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# Measuring Cost Efficiency of Ukrainian Banks in 2008

## Abstract

*The paper presents the results of a stochastic frontier analysis (SFA) of cost-efficiency of Ukrainian banks. As of lack of data on the personnel costs, we had to set limits to the year of 2008 only. To modeling banking activity, we apply the intermediary approach as one of the most commonly used in literature. Considering the results of statistical tests, we chose translog functional form of cost function and half–normal distribution of random inefficiency term. As a result of the research, we found out that efficiency of Ukrainian banks varies within 0.5224 and 0.9869 with an average value of 0.8734. Having checked a range of hypotheses, we discovered insignificant distinctions among banks by their size, type of owner and location.*

## 1. Introduction

Present state of economy of Ukraine requires constant attention to banking system, conducting of a policy aimed at a creation of favorable conditions of stable and efficient functioning. Banking system plays a key role in the modern market economics. It is banks that attract deposits and give loans to the market participants, contribute to increasing competition and efficient re-distribution of money resources.

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The economic crisis and post-crisis unstable political situation in the country predetermines the necessity of banking activity assessment and discovering of the causes of worsening financial position of commercial banks in order to preserve their financial stability. This is an important precondition of the country's coming out of the crisis, securing its economic rise and investment attractiveness. That is why information on bank's efficiency is rather important for the market participants. The problem is that none of the existing coefficients on banking activity (either absolute, or relative) give exhaustive information on bank's efficiency. Therefore in the modern practice of efficiency measurement along with classical analysis of financial coefficients more sophisticated methods of frontier analysis are used. One of the main advantages of these methods is a possible integral estimation of efficiency of banking activity. With such an approach the results of activity of a certain bank can be integrally compared with the results of the selected banks and at present are the best-practice ones (i.e. make the most of the existing technology), namely are on the so called frontier. The methods of frontier analysis can be parametric or non-parametric depending on the assumption used modeling a frontier.

In our previous research papers (see Pilyavskyy and Matsiv 2010, pp. 91-106, Pilyavskyy et al. 2010, pp. 16-22) we used a non-parametric method of frontier analysis, namely DEA, while in this very paper we use one of the parametric approaches, i.e. *stochastic frontier analysis* (SFA). SFA is widely used for bank's efficiency estimation in Central and Eastern Europe, in particular Russia (Byelousova 2009, pp.489-519, Styrin 2005, pp.1–29, Peresetsky 2010), Hungary (Hasan and Marton 2003, pp.2249–2271), Slovenia (Stavárek and Šulganová J. 2009), Czech Republic (Weill et al. 2006). As to Ukraine, we are acquainted only with one paper devoted to efficiency measurement of Ukrainian banks using SFA method (see Mertens and Urga 2001, pp. 292-308). That is why we consider research in this direction rather vital. In this research paper we suppose to check if:

- cost-inefficiency is present in the Ukrainian banking system;
- foreign banks are more efficient, than Ukrainian ones;
- efficiency of Ukrainian banks depends on their size;
- efficiency of Ukrainian banks somehow differs depending on their location.

The structure of our paper is as follows. In section 2 method and model of banking activity as well as data used for estimation of efficiency of Ukrainian banks are discussed. In section 3 we provide the main results of efficiency measurement and test some hypotheses. Finally, in section 4 we summarize.

## 2. Method, model, data

The foundations of the methodology of frontier analysis and modern efficiency estimation are in the paper by Farrell (Farrell 1957, pp. 253-290), who, in his turn, on the basis of the preceding works by Debreu (Debreu 1951, pp. 273-292) and Koopmans (Koopmans 1951, pp. 33-97), offered simple measure of economic efficiency of a firm and its decomposition onto allocative and technical. Depending upon the way a production frontier is built, methods of frontier analysis fall under: non-parametric, in which linear programming technique is used and parametric, where econometric analysis is applied. SFA method is the most widely used of the parametric methods.

SFA was introduced in the works by Aigner et al. (Aigner et al. 1977, pp. 21-37) and Meeusen and van den Broeck (Meeusen and van den Broeck 1977, pp. 435-444) independently from one another. In the approach to measurement of technical efficiency, econometric analysis is used to model production function, which contains two random components. One of them estimates random errors, while the other one deals with inefficiency measurement. Then firm's efficiency depends on a functional form for approximation of a production frontier and a distribution form of random components. Cobb-Douglas and translog are the two functional forms most often used for efficiency estimation, taking into consideration a multiplicative nature of efficiency and that Cobb-Douglas and translog can be linearized.

