EVALUATING THE PERFORMANCE OF COMMERCIAL BANKS IN UKRAINE: FRONTIER EFFICIENCY APPROACH

by

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Abstract

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This paper evaluates the current situation in the banking sector of Ukraine. We aim at finding evidence in support of the hypothesis of high competitiveness in the banking industry. The necessary condition for competitiveness in the industry is that firms operating in the market are at least technically efficient otherwise they will be compelled to exit the market. The technical and scale efficiency scores are obtained from the nonparametric frontier technique known as data envelopment analysis. It is found that most banks disregarding of the size, ownership, or region where the head office is located have efficiency scores which are quite high comparing to studies done for other countries, which satisfies the necessary condition and supports the hypothesis that banking sector in Ukraine is highly competitive.

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GLOSSARY

Balance sheet A statement of the financial position of the enterprise/bank as at a stated date. It shows assets, capital, and liabilities.

Constant returns to scale (CRS) Technology is said to exhibit CRS if an increase in all inputs by t leads to an increase in all outputs by t.

Decreasing returns to scale (DRS) Technology is said to exhibit DRS if an increase in all inputs by t leads to an increase in all outputs by less than t.

Increasing returns to scale (IRS) Technology is said to exhibit IRS if an increase in all inputs by t leads to an increase in all outputs by more than t.

Variable returns to scale (VRS) Technology exhibits VRS if it can exhibit CRS, DRS, and IRS in different regions.

INTRODUCTION

Banking system is one of the key elements of the market economies. It provides a source of finance resources for enterprises. Sound banking system favors monetization of the economy and upswing in business activity.

In Ukraine, similar to many other countries, the banking system consists of two levels. Central bank, the National Bank of Ukraine (NBU), is on the first level. It conducts monetary policy in the country and at the same time it is the main regulatory body for the commercial banks. Commercial banks constitute the second level.

Even though the Ukrainian banking system has been mainly established in 1992, there is still much turmoil in this industry. This instability can be attributed to the difficulties in the overall economic situation, especially to the gradual deteriorating of some of the state owned and privatized enterprises and the generally accepted practice not to pay debts. Additionally, small newly-emerged enterprises are subject to high risks. And finally, banks face more and more competition from the side of the banks with foreign capital. All of this contributes to the fact that banking is risky in Ukraine. Moreover, the regulating norms in the whole economic environment are constantly being elaborated or revised. The NBU monitors the banks' performance by checking the fulfillment of 14 indices[1]. However, it is quite difficult to rank the banks on the basis of index-to-index comparison, since banks may successfully fulfill some of the indices while failing some others. It is desirable to have an aggregated indicator of performance. The integrated index is obtained from CAMEL (Capital adequacy,

[1] According to the *Instruction on the Order of Regulating and Analyzing Activities of Commercial Banks* enacted by the Board of the NBU on April 14th, 1998

Assets quality, Management, Earnings, and Liquidity) methodology adopted for Ukraine. However, it is a costly and time consuming procedure[2]. Different banks have worked out their own methodologies in order to rank their branches (methodologies by Kromonov and Shyrynska). All of them are based on calculating many indices and then making weighted average of them. The efficiency frontier approach is an alternative. It requires careful consideration while elaborating the model, which can be considered as fixed costs. But it gives back a desirable result – every bank obtains an efficiency score, so, the ranking becomes easy. The efficiency frontier method is more universal than most standard measures (CAMEL is an exception – it is also very detailed) and less costly than CAMEL. Moreover, it is a fundamentally new approach for Ukraine, thus it might give new insight to the situation in the industry and performance of the separate banks. Moreover, the frontier methods indicate the source of scale inefficiency, if it is found, which is also desirable for managerial purposes.

Another dimension where efficiency scores are widely used is to evaluate the current situation and the changes in the market, such as consequences of the changes in the legal norms, introduction of the innovations to the market, as well as consequences of mergers and acquisitions.

In this paper efficiency frontier approach is used to evaluate the current situation in the banking sector. In the beginning of the 2002, Mr. Stelmach, the head of the NBU (January 21th, 2000 till December 17th, 2002), declared the policy on the increasing the stability and viability of the banking sector through enhancing healthy competition. However, the primary goal of the NBU is to conduct monetary policy and support national currency. Thus, the measures aimed at

[2] CAMEL approach is costly in terms of time and money because it implies individual inspection of every bank, so it is almost impossible to rank all the banks operating in the country at the same time.

improving banking competition were interacting with the measures aimed at achieving overall macroeconomic goals.

First of all, the NBU lowered the refinancing rate from the 15% in the beginning of the 2002 to 7% in the end, which definitely makes banks less worried since they always can exploit the NBU as a lender of the last resort.

Second, NBU set higher capital requirements which encourages small banks join together or increase in size. As a result, the total equity capital has increased by 30 % comparing to the beginning of the 2002.

Third, the NBU established a zero rate of required reserves for time deposits. This was done for stimulating people in making time deposits; however this has an ambiguous effect on banks. On the one hand, they have cheap long-time resources, which obviously led to the lowering of the average rate on bank loans from 30.7% in the beginning of the 2002 to 19.1% in the end. On the other hand, banks may tend to be less careful in choosing loan portfolio, because the resources become less expensive.

The positive tendency is that the NBU is accurately paying interest on the government bonds which have been converted in the 1998 (maturity date was postponed and many banks had liquidity problems then). Moreover, newly issued t-bills are very versatile and convenient for banks to work with them. The overall stabilization of the exchange rate (even appreciation of hryvna was observed in 2002) reduces exchange rate risks. And the increasing monetization of the economy enhanced banking activity in Ukraine.

This brief overview leads us to the main question of this research, namely, whether this mixture of the policy measures has actually leaded to increase in competition. Unfortunately, we cannot observe the banking data for the previous years, but we can check what the market structure of the banking sector now is.

The hypothesis we are going to test in the paper is that Ukrainian banking sector is highly competitive. The necessary condition for competitiveness in the industry is that the firms operating in the market should be at least technically efficient; otherwise they will be compelled to exit the market

Chapter 1

PREVIOUS RESEARCH

There are more than one hundred studies that apply efficiency frontier analysis to financial institutions in more than twenty countries. They concern several types of financial institutions -- commercial banks, savings and loans, credit unions, and insurance companies.

In general, as Berger and Humphrey (1997) suggest, this vast literature on the efficiency analysis may be subdivided into three main strands on the basis of application: governmental policy, evaluating managerial performance, and research issues.

Governmental issues include investigating failure of the financial institutions and problem loans, deregulation issues, and market concentration. Berger and DeYoung (1997) find low efficiency to indicate future problem loans. Cebenoyan, Cooperman, and Register (1993) find that banks with lower efficiency scores tend to fail more often than banks with high efficiency scores. Thus, efficiency measures can improve the predictive power of the failure predicting models. Deregulation is usually undertaken by the government in order to improve the competitive viability of the industry. The empirical works suggest that deregulating measures in some cases improve efficiency of the institutions in the industry, for instance, in Norway (Berg, Førsund, and Jansen, 1991), and Turkey (1992, Zaim, 1995). However, in case of U.S., there is evidence that deregulation did not change efficiency (Elyasiani, Mehdian, 1995). Market structure and market concentration are subjects of the antitrust policy. A positive relationship between market concentration and profitability might be explained in two ways. First explanation is that it might be due to the fact that firm which has market power can charge high prices. Demsetz (1973) pointed out another possible explanation. He linked high profitability with concentration through efficiency. He suggested that efficient firms have more competing power and thus, gain dominant market shares and obtained empirical support for this hypothesis. The further investigating of the link between market power and efficiency is still possible.

Concerning the second strand of efficiency studies, namely managerial performance, in principle, any efficiency study can be used to evaluate managerial performance, as long as there is information on the characteristics of the relatively efficient and inefficient firms. Management practices or characteristics that are found to be relatively common in "best-practice" firms may be called "best practices" and may be considered as desirable or even implemented as compulsory by the regulators. It is also important to identify and try to avoid the "worst practices" which are common among relatively inefficient institutions. However, it would obviously interesting to reveal the particular determinants of firm efficiency. Unfortunately, this is often impossible because of lack of detailed data (since it is confidential). One of the exceptions is the work by Fried, Lovell, and Vanden Eeckaut (1993) on the performance of credit unions in U.S. The incorporation of price and service variety components into the output results in more accurate benchmarking of the credit unions. Fried et al. have found that credit unions were capable to increase services by 12% with no increase in recourses and that there was more room for improvement in quality dimension than in the price and variety dimensions.

A large part of the literature in efficiency analysis has been focused on measurement issues. The primary information about the idea of the frontier methods can be derived from the paper by Farrell (1957). After many frontier efficiency methods being introduced[3], the further studies cover the questions like the comparability of efficiency estimates derived from different methods (Bauer et al. 1998), the sensitivity of the results to the breaking or changing the distribution assumptions. The possible causes of the differences in the efficient estimates of the financial institutions are stemming from (1) differences in the efficiency concept used; (2) differences in the measurement methods used within the concepts; and (3) potential determinants of the efficiency – characteristics of the institution and its operating environment.

Even though the literature on the comparison of efficiency frontier techniques is vast, there is no final conclusion about which technique or which model within the technique is preferable. Bauer et al. (1998) conclude that whenever efficiency measure is going to be used for decision making, it should be double-checked by applying more than one approach. All efficiency frontier techniques are divided into two large groups: parametric and nonparametric. Some researchers employ one of parametric and one of nonparametric methods (Eisenbeis et al., 1999); others have preferences towards either parametric or nonparametric technique (Berger and DeYoung, 1997, Berg et al., 1992, Grabowski et al., 1993). Most of these issues are discussed in the next chapter when the choice of methodology is substantiated.

