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Efficiency Of The Ukrainian Banking Sector

The aim of this paper is to study the cost efficiency of the Ukrainian banking sector based on the data from banks' annual reports to the National Bank of Ukraine. This study applied the stochastic frontier methodology to a sample of 233 Ukrainian banks for a six-year period between 2014 and 2019, which showed that the overall mean cost efficiency of Ukrainian banks in the sample is 0.593. The results indicate that the same level of output could be produced with 59.3% of inputs if the banks were operating on the efficient frontier. The results of this study confirm that the Ukrainian banking sector is inefficient and high cost since roughly 40% of inputs are wasted during the production of financial services process.

Keywords: *stochastic frontier methodology, translog, banking sector, cost efficiency estimates, variables*

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Introduction

Banks are one the central links in the system of market mechanism. Development of their activity is one of the necessary components for economic growth and stability. Since banks provide finance for companies and potentially can change and improve competitiveness, efficiency of banking system has crucial role, especially for transition economies. Banking systems of transition economies in Eastern European countries and those former Soviet Union countries have gone through major changes and transformations throughout 1990s. Governments and central banks of these countries adopted several policies to promote the transformation of socialist banking systems into market-oriented ones [1]. While some countries have achieved success in reforming their financial sectors and removing the obstacles on the way to market-oriented banking system, financial sectors of some countries are still underdeveloped and experience a very low level of financial intermediation. In these circumstances, measuring and assessing efficiency of banking systems of such countries is of great importance, because the more efficient a banking sector of a country becomes, the more stable and developed becomes the economy of this country and therefore, it has a direct impact on financial sector development and transition towards the market-based banking system.

This paper is concentrated on banking sector of Ukraine. Transformation of Ukrainian banking system towards market-based one began after its independence establishment in 1991. According to Kyj & Isik [2], after the Soviet Union collapse development of the banking sector in Ukraine took slightly different path from most countries in the region. While its government conducted series of financial reforms, as well as did governments of most Central and Eastern European countries, the development of banking system in Ukraine, unlike most other transition countries, resulted in appearance of relatively high number of private, domestically owned institutions. More so, in Ukraine compared to other Eastern European countries, transaction and intermediation costs are very high due to thin capital and money markets, substantial asymmetric information, inefficient provision by the state of the rule of law, and lack of trust of the populace in the banking system [3]. Success of market transformations of Ukrainian emerging market economy largely depends on how effective and efficient its banking system will operate. Although many regulations and different supervisory frameworks were created to ease banking system transformation and result in economic growth and financial stability, increasing efficiency in banking sector is still very important issue for both the policy makers and sector participants themselves.

The aim of this paper is to study cost efficiency of Ukrainian banking sector for a period of 2014–2019 using Stochastic Frontier approach. In studies by Grigorian and Manole [4] and Fries and Taci [1] Ukrainian banking sector is referred to as inefficient and high cost, but their studies are cross-country ones and the amount of Ukrainian banks in their samples did not cover even 25% of the sector. This study will try to extend the existing literature on efficiency of Ukrainian banking by using the dataset which concentrates exclusively on Ukraine and encompasses all the banks operating in Ukraine in years of sample, plus providing some additional to existing results of stochastic frontier methodology applied to more up to date data.

Literature review

International surveys

The topic of banking systems' efficiency was investigated widely for last decade. Not only did researchers study bank's efficiency of a particular country, but also conducted cross-country surveys and international comparisons. Berger and Humprey [5] conducted a massive survey of 130 studies of financial institution efficiency covering 21 countries. They concluded that the efficiency estimates from nonparametric (DEA and FDH) studies are similar to those from parametric frontier models (SFA, DFA, and TFA), but the nonparametric methods generally yield slightly lower mean efficiency estimates and seem to have greater dispersion than the results of the parametric models. According to their study, overall, depository financial institutions (banks, S & Ls (savings and loan associations), credit unions) experience an average efficiency of around 77%. The authors noted that the efficiency estimates from nonparametric studies are similar to those from parametric frontier models, but the nonparametric methods generally yield slightly lower mean efficiency. Allen and Rai [6] estimated a global cost function for international banks to test for input and output inefficiencies. They used 1988–1992 data from the Global Vantage database, published by Standard and Poor's Compustat service and obtained usable data for 194 banks in fifteen countries. The results of this study suggest that for banks in the sample the prevalence of input X-inefficiencies far outweighs that of output inefficiencies (as measured by economies or diseconomies of scale or scope). Moreover, their results suggest that the distribution-free model overestimates the magnitude of X-inefficiencies relative to the stochastic cost frontier approach. The authors divided countries into two groups delineated by their regulatory environment. Results reveal that large banks in separated banking countries exhibited the largest measure of input inefficiency amounting to 27.5 percent of costs as well as significant levels of diseconomies of scale. All other banks of the sample have significantly lower X-inefficiency measures, in the range of 15 percent of total costs.

