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The Impact of the Russian Financial Crisis on the Efficiency of Russian Banks

Shigeki Ono

This article looks into the efficiency of large Russian banks. In this analysis we employ data envelopment analysis. The characteristics of this approach enable us to investigate the efficiency without specifying assumptions on the form of the production function and to easily implement the analysis using multiple outputs. We measure technical and scale efficiency scores, and analyze reasons of inefficiency for each bank. Furthermore, we classify banks into six categories and discuss the characteristics of each category. Finally, using regression analysis, we discuss the correlation of technical efficiency scores with the ratio of income and expense items to the total income, and analyze the influence of the Russian financial crisis on the efficiency of banks.

1. Introduction

After the collapse of the Soviet Union, many Russian banks gained profits through revaluation of foreign currencies, and speculative operations, which increased their assets sharply. However, the Russian financial crisis in 1998 led some large banks into bankruptcy.[1] The situation before the Russian financial crisis is analyzed in detail in Dmitriev et al. (1996), OECD (1997), Matovnikov et al. (1998), CBR (1998a) and BEA (1998). We can list as research, that features the banking system before and after the Russian financial crisis, Astapovich et al. (1999), CBR (1999), BEA (1999), CBR (2000), BEA (2000), Tompson (2000), CBR (2001), Lane (2003) and Mizobata (2003). These reports are quite useful in order to realize the development of the systemic risk and consequences in the Russian banking sector. However, time-series changes in the activities of particular banks remained unclear. Though Lane and Lavrentieva (2003) picked three major banks, analyzing their activities before and after the financial crisis, this research does not provide us with a comparative viewpoint of these banks.

In order to analyze the influence of the Russian financial crisis and time-

series changes of Russian banking activities we seek to estimate the efficiency of the twenty largest Russian banks from the aspect of their income and expense situation from 1997 to 2000. We limited the objects for analysis to the twenty largest banks because they give us the general picture of the Russian banking system, taking into account their influence on the Russian economy.[2] Furthermore, data regarding the detailed financial statement are more limited as the size of banks becomes smaller. In this paper we will measure the overall technical efficiency score, the pure technical efficiency score and the scale efficiency score, using the data envelopment analysis（DEA）,[3] and discuss whether inefficiency is due to waste of inputs or scale inefficiency. Here, the overall technical efficiency score is calculated under the assumption of constant returns to scale while the pure technical efficiency score is calculated under the assumption of variable returns to scale. The scale efficiency score is calculated as the ratio of overall technical efficiency to pure technical efficiency, this ratio reveals whether a decision making unit（DMU）is operating at the efficient scale or not. Furthermore, we classify banks into six categories and look into characteristics of each category in aspects of banking activities and efficiency scores. Finally, we analyze correlation of technical efficiency scores with the ratio of income and expense items to the total income, and with the ratio to the total asset of liabilities to nonresidents and capital-asset ratio, using regression analysis. In this paper we utilize data from the financial statement, including balance sheet, profit and loss statement, share prospectus, quarterly securities statement and annual reports, which are obtained from the website of the Central Bank of Russia.

In order to estimate the efficiency of DMU by DEA we have to derive the locus of efficient production plans, or the frontier, and then measure the distance between the frontier and the point calculated by some observed inputs and outputs for each DMU. Given a sample of DMU with observed inputs and outputs, the derivation of the locus of efficient production plans can be achieved through the implementation of two alternative methodologies: one parametric and one that is non-parametric.[4] This paper uses the non-parametric approach to estimate the efficiency of each bank. This means that the approach utilizes the observed inputs and outputs to construct the best practice reference units in input/output space, without estimating parameters. In the analysis we computed the efficiency of input usage to produce a given level of outputs; therefore it can be referred to as an input-based method.[5] There are several favorable characteristics of this approach. First, there is no need to specify the estimated production function, which the parametric approach requires. Second, not only can it easily implement multiple outputs, it also provides efficiency scores for each individual bank without having data on

input prices, in contrast to the parametric cost function estimation.

The outline of this paper is as follows. Section 2 specifies outputs and inputs for the banking sector and gives a description of the data for twenty banks. The empirical results of the efficiency analysis are presented in Section 3. The last section is the summary and conclusion. The appendix illustrates the methodology of non-parametric linear programming, which is used to calculate the efficiency.

2. Specification of Outputs and Inputs

First, we discuss the specification of outputs and inputs, and then discuss the meaning of the employment of DEA in the analysis of Russian banking.

A definition of banking activity is necessary in order to analyze the efficiency of the banking sector. Former studies on banking activity used various data as inputs and outputs. We can broadly classify methods of analysis into three categories, one method is the production approach. According to this approach, banks are considered as producers of deposit accounts and loan services.[6] Therefore, outputs are measured by the number of accounts, loans, and so on. A second method is the intermediation approach. According to this method, banks are regarded intermediators which transfer financial resources from units in surplus to units in deficit.[7] A third alternative is the asset approach, which is a variant of the intermediation approach. This method utilizes assets, mainly the production of loans, as outputs.[8]

Before we decide which approach we use, let us survey the Russian situation. As Gerashchenko（1993）indicated,「the practice in works of commercial banks［in Russia］shows that stockholders of banks in general enjoy privileged terms for loans. The share of those debtors reached to 80‑90% in some cases.」（Words in brackets added by this author）. Furthermore, particular banks raise local government funds at a low interest rate. Therefore, in the analysis of the Russian banking sector we have to reflect the profitability of banks.

The production approach has been applied to the evaluation of the relative efficiency of branches within a particular bank.   However, when analyzing a great number of banks, it is not easy to acquire the necessary data. Furthermore, this approach does not enable us to take the profitability of banks into account. The intermediation approach and the asset approach have been widely used in cross-section studies. For example, English et al.（1993）utilized deposits, labor and purchased funds as inputs, and loans and investments as outputs. Berger and Humphrey（1990）employed labor, purchased funds and capital as inputs, and deposits and loans as outputs. The intermediation approach, rather than asset approach, gives us the possibility to utilize expense

items as inputs and income items as outputs.[9] Regarding banks as intermediators, we measure the banks' efficiency in this paper.

In the analysis we chose total interest expense (x_{1j}) and total non-interest expense (x_{2j}) as inputs, and total interest income (y_{1j}) and total non-interest income (y_{2j}) as outputs. Total interest expense mainly includes interest expense on deposits and issued bonds. The major components of total non-interest expense are expenses for foreign exchange operations, securities operations, provision for loan loss, various commissions, salaries, depreciation, and communication expense. Total interest income chiefly includes interest income from bonds and loans to customers including banks. Total non-interest income consists of income from foreign exchange operations, securities operations, various commissions, and so on.[10] The descriptive statistics are provided in Table 1.

The utilization of DEA gives us advantages for the Russian banking analysis besides the above-mentioned viewpoints. Russian banks gain their profits from various sources, including interest income and operating income, and they make expenses for various objectives, including interest expenses and operating expenses. Here, we can reflect the characteristics of their activities, choosing the favorable weight variables in DEA. The methodology of efficiency estimation is explained in the appendix.