Most of the available papers are based on U.S. banking data. This is partly because there is large number of banks in U.S.; and the large number of observations is very desirable for all efficiency methods to be able to rely on the asymptotic properties of the estimators. As Berger and Humphrey (1997) note in their survey of efficiency studies, the average technical efficiency of U.S. banks by nonparametric technique varies from 0.31 to 0.97 (with the mean of 0.72 and std.

[3] For the origins of the data envelopment analysis, method used in this paper, see Charnes, Cooper, and Rhodes (1978).

dev. of 0.17); and for parametric techniques the range is from 0.61 to 0.95 (with the mean of 0.84 and std. dev. of 0.06). So, on average, parametric techniques give higher efficiency scores with lower standard deviation. However, this result is not always confirmed. For example, Eisenbeis et al. (1999) find efficiency scores derived from the parametric model to be higher than from nonparametric technique.

The literature on transition economies is not that vast. Yildirim and Philippatos (2001) examine cost and profit efficiencies for twelve transition economies of Central and Eastern Europe (Ukraine is not included) employing two different parametric techniques. For instance, for Russian Federation, the cost efficiency score derived from the stochastic frontier approach equals 0.695 which is lower than the cost efficiency derived from the same method for U.S. banks (0.868) (Berger and Mester, 1997).

The paper by Mertens and Urga (2001) evaluates efficiency of the Ukrainian banking sector in the 1998, the year when the financial crisis led to great banking sector losses. The authors use two parametric techniques to estimate cost and profit efficiencies. They find cost efficiency to equal on average 0.74, and profit – 0.69. The other findings include: large banks are less efficient in terms of cost but more efficient in terms of profit (due to monopoly power) than small and medium banks; there is observed economies of scale for the whole sample and diseconomies of scale for the largest banks.

All efficiency techniques are naturally based on a number of assumptions. The main assumptions in the parametric techniques concern the functional form of the frontier and the structure of the error term. There are a number of studies that try to relax or change assumptions and investigate whether the results are sensitive to the changes. The common assumption that is very controversial is that the inefficiency error term has a half-normal distribution, which means that the inefficiency can only add to the costs of a firm and cannot subtract. However, other distributions, such as truncated normal, exponential, gamma, or even uniform can also be applied. Another possible problem arises from the assumption of homoscedasticity of both random and inefficiency terms. The problem is that the inefficiency measures are derived from the errors of the estimated frontier model, and the errors may be sensitive to the homoscedasticity assumption. Caudill et al. (1995) finds that not accounting for heteroscedasticity in the inefficiency term can lead to incorrect efficiency estimates. As the authors state, if in large firms' profits and costs are more volatile than in small firms, then small firms will turn out to be less efficient. Hadri (1999) goes further and checks the assumption of the homoscedasticity of the random error. He finds that accounting for heteroscedasticity in the random error term also may also change the results.

Many researchers use a so-called two-step procedure (Berger and Mester, 1997, Fried et al., 1993, Yildirim and Philippatos, 2002). In the first step, the efficiency estimates are derived, in the second step; the efficiency estimates are regressed on a number of the possible determinants of the efficiency. The R^2 of such regressions is usually very low -- from 7% to 35% in different studies. This approach is not correct. Grosskopf (1996) identifies several shortcomings of this procedure. First, if independent variables which are included in the second step are expected to affect efficiency scores they obviously should have been included in the original model. Second, if the variables which were specified in the original model are correlated with those that are specified in the second step, then the obtained regression coefficient will be both biased and inconsistent. Third, there is intrinsic contradiction: in the original model researcher makes an assumption on the distribution of the inefficiency term (often half-normal) and in the second step s/he tries to explain the *half-normally distributed* inefficiency with the help of some other variables. Even though, this fact is well known, it is still employed in some recent studies (Mertens and Urga, 2001). The usual regressors of the efficiency are asset size, level of capitalization, geographic region, organizational form, and ownership.

To conclude, even though, the efficiency literature is very vast; the frontier approach has seldom been applied to the transition economies, which is partly explained by the unavailability of the detailed data in these economies. So, this area is not investigated and it obviously has a practical implication as it has already been discussed in the introduction.

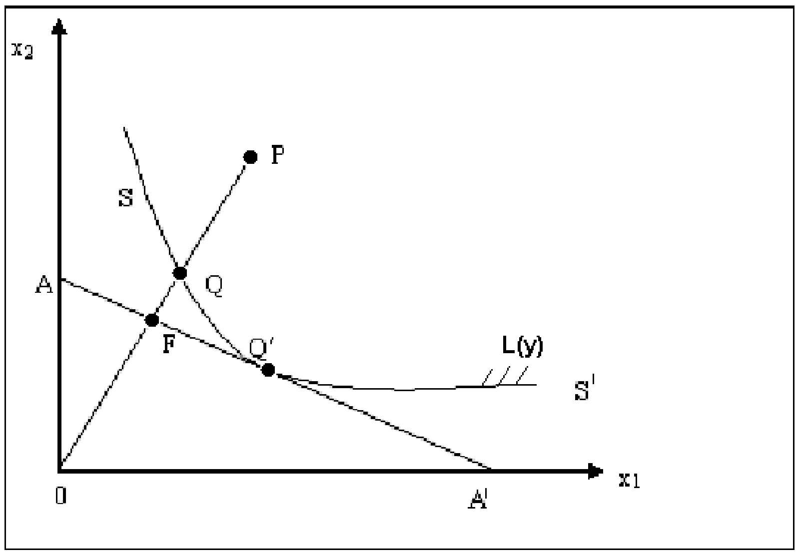
Chapter 2

MODEL SPECIFICATION

Frontier efficiency score shows deviations in performance from the "best-practice" decision making units (firms within an industry or branches within a firm) on the efficient frontier, holding constant exogenous market factors. The efficiency measure shows how successful the firm is in producing as much as possible outputs from a given set of inputs (output-orientated efficiency) or in using as little as possible inputs given a set of produced outputs (input-orientated efficiency). The choice between input and output orientation depends on the industry specifics and on the data availability. Following many other studies (Bauer et al., 1998, Eisenbeis et al., 1999, Berger and DeYoung, 1997), we are going to employ the input-orientated measure. One of the reasons for it is that in banking sector outputs are not completely variable, and in reality, a bank cannot achieve any output scale, at least in the short run. The following Figure 1 shows the input-orientated efficiency measure. The intuition for the output orientation is the same. For simplicity we will consider a firm that uses two inputs x_1 and x_2 to produce an output (possibly vector) y. The input-orientated efficiency measure shows how much inputs can be saved producing the same output. On the graph you can see an input requirement set which shows the combination of inputs needed to produce an output vector y. This is equivalent to graphing the usual technology function in input-output coordinates. So, we may look at this set as the representation of technology. Efficiency measure shows how a firm is doing relative to the benchmark. This benchmark is called the best-practice frontier. The best-practice frontier may be expressed in three equivalent ways. First, as a technology function in (x, y), where x and y can be vectors,—it shows all combinations of x and y that are technically achievable. Second, as an input isoquant – a boundary of the input requirement set L(y)-- that shows all combinations of inputs that can be used to produce the same output vector y. And third, as an output isoquant—upper boundary of the output set--that shows all combinations of outputs that can be achieved with the same input vector. SS' is an input isoquant. It represents the technology used by the best firms – they use minimum of inputs. 0Q/0P is the measure of technical efficiency for the firm observed at point P. So, at P, bank is not technically efficient. The corresponding technical efficient point is Q. If we have data on input prices, we can construct a ratio of input prices AA'. Although point Q is technically efficient, it is not allocatively efficient, because point Q' is less expensive. The allocative inefficiency comes from the incorrect proportions of the inputs used regarding on their prices. A bank can lower its costs by 0F/0Q by moving from Q to Q'. The measure of the allocative efficiency is 0F/0Q. Total efficiency is a product of the allocative and technical efficiency, so it equals 0F/0P. The pure technical efficiency scores obviously do not include allocative inefficiencies. However, in the case of Ukraine and other transition countries, the technical efficiency tend to be more precise in ranking the banks and evaluating the situation in the industry than the overall efficiency scores due to the fact that the input prices are often unreliable. Most notably, reported figures of salary and wage expenses often misrepresent the real expenses on labor, because salaries are often paid in a hidden way, for example, through opening deposit accounts for the employees. This is done mainly to avoid tax payments and to conceive the extremely high salaries to the top management especially if the bank suffers liquidity or other problems. Thus, for Ukraine, technical efficiency seems to be more credible than overall efficiency[4].

[4] The overall efficiency scores obtained from the available data are unreasonably low at the account of great allocative inefficiency, which indicates the input price measurement error.

Figure 1
Technical and allocative input-orientated efficiency measures



In the above discussion we assumed that efficient production function (represented by the isoquant SS′ in the figure) is known. However, determining this function is the main challenge of all frontier methods. There are two main approaches to determining this best-practice frontier which serves as a benchmark against which relative efficiencies are estimated. One of them is to assume a specific functional form for the best technology (called a parametric approach). Another is to construct the best-practice frontier basing on the best results observed in practice.

There is no consensus among researches on the preferred method for determining the best-practice frontier. If we go in more technical details, frontier methods differ in the assumptions imposed on data. Assumptions concern:

i. functional form of the best-practice frontier (a more restrictive parametric functional form versus a less restrictive nonparametric form)

ii. whether or not random error is allowed (it may temporarily give some firm high or low outputs, inputs, costs, or profits);

iii. if random error is allowed, which probability distribution do inefficiencies have (half-normal, truncated normal or others).

Thus, the assumptions specify how much shape is imposed on the frontier and distribution of inefficiencies, if random error is allowed.

