses for foreign exchange operations, securities operations, and various commissions. Administrative expenses include maintenance costs of facilities, salaries, depreciation, communication expense, and other expenses. Interest income chiefly includes interest income from bonds and loans to customers including banks. Non-interest income consists of income from foreign exchange operations, securities operations, various commissions, and so on.

these items are related to the provision of loans.

We obtained data regarding the profit and loss statement from the website of the Central Bank of Russia. The items of "operating income and expenses of foreign currency, bonds, and others" are disclosed as the net operating income. Since this income sometimes takes a negative value, we calculate the gross operating income and expenses on the basis of the detailed profit and loss accounts (Form 102). Since we focus on analyzing the current situation, in which the nonresident share in the Russian banking system is increasing rapidly, we discuss the situation from 2004 through 2006.

Since 1,189 banks were in operation as of January 1, 2007, we analyze banks that were listed among the 100 largest banks and periodically disclosed Form 102. Data covers 73.6 % of the total bank assets, which makes it possible to determine the general situation of the Russian banking system. All variables are measured in thousands of Russian rubles. The descriptive statistics are provided in Table 1. Whereas domestic banks, on average, gain more interest income than foreign banks, foreign banks obtain more non-interest income than domestic banks.

Table 1 . Descriptive statistics of the input and output variables (thousand rubles)

	Domestic		Foreign	
	Mean	St. dev.	Mean	St. dev.
2004				
Number of banks	73		8	
Outputs				
Interest income	5,161,792	20,342,158	2,374,320	1,702,785
Non-interest income	16,871,879	65,617,321	20,210,285	31,197,857
Inputs				
Interest expenses	2,969,456	11,347,056	839,879	748,823
Non-interest expenses	15,283,276	59,237,508	18,797,860	30,680,313
Administrative expenses	1,996,242	8,321,663	1,202,246	682,740
2005				
Number of banks	73		8	
Outputs				
Interest income	7,124,805	27,567,713	3,851,108	2,975,475
Non-interest income	27,466,939	105,216,935	36,543,886	46,744,753
Inputs				
Interest expenses	3,901,519	14,566,037	2,230,394	2,026,714
Non-interest expenses	25,223,575	97,387,758	34,672,596	45,921,123
Administrative expenses	2,685,901	10,309,430	1,924,626	1,303,850
2006				
Number of banks	73		8	
Outputs				
Interest income	9,676,651	34,819,188	6,028,380	5,054,539
Non-interest income	35,263,991	121,927,628	46,552,662	57,099,268
Inputs				
Interest expenses	5,277,412	16,602,389	3,250,588	3,018,113
Non-interest expenses	32,037,403	112,996,043	43,982,896	55,846,528
Administrative expenses	3,658,417	12,750,327	2,865,680	2,128,635

Source: Calculated by the author on the basis of the data on the website of the Central Bank of Russia.

Consideration must be given to the fact that Russian banks experience data problems in the same way as banks in other transition countries. Though their compliance with accounting rules is dubious, we assume that each bank commits non-compliance activities equally, exerting no influence on our measuring of relative efficiency scores.

4. The empirical results

4.1. Technical and scale efficiency scores

In our paper, technical efficiency indicates how efficient the expenditures of Russian banks were in order to earn a given level of income under the assumption of constant returns to scale. The pure technical efficiency indicates how efficient their expenditures were in order to earn a given level of income under the assumption of variable returns to scale. The scale efficiency score is calculated as the ratio of the technical efficiency to the pure technical efficiency. This ratio reveals whether or not a bank is operating at an efficient scale.

Table 2 exhibits the resulting technical efficiency, pure technical efficiency, and scale efficiency scores of 73 domestic banks and 8 foreign banks.¹⁰⁾ We

Table 2 . The summary of the mean efficiency scores calculated relative to the separate and common frontiers for the years 2004-2006

	Separate frontiers		Common frontiers	
	Domestic	Foreign	Domestic	Foreign
2004				
TE	0.6929	0.9998	0.6929	0.7743
PTE	0.7722	1.0000	0.7694	0.8598
SE	0.8973	0.9998	0.9006	0.9006
2005				
TE	0.6758	0.9736	0.6744	0.7258
PTE	0.7538	0.9923	0.7480	0.8043
SE	0.8965	0.9812	0.9016	0.9024
2006				
TE	0.6724	0.9661	0.6712	0.6939
PTE	0.7803	0.9985	0.7741	0.8054
SE	0.8617	0.9676	0.8671	0.8616
All				
TE	0.6804	0.9798	0.6795	0.7313
PTE	0.7688	0.9969	0.7638	0.8231
SE	0.8850	0.9828	0.8896	0.8885

Note: TE, technical efficiency; PTE, pure technical efficiency; SE, scale efficiency.