Table 1 . Descriptive Statistics of the Input and Output Variables （Thousand Rubles）

	Average	St. dev.	Max	Min
Interest expense	$3,701,692$	$9,169,858$	$48,860,601$	$27,012$
Non-interest expense	$22,112,708$	$59,148,823$	$342,967,917$	$288,408$
Interest income	$4,113,116$	$11,611,829$	$72,704,626$	$142,241$
Non-interest income	$21,739,808$	$60,453,131$	$351,370,673$	$78,591$

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

3.　The Empirical Results
3. 1　Technical and scale efficiency scores

In our paper the overall technical efficiency indicates how efficient the twenty largest Russian banks made expenses to earn a given level of income under the assumption of constant returns to scale （input-based method）. The pure technical efficiency indicates how efficient they made expenses to earn a given level of income under the assumption of variable returns to scale. The scale efficiency indicates whether they earn incomes at a favorable scale or not.

Tables 2 through 4 exhibit the resulting overall technical efficiency scores, pure technical efficiency scores and scale efficiency scores of twenty banks, re-

Table 2． Overall Technical Efficiency Scores

Bank	1997	1998	1999	2000
Sberbank	0.9475	0.9026	0.8742	0.8781
Inkombank	0.8766	—	—	—
SBS-Agro	0.9941	—	0.5746	0.7062
ONEKSIM-bank	0.9239	0.8184	0.8731	—
Rossiiskii kredit	0.8206	0.6996	0.8250	0.5996
Vneshtorgbank	1.0000	0.8186	0.8932	1.0000
Menatep	1.0000	—	—	—
MPB	0.9483	0.8471	0.9613	0.9052
Alfa-bank	0.8655	1.0000	0.8490	0.8364
NRB	0.9496	0.7875	0.8523	0.9494
Mosbiznesbank	0.8744	0.5804	—	—
Gazprombank	1.0000	1.0000	0.8553	0.8558
Avtobank	0.9580	0.5771	0.8279	0.8244
Imperial	0.8371	—	—	0.1223
MMB	0.8849	0.8346	0.8518	0.8507
Tokobank	0.9451	—	—	—
Most-bank	0.8722	0.8272	0.8554	—
Bank Moskvy	1.0000	1.0000	0.8395	0.8353
PSB	0.8900	0.8177	—	—
Vozrozhdenie	0.9136	0.6981	0.8431	0.7533

Note 1 : MPB－Mezhdunarodnyi Promyshlennyi Bank, NRB－
Natsional'nyi Rezervnyi Bank, MMB－Mezhdunarodnyi
Moskovskii Bank, PSB－Promstroibank Rossii.

Note 2 : Inkombank, Menatep, Mosbiznesbank, Most-bank, PSB
and Tokobank had their banking licenses recalled by the
Central Bank of Russia on October 29, 1998, May 18, 1999,
July 2, 1999, April 20, 2001, July 2, 1999 and August
31, 1998, respectively. ONEKSIM-bank's license was an-
nulled on November 21, 2000 because of its consolidation
with the other bank.

Note 3 : SBS-Agro did not submit the financial statement for the
year 1998 to the Central Bank of Russia in accordance
with its regulation.

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

spectively. First, let us survey overall technical efficiency scores. The number
of overall technically efficient banks was four in the year 1997, three in the
year 1998, zero in the year 1999 and one in the year 2000. According to the de-
scriptive statistics（Table 5）, the average score in the year 1997 was the high-
est of the analyzed years. The average overall technical efficiency score in

Table 3. Pure Technical Efficiency Scores

Bank	1997	1998	1999	2000
Sberbank	1.0000	1.0000	1.0000	1.0000
Inkombank	0.9865	—	—	—
SBS-Agro	0.9960	—	0.6087	0.7368
ONEKSIM-bank	0.9458	0.8561	0.9242	—
Rossiiskii kredit	0.8218	0.6999	0.8828	0.6243
Vneshtorgbank	1.0000	0.8433	0.9121	1.0000
Menatep	1.0000	—	—	—
MPB	1.0000	0.8677	1.0000	0.9309
Alfa-bank	0.8812	1.0000	0.9090	0.8804
NRB	0.9740	0.8206	0.8589	0.9503
Mosbiznesbank	0.8774	0.5983	—	—
Gazprombank	1.0000	1.0000	0.8949	0.9162
Avtobank	0.9610	0.5935	0.8434	0.8371
Imperial	0.9335	—	—	0.1741
MMB	0.9709	0.8361	0.8913	1.0000
Tokobank	0.9666	—	—	—
Most-bank	0.8735	0.8291	0.8651	—
Bank Moskvy	1.0000	1.0000	0.8407	0.8387
PSB	0.8913	0.8380	—	—
Vozrozhdenie	0.9269	0.7228	0.8557	0.7696

Note: See notes of Table 2.

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

1997 was 0.9215 whereas it was 0.8139 in 1998, 0.8411 in 1999 and 0.7782 in 2000. The reason why the average score in 2000 decreased sharply can be explained by the existence of a bank with a quite low efficiency score. If we do not take that bank into account, the average efficiency score in 2000 increases to 0.8329. Standard deviation of overall technical efficiency scores in 1997 was at a relatively lower level of 0.0577. Therefore, the large value of the average score means that the efficiency scores of banks were high for the most part. The higher value of standard deviation in 2000 can be similarly explained by the existence of a bank with a lower efficiency score. Its value decreases to 0.1072 from 0.2222 if we exclude the score of the bank.

The number of purely technically efficient banks was six in 1997, four in 1998, two in 1999 and three in 2000. According to the descriptive statistics (Table 6), the average value in 1997 was 0.9503, which was the highest value of the analyzed years. Standard deviation in 1997 was the smallest through four

Table 4. Scale Efficiency Scores

Bank	1997	1998	1999	2000
Sberbank	0.9475	0.9026	0.8742	0.8781
Inkombank	0.8886	—	—	—
SBS-Agro	0.9981	—	0.9439	0.9585
ONEKSIM-bank	0.9768	0.9560	0.9447	—
Rossiiskii kredit	0.9986	0.9996	0.9346	0.9604
Vneshtorgbank	1.0000	0.9707	0.9793	1.0000
Menatep	1.0000	—	—	—
MPB	0.9483	0.9762	0.9613	0.9723
Alfa-bank	0.9822	1.0000	0.9340	0.9500
NRB	0.9750	0.9598	0.9923	0.9991
Mosbiznesbank	0.9965	0.9701	—	—
Gazprombank	1.0000	1.0000	0.9557	0.9341
Avtobank	0.9969	0.9724	0.9817	0.9849
Imperial	0.8967	—	—	0.7024
MMB	0.9114	0.9983	0.9556	0.8507
Tokobank	0.9778	—	—	—
Most-bank	0.9985	0.9977	0.9888	—
Bank Moskvy	1.0000	1.0000	0.9985	0.9960
PSB	0.9985	0.9757	—	—
Vozrozhdenie	0.9856	0.9658	0.9852	0.9788

Note: See notes of Table 2.

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

Table 5. Descriptive Statistics of Overall Technical Efficiency Scores

Year	Average	St. dev.	Max	Min
1997	0.9251	0.0577	1.0000	0.8206
1998	0.8139	0.1340	1.0000	0.5771
1999	0.8411	0.0839	0.9613	0.5746
2000	0.7782	0.2222	1.0000	0.1223

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

years, or 0.0545. On the other hand, the average of scale efficiency scores in 1998 was higher than those of other years (Table 7).