The choice of methodology is basically the choice between parametric and nonparametric techniques. The two techniques use different methods to estimate the efficient frontier. Parametric methods approximate technology by some function – often, translog, sometimes more flexible (Fourier). This leads to many arbitrary assumptions: the functional form of the frontier itself, the distribution of the inefficiency term and the distribution of the random term[5]. Notably, the scores may differ at least slightly depending on the distributional assumptions. Efficiency scores differ if we relax the assumption on the homogeneity of inefficiency and/or random term (Hadri, 1999, Caudill et al., 1995). The nonparametric approaches, such as data envelopment analysis (DEA) and free disposal hull method, have the following advantages. (1) They do not require specification of the functional form of the frontier; and (2) they do not require any assumptions concerning the form of the distribution of the inefficiencies. Moreover, as Farrell (1957) notes, it is very difficult to work out a theoretical production function for any relatively complex production process, so nonparametric frontier is more desirable in describing complex production processes. And finally, judging from the psychological point of view, it is "better

[5] Unless panel data is used.

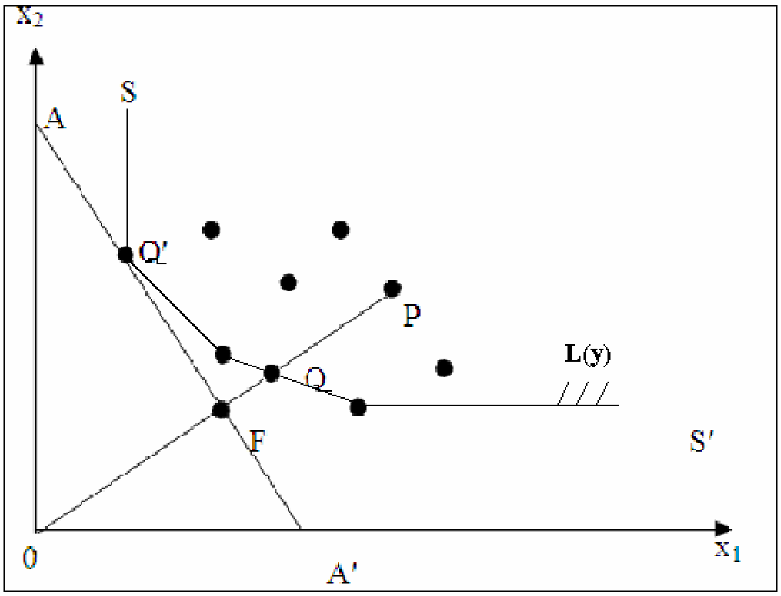
to compare performances with the best actually achieved than with the unattainable ideal" (Farrell, 1957).

The key drawback of the nonparametric techniques is that they generally do not allow for random error, although stochasticity can be introduced with the help of the bootstrapping procedure. Thus, there is assumed to be no measurement error in constructing frontier, no luck that can temporarily give one firm better performance, and no inaccuracies in measuring inputs and outputs due to difference between accounting and economic values. The presence of one or more of these errors will alter the efficiency measure of the firm and which is more important may alter the efficiency measure of all the firms if the error has occurred in the unit that is on the frontier. This leads to the fact that all the nonparametric efficiency methods on average give lower efficiency scores than parametric methods, although exceptions are possible. Banking industry seems to minimize the drawback of the nonparametric methods since accounting data is usually very precise by definition, since errors may lead to serious punishments from the NBU[6].

The method used within this paper is data envelopment analysis (DEA). DEA is a linear programming technique where the best-practice frontier is estimated as smallest convex disposal hull that fits all the observations of the inputs and outputs in the sample. The input isoquant looks as it is shown in Figure 2.

[6] Except for the labor expenses discussed above.

Figure 2
Nonparametric efficiency frontier



Formally, for the case of constant returns to scale technology and strong disposability of inputs and outputs, the input isoquant is defined as a boundary of the input requirement set L(y), defined as

$$
\begin{aligned}
& L(y/C,S)=\{(x_1,\ldots,x_N): \\
& \sum_{k=1}^{K} z_k y_{kn} \geq y_m, m=1,\ldots,M, \\
& \sum_{k=1}^{K} z_k x_{kn} \leq x_n, n=1,\ldots,N, \\
& z_k \geq 0, k=1,\ldots,K\}
\end{aligned}
\qquad (1)
$$

Where $(x_1,\ldots,x_N)$ is a vector of inputs, $(y_1,\ldots,y_M)$ is a vector of outputs, and $(z_1,\ldots,z_K)$ is a vector of intensity variables used in construction of the best technology.

The so called input-orientated Farrell (1957) measure of technical efficiency of every banking firm i (i=1,…,K) is obtained from solving the linear programming problem:

$$\min_{\lambda, z} \lambda$$
$$s.t.$$
$$\sum_{k=1}^{K} z_k x_k \leq \lambda x_i \ , \qquad (2)$$
$$\sum_{k=1}^{K} z_k y_k \geq y_i ,$$
$$z_k \geq 0, k = 1,..., K$$

Even though DEA approach does not impose distributional assumptions on the frontier function, it still needs several other assumptions. We need to decide if weak or strong disposability of inputs and outputs is relevant. Equality sign near inputs: $\sum_{k=1}^{K} z_k x_k = \lambda x_i$ would reflect weak disposability of inputs which means that inputs can cause congestion – too many of input leads to decrease in production. This is clearly not the case for banks where increase in inputs definitely cannot reduce outputs. It is also necessary to decide on the returns to scale assumption. Constant returns to scale do not impose restrictions on $\sum_k z_k$. Variable returns to scale (VRS) correspond to the restriction $\sum_k z_k = 1$ added to (1) and (2). The advantage of the VRS is that it is less sensitive to misspecification. VRS seem to be a very natural assumption for the banking sector since banks usually have some scale economies. Big banks tend to have more big loans and deposits, thus, the costs for checking the financial position of the clients are less than in the small banks which have to deal with small clients. However, VRS assumption has a disadvantage when the sample is rather thin in either large or small banks. The banks may appear efficient only because there are no or very few banks of the same size to compare with. CRS allows comparing large banks with much smaller, thus, preventing them from being alleged efficient because of lack of comparable in size banks (see also Berg et al., 1993). We would stick with the CRS, and the obtained efficiency scores will possibly be lower than under VRS. As far as we need high scores for supporting the hypothesis of competitiveness and do not want to consider banks efficient by mistake, using CRS will add more robustness to the obtained results.

The next step after determining the efficiency method is to determine the inputs and outputs of the model. There have been two approaches concerning what to consider banking inputs and outputs. Neither is perfect since neither fully captures the dual roles of financial institutions. From the production approach the bank's purpose is to provide transactions and document processing services. So, inputs are only physical -- labor and capital and their costs, outputs are number of deposit or loan accounts serviced. From the intermediation approach bank is an intermediary between the savers and investors. So, inputs include also the input of funds and their interest costs, outputs are usually amounts of loans and deposits. The intermediation approach is much more common in recent literature. However, the inputs and outputs vary even within this approach due to institutions specifics or non-availability of data. There are especially many ways of accounting deposits. Deposits have both input and output characteristics. As Berger and Humphrey (1997) mention, deposits can be considered inputs because they are paid for with interest payments and the funds raised provide the bank with raw material of ingestible funds. However, deposits are also associated with liquidity and payment services provided to depositor. The survey of the literature shows that including deposits as an output gives somewhat higher efficiency scores than specifying deposits as inputs. This does not spoil the results when the interest is focused on the ranking of the banks. The intermediation approach was first developed by Sealey and Lindley (1977) for modelling production in a financial firm. They argue that not all technical outputs of a bank (such as total assets, total deposits, number of deposit and loan accounts, operating income) are also economic outputs. Sealey and Lindley develop an appropriate classification of banking inputs and outputs, according to which all earning assets should be considered as outputs, whereas loanable funds, capital, labor and fixed assets are considered to be inputs. Loanable funds (deposits) are an intermediate output, i.e. they are produced through other operational activity of the bank. We will go with Sealey and Lindley in identifying inputs and outputs.

Chapter 3

DATA DESCRIPTION

By the end of the 2002, there were 158 commercial banks in Ukraine. The data set consists of 148 banks which constitutes practically the entire banking sector of Ukraine. The balance sheet data is available at one period (01.10.2002), so the cross-sectional model is used.

In accordance with the intermediation approach, all earning assets should be classified as outputs, and physical capital, financial capital, and labor should be inputs. Given the balance sheet at 01.10.2002, the commercial banks have three major types of financial assets: loan portfolio, current assets, and securities. Strictly speaking, current assets are non-earning assets. However, the quantity of current assets which the bank holds reflects management position towards risk. The more current assets the bank has, the higher its liquidity indices are, and thus, the bank is less likely to be unable to pay its liabilities (for example, pay out demand deposits). If current assets are not included, a bank might be penalized for being too risk-averse. As far as liquidity indices are most often violated in Ukraine, we would include current assets into the model. Many researchers do not stick to the strict definition of the intermediation approach. Berger and Mester (1997) include all financial assets into outputs, i.e., current assets are included. Many researchers include demand deposits as outputs (Berger and DeYoung, 1997, Bauer et al., 1998 and others), so, this specification will also be tried. The inputs include labor, physical capital, and borrowed money. Borrowed money is composed of time deposits, loans from other banks, and budget funds. As far as the number of employees is unavailable, it is approximated by the amount of total assets. This is rather standard proxy since the number of full-time equivalent employees is very often not reported and thus, is unavailable in many other papers. Table 1 gives descriptive statistics for the variables used.