Source: Calculated by the author on the basis of the data on the website of the Central Bank of Russia.

¹⁰⁾ Russia's 100 largest banks consisted of 90 domestic banks and 10 foreign banks as of January 1, 2007. Since Form 102 is not available for 17 domestic banks and 2 foreign banks, we could not include these 19 banks into our analysis. As indicated above, if Form 102 is not available, we cannot

calculated the efficiency scores under both separate and common frontiers. As is presented in the results, foreign banks showed higher efficiency scores than domestic banks in all cases except for the scale efficiency in 2005. Following other studies, including those of Isik and Hassan (2002) and Havrylchuk (2006), we tested the hypothesis that all banks come from the same population. Both parametric (ANOVA) and non-parametric (Wilcoxon Rank-Sum and Kolmogorov-Smirnov) tests fail to reject the null hypothesis; therefore, it is not inappropriate to construct the frontiers on the basis of all bank data under study (see Table 3).

Table 3 . Summary of parametric and non-parametric tests of the hypothesis that domestic and foreign banks come from the same population

	Analysis of variance test		Wilcoxon Rank-Sum test		Kolmogorov-Smirnov test	
	F (prob> F)		z (prob> z)		D (prob> D)	
2004						
TE	1.443	(0.223)	-1.177	(0.239)	0.781	(0.576)
PTE	1.622	(0.206)	-1.372	(0.170)	0.851	(0.464)
SE	0.008	(0.930)	-0.296	(0.767)	0.662	(0.774)
2005						
TE	1.603	(0.209)	-1.130	(0.259)	1.026	(0.244)
PTE	2.755	(0.101)	-1.418	(0.156)	1.071	(0.201)
SE	0.466	(0.497)	-0.980	(0.327)	0.970	(0.304)
2006						
TE	1.300	(0.257)	-1.132	(0.258)	1.043	(0.227)
PTE	0.637	(0.427)	-1.418	(0.156)	1.071	(0.201)
SE	0.132	(0.717)	-0.212	(0.832)	0.651	(0.790)

Note: Analysis of variance (ANOVA) is a parametric test that tests the null hypothesis, in which the domestic banks and foreign banks have the same mean. Wilcoxon rank-sum is a non-parametric test that tests the equality of the population medians. The Kolmogorov-Smirnov test is a non-parametric test that tests two data samples that come from the same distribution.

The resulting efficiency scores in Table 2 show that the technical efficiency of domestic banks relative to that of common frontiers had a tendency to decrease. Specifically, while it was 0.6929 in 2004, it decreased to 0.6744 in 2005. Furthermore, it dropped to 0.6712 in 2006. Although the efficiency scores of foreign banks were higher than those of domestic banks, their efficiency had the same tendency as that of the domestic banks. Whereas the average technical efficiency score of foreign banks relative to that of common frontiers was 0.7743 in 2004, it declined to 0.7258 in 2005 and to 0.6939 in 2006.

The technical efficiency score is equal to the pure technical efficiency score multiplied by the scale efficiency score. Therefore, we conclude that the

calculate the gross "operating income and expenses of foreign currency, bonds, and others" because the items of "operating income and expenses of foreign currency, bonds, and others" are disclosed as the net operating income in the normal profit and loss statement.

technical efficiency score is due to the waste of inputs rather than scale inefficiency if the pure technical efficiency score is smaller than the scale efficiency score, and vice versa. The figures in Table 2 indicate that technical inefficiency was mainly caused by the waste of inputs. The reasons for the changes in the efficiency scores from 2004 through 2006 are discussed in the following subsection.

4.2. Malmquist Index results

In this subsection, we report the productivity changes in the domestic and foreign banks. The Malmquist Index means are shown in Table 4. The productivity from 2004 to 2005 decreased by 1.9 % in the case of the domestic banks and 9.8 % in foreign banks. The productivity of the domestic banks increased slightly from 2005 to 2006 (about 0.2 %). However, that of the foreign banks continued to fall (about 6 %).