Now let us turn our attention to reasons for overall technical inefficiency. The overall technical efficiency score is equal to the pure technical efficiency score multiplied by the scale efficiency score. Therefore, we can conclude that

Table 6 . Descriptive Statistics of Pure Technical Efficiency Scores

Year	Average	St. dev.	Max	Min
1997	0.9503	0.0545	1.0000	0.8218
1998	0.8337	0.1352	1.0000	0.5935
1999	0.8776	0.0923	1.0000	0.6087
2000	0.8199	0.2245	1.0000	0.1741

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

Table 7 . Descriptive Statistics of Scale Efficiency Scores

Year	Average	St. dev.	Max	Min
1997	0.9739	0.0362	1.0000	0.8886
1998	0.9763	0.0260	1.0000	0.9026
1999	0.9593	0.0329	0.9985	0.8742
2000	0.9358	0.0835	1.0000	0.7024

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

the overall technical efficiency score is due to waste of inputs rather than scale inefficiency if the pure technical efficiency score is smaller than the scale efficiency score, and vice versa. As can be seen in Tables 2 through 4, Sberbank's overall technical efficiency scores 0.9475 in 1997, 0.9026 in 1998, 0.8742 in 1999 and 0.8781 in 2000 while its pure technical efficiency scores are 1.0000 through the analyzed periods. Sberbank's overall technical inefficiency can be explained exclusively by scale inefficiency. As for other banks, overall technical inefficiency is explained by scale inefficiency only in six cases whereas there are forty-four cases in which pure technical inefficiency, or waste of inputs, is the main reason for overall technical inefficiency.

Here, let us analyze the efficiency scores by categories of banks. We have classified banks into six categories.[11]

The first category is banks under the control of the federal government (Sberbank, Vneshtorgbank and MMB[12]).

The second category is former governmental banks in the Soviet era (Mosbiznesbank, PSB and Vozrozhdenie).

The third category is the organizer of the bank-industrial group[13] (Inkombank, SBS-Agro,[14] ONEKSIM-bank, Rossiiskii kredit, Menatep, Alfa-bank and Most-bank).

The fourth category is "relative" banks of the Russian industrial elite (NRB, Gazprombank and Imperial).

The fifth category is a bank under the control of the local government

（Bank Moskvy）.

The sixth category is banks with a relatively high share of foreign capital （MPB, Avtobank and Tokobank）.

Banks of the first category were all purely technically efficient in 2000. Vneshtorgbank is also overall technically efficient. The overall inefficiency of Sberbank and MMB is due to scale inefficiency, not waste of inputs. As is mentioned below, Vneshtorgbank received aid from the Central Bank of Russia in the form of acquisition of newly issued shares.

Two out of three banks of the second category had their banking licenses recalled by the Central Bank of Russia.[15]   The other bank's efficiency score was not high. Former governmental banks faced problems of close historic connections with depression industries such as agriculture, machinery, the military-industrial complex and metallurgy （BEA （1999）, Chapter 16, p. 2）, which is one of the reasons for the difficulties of banks of the second category.

The banks of the third category raised funds from deposits of companies under their control. Other sources for funds were inter-bank loans, borrowing from nonresidents, and deposits of individuals （BEA （1999）, Chapter 16, pp. 2-3）.[16] Loans granted by nonresidents, futures and forward contracts of foreign currency caused a great deal of loss for banks. Four out of seven banks of this category had their banking licenses recalled by the Central Bank of Russia. Efficiency scores of the other three banks were not high except for Alfa-bank.

Two out of three banks of the fourth category worked relatively efficiently. In the case of Gazprombank, Gazprom, a natural gas monopoly, gave aid to Gazprombank by acquiring part of Gazprombank's newly issued shares. Furthermore, Gazprombank participated in the long-term projects of Gazprom, such as gas pipeline construction （*Godovoi otchet za 1998 god: Gazprombank*, p. 13, p. 15）.

Bank Moskvy, which belongs to the fifth category, worked relatively efficiently. It could raise deposits from funds of Moscow's local government budget and grant loans to projects of Moscow City.

One out of three banks of the sixth category had its banking license recalled（Tokobank）. The other two banks worked relatively efficiently. The case of Tokobank indicates that the simple capital participation of nonresidents did not help to overcome the lax management （European Bank for Reconstruction and Development held about a 10 percent share of Tokobank at the end of 1997）. Tokobank had granted loans to large shareholders at low interest rates, and its weak loan management led to a great deal of bad loans. Furthermore, the bank actively dealt with futures and forward contracts, which caused a large amount of loss during the Russian financial crisis. As a result Tokobank

had its banking license recalled on August 31, 1998 (BEA (1999), Chapter 16, pp. 6-7).

3.2   Correlation of overall technical efficiency with income and expense items

Let us discuss the correlation of overall technical efficiency scores with the ratio of income and expense items to the total income, using regression analysis[17]. In the analysis will become clear the structural changes of income and expense before and after the financial crisis and the relations between the efficiency scores and the structure of income and expense. We have to pay attention to the situation that the number of samples is not enough because of the limitation in data regarding the detailed financial statement. Income and expense items include (1) income from foreign currency operations, (2) expense from foreign currency operations,[18] (3) income from revaluation and operations of precious metals, securities and other assets,[19] (4) expense from revaluation and operations of precious metals, securities and other assets,[20] (5) interest income from loans granted to banks, (6) interest income from loans granted to other customers, (7) interest expense from deposits by banks, (8) interest expense from deposits by other customers, (9) interest income from securities, (10) provision for loan loss, (11) other current income,[21] and (12) other current expenses.[22] For descriptive statistics of these items, see Table 8, and for the results of regression analysis, see Table 9.

Regarding items (1) - (2): These items are directly influenced by the depreciation of the ruble in the financial crisis in 1998. Whereas the ratio of income from foreign currency operations to the total income was 16.7 percent in 1997, it increased drastically to 55.6 percent in 1998. It also remained at high levels in 1999 and 2000 (75.2 percent and 57.9 percent, respectively). On the other hand, while the ratio of expense from foreign currency operations to the total income was 34.7 percent in 1998, it increased to 77.6 percent in 1999 and 64.4 percent in 2000.[23] The drastic change of the ratio of income and expense from foreign currency operations is related to the depreciation of the ruble and revaluation of assets and liabilities in foreign currency.

Here, let us survey the foreign currency operations before the Russian financial crisis. More than 70 percent of household deposits were concentrated in Sberbank. Therefore, a large share of the dominant Moscow banks raised foreign loans, which resulted in a rise of foreign-denominated liabilities. The share of foreign loans in balance sheet liabilities for the twenty largest banks exceeded 20 percent (Tsentr Razvitiia (1999), p. 14). During the course of 1998, banks sought to address the growing imbalance in their open foreign positions by issuing new credits in, or converting old credits into, foreign cur-

Table 8． Descriptive Statistics about the Ratio
of Income and Expense Items to the Total Income