Table 1
Descriptive statistics for the banks included in the sample

thousand UAH	Average	Min	Max	Std deviation
Assets	413 050	130	6 856 820	100 364
loans	279 469	4 992	4 839 067	652 072
Securities	30 020	0	1 175 829	124 528
Current assets	63 501	89	1 338 949	156 143
Demand deposits	116 947	133	2 776 084	377 817
Physical capital	29 675	219	508 668	79 128
Financial capital	172 031	81	3 009 125	399 114

Ukrainian banks are relatively heterogeneous in terms of assets size. Among the largest are the two state-owned banks (Oschadbank and Ukreximbank), former state-owned banks (Prominvestbank) and newly emerged but very rapidly evolving giants (Aval and Privatbank). There are several large banks and some medium which have significant volumes of securities in their portfolios, whereas most of the small banks practically do not work with securities.

Chapter 4

EMPIRICAL RESULTS

The software used for the estimation of the frontiers and obtaining individual efficiencies is OnFront Version 2.1 and DEAP Version 2.1.

In order to check the scores for robustness, several models are estimated. The model which includes demand deposits as an output gives slightly higher scores than the classical model without deposits. Thus, our conclusions will be stronger if we use the model without deposits in our analysis. Besides estimating several models, Bauer et al. (1998) developed several other "consistency conditions" for checking obtained efficiency scores. Particularly, they also advice to compare efficiency measures with standard non-frontier measures. Some of the standard measures is rate of return on assets (ROA) which is computed as the ratio of the net income to the total assets, the negative of the total operating and interests cost per dollar of assets (-TC/TA), and the negative of total cost per dollar of revenue (-TC/TR). The DEA frontier scores are consistent with the standard performance measures.

Table 2
Spearman rank-order correlations with standard measures

	ROA	-TC/TA	-TC/TR
DEA with deposits	0.197*	0.149**	0.225*
DEA without deposits	0.198*	0.217*	0.235*

* Reject H_0: no association between rank pairs in favor of H_1: the correlation between the rank pairs is positive at 1% level of significance.
** Reject H_0: no association between rank pairs in favor of H_1: the correlation between the rank pairs is positive at 5% level of significance.

The statistically significant Spearman rank-order correlations can be viewed as an evidence of the robustness of the estimated efficiency scores. The model without deposits gives slightly higher correlation coefficients. The results do not contradict to previous studies: Bauer (1998) found DEA estimates to be much less consistent with the correlation coefficient of 0.053, and stochastic frontier methods gave him higher correlations of 0.207 on average. The fact that the correlations are rather low stresses the point that efficiency measures introduce some new information and are not just a perfect substitute for the standard measures. The robustness of the results is also demonstrated by deleting banks on the frontier, reestimating efficiency scores and correlating the new efficiency ranking with the ranking prior to deleting any observations. The Spearman rank order correlation coefficient is 0.824 (significantly different from zero at 1% level of significance) which attests to robustness.

To perform a more detailed analysis of the distribution of efficiency values among banks, all banks are divided into three groups according to the NBU methodology. The main criterion is asset size, however, other criteria, such as equity capital size, are taken into account for the banks which have asset size close to the marginal for the group. The first group (large banks) contains 8 banks (5.4 % of the sample) with the asset size more than 1 700 mln UAH[7]. 46 banks (31.1 %) with the assets of more than 200 mln UAH belong to the second group (medium banks). And the third group (small banks) contains 94 commercial banks (53.5 %). Efficiency scores are presented in the Table 3.

[7] The exception is made for Reiffiezenbank Ukraine which has 1 300 mln UAH of assets but also belongs to the first group.

Table 3
Technical efficiency of Ukrainian banks

	Mean technical efficiency	Standard deviation	Min	Max
All sample (148 banks)	0.896	0.11	0.39	1.00
Large (8 banks)	0.901	0.05	0.82	1.00
Medium (46 banks)	0.913	0.07	0.73	1.00
Small (94 banks)	0.887	0.12	0.39	1.00

The obtained results imply that banks on average have very high efficiency scores. The interval formed by the mean plus and minus one standard deviation covers efficiency values from 0.79 to 1.01 and captures 91% of the observations. 23 banks (16%) have unit scores of technical efficiency.

Pastor, Perez, and Quesada (1994) in a cross-country study find the average DEA-based technical efficiency for the 8 developed countries to be 0.86, ranging from 0.55 (U.K.) to 0.95 (France). The authors pooled cross-section data to estimate a common frontier. The result for Ukraine is also quite comparable to the country-specific technical efficiency scores obtained from DEA approach: 0.86 for Finland, 0.81 for Norway, 0.77—0.96 for U.S. (Berger and Humphrey, 1997). However, we cannot make a conclusion that Ukrainian banks can compete with the banks in developed countries, because in each case the efficiency scores are determined relative to the country-specific technology frontiers. Nevertheless, we can conclude that the distance of the Ukrainian banks away from the best-practice frontier is close to that in developed countries. It may imply that Ukrainian banks face not less and probably even more competition than banks in western countries.

In order to evaluate the impact of the policy measures of the NBU during 2001--2002, it would be interesting to compare the average efficiency for 2002 with that for the previous years. Mertens and Urga (2001) have found cost efficiency scores for Ukrainian banks in the 1998 equal to 0.63 if derived from stochastic frontier approach and to 0.84 if thick frontier approach is employed. It is worth noting that 1998 was a year of great economic instability. Financial crisis that occurred in August 1998 in the Russian Federation combined with internal problems and vulnerability of the Ukrainian economy caused hryvna devaluation. In order to avoid default on internal debt, Ukrainian government postponed the maturity date for the government obligations. Together with the increase in reserve requirements, and increase in the refinancing rate of the NBU, this caused serious liquidity problems for most commercial banks. As a result, commercial banks lost approximately 30% of their capital by the estimation of the Association of the Ukrainian banks. As a result, we may suspect that many banks might have not been able to demonstrate high technical efficiency under such unfavorable conditions. However, strict comparison of the efficiency levels for 1998 and 2002 seems to be problematic since the increase in efficiency scores may reflect difference in methodology[8] as well as real increase in the efficiency of the banking sector in 2002 comparing to 1998.

It is seen from the Table 3, medium banks have a slightly higher average efficiency scores than all other groups of banks. However, the difference between the means is statistically insignificant[9]. One of the ways of visual comparison of the distributions of the efficiencies for different subgroups is to look at density functions obtained with the help of kernel density estimator (Appendix 2), which is, intuitively, a "smooth" histogram method. The large and medium banks are

[8] Cost efficiency is a product of allocative and technical efficiency scores all of which range from zero to one. In the presence of allocative inefficiency which is usually the case, cost efficiency scores will be lower than pure technical efficiency scores.

[9] See appendices 4 and 5 for the description of the tests and the E-Views outputs for the tests.

pooled into one group because the number of large banks is insufficient for plotting kernel estimated density function.

As far as visual inspection is not convincing, we employ testing procedures. Grosskopf (1996) recommends using Wilcoxon and Van der Waerden nonparametric statistical tests for testing the hypothesis that the subgroups have the same general distribution against the alternative that at least one subgroup has a different distribution. When comparing large, medium, and small banks, we use Kruskal -Wallis test which is the generalization of the Wilcoxon test for more than two groups. Both of the recommended tests indicate that the H_0 of equality of distributions cannot be rejected. However, Brown-Forsythe and Levene tests on equality of variances give a different result: we can reject zero hypothesis of equality at 5% level of significance. Small banks have higher variance than all other banks. This implies that the most inefficient banks and as a result, possibly, the first candidates for bankrupts are most likely to be found among the small banks. This is supported by the real life evidence: 24 out of the 28 banks that were officially declared "in the state of liquidation" at 01.09.02 were very small.

Another dimension to look at banks is to look at the region of their location. The most developed region of Ukraine judging from the level of monetary relations[10] is naturally Kyiv region with the index equal to 0.161, whereas the average for Ukraine is 0.519. So, it is not surprising that 80 out of 148 banks have their head offices located in Kyiv. Of course, some banks have branch offices all over Ukraine. Even though Table 3 shows that banks located in Kyiv have slightly higher mean efficiency and slightly higher median value of efficiency than banks located in all other regions of Ukraine, the differences are insignificant at 20%).

[10] The index is composed of three components: money resources on banking accounts, volume of sales except for barter agreements in money terms, accounts payables.

The impact of the form of ownership on the efficiency scores is also a question of interest. World Bank in the report at May 7th, 2003, stresses that "continued state ownership of banking sector has big economic costs for banking sector for transition countries". This is not entirely the case of Ukraine, since there are only two state-owned banks here: Oschadbank (savings bank) and Ukreximbank (exports-imports bank). Both of them belong to the group of the large banks and own 12% of the total assets of the banking sector. Their ranks in our study are quite low: 100 and 129[11] respectively, which goes in line with what the World Bank suggests. Other banks have the following ownership structure: 93 banks are open joint-stock companies, and 55 are closed joint-stock companies. The kernel estimated density functions can be seen in the Appendix 3. The means as well as the medians for both subgroups are different at 10% level[12]. One of the possible explanations of the higher technical efficiency scores for the closed joint-stock companies is that in the closed joint-stock banks, the shareholders (who are mainly employees and managers) have more direct ways of influence on the bank's performance. Only one out of four tests rejects equality of variances at 5% level. The summary statistics for the region and ownership subgroups is presented in the Table 4.

11 Banks with the same efficiency scores obtain the same rank. Thus, several banks might have the same rank.

12 Five out of seven tests for median equality reject H_0 of equality. The recommended Wilcoxon and Van der Waerden tests are among those which reject equality.

Table 4
Descriptive statistics of the efficiency scores by groups

	Kyiv	Non-Kyiv	Open joint-stock companies	Closed joint-stock companies
Mean	0.915	0.891	0.885	0.915
Median	0.900	0.910	0.910	0.920
Standard deviation	0.111	0.098	0.113	0.087

The next step is to examine whether the banks are scale efficient and if no, what is the source of the scale inefficiency. The scale efficiency estimate is defined as a ratio of the efficiency estimate assuming CRS to the efficiency estimate assuming variable returns to scale (VRS). The scale efficiencies are given in the Table 5.