The Malmquist Index results are consistent with the efficiency scores analyzed in the previous subsection. The efficiency and productivity of the domestic banks fell from 2004 through 2005 and remained almost unchanged between 2005 and 2006. On the other hand, the efficiency scores of the foreign banks had a tendency to decrease through the years analyzed, and their productivity also continued to fall.

Both the efficiency and productivity means of Russian domestic banks could reflect the general situation of the Russian economy. The growth of the gross domestic product was 7.2 % in 2004, 6.4 % in 2005, and 6.7 % in 2006 (Rosstat, 2006, p. 305; Rosstat, 2007, p. 7). The change of the industrial produce index was 8.3 % in 2004, 4.0 % in 2005, and 3.9 % in 2006 (Rosstat, 2006, p. 369; Rosstat, 2007, p. 11). These macroeconomic indicators show the slowdown of

Table 4. Malmquist Index means and standard deviation (in parentheses)

	Effch	Techch	Pech	Sech	Tfpch
Changes from 2004 to 2005					
Domestic	0.9245 (0.1298)	1.0695 (0.1502)	0.9355 (0.1387)	0.9996 (0.1397)	0.9814 (0.1607)
Foreign	0.9441 (0.1727)	0.9610 (0.1428)	0.9381 (0.1204)	1.0089 (0.1366)	0.9024 (0.1965)
All	0.9264 (0.1334)	1.0588 (0.1522)	0.9358 (0.1364)	1.0005 (0.1386)	0.9736 (0.1649)
Changes from 2005 to 2006					
Domestic	1.0649 (0.2020)	0.9440 (0.0796)	1.0524 (0.2006)	1.0188 (0.1253)	1.0015 (0.1829)
Foreign	1.0520 (0.1461)	0.8991 (0.0706)	1.0286 (0.1851)	1.0286 (0.0524)	0.9395 (0.0898)
All	1.0636 (0.1965)	0.9396 (0.0795)	1.0500 (0.1982)	1.0198 (0.1199)	0.9953 (0.1765)

Note: Effch, technical efficiency change relative to constant returns to scale technology. Techch, technological change. Pech, pure technical efficiency change relative to variable returns to scale technology. Sech, scale efficiency change. Tfpch, total factor productivity change. The figures in parentheses are the standard deviation.

Effch = Pech * Sech, Tfpch = Effch * Techch.

the economy in 2005 and the almost unchanging situation in 2006, which coincides with the trend of the efficiency and productivity means of the Russian domestic banks.

However, there is no explanation for the reduction in productivity among the foreign banks. If we analyze the productivity with the efficiency, we could conclude that banks' efficiency scores were on the course of equalization by the decrease of foreign banks' productivity. When the productivity and efficiency are both analyzed, the decrease in productivity among the foreign banks demonstrates that the efficiency scores were on an equalization course. There remain the priorities of foreign banks over domestic banks in efficiency scores, but they are diminishing, probably as a result of the competition with domestic banks.

4.3. Regression analysis of efficiency scores and determinants of efficiency

Finally, the determinants of bank efficiency are analyzed. Since the efficiency scores of DEA take a value from 0 to 1, we use a Tobit regression. In order to clarify various characteristics among the banks, we introduce state bank, foreign bank, and Moscow-located bank dummy variables. Since we utilized indicators in "the profit and loss statement" as inputs and outputs in DEA, we use balance sheet items, such as a logarithm of bank assets and outstanding loans divided by bank assets, as independent variables. Furthermore, we included ROA reflecting the profitability of banks in the independent variables. We did not take public listing into account since only two banks are listed in the Russian stock exchanges.

The results of the Tobit regression are presented in Table 5. The foreign banks tend to be more technically efficient than the domestic banks, with the coefficient of the foreign bank dummy being positive and statistically significant in the technical efficiency. The higher efficiency of foreign banks could be caused by their priorities to raise funds in international markets and various management techniques over domestic banks. However, the decreasing tendency of the foreign banks' priorities must be noted, as indicated in the previous subsection.

The coefficient of the state bank dummy is not statistically significant, whereas state banks are expected to be more efficient than non-state banks since many Russian leading banks belong to this category. This could be because each state bank has specific characteristics, and, thus, state banks are inconsistent. The analysis of individual banks shows a tendency for larger state banks to be purely technically efficient and scale-inefficient, while middle-sized state banks are purely technically inefficient and scale-efficient.