Having somewhat modified a model used for technical efficiency measurement, SFA also allows cost-efficiency estimation. Cost-function can be expressed as follows:

$$\ln C = f(y, w, z) + u + v \tag{1}$$

here: $C$ – costs, $y$ – outputs (volume of output), $w$ – prices for inputs (resources), $z$ – so called netputs (fixed parameters), $u$ – random inefficiency term, $v$ – random error term. Distribution of random error term can be considered normal, while random inefficiency term - half-normal, truncated normal, exponential, gamma etc. There are no clear criteria for choosing a distribution of random inefficiency term. That is why, more often they choose either half-normal or truncated normal distributions of random inefficiency term.

Then, having $K$ banks, efficiency of bank $k$ ($k = 1,\ldots,K$) of them ($Eff_k$) can be calculated as follows:

$$Eff_k = e^{-\hat{u}_k}, \tag{2}$$

where $\hat{u}_k$ - estimate of parameter $u_k$.

Unfortunately, there exists no simple way of calculating $\hat{u}_k$ of $u_k$. It depends upon both distribution $u_k$, and a chosen method of estimation. For details see, e.g. Kumbhakar and Lovell (Kumbhakar and Lovell 2000).

Efficiency of the banking system on the whole ($Eff$) is arithmetic mean of measures of efficiency of individual banks:

$$Eff = \frac{\sum_{k=1}^{K} Eff_k}{K} \tag{3}$$

In our research, for efficiency measurement of Ukrainian banks we use data on the activity of Ukrainian banks in 2008[1] that are on the NBU's Web site[2]. Selecting data for the research we applied the intermediary approach to modeling banking activity (see Sealey and Lindley 1977, pp. 1251–1266).

According to the intermediary approach banks are considered as financial intermediaries between depositors and borrowers. Banks 'produce' intermediary services attracting deposits and other obligations and allocate them in earning assets (loans, securities, etc.). Loans and securities and other earning assets are outputs in our model. Prices of labor, borrowed funds and physical capital make price of inputs. We use an amount of banking capital as a netput (fixed input) (in details for the list of variables see table 1). However, independent variables that form a regression-equation may significantly correlate with each other, but that is undesirable, because of sensitivity of regressors even to inconsiderable data changes, so we calculated variance inflation factors (VIF) (see Gujarati 2004) to discover multicolinearity. For all independent variables VIF's values appear to be less than 10, so it can be considered that there is no multicolinearity.

[1] We use data of 2008, since the NBU ceased publishing data on personnel costs after 2008 and it is the key parameter for efficiency estimation.

[2] www.bank.gov.ua

**Table 1. Variables and their definitions**

| Variable | Name | Definition |
|---|---|---|
| TC | Total costs | operative costs, interests and charges |
| TL | Total loans | personal or commercial loans but for the reserves under them |
| SOEA | Securities and other earning assets | securities (incl. state securities) and assets in other banks but for the reserves under them |
| PBF | Price of borrowed funds | interest and charge costs divided by all the types of borrowed funds |
| PL | Price of labour | personnel costs divided by assets[3] |
| PPC | Price of physical capital | total administrative costs divided by tangible and intangible assets |
| BC | Capital of bank | banking capital |

Source: developed by the authors.

Consequently, we have data on activity of 151 Ukrainian banks in 2008. The following step is to choose a functional form and a distribution of a random inefficiency term. In order to choose between functional forms of either Cobb-Douglas or Trans-Log models, we used the Log-Likeliood Ratio Test (LR Test) (see Coelli et al 2005). According to the results of the test, on the level of significance equal to 0.05, a half-normal distribution is preferred. We also used the LR Test to choose a distribution of random efficiency term between half-normal and truncated normal. A half–normal distribution is preferred according to the results of the test on the significance level of 0.05. Consequently, the specification of our model is as follows:

[3] Let us note that the best approximation of labour costs is a ratio of personnel costs to a number of employees. Unfortunately, NBU do not publish data on a number of personnel.