Table 5
Scale efficiencies and the sources of inefficiency

	Mean scale efficiency	Standard deviation	Scale efficient	Scale inefficient because of	
				IRS*	DRS**
All sample (148 banks)	0.972	0.06	23%	22%	55%
Large (8 banks)	0.905	0.05	12%	0%	88%
Medium (46 banks)	0.973	0.03	15%	2%	83%
Small (94 banks)	0.968	0.07	27%	34%	39%

* IRS = increasing returns to scale
**DRS=decreasing returns to scale

The table shows that 22% of the banks in the sample are scale efficient, 55% of the banks are scale inefficient because of DRS, and 22% of the sample are scale inefficient because they do not exploit IRS. So, most of the banks in the banking industry suffer from DRS even though the largest bank in Ukraine (Aval) with 6 857 mln UAH of the asset size is hardly compared to the average bank in Germany. The scale inefficiency is, however, very small, especially for medium and small banks.

The technical and scale efficiency scores add to revealing the "big picture" of the financial sector in Ukraine. Decreasing returns to scale should possibly indicate that the demand for banking services is too low for large banks. Large banks cannot count on the accordingly large clients. There are too few really big firms which need services of the big banks. These results go in accordance with reality. As far as banks are intermediaries between economy counteragents, the demand for the banking services reflects the overall level of the monetary relations in the country which occurs to be very low comparing to that of the developed countries. For instance, the share of consumer deposits in the banks' liabilities constitutes 35%, whereas in the developed countries this share is more than 50%. So, banks have to buy resources from the NBU[13] or other banks which increases the interest rate on the loans. Even though NBU consistently lowers the refinancing rate, banks are usually not encouraged to use NBU as "last resort" very often. It should be noted, that barter agreements are still present in the economy. The result is that enterprises need less money to go on with their activities. Securities on average constitute only 7% in total assets which indicates that the market for securities is underdeveloped. Small banks practically do not work with securities. However, the positive tendencies are being observed. During 2002, the share of consumer deposits has increased by 30%, the share of time deposits in the borrowed funds has also increased. So, the banks widen their resources; however the main source remains to be own capital and short-term or

[13] The average interest rate on deposits is 5% for businesses and 8% for consumers (January 2003). NBU rate is 7% since December 4th, 2002.

demand deposits (Herald of the National Bank of Ukraine, March 2003). Even though, the interest rate on loans has decreased significantly. The share of the trade loans in the loan portfolio decreased in favor of loans to productive enterprises (Herald of the National Bank of Ukraine, November 2002). If these tendencies would persist, the bank services would be more and more demanded. As far as banks are only slightly scale inefficient, it is possible that future development of the economic activity would soon allow banks to be able to improve scale economies.

High technical efficiency scores support the hypothesis of high level of competition in Ukrainian banking sector. This result is also buttressed up by some facts. First, legal barriers to entry at the market of banking services mainly concern the size of the statutory capital. Second, there are no restrictions on branching[14] in banking. And third, banks in Ukraine face competition from the side of banks with foreign capital[15].

[14] At 01.01.2003 there were 1 401 bank branches in Ukraine.

[15] At the beginning of the 2003, there are 20 banks (12.7% of the total quantity of banks in Ukraine) with foreign capital. 7 of them have 100% foreign capital.

Chapter 5

CONCLUSIONS AND DIRECTIONS FOR FURTHER RESEARCH

On the overall, banking sector in Ukraine appears to be very close to be technically and scale efficient. The average technical efficiency score of 0.896 is a little higher than in most developed countries[16] (see survey by Berger and Humphrey, 1997). However, this does not indicate that Ukrainian banks can successfully compete with western banks. In every country efficiencies are estimated relative to that country specific frontier. As far as best-practice frontiers can differ, cross-country comparisons are problematic. However, the comparison can be made in terms of competition in banking sector in Ukraine and in other countries. The obtained result for Ukraine indicates that competition among Ukrainian banks might be even tougher than in many developed countries.

Moreover, even though commercial banks in Ukraine differ in such parameters as size, location of the head office, and ownership, there are only slight, and in most cases statistically insignificant, differences in efficiency distributions for different subgroups of banks. Thus, commercial banks are not only close to efficient but also highly homogeneous which is an indication that banking is a competitive industry.

Competitiveness is an issue of particular importance for the countries which intend to enter European Union or other highly harmonized financial market. In order to see how Ukrainian banks perform relative to the banks of other

[16] Only technical efficiencies derived from DEA are compared in order to make efficiencies as comparable as possible.

countries (for instance, Poland which is gong to enter EU soon) it would be valuable to pool the data for the countries in question and estimate a common frontier. Of course, countries differ in regulatory and economic environment as well as quality of banking services which may not be reflected when common frontier is estimated. However, the obtained efficiency scores will still reflect the competitiveness of Ukrainian banks in the common financial market. It should be mentioned that in our study most of the banks with 100% foreign capital obtained a unit technical and scale efficiency scores. Thus, in our sample they define the best-practice technology frontier.

Another direction of further investigation requires panel data for several years. It would make possible to estimate the Malmquist productivity index and decompose it into¸ for example, the change in efficiency and the change in technology. If we obtain the data for the next or previous several years, we would see which component is the main determinant for the productivity change of the banking sector. As it is seen from the current paper, the resources of the improvement in productivity at the account of technical efficiency are almost exhausted. Thus, the further improvement is more possible if the new technology is being adopted. It is also quite possible that components of the Malmquist productivity index move in opposite directions. For instance, improvement in technology may go in line with the decrease in efficient use of technology, since only the most progressive and probably large or medium banks can quickly adopt technological improvements whereas small banks will become more inefficient relative to the new best-practice frontier.

Thus, future research may concern either comparison of Ukraine with other countries or possibilities for the Ukrainian banks to be represented in other countries (Poland, or Russia to start with) or further investigating of the resources of the development of the banking sector within Ukraine.

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APPENDIX 1

Estimation Output: Technical and scale efficiency scores

Bank	Technical efficiency (constant returns to scale)	Technical efficiency (variable returns to scale)	Scale efficiency
"АВАЛЬ"	0.95	1	0.95
ПРИВАТБАНК	0.87	1	0.87
ПРОМІНВЕСТБАНК	0.91	1	0.91
ОЩАДБАНК	0.87	1	0.87
УКРЕКСІМБАНК	0.82	1	0.82
УКРСОЦБАНК	0.89	0.98	0.908163
УКРСИББАНК	0.9	0.98	0.918367
РАЙФФАЙЗЕНБАНК УКРАЇНА	1	1	1
"НАДРА"	0.94	1	0.94
ПЕРШИЙ УКР.МІЖНАРОДНИЙ БАНК	0.86	0.99	0.868687
БРОКБІЗНЕСБАНК	0.86	0.92	0.934783
ПРАВЕКС-БАНК	0.87	0.92	0.945652
КРЕДИТПРОМБАНК	0.98	1	0.98
"ПІВДЕННИЙ"	0.96	1	0.96
КРЕДИТ БАНК (УКРАЇНА)	0.87	0.89	0.977528
"ФІНАНСИ ТА КРЕДИТ"	0.83	0.86	0.965116
СІТІБАНК (УКРАЇНА)	0.97	1	0.97
"КРЕДИТ-ДНІПРО"	0.93	1	0.93
УКРАЇНСЬКИЙ КРЕДИТНИЙ БАНК	0.91	0.91	1
ВАБАНК	0.9	0.91	0.989011
ІНГ БАНК УКРАЇНА	1	1	1
"ФОРУМ"	0.97	0.98	0.989796
УКРГАЗБАНК	0.87	0.87	1
ДОНГОРБАНК	0.89	0.92	0.967391
МТ-БАНК	0.89	1	0.89
"МРІЯ"	0.95	0.96	0.989583
МОРСЬКИЙ ТРАНСПОРТНИЙ БАНК	0.94	0.94	1
"БІГ ЕНЕРГІЯ"	0.91	0.93	0.978495
УКРІНБАНК	0.85	0.85	1

Bank	Technical efficiency (constant returns to scale)	Technical efficiency (variable returns to scale)	Scale efficiency
БАНК КРЕДІ ЛІОНЕ УКРАЇНА	1	1	1
ХФБ БАНК УКРАЇНА	1	1	1
"ХРЕЩАТИК"	0.98	0.98	1
ЕКСПРЕС-БАНК	0.9	1	0.9
"КИЇВ"	0.86	0.86	1
ІНДУСТРІАЛБАНК	1	1	1
ІНДУСТРІАЛЬНО-ЕКСПОРТНИЙ БАНК	0.9	0.9	1
АЛЬФА-БАНК	0.92	0.96	0.958333
"ДІАМАНТ"	0.99	1	0.99
МЕГАБАНК	0.89	0.89	1
УКРГАЗПРОМБАНК	1	1	1
"ДНІСТЕР"	0.91	0.91	1
ЕНЕРГОБАНК	0.75	0.76	0.986842
ПРЕМ'ЄРБАНК"	0.76	0.84	0.904762
АВТОЗАЗБАНК	0.96	1	0.96
ТАС-КОМЕРЦБАНК	0.96	0.99	0.969697
ЗАХІДІНКОМБАНК	0.94	0.94	1
"КИЇВСЬКА РУСЬ"	0.9	0.92	0.978261
ЕКСПОБАНК	0.91	0.94	0.968085
ПОЛТАВА БАНК	0.73	0.73	1
ІМЕКСБАНК	0.96	0.97	0.989691
"НОВИЙ"	0.87	0.88	0.988636
"АЖІО"	0.86	0.88	0.977273
"НАЦІОНАЛЬНИЙ КРЕДИТ"	0.98	0.98	1
ПРОМИСЛОВО-ФІНАНСОВИЙ БАНК	0.93	0.98	0.94898
"НРБ-УКРАЇНА"	1	1	1
БАНК ПЕТРОКОММЕРЦ-УКРАЇНА	0.92	0.92	1
"НАЦІОНАЛЬНІ ІНВЕСТИЦІЇ"	1	1	1
ПЕРШИЙ ІНВЕСТИЦІЙНИЙ БАНК	0.84	0.89	0.94382
УКРПРОМБАНК	0.99	0.99	1
"АРКАДА"	0.91	0.94	0.968085
ІНТЕРБАНК	0.95	0.95	1
"МЕТАЛУРГ"	0.97	1	0.97
"АЛЛОНЖ"	0.9	0.91	0.989011
ОБ'ЄДНАНИЙ КОМЕРЦІЙНИЙ БАНК	0.76	0.76	1
РЕАЛ БАНК	1	1	1