Moscow-based banks tended to be less efficient than non Moscow-based banks regarding technical and pure technical efficiency, with the coefficients of the Moscow-based bank dummy being negative and statistically significant. We expected the coefficients to be positive since Moscow has a relatively well-developed financial market and its banks profited from various financial operations. The reason for the negative coefficients of the dummy variables could be attributed to severe competition among Moscow-based banks. On the other

Table 5. Tobit regression of the efficiency scores on bank indicators

Dependent variable	TE	PTE	SE
Foreign	0.0760 (2.275) **	0.0766 (1.896)	0.0115 (0.537)
State	-0.0156 (-0.494)	0.0237 (0.625)	-0.0278 (-1.3717)
Moscow	-0.0617 (-2.716) ***	-0.0719 (-2.633) ***	-0.0013 (-0.087)
Log of assets	-0.0579 (-2.529) **	0.1052 (3.721) ***	-0.1557 (-10.605) ***
Loans/assets	0.0012 (1.880)	0.0016 (2.217) **	-0.0006 (-1.473)
ROA	0.0183 (4.691) ***	0.0180 (3.763) ***	0.0052 (2.225) **
Constant	1.0474 (6.287) ***	-0.1060 (-0.516)	2.0968 (9.612) ***
Number of obs.	243	243	243
LT Chi Sq.	51.48 ***	48.07 ***	145.01 ***

Note 1 : TE, technical efficiency; PTE, pure technical efficiency; SE, scale efficiency. Independent variables are calculated as follows. *Foreign*: a dummy that takes 1 in case of a foreign bank and 0 otherwise; *State*: a dummy that takes 1 in case of a state bank and 0 otherwise; *Moscow*: a dummy that takes 1 in case of a Moscow-located bank and 0 otherwise; *Log of assets*: logarithm of bank assets; *Loans/Assets*: loans outstanding divided by bank assets. *ROA*: return on assets.

Note 2 : We applied the statistical tests, assuming random samples.

** Significant at 5% level.

*** Significant at 1% level.

hand, many leading regional banks have close relationships with local influential companies (Expert RA, 2007, p. 15), which could help them attain stable profits.

Banks with larger assets have a tendency to be more efficient under the assumption of variable returns to scale, that is, regarding pure technical efficiency. On the other hand, the more assets a bank has, the lower the scale efficiency scores tend to be. Therefore, banks with more assets have a tendency to utilize inputs with less waste, but they tend to be scale-inefficient. As a result, banks with larger assets tend to be less technically efficient, which indicates the negative and statistically significant coefficient of the logarithm of assets regarding technical efficiency.

Banks with a larger share of loans among their assets have a tendency to be more purely technically efficient. However, the value of the coefficient is small. The coefficients in the analysis of both technical efficiency and scale efficiency are not statistically significant. This suggests that banks obtain profits from various sources and that interest income from bank loans is not the main determinant of gross profits.

Banks with a higher return on assets tend to be more efficient regarding technical, pure technical, and scale efficiency. Therefore, banks obtaining more profits relative to their assets have a tendency to show higher technical, pure

technical, and scale efficiency, although the indicators representing the amount of assets are not included as inputs and outputs.

5. Conclusions

In this study, we measured the efficiency scores of Russian domestic and foreign banks from 2004 through 2006 and discussed the determinants of the efficiency. We used DEA for our analysis and calculated the scores of the technical, pure technical, and scale efficiency by applying the profit approach. We then conducted parametric and non-parametric tests to clarify whether or not domestic and foreign banks come from the same population. Furthermore, we computed the Malmquist Indices to analyze changes in a bank's productivity. Finally, a Tobit regression was performed, the results of which were used to determine a bank's efficiency.

In our analysis, we indicated that it was not inappropriate to construct the frontiers on the basis of all bank data, conducting parametric and non-parametric tests. We then reported that foreign banks tended to be more technically efficient than domestic banks, although the priorities of foreign banks had a tendency to diminish, which was also indicated in the analysis of Malmquist Indices.

The Tobit regression analysis produced the following results. First, foreign banks tend to be more technically efficient than domestic banks. Second, Moscow-based banks are less efficient than non-Moscow-based banks. Third, banks with more assets have a tendency to use inputs with less waste, but they tended to be scale-inefficient. As a result, banks with more assets tend to be less technically efficient. Fourth, banks with a larger share of loans among their assets have a tendency to be more purely technically efficient. However, the value of the coefficient is small. Fifth, banks with a higher return on assets tend to be more efficient regarding technical, pure technical, and scale efficiency.

The presence of foreign banks will become stronger in the Russian banking sector. We plan to conduct a similar analysis with long-term data, classifying them into several categories.