	Year	Average	St. dev.	Max	Min
Income from foreign currency operations	1997	16.7	13.6	55.2	2.3
	1998	55.6	26.9	91.7	9.1
	1999	66.0	27.0	98.8	14.9
	2000	57.9	28.7	98.1	4.9
Expense from foreign currency operations	1998	34.7	31.0	97.8	0.7
	1999	61.7	31.4	97.6	5.6
	2000	64.4	24.1	103.0	17.0
Income from revaluation and operations of precious metals, securities and other assets	1998	10.6	9.7	38.7	1.7
	1999	6.6	7.9	26.2	0.1
	2000	7.9	9.0	33.4	0.1
Expense from revaluation and operations of precious metals, securities and other assets	1998	18.2	16.4	55.5	2.1
	1999	4.1	5.0	14.6	0.1
	2000	5.0	9.1	33.9	0.0
Interest income from loans granted to banks	1997	8.1	5.7	23.1	1.5
	1998	5.7	5.9	21.9	1.0
	1999	5.7	9.7	31.7	0.0
	2000	6.2	14.8	55.2	0.0
Interest income from loans granted to other customers	1997	26.7	11.7	55.2	5.8
	1998	15.2	11.8	37.3	3.6
	1999	10.5	9.7	32.0	0.3
	2000	11.5	7.8	24.8	1.0
Interest expense from deposits of banks	1997	10.9	6.3	27.1	2.3
	1998	10.8	7.9	25.8	1.3
	1999	7.2	9.7	30.8	0.0
	2000	2.6	2.7	9.3	0.0
Interest expense from deposits of other customers	1997	25.3	12.6	48.9	2.9
	1998	12.3	8.0	26.7	2.5
	1999	9.4	10.6	40.4	0.1
	2000	12.0	15.6	58.4	0.3
Interest income from securities	1997	9.4	12.3	50.7	0.0
	1998	5.5	7.2	27.5	0.6
	1999	4.2	8.0	31.1	0.2
	2000	4.3	6.5	23.4	0.0
Provision for loan loss	1997	9.7	11.5	45.4	0.5
	1998	11.5	14.4	52.3	−10.4
	1999	11.6	14.6	49.6	0.0
	2000	54.3	151.5	555.6	−9.4
Other operating income	1997	19.8	12.5	49.7	1.0
Other current expense	1997	35.1	14.0	67.5	13.2

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

Table 9 . Correlation of Overall Technical Efficiency Scores
with the Ratio of Income and Expense Items to the Total Income

Year	Regression	
1997	$OTE = 0.9591 - 0.0020 FOIN$,	$R^2 = 0.2287$
1998	$OTE = 0.6453 + 0.0030 FOIN$,	$R^2 = 0.3699$
1999	$OTE = 0.8556 - 0.0002 FOIN$,	$R^2 = 0.0050$
2000	$OTE = 0.6614 + 0.0020 FOIN$,	$R^2 = 0.0677$
1998	$OTE = 0.7849 + 0.0008 FOEX$,	$R^2 = 0.0374$
1999	$OTE = 0.8728 - 0.0005 FOEX$,	$R^2 = 0.0370$
2000	$OTE = 1.0680 - 0.0045 FOEX$,	$R^2 = 0.2388$
1998	$OTE = 0.9082 - 0.0089 OISEC$,	$R^2 = 0.4132$
1999	$OTE = 0.8339 + 0.0011 OISEC$,	$R^2 = 0.0108$
2000	$OTE = 0.7047 + 0.0093 OISEC$,	$R^2 = 0.1423$
1998	$OTE = 0.8699 - 0.0031 OESEC$,	$R^2 = 0.1413$
1999	$OTE = 0.8295 + 0.0028 OESEC$,	$R^2 = 0.0286$
2000	$OTE = 0.8888 - 0.0223 OESEC$,	$R^2 = 0.8291$
1997	$OTE = 0.0006 + 0.9205 IIBLOAN$,	$R^2 = 0.0032$
1998	$OTE = 0.8527 - 0.0068 IIBLOAN$,	$R^2 = 0.0891$
1999	$OTE = 0.8379 + 0.0006 IIBLOAN$,	$R^2 = 0.0044$
2000	$OTE = 0.7677 + 0.0017 IIBLOAN$,	$R^2 = 0.0126$
1997	$OTE = 0.0004 - 0.9145 IILOAN$,	$R^2 = 0.0065$
1998	$OTE = 0.9206 - 0.0070 IILOAN$,	$R^2 = 0.3868$
1999	$OTE = 0.8352 + 0.0006 IILOAN$,	$R^2 = 0.0043$
2000	$OTE = 0.9053 - 0.0111 IILOAN$,	$R^2 = 0.1491$
1997	$OTE = 0.9081 + 0.0016 IEBLOAN$,	$R^2 = 0.0290$
1998	$OTE = 0.9013 - 0.0081 IEBLOAN$,	$R^2 = 0.2245$
1999	$OTE = 0.8369 + 0.0006 IEBLOAN$,	$R^2 = 0.0044$
2000	$OTE = 0.7157 + 0.0237 IEBLOAN$,	$R^2 = 0.0850$
1997	$OTE = 0.9281 - 0.0001 IELOAN$,	$R^2 = 0.0007$
1998	$OTE = 0.8512 - 0.0030 IELOAN$,	$R^2 = 0.0324$
1999	$OTE = 0.8345 + 0.0007 IELOAN$,	$R^2 = 0.0079$
2000	$OTE = 0.7401 + 0.0032 IELOAN$,	$R^2 = 0.0496$
1997	$OTE = 0.9004 + 0.0026 IISEC$,	$R^2 = 0.3134$
1998	$OTE = 0.8485 - 0.0062 IISEC$,	$R^2 = 0.1120$
1999	$OTE = 0.8377 + 0.0008 IISEC$,	$R^2 = 0.0059$
2000	$OTE = 0.7184 + 0.0140 IISEC$,	$R^2 = 0.1694$
1997	$OTE = 0.9114 + 0.0014 PROV$,	$R^2 = 0.0798$
1998	$OTE = 0.8356 - 0.0019 PROV$,	$R^2 = 0.0412$
1999	$OTE = 0.8890 - 0.0041 PROV$,	$R^2 = 0.5206$
2000	$OTE = 0.8499 - 0.0013 PROV$,	$R^2 = 0.8101$
1997	$OTE = 0.9424 - 0.0009 OCI$,	$R^2 = 0.0360$
1997	$OTE = 1.0161 - 0.0026 OCE$,	$R^2 = 0.3981$

Note 1 : The number of samples is 20 in 1997, 15 in 1998, 14 in 1999 and 13 in 2000.

Note 2 : The following explanation variables are their ratio to the total income. *FOIN* −income from foreign currency operations, *FOEX* −expense from foreign currency operations, *PROV* −provision for loan loss, *OISEC* −income from revaluation and operations of precious metals, securities and other assets, *OESEC* −expense from revaluation and operations of precious metals, securities and other assets, *IISEC* −interest income from securities, *IIBLOAN* −interest income from loans granted to banks, *IILOAN* −interest income from loans granted to other customers, *IEBLOAN* −interest expense from deposits by banks, *IELOAN* −interest expense from deposits by other customers, *OCI* −other current income, *OCE* −other current expense.

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

rency (BEA (1999), Chapter 16, p. 4). Therefore, it is quite understandable that the depreciation of the ruble led to the increase of the ratio of income and expense from foreign currency operations since Russian large banks had a large amount of assets and liabilities in foreign currency. The ratio of income and expense from foreign currency operations to the total income was also at a high level in 1999 and 2000. This can be partly explained by the increase of assets and liabilities in foreign currency.