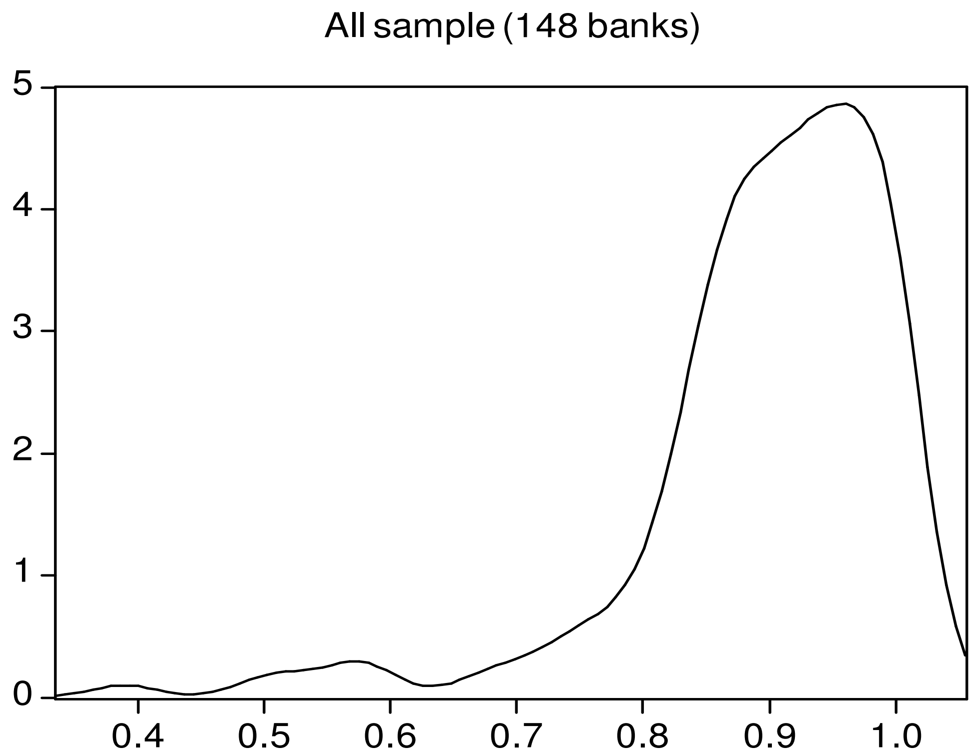
Bank	Technical efficiency (constant returns to scale)	Technical efficiency (variable returns to scale)	Scale efficiency
ФАКТОРІАЛ-БАНК	0.72	0.74	0.972973
"ЗОЛОТІ ВОРОТА"	0.96	0.96	1
"КЛІРИНГОВИЙ ДІМ"	0.97	0.97	1
ЛЕГБАНК	0.94	0.94	1
УКРАЇНСЬКИЙ ПРОФЕСІЙНИЙ БАНК	0.97	0.97	1
ПРОМЕКОНОМБАНК	0.93	0.93	1
"БАЗИС"	0.81	0.82	0.987805
"ТАВРИКА"	0.91	0.93	0.978495
ЕЛЕКТРОН БАНК	0.85	0.85	1
"ДОНКРЕДИТІНВЕСТ"	1	1	1
"МУНІЦИПАЛЬНИЙ"	0.93	0.94	0.989362
БАНК РЕГІОНАЛЬНОГО РОЗВИТКУ	0.95	1	0.95
"УНІВЕРСАЛЬНИЙ"	0.94	0.97	0.969072
МІКРОФІНАНСОВИЙ БАНК	1	1	1
МІЖНАРОДНИЙ КОМЕРЦІЙНИЙ БАНК	0.87	0.87	1
УНІВЕРС.БАНК РОЗВИТКУ ТА ПАРТН.	1	1	1
"ІНТЕГРАЛ"	0.95	0.96	0.989583
"СИНТЕЗ"	1	1	1
УКРКОМУНБАНК	0.95	0.95	1
РОСТОК БАНК	0.84	0.84	1
НАШ БАНК	0.88	0.96	0.916667
БАНК ТОРГОВОГО СПІВРОБІТНИЦТВА	0.83	0.83	1
"ГРАНТ"	0.91	0.91	1
"МЕРКУРІЙ"	0.89	0.89	1
СТАРОКИЇВСЬКИЙ БАНК	0.89	0.9	0.988889
"ДОНЕЧЧИНА"	0.95	0.95	1
"ПЕРСОНАЛЬНИЙ КОМП'ЮТЕР"	0.5	0.51	0.980392
ТРАНСБАНК	0.97	0.98	0.989796
"ПРИЧОРНОМОР'Я"	0.95	0.95	1
СХІДНОЄВРОПЕЙСЬКИЙ БАНК	0.87	0.87	1
ПОЛІКОМБАНК	0.88	0.89	0.988764
ІКАР-БАНК	0.86	0.86	1
"ПРИКАРПАТТЯ"	0.69	0.69	1
ДОНБІРЖБАНК	1	1	1

Bank	Technical efficiency (constant returns to scale)	Technical efficiency (variable returns to scale)	Scale efficiency
ТАС-ІНВЕСТБАНК	1	1	1
"ТК КРЕДИТ"	0.95	0.95	1
ЗЕМЕЛЬНИЙ БАНК	1	1	1
"СТОІК"	0.52	0.52	1
"ДЕМАРК"	0.86	0.87	0.988506
"УКРАЇНСЬКИЙ КАПІТАЛ"	0.86	0.88	0.977273
УКРАЇНСЬКИЙ КРЕДИТНО-ТОРГОВИЙ БАНК	0.86	0.86	1
"КАПІТАЛ"	0.91	0.91	1
ІНТЕРКОНТИНЕНТБАНК	0.93	0.94	0.989362
"АВТОКРАЗБАНК"	0.83	0.83	1
ІННОВАЦІЙНО-ПРОМИСЛОВИЙ БАНК	0.8	0.81	0.987654
КООПІНВЕСТБАНК	0.88	0.88	1
БАНК ПЕКАО (УКРАЇНА)	0.85	0.86	0.988372
"ЗЕМЕЛЬНИЙ КАПІТАЛ"	0.96	0.97	0.989691
"ЛЬВІВ"	0.79	0.79	1
ОДЕСА-БАНК	0.93	0.94	0.989362
МІСТО-БАНК	0.95	0.96	0.989583
"МОРСЬКИЙ"	0.8	0.81	0.987654
АГРАРНИЙ КОМЕРЦІЙНИЙ БАНК	0.93	0.94	0.989362
ІНВЕСТБАНК	0.84	0.84	1
РЕГІОН БАНК	0.94	0.95	0.989474
КОМЕРЦІЙНИЙ ІНДУСТРІАЛЬНИЙ БАНК	0.84	0.85	0.988235
"ПІВДЕНКОМБАНК"	0.57	0.57	1
УКРСПЕЦІМПЕКСБАНК	0.88	1	0.88
ТЕХНОБАНК	0.85	0.86	0.988372
ДІАЛОГБАНК	0.98	1	0.98
"ПОРТО-ФРАНКО"	1	1	1
ОЛБАНК	0.9	0.91	0.989011
"СЛАВУТИЧ"	0.95	0.95	1
ЧОРН.БАНК РОЗВИТКУ ТА РЕКОНСТР.	0.59	0.6	0.983333
"ПРИВАТІНВЕСТ"	0.99	1	0.99
"УКООПСПІЛКА"	0.93	0.93	1
"ГАРАНТ"	0.81	0.81	1
ЗАХІДБУДГАЗБАНК	0.67	0.68	0.985294
"АНТАРЕС"	1	1	1
РАДАБАНК	1	1	1