$$\ln\left(\frac{TC}{PPC \cdot BC}\right) =$$

$$= \beta_0 + \beta_1 \ln\frac{TL}{BC} + \beta_2 \ln\frac{SOEA}{BC} + \beta_3 \ln\frac{PBF}{PPC} + \beta_4 \ln\frac{PL}{PPC} + \beta_5 \ln^2\frac{TL}{BC} +$$

$$+\beta_6 \ln^2\frac{SOEA}{BC} + \beta_7 \ln^2\frac{PBF}{PPC} + \beta_8 \ln^2\frac{PL}{PPC} + \beta_9 \ln\frac{TL}{BC}\ln\frac{SOEA}{BC} +$$

$$+\beta_{10} \ln\frac{TL}{BC}\ln\frac{PBF}{PPC} + +\beta_{11} \ln\frac{TL}{BC}\ln\frac{PL}{PPC} + \beta_{12} \ln\frac{SOEA}{BC}\ln\frac{PBF}{PPC} +$$

$$+\beta_{13} \ln\frac{SOEA}{BC}\ln\frac{PL}{PPC} + +\beta_{14} \ln\frac{PBF}{PPC}\ln\frac{PL}{PPC} + u + v \tag{4}$$

Random components are distributed in the following way:

$$v \sim N(0, \sigma_v^2), \qquad u \sim N_+(0, \sigma_u^2) \tag{5}$$

It is known that the cost function has to be homogeneous. To satisfy this condition, we used one of the prices (PPC), namely *numeraire*, and divided total costs by it. In order to eliminate a heteroscedasticity effect, total costs and all outputs were divided by banking capital.

## 3. Results

To estimate the efficiency of Ukrainian banks, we applied R program, namely Benchmarking package (see Bogetoft and Otto 2011). The estimates of cost-function parameters (4) are given in, Table 2.

**Table 2. Summary of estimation**

| Parameter name | Estimator of parameter | Std.err | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| $\beta_0$ | -1.50712 | 0.08606 | -17.5126 | 0.000 |
| $\beta_1$ | 0.65071 | 0.05497 | 11.8368 | 0.000 |
| $\beta_2$ | 0.50007 | 0.06704 | 7.4589 | 0.000 |
| $\beta_3$ | 0.39522 | 0.05632 | 7.0176 | 0.000 |
| $\beta_4$ | 0.61489 | 0.07581 | 8.1113 | 0.000 |
| $\beta_5$ | 0.11808 | 0.01891 | 6.2449 | 0.000 |
| $\beta_6$ | 0.07776 | 0.01102 | 7.0588 | 0.000 |
| $\beta_7$ | 0.11479 | 0.01545 | 7.4289 | 0.000 |
| $\beta_8$ | 0.11395 | 0.01562 | 7.2942 | 0.000 |
| $\beta_9$ | -0.20917 | 0.02032 | -10.2942 | 0.000 |
| $\beta_{10}$ | 0.00609 | 0.02680 | 0.2272 | 0.820 |
| $\beta_{11}$ | 0.04712 | 0.02704 | 1.7424 | 0.083 |
| $\beta_{12}$ | 0.06520 | 0.02262 | 2.8819 | 0.004 |
| $\beta_{13}$ | -0.05360 | 0.02698 | -1.9868 | 0.048 |
| $\beta_{14}$ | -0.21266 | 0.02898 | -7.3376 | 0.000 |
| $\Lambda$ | 4.60382 | 1.30053 | 3.5400 | 0.000 |

$\sigma^2 = 0.035358$, $\sigma_v^2 = 0.001593$, $\sigma_u^2 = 0.033765$

log likelihood = 120.2094, $\lambda = \sqrt{\frac{\sigma_u^2}{\sigma_v^2}}$

Source: developed by the authors using the R program, Benchmarking package.

Having used the Wald test (see Coelli et al 2005), on the significance level of 0.05, we can affirm that inefficiency is present in the Ukrainian banking system. Moreover, taking into consideration the results of estimation, 95% of total variation can be explained by the inefficiency and only 5% - by random errors.

The average cost-efficiency of Ukrainian banks is rather high; it is 0.8734, while individual measures of cost-efficiency vary within 0.5224 to 0.9869. Within the framework of our research we also discuss cost-efficiency of Ukrainian banks by their size[4], type of owners (banks with foreign capital and Ukrainian ones) and their location (Kyiv or regional).