We regressed overall technical efficiency scores to the ratio of income from foreign currency operations to the total income, and to the ratio of expense from foreign currency operations to the total income. The coefficient of determination in the former regression analysis was relatively higher: 0.2287 in 1997 and 0.3699 in 1998. The relatively stronger positive correlation of overall technical efficiency scores with the ratio of income from foreign currency operations to the total income in 1997 and 1998 means that the banks that received more income from foreign currency operations are more efficient. However, the remarkable increase of the ratio of expense from foreign currency operations to the total income in 1999 and 2000 offset the income from foreign currency operations. Banks with a larger ratio of expense from foreign currency operations tended to be less efficient in 2000 and the coefficient of determination was 0.2388.

Regarding items (3) - (4): These items are related to futures and forward contracts, which did great damage to the Russian banking system in the financial crisis. The average ratio of income from revaluation and operations of precious metals, securities and other assets to the total income in 1998 was 10.6 percent, a little higher than other years (data in 1997 is not available). Regression analysis indicates that the coefficient of determination in 1998 was 0.4132 and overall technical efficiency scores had a negative correlation to the ratio of item (3) to the total income. The reason why banks with less income from revaluation and operations of precious metals, securities and other assets were more efficient in 1998 can be explained as follows: whereas these banks gained less income from foreign currency operations, some banks received a great deal of income from the revaluation of accounts in foreign currency. Here, let us pick out Sberbank, Avtobank and Rossiiskii kredit for an example. Their overall technical efficiency scores in 1998 were 0.9026, 0.5771 and 0.6996, respectively, whereas their ratios of income from foreign currency operations were 80.0 percent, 30.1 percent and 22.7 percent, and their ratios of item (3) to the total income were 8.3 percent, 36.4 percent and 17.6 percent. Furthermore, in order to clarify the amount of income from foreign currency operations let us calculate its ratio to the total asset. The value in 1998 was 93.9 percent in the case of Sberbank, but it was 3.7 percent and 8.3 percent in the

case of Avtobank and Rossiiskii kredit, respectively. We can realize that Sber-
bank gained quite a large amount of income from foreign currency operations
in 1998, which led to its high efficiency score.

The average ratio of expense from revaluation and operations of precious
metals, securities and other assets in 1998 was 18.2 percent which was larger
than other years（data in 1997 is not available）. One of the reasons for its rela-
tively high value is related to futures and forward contract expenses. A sub-
stantial amount of the hard-currency liabilities of the large Russian banks
were off-balance-sheet. Net obligations of Russian banks according to futures
and forward contracts related to foreign currency were believed to be at least
6 billion US dollars in the first half of 1998, of which 3 billion US dollars were
concentrated in the nine largest banks （Tsentr Razvitiia （1999）, p. 15）. The
amount of unpaid futures contracts was estimated at 1 billion US dollars in
August 1998, of which the liabilities to nonresidents accounted for about one
third （BEA （1999）, Chapter 16, p. 11）. The above-mentioned situation indi-
cates that during the Russian financial crisis some banks paid a great deal of
expenses related to futures and forward contracts, this became one element in
the increase of the ratio of item （4）to the total income. According to regression
analysis, overall technical efficiency scores had a quite strong negative corre-
lation to the ratio of the expense to the total income in the year 2000. The coef-
ficient of determination reached 0.8291 in 2000, which was largely influenced
by Imperial and Rossiiskii kredit. Their overall technical efficiency scores in
2000 were 0.1223 and 0.5996, respectively, while their ratios to the total income
of expense from revaluation and operations of precious metals, securities and
other assets were 33.9 percent and 9.7 percent. According to the detailed
profit and loss statement of Imperial, expense from forward contracts ac-
counted for 80.4 percent of that expense. In the case of Rossiiskii kredit ex-
pense from option and forward contracts accounted for 28.1 percent while ex-
pense from revaluation of securities and other expense related to securities ac-
counted for 71.9 percent.

Regarding items （5）-（8）: These items reflect lending and deposit-
collecting activities, which are regarded as the principle operations of banks.
The average ratio of interest income from loans and expense from deposits to
the total income decreased in the years 1998-2000 in comparison with the
year 1997. One of the reasons would be the relative increase of income from
foreign currency operations.

The characteristic related to the ratio of the interest income to the total
income is that it does not have a positive correlation to overall technical effi-
ciency scores if it indicates a high value of the coefficient of determination.
The coefficient of determination indicates a high value of 0.3868 in the regres-

sion of overall technical efficiency scores to the ratio of interest income from loans granted to customers except banks to the total income in 1998. The result showed a negative correlation. The relatively large ratio of interest income to the total income, that is, a relatively small ratio of income from foreign currency operations to the total income can also explain why a negative correlation was indicated. As mentioned above, in the case of Sberbank the ratio of income from foreign currency operations was large, or 80.0 percent, and the ratio of interest income from loans granted to customers except banks was at the low level of 4.7 percent in 1998. On the other hand, the ratios of interest income from loans granted to customers except banks in the case of Rossiiskii kredit, Mosbiznesbank and Avtobank were 19.5 percent, 32.2 percent and 34.5 percent, respectively, and the ratios of income from foreign currency operations were relatively lower. Furthermore, we have to take the following situation into account in order to understand the above-mentioned fact. The characteristics of Russian banks' activities consist in the derivation of profits by dominant large Moscow banks primarily from implicit or explicit cooperation with state financial organs, including the Ministry of Finance, because of a scarcity of profitable loan opportunities in the real sector of the economy. This included holding portfolios of government securities, servicing budget funds at little or no interest, or financing various federal budgetary operations under state guarantees（OECD（2000）, p.38）. This situation means that the main activity of the banks did not consist in granting loans to private companies.

The ratio of interest expense of deposits by banks to the total income was 10.9 percent in 1997, and it was almost unchanged in 1998. This fact can be explained as follows. Banks raised deposits in foreign currency from other banks and the amount, in ruble terms, increased because of the ruble's depreciation to the US dollar. On the other hand, the ratio of interest expense of deposits by other customers decreased from 25.3 percent in 1997 to 12.3 percent in 1998. The coefficient of determination in the regression of overall technical efficiency scores to the ratio of interest expense of deposits by banks to the total income indicated a relatively high value of 0.2245 in 1998. This is possibly related to the liabilities in foreign currency. However, data substantiating this are not available.

Regarding item（9）: As mentioned above, Russian banks held portfolios of government securities. The default of the Russian federal government exerted a influence on the interest income from securities. The average ratio of interest income from securities was 9.4 percent in 1997, and it decreased to 5.5 percent in 1998, 4.2 percent in 1999 and 4.3 percent in 2000. According to regression analysis, there was a relatively strong positive correlation to overall technical efficiency in 1997, and the coefficient of determination was 0.3134.

Before the Russian federal government default in 1998, government bonds were regarded to be high-yielding and riskless. The average annual yield rate of short-term government bonds was 34.73 percent on December 1, 1997 (CBR (1998b), p. 32) whereas the annual increase rate of the consumer price index in 1997 was 11.0 percent (Goskomstat (1997), p. 174). GKOs (treasury bills), which approached 30 percent of aggregate bank assets by 1998, provided banks with a particularly vital source of profits between 1996 - 98 (OECD (2000), p. 38). Therefore, it is understandable that the banks which gained more income from securities interest tended to be more overall technically efficient. After the default of the Russian government the ratio of interest income decreased. While the coefficient of determination was quite low in 1999, it increased to 0.1694 in 2000. Since the ratio of interest income from securities has relatively higher positive correlation with the efficiency scores in 2000, banks which gained more interest income from securities tended to be more efficient.