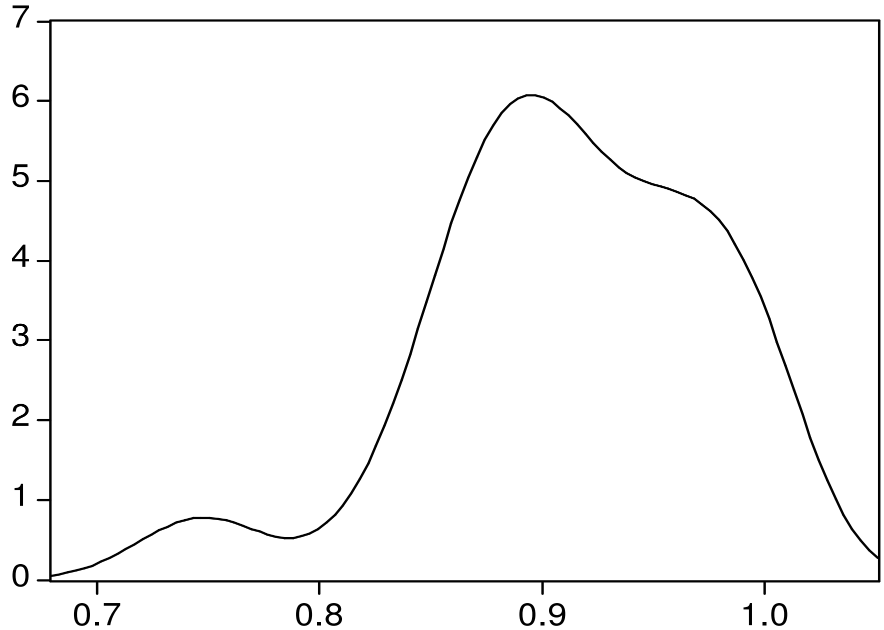
Bank	Technical efficiency (constant returns to scale)	Technical efficiency (variable returns to scale)	Scale efficiency
"АЛЬЯНС"	0.98	1	0.98
"СТОЛИЧНИЙ"	0.98	1	0.98
"ВЕЛЕС"	0.84	0.88	0.954545
КОРАЛ-БАНК	0.87	0.9	0.966667
ФІНБАНК	1	1	1
ТММ-БАНК	0.39	1	0.39
СХІДНО-ПРОМИСЛОВИЙ КОМЕРЦ. БАНК	1	1	1
"ЮНЕКС"	0.57	0.78	0.730769
"БУКОВИНА"	1	1	1
ПРАЙМ-БАНК	0.91	1	0.91
"ЄВРОПЕЙСЬКИЙ"	0.94	1	0.94
КЛАСИКБАНК	0.77	0.94	0.819149
"ФЕБ"	1	1	1
mean	0.896	0.922	0.973
median	0.91	0.95	0.99
max	1.00	1.00	1.00
min	0.39	0.51	0.39
standard deviation	0.11	0.10	0.06

APPENDIX 2

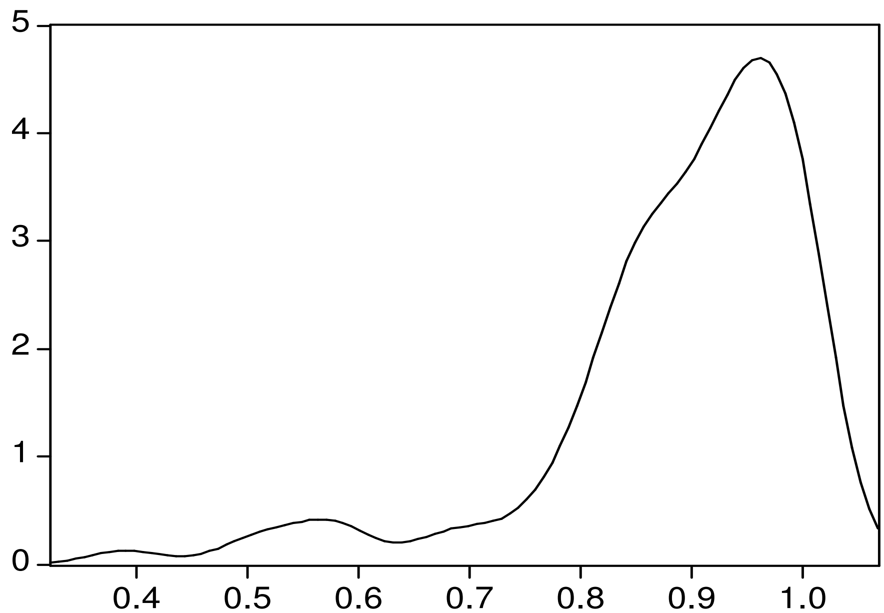
Density functions for
(a) all banks; (b) large and medium banks; (c) small banks
(Built with the help of Kernel density estimator)



Large and Medium Banks (54)

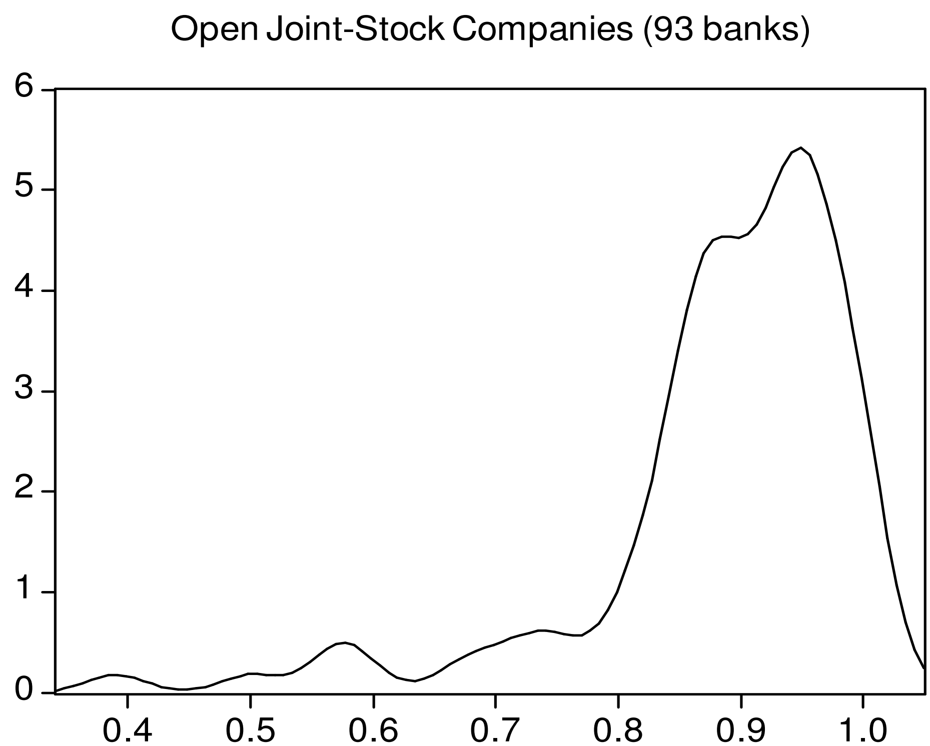


Small Banks (94)

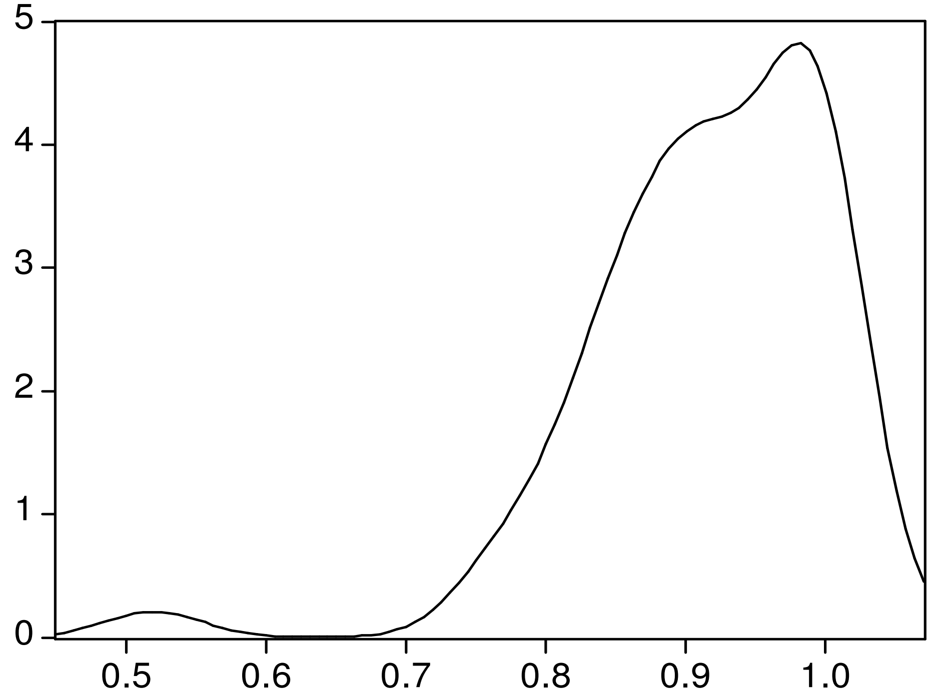


APPENDIX 3

Density functions for
(a) banks—open joint-stock companies;
(b) banks—closed joint-stock companies
(Built with the help of Kernel density estimator)



Closed Joint-Stock Companies (56 banks)



APPENDIX 4
Description of statistical tests used in the paper[17]

Mean Equality Test

The idea of the test is that if the subgroups have the same mean, then the variability between the sample means (between groups) should be the same as the variability within any subgroup (within group).

Denote: N—number of observations; M—number of groups; $x_{m,i}$—*i*-th observation in group m, where *i*=1,…,n_m, $\bar{x}$ is the sample mean, and $\bar{x}_m$ is a mean for group m.

Between groups sum of squares =B= $\sum_{m=1}^{M} n_m \left(\bar{x}_m - \bar{x}\right)^2$,

Within group sum of squares =W= $\sum_{m=1}^{M} \sum_{i=1}^{n_m} \left(x_{im} - \bar{x}_m\right)^2$.

Test statistic= $\frac{B/(M-1)}{W/(N-M)}$

Test statistic follows F-distribution under H_0 of equality of means. (M-1) and (N-M) are numerator and denominator degrees of freedom respectively.

Median (Distribution) Equality Tests

[17] Description of tests is based on E-Views help.

Median (distribution) tests are rank-based nonparametric tests of the H_0 that the subgroups have the same distribution against H_1 that at least one subgroup has a different distribution. Even though E-Views names this group of tests "median tests" and we preserve this name in the current paper, the tests focus on many different statistics of the subgroups.

Wilcoxon test This test is possible only for two subgroups. To perform the test, E-Views computes the absolute values of the difference between each observation and the classification variable, and ranks these differences. The idea is that if that under H_0 of equality of distributions in the two subgroups, the sums of ranks in each subgroup should be the same. Test statistic is asymptotically distributed as t-distribution.