**Table 3. Results of efficiency estimation**

| | N | mean | min | max | Std |
|---|---|---|---|---|---|
| All banks | 151 | 0.8734 | 0.5224 | 0.9869 | 0.0885 |
| *Banks by size* | | | | | |
| I (The Largest) | 17 | 0.9153 | 0.8340 | 0.9869 | 0.0470 |
| II (Large) | 19 | 0.8785 | 0.7019 | 0.9612 | 0.0739 |
| III (Medium) | 21 | 0.8768 | 0.7044 | 0.9652 | 0.0730 |
| IV (Small) | 94 | 0.8640 | 0.5224 | 0.9797 | 0.0974 |
| *Banks by owner* | | | | | |
| With foreign capital | 44 | 0.8708 | 0.5224 | 0.9797 | 0.0877 |
| Ukrainian | 107 | 0.8744 | 0.5697 | 0.9869 | 0.0888 |
| *Banks by location* | | | | | |
| In Kyiv | 96 | 0.8765 | 0.5697 | 0.9869 | 0.0944 |
| In regions | 55 | 0.8678 | 0.5224 | 0.9709 | 0.0769 |

Source: developed by the authors.

We can see from table *3 that the larger the banks are, the higher is their efficiency*. Thus, the efficiency of the largest banks is 0.9153, while of the small ones – 0.8640. In the largest-bank-group the least efficiency variation is observed, while in the group of small banks it is the highest. However, having used an ANOVA to check a hypothesis on efficiency differences among the

[4] In the paper we use the NBU's methodology of differentiation of banks into groups. The methodology anticipates referring a certain bank to one of four groups by amount of their assets and regulatory capital.

bank groups by their size on the significance level of 0.05, we can affirm that there exist no differences in efficiency of banks by the groups.

As to the efficiency of banks by the type of owner, the average value of banks with foreign capital (0.8708), it hardly differs from that of Ukrainian banks (0.8744). The thing is quite the same with the banks located in Kyiv or regions (the average values respectively are 0.8765 and 0.8678). On the significance level of 0.05 the *t*- tests also point to the fact that efficiencies of foreign banks vs domestic ones, as well Kyiv banks vs regional ones do not differ.

## 4. Summary

The paper is a preliminary research of a possible application of stochastic frontier analysis to estimation of cost-efficiency of Ukrainian banks. Unfortunately, as of lack of data on the personnel costs, we had to set limits to the year of 2008 only. According to the results of efficiency measurement, we found out that the efficiency of Ukrainian banks varies within 0.5224 and 0.9869 with an average value of 0.8734.

Having checked a range of hypotheses, we discovered insignificant distinctions among banks by their size, type of owner and location.

## Appendix A

**Table A.1. Descriptive statistics of data used for estimation***

| Variable | mean | min | max | Std |
|---|---|---|---|---|
| TC | 544 081 | 7 396 | 10 000 821 | 1 194 851 |
| TL | 4 431 940 | 25 548 | 64 420 601 | 10 067 381 |
| OEA | 800 842 | 1 343 | 18 916 820 | 1 949 545 |
| PBF | 0.086 | 0.011 | 0.262 | 0.033 |
| PL | 0.027 | 0.003 | 0.143 | 0.017 |
| PPC | 0.332 | 0.027 | 0.978 | 0.221 |
| BC | 747 273 | 28 057 | 15 471 943 | 1 721 791 |

* Variables TC, TL, OEA and BC given in thousands of UAH

Source: developed by the authors.

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## Streszczenie

### POMIAR EFEKTYWNOŚCI KOSZTOWEJ BANKÓW UKRAIŃSKICH W 2008

*W artykule przedstawiono wyniki stochastycznej analizy granicznej (SFA) efektywności kosztowej banków ukraińskich. Ze względu na braki w danych dotyczących kosztów personelu, analizę ograniczono do roku 2008. W modelowaniu działalności bankowej, zastosowano podejście pośrednika jako jeden z powszechnie stosowanych w literaturze. Biorąc pod uwagę wyniki testów statystycznych, wybrano funkcjonalną formę funkcji kosztów I pół-normalny rozkład losowy.*