Regarding item (10): Non-performing loans exert a negative influence on banking activities. This problem is significant in Russian banking since the depreciation of the ruble affected the activities of companies, which could lead to the increase of non-performing loans. The average ratio of provision for loan loss to the total income was 9.7 percent in 1997, and slightly increased to 11.5 percent in 1998 and 11.6 percent in 1999. It rose drastically to 54.3 percent in 2000. As mentioned below, the value of Imperial largely pushed up the average score. Whereas the standard deviation was 11.5 in 1997, 14.4 in 1998 and 14.6 in 1999, it increased to 151.5 in 2000. This means that this ratio varies widely between banks. The ratio of provision for loan loss to the total income has quite a strong negative correlation to overall technical efficiency scores in 1999 and 2000. The coefficient of determination is 0.5206 for the data of 1999 and 0.8101 for the data of 2000. After the Russian financial crisis, banks with more provision for loan loss tended to be less efficient.

Here, let us survey the situation of Imperial. While Imperial's efficiency score in 1997 was 0.8371, it drastically decreased to 0.1223 in 2000. According to Imperial's profit and loss statement, provision for loan loss amounted to 6.0 billion rubles, or 555.6 percent of the total income, which led to 7.4 - billion ruble loss for the year 2000. [24]

Regarding items (11) - (12): Other operating income was related to the data in 1997, as mentioned above. Its average ratio to the total income was 19.8 percent. The coefficient of determination was at a low level of 0.0360. Other operating expense was also related to the data in 1997. Its average ratio to the total income was 35.1 percent. The coefficient of determination was relatively high and it was 0.3981. However, it contains many kinds of items, in-

cluding expense from foreign currency operations, securities operations and running expenses. Therefore, it is quite difficult to analyze the primary factors that influenced overall efficiency scores.

3.3 Liabilities to nonresidents and the ratio of capital to the total asset

Liabilities to nonresidents have great significance in the Russian banking system. As mentioned above, the share of foreign loans in balance sheet liabilities for the twenty largest banks exceeded 20 percent. We analyze in this section the changes of liabilities to nonresidents and their relation with efficiency scores.

Furthermore, the ratio of capital to the total asset（capital-asset ratio）is useful for the analysis of the soundness of banking activities. The capital-asset ratio in some banks drastically decreased after the Russian financial crisis while other banks newly issued their shares to increase the capital-asset ratio. We also refer to the relation of the capital-asset ratio with the efficiency scores.

The average ratio of liabilities to nonresidents to the total asset was 15.6 percent at the beginning of 1999（Table 10）.[25] According to the regression of overall technical efficiency scores to the share of liabilities to nonresidents of the total asset, the coefficient of determination was 0.2858, and the liabilities of banks to nonresidents had a negative correlation to overall technical efficiency scores（Table 11）.

The average capital-asset ratio had a tendency to decrease year by year. Whereas it was 15.6 percent in 1997, it decreased to 8.6 percent in 1998, 4.1 percent in 1999 and −15.8 percent in 2000（Table 10）. The standard deviation was almost unchanged from 1997 to 1999（8.0, 7.9 and 9.1, respectively）, it increased remarkably to 71.7 in 2000. The high level of standard deviation was due to the existence of three banks with large negative capital and three banks with over 30 percent capital-asset ratio. According to regression analysis, the coefficient of determination was lower in 1997 and 1998. However, it increased sharply to 0.8151 in 1999 and 0.4144 in 2000（Table 11）. After the Russian financial crisis, the correlation of overall technical efficiency scores with the ratio of capital to the total asset became stronger, and banks with a higher capital-asset ratio tended to be more efficient.

Here, let us pick some examples. Vneshtorgbank was damaged by futures contracts during the Russian financial crisis. Therefore, Vneshtorgbank increased its share by 7.5 billion rubles on April 29, 1999, by 140 billion rubles on December 20, 1999 and by 20 billion rubles on September 4, 2000. It is not clear from the share prospectus of Vneshtorgbank who obtained the newly is-

Table 10. Descriptive Statistics about the Ratio to Asset of Liability to Nonresidents
and Capital-Asset Ratio

	Year	Average	St. dev.	Max	Min
Liability to nonresidents	1998	15.6	14.8	54.0	0.6
Capital / Asset	1997	15.8	8.0	34.9	5.9
	1998	8.6	7.9	25.1	−9.2
	1999	4.1	9.1	31.8	−100.7
	2000	−15.8	71.7	41.5	−161.6

Source: Calculated by the author on the basis of the data in the website of the Central Bank of Russia and *Kommersant den'gi*, March 31, 1999, pp. 11-14.

Table 11. Correlation of Overall Technical Efficiency Scores
with the Ratio to Asset of Liability to Nonresidents and Capital-Asset Ratio

Year	Regression
1998	$OTE = 0.9076 - 0.0048 NONRESI,\ R^2 = 0.2858$
1997	$OTE = 0.8906 + 0.0022 CAPASSET, R^2 = 0.0092$
1998	$OTE = 0.7575 + 0.0043 CAPASSET, R^2 = 0.1528$
1999	$OTE = 0.8319 + 0.0022 CAPASSET, R^2 = 0.8151$
2000	$OTE = 0.8098 + 0.0020 CAPASSET, R^2 = 0.4144$

Note 1 : The number of samples is 12 in 1998 in first line regression. In other regressions the number of samples is 20 in 1997, 15 in 1998, 14 in 1999 and 13 in 2000.

Note 2 : *NONRESI* −ratio of liabilities to nonresident to the total asset, *CAPASSET* −capital-asset ratio.

Source: Calculated by the author on the basis of the data in the website of the Central Bank of Russia and *Kommersant den'gi*, March 31, 1999, pp. 11-14.

sued shares. However, judging from the increase in percentage of Vneshtorgbank's shares that the Central Bank of Russia held (96.65 percent in the middle of 1997[26] to 99.95 percent at the beginning of 2001[27]), we can conclude that the Central Bank of Russia obtained almost all newly issued shares. As a result, the capital-asset ratio of Vneshtorgbank increased from 8.0 percent at the beginning of 1999 to 41.5 percent at the beginning of 2001. Vneshtorgbank increased its efficiency score to 0.9403 in 1999 and it achieved 1.0000 again in 2000. It seems that the capital increase contributed to the rise of its efficiency scores. Rossiiskii kredit was also damaged by the Russian financial crisis. One of the reasons was the high level of the ratio of liabilities to nonresidents to the total asset (54.0 percent). Though the ratio of capital to the total asset was 8.9 percent in 1997, it decreased to −161.6 percent in 2000. Its overall technical efficiency score also decreased from 0.8206 in 1997 to 0.5996 in 2000. Rossiiskii kredit had fallen under the control of the Agency for Restructuring of Financial Organizations on October 18, 1999 (*Kommersant-daily,* October 19, 1999, p. 5).

4. Summary and Conclusion

First, we measured the efficiency scores of Russian large banks and discussed reasons for inefficiency in this paper. According to DEA, overall technical efficiency scores in the year 1997 were the highest of the analyzed years. No banks indicated higher overall technical efficiency scores than those during the year 1997. The reason for inefficiency for most banks was waste of inputs, however Sberbank was inefficient due to scale inefficiency for four years. Furthermore, we classified banks into six categories and analyzed characteristics of each category, taking efficiency scores into account. All of the banks under the control of the federal government worked purely technically efficient. Many former governmental banks and banks which formed the bank-industrial group went bankrupt. In general, other banks of these categories worked at a relatively low efficiency level. Several "relative" banks of the industrial elite companies received aid from them and granted loans related to their projects. The bank under the control of the local government had advantages in aspects of raising funds and granting loans. The activities of banks with a high share of foreign capital varied from bank to bank.