Kruskal-Wallis test. This test is a generalization of the Wilcoxon test for more than two groups. The idea behind this test is to rank all observations in the series from the smallest to the largest and to compare the sums of ranks for different subgroups. If the subgroups have the same median, the sums should be similar. Under H_0 of the equality of distributions in different subgroups, the test statistic is approximately distributed asχ^2 with M-1 degrees of freedom, where M is a number of groups.

Van der Waerdan test. This test is analogous for the Kruskal-Wallis test, but it "smoothes" the ranks by converting them into normal quantiles. Under H_0 of the equality of distributions in different subgroups, the test statistic is approximately distributed asχ^2 with M-1 degrees of freedom, where M is a number of groups.

Ch-square test This is a rank-based test. It compares the number of observations above and below the median in each group. Under H_0 of the equality of distributions in different subgroups, the test statistic is approximately distributed as χ^2 with M-1 degrees of freedom, where M is a number of groups.

<u>Variance Equality Tests</u>

All of the following tests have the same H_0 that all subgroups have the same variance against H_1 that at least one group has a different variance.

F-test This test is possible for two groups only. The test statistic is calculated as a ratio of the variances of the two subgroups, the larger variance being in the numerator. Test statistic distributed as F-distribution under H0. Numerator and denominator degrees of freedom equal number of observations in the respective group minus one.

Siegel-Tukey test Also possible for two groups only. This test repeats the steps of the Kruskal-Wallis test described above. The difference is in the ranking. Siegel-Turkey test ranks observations in such a way: Rank 1 is assigned to the lowest observation, rank 2 -- to the highest observation, rank 3 goes to the second highest observation, rank 4 to the second lowest, rank 5 to the third lowest and so on.

Levene test The test is based on the analysis of the variance of the absolute difference from the mean. Test statistic is approximated to F-distribution with M=1 numerator degrees of freedom and N-M denominator degrees of freedom (N—number of observations, M—number of groups).

Brown-Forsythe test The same as Levene test, except for the absolute difference from the median is taken instead from the absolute difference from the mean.

APPENDIX 5

E-views outputs of tests

Test for equality of means between groups of different SIZE

H_0: means are equal

H_1: means are different

Result: cannot reject H_0 at any appropriate level of significance

Test for Equality of Means Between Series
Date: 05/15/03 Time: 12:56
Sample: 1 148
Included observations: 148

Method	df	Value	Probability
Anova F-statistic	(2, 145)	0.956002	0.3868

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	2	0.021148	0.010574
Within	145	1.603779	0.011061
Total	147	1.624927	0.011054

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
LARGE	8	0.901250	0.054625	0.019313
MEDIUM	46	0.913261	0.065322	0.009631
SMALL	94	0.887234	0.122294	0.012614
All	148	0.896081	0.105138	0.008642

Test for equality of medians between groups of banks of different SIZE

H_0: medians are equal

H_1: medians are different

Result: cannot reject H_0 at any appropriate level of significance

Test for Equality of Medians Between Series
Date: 05/15/03 Time: 13:18
Sample: 1 148
Included observations: 148

Method	df	Value	Probability
Med. Chi-square	2	2.022879	0.3637

Adj. Med. Chi-square	2	1.104130	0.5758
Kruskal-Wallis	2	0.460079	0.7945
Kruskal-Wallis (tie-adj.)	2	0.462650	0.7935
van der Waerden	2	0.522348	0.7701

Category Statistics

Variable	Count	Median	> Overall Median	Mean Rank	Mean Score
LARGE	8	0.895000	2	67.12500	-0.108823
MEDIUM	46	0.910000	22	77.29348	0.062826
SMALL	94	0.925000	48	73.76064	-0.044277
All	148	0.910000	72	74.50000	-0.014477

Test for equality of variances between groups of banks of different SIZE

H_0: variances are equal

H_1: variances are different

Result: reject H_0 at 5% level of significance

Test for Equality of Variances Between Series
Date: 05/15/03 Time: 13:26
Sample: 1 148
Included observations: 148

Method	df	Value	Probability
Levene	(2, 145)	4.781168	0.0098
Brown-Forsythe	(2, 145)	3.126985	0.0468

Category Statistics

Variable	Count	Std. Dev.	Mean Abs. Mean Diff.	Mean Abs. Median Diff.
LARGE	8	0.054625	0.039062	0.038750
MEDIUM	46	0.065322	0.050794	0.050652
SMALL	94	0.122294	0.086971	0.083191
All	148	0.105138	0.073137	0.070676

Bartlett weighted standard deviation: 0.105169

Test for equality of means between Kyiv and non-Kyiv banks
H_0: means are equal
H_1: means are different
Result: cannot reject H_0 at any appropriate level of significance

Test for Equality of Means Between Series
Date: 05/15/03 Time: 14:05
Sample: 1 148
Included observations: 148

Method	df	Value	Probability
Anova F-statistic	(1, 146)	0.272407	0.6025

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	1	0.003026	0.003026
Within	146	1.621901	0.011109
Total	147	1.624927	0.011054

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
NON-KYIV	68	0.891176	0.098018	0.011886
KYIV	80	0.900250	0.111275	0.012441
All	148	0.896081	0.105138	0.008642

Test for equality of medians between Kyiv and non-Kyiv banks
H_0: medians are equal
H_1: medians are different
Result: cannot reject H_0 at any appropriate level of significance

Test for Equality of Medians Between Series
Date: 05/15/03 Time: 14:07
Sample: 1 148
Included observations: 148

Method	df	Value	Probability
Wilcoxon/Mann-Whitney		0.842640	0.3994
Wilcoxon/Mann-Whitney (tie-adj.)		0.844991	0.3981
Med. Chi-square	1	0.127279	0.7213
Adj. Med. Chi-square	1	0.036772	0.8479

Kruskal-Wallis	1	0.713288	0.3984
Kruskal-Wallis (tie-adj.)	1	0.717274	0.3970
van der Waerden	1	0.585162	0.4443

Category Statistics

Variable	Count	Median	> Overall Median	Mean Rank	Mean Score
NON-KYIV	68	0.910000	32	71.27206	-0.076565
KYIV	80	0.915000	40	77.24375	0.038298
All	148	0.910000	72	74.50000	-0.014477

Test for equality of variances between Kyiv and non-Kyiv banks
H_0: variances are equal
H_1: variances are different
Result: cannot reject H_0 at 20% level of significance

Test for Equality of Variances Between Series
Date: 05/15/03 Time: 14:08
Sample: 1 148
Included observations: 148

Method	df	Value	Probability
F-test	(67, 79)	1.288800	0.2778
Siegel-Tukey		0.708525	0.4786
Levene	(1, 146)	0.081963	0.7751
Brown-Forsythe	(1, 146)	0.079651	0.7782

Category Statistics

Variable	Count	Std. Dev.	Mean Abs. Mean Diff.	Mean Abs. Median Diff.	Mean Tukey-Siegel Rank
NON-KYIV	68	0.098018	0.074308	0.072941	71.79218
KYIV	80	0.111275	0.070713	0.069250	76.80164
All	148	0.105138	0.072364	0.070946	74.50000

Bartlett weighted standard deviation: 0.105399

Test for equality of means between banks- open and closed joint-stock companies

H_0: means are equal

H_1: means are different

Result: reject H_0 at 10% level of significance

Test for Equality of Means Between Series
Date: 05/15/03 Time: 14:14
Sample: 1 148
Included observations: 148

Method	df	Value	Probability
Anova F-statistic	(1, 146)	3.012626	0.0847

Analysis of Variance

Source of Variation	df	Sum of Sq.	Mean Sq.
Between	1	0.032852	0.032852
Within	146	1.592075	0.010905
Total	147	1.624927	0.011054

Category Statistics

Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
open	93	0.884624	0.113190	0.011737
closed	55	0.915455	0.087492	0.011797
All	148	0.896081	0.105138	0.008642

Test for equality of medians between banks- open and closed joint-stock companies

H_0: medians are equal

H_1: medians are different

Result: most tests reject H_0 at 10% level of significance

Test for Equality of Medians Between Series
Date: 05/15/03 Time: 14:15
Sample: 1 148
Included observations: 148

Method	df	Value	Probability
Wilcoxon/Mann-Whitney		1.674508	0.0940
Wilcoxon/Mann-Whitney (tie-adj.)		1.679179	0.0931
Med. Chi-square	1	0.582836	0.4452
Adj. Med. Chi-square	1	0.351973	0.5530
Kruskal-Wallis	1	2.810624	0.0936

Kruskal-Wallis (tie-adj.)	1	2.826328	0.0927
van der Waerden	1	3.648036	0.0561

Category Statistics

Variable	Count	Median	> Overall Median	Mean Rank	Mean Score
open	93	0.910000	43	69.95699	-0.127303
closed	55	0.920000	29	82.18182	0.176301
All	148	0.910000	72	74.50000	-0.014477

Test for equality of variances between banks- open and closed joint-stock companies

H_0: variances are equal

H_1: variances are different

Result: F-test rejects H_0 at 5% level of significance

Test for Equality of Variances Between Series
Date: 05/15/03 Time: 14:16
Sample: 1 148
Included observations: 148

Method	df	Value	Probability
F-test	(54, 92)	1.673714	0.0297
Siegel-Tukey		0.918620	0.3583
Levene	(1, 146)	0.987377	0.3220
Brown-Forsythe	(1, 146)	0.539979	0.4636

Category Statistics

Variable	Count	Std. Dev.	Mean Abs. Mean Diff.	Mean Abs. Median Diff.	Mean Tukey-Siegel Rank
open	93	0.113190	0.077343	0.074409	76.98776
closed	55	0.087492	0.064793	0.064545	70.29343
All	148	0.105138	0.072679	0.070743	74.50000

Bartlett weighted standard deviation: 0.104425