Research Fellow, Hokkaido University

Appendix A

A.1. Measuring Technical Efficiency

This section presents the non-parametric approach used to estimate the efficiency of each decision making unit (DMU) on the basis of Cooper et al. (2000). This approach is aimed at determining an envelopment surface, and the frontier is derived by joining those points in the input-output space so there is no case that produces the same outputs with less inputs. In the case of constant returns to scale, the frontier will be linear in the one-input and one-output model. Suppose there are n DMUs and let the input and output data for DMU _{j} ($j = 1, 2, \dots, n$) be $\mathbf{x}_j = (x_{1j}, x_{2j}, \dots, x_{mj})^T$ and $\mathbf{y}_j = (y_{1j}, y_{2j}, \dots, y_{sj})^T$ (m input items and s output items are selected, and each item is not negative. $\mathbf{x}_j$ and $\mathbf{y}_j$ are input and output column vectors, respec-

tively). The input data matrix $\mathbf{X}$ is $m \times n$ and the output data matrix $\mathbf{Y}$ is $s \times n$.

Let the DMU_{*j*} to be evaluated on any trial be designated as DMU_{*o*} where *o* ranges over 1, 2, ..., *n*. In the case of constant returns to scale the primal DEA ratio model can be stated for DMU_{*o*} as follows:

$$\min \quad \theta_c \quad (\text{A-1})$$

$$\text{subject to} \quad -\mathbf{X}\lambda + \theta_c \mathbf{x}_o \geq \mathbf{0}, \quad (\text{A-2})$$

$$\mathbf{Y}\lambda \geq \mathbf{y}_o, \quad (\text{A-3})$$

$$\lambda \geq \mathbf{0}. \quad (\text{A-4})$$

Here, θ_c is a scalar and optimal θ_c , which is denoted as θ_c^* , indicates the efficiency score of a specific DMU_{*o*}. We have $0 \leq \theta_c^* \leq 1$, and refer to θ_c^* as technical efficiency. In (A-2)-(A-4), $\lambda = (\lambda_1, \lambda_2, \dots, \lambda_n)^T$ is a column vector used to construct a convex hull connecting all the data points.

The dual form of (A-1)-(A-4) can be expressed by:

$$\max \quad \mathbf{u}\mathbf{y}_o \quad (\text{A-5})$$

$$\text{subject to} \quad -\mathbf{v}\mathbf{X} + \mathbf{u}\mathbf{Y} \leq \mathbf{0}, \quad (\text{A-6})$$

$$\mathbf{v}\mathbf{x}_o = 1, \quad (\text{A-7})$$

$$\mathbf{v} \geq \mathbf{0}, \quad \mathbf{u} \geq \mathbf{0}, \quad (\text{A-8})$$

where $\mathbf{v}$ is a row vector for input multipliers and $\mathbf{u}$ is a row vector for output multiplier derived from (A-1)-(A-4). Each DMU can choose the most favorable value of these variables.

Furthermore, we define the input excesses $\mathbf{s}^- \in R^m$ and the output shortfalls $\mathbf{s}^+ \in R^s$ and identify them as "slack" vectors by:

$$\mathbf{s}^+ = \mathbf{Y}\lambda - \mathbf{y}_o, \quad (\text{A-9})$$

$$\mathbf{s}^- = \theta_c \mathbf{x}_o - \mathbf{X}\lambda, \quad (\text{A-10})$$

with $\mathbf{s}^+ \geq \mathbf{0}$, $\mathbf{s}^- \geq \mathbf{0}$ for any feasible solution (θ_c, λ) of (A-1)-(A-4).

To discover the possible input excesses and output shortfalls, we solve the following linear programming problem, using our knowledge of θ_c^* .

$$\text{maximize} \quad \omega = \mathbf{e}\mathbf{s}^- + \mathbf{e}\mathbf{s}^+ \quad (\text{A-11})$$

$$\text{subject to} \quad \mathbf{s}^- = \theta_c^* \mathbf{x}_o - \mathbf{X}\lambda, \quad (\text{A-12})$$

$$\mathbf{s}^+ = \mathbf{Y}\lambda - \mathbf{y}_o, \quad (\text{A-13})$$

$$\lambda \geq \mathbf{0}, \mathbf{s}^+ \geq \mathbf{0}, \mathbf{s}^- \geq \mathbf{0}, \quad (\text{A-14})$$

where $\mathbf{e} = (1, \dots, 1)$ (a vector of ones).