We also analyzed the correlation of overall efficiency scores with income and expense items to the total income for each year, using regression analysis. In 1997, overall technical efficiency scores had relatively stronger positive correlations to the ratios of income from foreign currency operations and interest income from securities to the total income. In 1998, overall technical efficiency scores had a relatively stronger positive correlation to the ratio of income from foreign currency operations to the total income, whereas it had a relatively stronger negative correlation to income from revaluation and operations of precious metals, securities and other assets, interest income from loans granted to customers except banks, and interest expense from loans granted by banks. Depreciation of the ruble to the US dollar gave the possibility for banks to make large profits. Therefore, banks with a lower share of income from foreign currency operations tended to be less efficient. Overall technical efficiency scores had a relatively stronger negative correlation to provision for loan loss in 1999, and to expense from foreign currency operations, provision for loan loss, expense from revaluation and operations of precious metals, securities and other assets in 2000. Therefore, overall technical efficiency scores had the tendency to be affected by the expense side in 1999 and 2000.

Finally, we analyzed the correlation of overall technical efficiency scores with the ratio of liabilities to nonresidents to the total asset, and with the capital-asset ratio. In the former regression analysis, overall technical efficiency scores showed a tendency to be lower as the ratio of liabilities to non-

residents to total asset became larger（data was available only in 1998）．In the latter regression analysis, overall technical efficiency scores had little correlation with the capital-asset ratio in 1997 and 1998． However, the coefficient of determination was higher in 1999 and 2000． After the Russian financial crisis, the correlation of overall technical efficiency scores with the capital-asset ratio became stronger.

In our paper the objects for analysis were limited to larger banks． We plan to expand on this work by applying these methods to banks in all districts of Russia and to discuss the difference by district and size of banks.

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Appendix　The non-parametric approach

A. 1. Measuring Overall Technical Efficiency

This section presents the non-parametric approach used to estimate the efficiency of each DMU. [28] 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 $(j = 1,2,\cdots,n)$ be $x_j = (x_{1j},x_{2j},\cdots,x_{mj})^T$ and $y_j = (y_{1j},y_{2j},\cdots,y_{sj})^T$ （m input items and s output items are selected, and each item is not negative. x_j and y_j are input and output column vectors, respectively）．The input data matrix X is $m \times n$ and the output data matrix Y is $s \times n$.

Let the DMU_j to be evaluated on any trial be designated as DMU_o where o ranges over $1, 2, \cdots,n$. In the case of constant returns to scale the primal DEA ratio model can be stated for DMU_o as follows:

min	θ_C	（A- 1 ）
subject to	$-X\lambda + \theta_C x_o \geq 0,$	（A- 2 ）
	$Y\lambda \geq y_o,$	（A- 3 ）
	$\lambda \geq 0.$	（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 overall technical efficiency. In （A- 2 ）-（A- 4 ）, $\lambda = (\lambda_1,\lambda_2,\cdots,\lambda_n)^T$ 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	uy_o	（A- 5 ）
subject to	$-vX + uY \leq 0,$	（A- 6 ）
	$vX_o = 1,$	（A- 7 ）
	$v \geq 0, \ u \geq 0,$	（A- 8 ）

where v is a row vector for input multipliers and 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 $s^- \in R^m$ and the output shortfalls $s^+ \in R^s$ and identify them as "slack" vectors by:

$$s^+ = Y\lambda - y_o, \tag{A-9}$$

$$s^- = \theta_C x_o - X\lambda, \tag{A-10}$$

with $s^+ \geq 0$, $s^- \geq 0$ 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^*.

maximize $\qquad \omega = es^- + es^+$ \hfill (A-11)

subject to $\qquad s^- = \theta_C^* x_o - X\lambda,$ \hfill (A-12)

$\qquad\qquad\quad s^+ = Y\lambda - Y_o,$ \hfill (A-13)

$\qquad\qquad\quad \lambda \geq 0, \ s^+ \geq 0, \ s^- \geq 0,$ \hfill (A-14)

where $e = (1, \cdots, 1)$ (a vector of ones).

If an optimal solution $(\theta_C^*, \lambda^*, s^{+*}, s^{-*})$ 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 $\qquad \theta_V$ \hfill (A-15)

subject to $\qquad -X\lambda + \theta_V x_o \geq 0,$ \hfill (A-16)

$\qquad\qquad\quad Y\lambda \geq y_o,$ \hfill (A-17)

$\qquad\qquad\quad e\lambda = 1,$ \hfill (A-18)

$\qquad\qquad\quad \lambda \geq 0,$ \hfill (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 $\qquad uy_o - u_0$ \hfill (A-20)

subject to $\qquad -vX + uY - u_0 e \leq 0,$ \hfill (A-21)

$\qquad\qquad\quad vx_o = 1,$ \hfill (A-22)

$\qquad\qquad\quad v \geq 0, \quad u \geq 0,$ \hfill (A-23)

$\qquad\qquad\quad u_0 \quad$ free in sign, \hfill (A-24)

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

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 overall technical efficiency to pure technical efficiency. The formula can be given as:

$$\text{Scale Efficiency} = \frac{\theta_C}{\theta_V}. \tag{A-25}$$

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 overall technical efficiency of B_1 is calculated as B_2B_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_3B_4/B_1B_4, and that of D_1 is calculated as D_3D_4/D_1D_4. Since the scale efficiency score is the ratio of the overall technical efficiency score to the pure technical efficiency score, its value of B_1 is calculated as B_2B_4/B_3B_4, and that of D_1 is calculated as D_2D_4/D_3D_4.

Figure 1 . Measuring Technical and Scale Efficiency
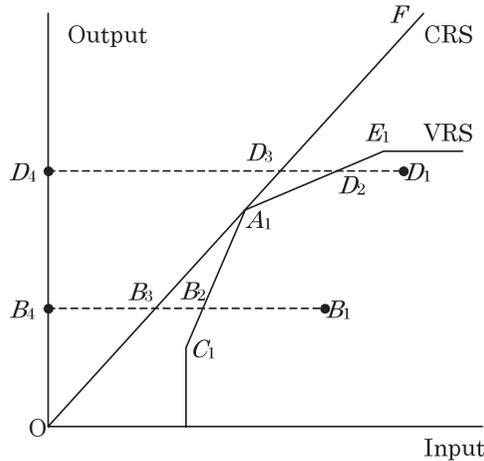
Note 1 : CRS—constant returns to scale, VRS—variable
　　　　returns to scale
Note 2 : A_1, B_1, C_1, D_1 and E_1 are the original data of
　　　　each decision making unit.

A. 4. Assurance Region

　　This study employs DEA/assurance region (DEA/AR) analysis that incorporates the following upper and lower bounds related to dual variables into (A-5) and (A-20)-(A-24):

$$\alpha_i^{\mathrm{L}} \leq v_i/v_1 \leq \alpha_i^{\mathrm{U}}, \quad i = 2,3,\cdots,m, \tag{A-26}$$

$$\beta_r^{\mathrm{L}} \leq u_r/u_1 \leq \beta_r^{\mathrm{U}}, \quad r = 2,3,\cdots,s. \tag{A-27}$$

Here, α_i^{L} and α_i^{U} are the lower and upper bounds, respectively, of the ratio of v_i to v_1, while β_r^{L} and β_r^{U} are the lower and upper bounds of the ratio of u_r to u_1. In this paper we will use the following lower and upper bounds:

$$0.5 \leq v_2/v_1 \leq 2, \quad 0.5 \leq u_2/u_1 \leq 2. \tag{A-28}$$

　　One of the characteristics of DEA consists of the possibility to choose the favorable weight variables (v_i,u_r) for each DMU. However, DMU can choose the value of zero as some weight variables, which leads to results which does not reflect the actual situation of DMU. Therefore, though this might be an ad hoc assumption, we decide bounds such that one weight variable for input (output) does not exceed double the other variable and does not fall below half of the other. This will be a proper assumption in order to avoid for DMU to choose excessive value of weight variables and retain the characteristics of DEA, that is, the possibility to choose the favorable weight variables.

Notes

(1) IMF (1998) distinguishes a number of broad types of economic or financial crises to currency crises, banking

crises, systemic financial crises and foreign debt crises（for detailed definition, see IMF（1998），pp. 74-76）. In this paper we utilize the term "financial crisis" as the broad concept, which consists of four classifications of IMF（1998）. OECD（2000）gives a comprehensive explanation of the Russian financial crisis. As to a series of measures, which the Central Bank of Russia and Russian government announced on August 17, 1998, see OECD（2000），pp. 34-44.

⑵　We chose the twenty largest banks on the basis of the total asset as of January 1, 1998.

⑶　In the article of DEA, the word "efficiency" is commonly used, which means the efficiency of input usage to produce a given level of outputs. Therefore, it is a relative concept, and in this approach the existence of one bank makes other banks inefficient.

⑷　Lewin and Knox Lovell（1990）give general surveys on the two methodologies.

⑸　Of course, there is anther aspect how efficient banks earn income to make a given level of expenses（output-based method）. However, it is impossible to decide 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.

⑹　Sherman and Gold（1985）and Ferrier and Lovell（1990）utilize this approach.

⑺　Aly et al.（1990），Rangan et al.（1998）and Berger and Humphrey（1991）utilize this approach.

⑻　English et al.（1993）use this approach.

⑼　Charnes et al.（1990）also take the approach which reflects the profitability of banks. They utilize total operating expense, total non-interest expense, provision for loan loss and actual loan losses as inputs, and total operating income, total interest income, total non-interest income, total net loans as outputs. The characteristics of this approach consist in the inclusion of total net loans into outputs.

⑽　New accounting standards for Russian banks were enacted by the Regulation of the Central Bank of Russian Federation No. 61 as of June 18, 1997 from the year 1998. Therefore, the accounting standards in the year 1997 are different from those of the years 1998-2000. Whereas income from sale of assets, which has nothing to do with banking activities, was included in the extraordinary profit of 1997, it has been included in the item "income from revaluation and operations of precious metals, securities and other assets" since 1998. However, judging from the detailed profit and loss statement of banks, that income is small in 1998-2000. Therefore, the influence to our analysis is limited.

⑾　We classified these categories, referring to BEA（1999），Chapter 16, Ono（1999）and Ono（2000）.

⑿　The shareholders of MMB were Sberbank（10 percent of issued shares），Vneshtorgbank（10 percent），and so on. Since Sberbank and Vneshtorgbank were under the control of the Central Bank of Russia, MMB was in fact under the control of the Central Bank of Russia. Therefore, we classified MMB to the first category. However, we have to note that in 1999 Bayerische Hypo- und Vereinsbank（Germany）became the largest shareholder of MMB.

⒀　Following BEA（1999），Chapter 16, p. 2, we did not use the term "financial-industrial group" because there are cases, in which the group is not registered as a financial-industrial group in accordance with the law, but in fact forms the group.

⒁　SBS-Agro was formed in December 1996 when Stolichnyi Bank Sberezhenii acquired a 50 percent share of Agroprombank, a former governmental bank.

⒂　We have to note that the recalling of the banking license by the Central Bank of Russia does not mean bank-

ruptcy of the bank. Article 11 of the Law on Bankruptcy of Enterprises as of November 19, 1992 provides for an arbitrage court to start a trial concerning the bankruptcy of a financial institution only after its banking license is recalled by the Central Bank of Russia. Article 36 of the Law on Bankruptcy of Financial Institutions as of February 25, 1999 also provides the same thing.

(16)   We acquired the BEA article through the Internet. Since the page number is different from the published version, we started numbering the pages of the article from the top of each chapter.

(17)   The total income is calculated as the summation of interest income, commissions received, income from foreign currency operations, income from revaluation and operations of precious metals, securities and other assets, dividend received and other current income（penalties received, income from factoring and forfeiting operations, and so on）. Furthermore, we regard the analysis as the complete survey. Therefore, any statistical tests are not applied here.

(18)   Items（2）,（3）and（4）could not be calculated in the year 1997 because of the old account standards.

(19)   According to the Regulation of the Central Bank of Russia, it includes dealing income of securities, income from revaluation of securities, income from realization of assets, income from operations of precious metals, income from option, forward and futures contracts, and so on.

(20)   Expense from revaluation and operations of precious metals, securities and other assets includes dealing expense of securities, expense from revaluation of securities, expense from realization of assets, expense from operations of precious metals, expense from options, forward and futures contracts, and so on.

(21)   This item is related to data in the year 1997 because of the account standard change. It includes commissions received, and so on.

(22)   This item is also related to data in the year 1997. It includes expense from foreign currency operations, expense from security operations, communication expense, depreciation of fixed capital, commissions paid, and so on.

(23)   As mentioned above, expense from foreign currency operations is unclear from the profit and loss statement in 1997.

(24)   When we discuss the situation of Imperial, we have to take the following circumstances into account. Imperial's license was recalled immediately after the Russian financial crisis in August 1998 by the Central Bank of Russia, and it was acknowledged to be bankrupt by the Arbitrage Court of Moscow City in May 1999. However, the Central Bank of Russia suspended the order for license recall from June 7, 1999 until October 7, 1999. There is an opinion that after the inauguration of the new Fuel and Energy Minister, Lukoil, an oil company, which was a shareholder of Imperial, asked the Fuel and Energy Minister to put pressure on the Central Bank of Russia（*Kommersant-daily*, June 8, 1999, p. 7）. On July 27, 1999 the Arbitrage Court decided that the suspension of the order of license recall was illegal. Afterward, the Arbitrage Court suddenly decided to quit examining the case concerning the acknowledgement of Imperial to be bankrupt on April 17, 2000（*Kommersant-daily*, April 18, 2000, p. 6）.

(25)   Calculated on the basis of data in *Kommersant den'gi*, March 31, 1999, pp. 11-14. The data regarding the amount of liabilities to nonresidents in other years are not available.

(26)   *Prospect emissii tsennykh bumag: Vneshtorhbank*, No. 3, pp. 2-3.

(27)   *Ezhekvartal'nyi otchet po tsennym bumagam: Vneshtorgbank*, 2000, 4th quarter, p. 3.

(28)   For a detailed explanation of this approach see Cooper et al.（2000）.

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