If an optimal solution $(\theta_c^*, \lambda^*, \mathbf{s}^{+*}, \mathbf{s}^{-*})$ of the two linear programming problems above satisfies $\theta_c^* = 1$ and zero-slack, then the DMU_{*o*} is called efficient.

A.2. Measuring Pure Technical Efficiency

In the case of variable returns to scale, the frontier will be convex in the one-input and one-output model.

$$\min \quad \theta_v \quad (\text{A-15})$$

$$\text{subject to} \quad -\mathbf{X}\lambda + \theta_v \mathbf{x}_o \geq \mathbf{0}, \quad (\text{A-16})$$

$$\mathbf{Y}\lambda \geq \mathbf{y}_o, \quad (\text{A-17})$$

$$\mathbf{e}\lambda = 1, \quad (\text{A-18})$$

$$\lambda \geq \mathbf{0}, \quad (\text{A-19})$$

where θ_v is a scalar and optimal θ_v , which is denoted as θ_v^* , is referred to as pure technical efficiency. We have $0 \leq \theta_v^* \leq 1$, and the dual form of (A-15)-(A-19) can be expressed by:

$$\max \quad \mathbf{u}\mathbf{y}_o - u_0 \quad (\text{A-20})$$

$$\text{subject to} \quad -\mathbf{v}\mathbf{X} + \mathbf{u}\mathbf{Y} - u_0 \mathbf{e} \leq 0, \quad (\text{A-21})$$

$$\mathbf{v}\mathbf{x}_o = 1, \quad (\text{A-22})$$

$$\mathbf{v} \geq 0, \quad \mathbf{u} \geq 0, \quad (\text{A-23})$$

$$u_0 \text{ free in sign}, \quad (\text{A-24})$$

where $\mathbf{e} = (1, \dots, 1)$, and u_0 is a scalar and the dual variable associated with the constraint $\mathbf{e}\lambda = 1$.

We can calculate slacks by the same procedure as (A-11)-(A-14). If $\theta_v^* = 1$ and zero-slack are satisfied, then the DMU_o is called efficient.

A.3. Measuring Scale Efficiency

In order to measure the scale efficiency we use another indicator, which is calculated as the ratio of technical efficiency to pure technical efficiency. The formula can be given as:

$$\text{Scale Efficiency} = \frac{\theta_c}{\theta_v}. \quad (\text{A-25})$$

Its score of one implies that DMU is scale efficient. When scale inefficiency exists, it is the consequence of operating at non-constant returns to scale.

Figure 1 illustrates these efficiency measures, utilizing the one-input and one-output model. In the case of constant returns to scale, only A_1 is regarded as efficient. For example, the technical efficiency of B_1 is calculated as B_3B_4 / B_1B_4 , and that of D_1 is calculated as D_3D_4 / D_1D_4 . Under the assumption of variable returns to scale A_1 , C_1 and E_1 are observations forming the efficient frontier, whereas B_1 and D_1 are inefficient observations. For example, the pure technical efficiency score of B_1 is calculated as B_2B_4 / B_1B_4 , and that of D_1 is calculated as D_2D_4 / D_1D_4 . Since the scale efficiency score is the ratio of the technical efficiency score to the pure technical efficiency score, its value of B_1 is calculated as B_3B_4 / B_2B_4 , and that of D_1 is calculated as D_3D_4 / D_2D_4 .

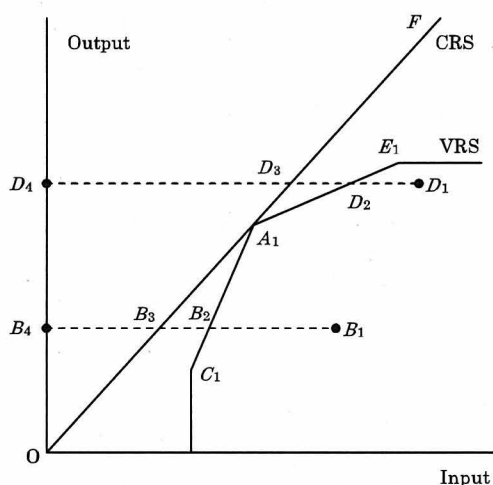


Fig. 1. Measuring Technical and Scale Efficiency

(Note 1) CRS – constant returns to scale, VRS – variable returns to scale

(Note 2) A_1 , B_1 , C_1 , D_1 and E_1 are the original data of each decision making unit.

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