Studies on efficiency of the American banking sector

There have been quite a few studies regarding efficiency of the American banks. Mester [7] modified the stochastic econometric cost frontier approach to investigate efficiency of mutual and stock S & Ls using 1991 data on U.S. S & Ls. Mester used data obtained from the Federal Reserve Board. His sample consisted from 1015 S & Ls (807 mutual S & Ls and 208 stock S & Ls) and included all the US S & Ls that had positive equity in each quarter of 1991, did not change holding company status in 1991, had been in operation at least live years as of December 1991, and had not changed their ownership form over that period. Results of study indicate average inefficiency in the 0.08–0.10 range for mutual S & Ls and in the 0.12–0.16 range for stock S & Ls. Mester [8] used stochastic cost frontier approach in order to investigate efficiency of banks operating in the Third Federal Reserve district (eastern Pennsylvania, southern New Jersey, and Delaware, USA) using 1991–92 data from the Consolidated Reports of Condition and Income that banks must file each quarter. The sample of 214 banks included all the banks in the Third Federal Reserve District except for the special purpose banks in Delaware (legislated under the Financial Center Development Act and the Consumer Credit Bank Act), de novo banks (i.e., banks less than five years old as of December 1992, which have start-up costs that more mature banks do not have), banks that were involved in a merger in 1992, and three very large banks (which very likely use different production techniques than the other banks). The cost frontier was modified by the author so that both bank default risk and output quality could be held constant when comparing the efficiency of the banks. The results of the study reveal that banks in the Third District appear to be operating at cost-efficient output sizes and product mixes, but there appears to be a significant level of X-inefficiency at the banks. Berger and Mester [9] reviewed the literature on the sources of efficiency at commercial banks and provided new evidence using a large data set of almost 6000 US commercial banks that were in continuous operation over the six-year period of 1990–1995. They examined three economic efficiency concepts: cost, standard profit, and alternative profit efficiencies and explored the effects of a number of different efficiency measurement methods on each of the three efficiency concepts. These methods included the use of different measurement techniques, different functional forms, and various treatments of output quality and financial capital. According to the authors, the results for each of the efficiency concepts were quite robust. They found that the choices made concerning measurement technique, functional form, and other variables usually make very little difference in terms of either average industry efficiency or the rankings of individual firms in their data set with an exception of equity capital. Carvallo and Kasman [10] investigated cost efficiency of banking industries of 16 Latin American and Caribbean countries. The data they used comprised of 481 deposit taking institutions over the period between 1995 and 1999 and consisted of 1487 observations. The results suggest the presence of inefficiency in all banking systems. The average value indicates that banks produce with 0.171 of cost inefficiency. The average value of 0.171 meant that the banks in their sample could have saved about 17% of total cost if they had used the best practice technology.

Studies on efficiency of European banking

Researchers have also studied the European banking sector and efficiency of banks in different European countries was measured in different studies. Altunbas, Gardener, Molyneux & Moore [11] applied the flexible Fourier functional form and stochastic cost frontier methodologies to estimate scale economies, X-inefficiencies and technical change for a large sample of 4104 European banks for a period of 1989–1997 obtained from Bankscope database. The results show that typically scale economies are found to range between 5% and 7%, while X-inefficiency measure appear to be much larger, between 20% and 25%. X-inefficiencies also appear to vary to a greater extent across different markets, bank sizes and over time. According to authors, this suggests that banks of all sizes can obtain greater cost savings through reducing managerial and other inefficiencies. Lang and Welzel [12] studied cost efficiency of a panel of 757 German cooperative banks for the period of 1989–1992. The authors applied the intermediation approach and specified translog cost function for the sample. The results of the study indicate an overall mean cost efficiency of 0.692 for all the banks in the sample. Resti [13] evaluated cost-efficiency of the Italian banking system by applying both parametric and non-parametric approaches on a common panel of 270 Italian banks over the five-year period of 1988–1992. According to this study, mean efficiency was found to be approximately 70%. However, the efficiency scores showed a high variance. The gap between the "best" and the "worst" banks in the sample was about 40–50 percentage points. Beccalli [14] measured and compared cost efficiency of UK and Italian investment firms over the period of 1995–1998. Her sample consisted of 190 observations for Italy and 928 observations for the UK. According to the author, it constituted more than 80% of the industry in terms of market share. Beccalli employed four different specifications of the stochastic frontier methodology and used a transcendental logarithmic cost functional for to measure X-efficiency. The results of this study indicated an average cost efficiency of 0.7092 for UK banks in the sample and 0.5923 for Italian banks (both assuming half normal distribution).

Altunbas, Liu, Molyneux & Seth [15] applied stochastic cost frontier methodology in order to evaluated scale, X-inefficiencies and technical change for a sample of Japanese commercial. The authors also investigated the impact of risk and quality factors on banks' cost. Their data comprised the population of Japanese commercial banks listed in Bankscope database for the years 1993–1996, and consisted of 139 banks for each year from 1993 to1995 and 136 in 1996. According to the results of the study, X-inefficiency estimates for banks in the sample range between 5% and 7%. Kwan [16] used the stochastic frontier approach to investigate the cost efficiency of multi-branch banks operating in Hong Kong. He used quarterly data for 51 banks from 1992 to 1999. Data was taken from reports that banks in Hong Kong must file with the Hong Kong Monetary Authority. According to this study, the average X-efficiency estimate of Hong Kong banks was found to be in the order of 16–30% of observed costs, which is, according to the author, similar in magnitude to the findings in the US and other European countries. In this paper, I apply the same definition of price of borrowed funds as was applied by Kwan.

Efficiency of banking sectors in transition economies

Several papers have focused on bank efficiency in transition economies. Margono, Sharma and Melvin II [17] estimated cost efficiency, economies of scale, technological progress and productivity growth among 134 Indonesian banks for a period of 1993–2000. According to their study during the pre-crisis period from 1993 to 1997 cost efficiency of sample of studied banks increased from 65% to 91%. After the economic crisis, average cost efficiency among Indonesian banks decreased to 53%. Cost efficiency among mid-size banks was found to be greater than in either small or large banks. Akinci and Matousek [18] studied cost efficiency and economies of scale of 25 Turkish banks during the period of 1991–2007. Data was taken from bank statistics published by the Banks Association of Turkey. The authors applied methodology based on model introduced by Battese and Coelli [19]. The results of this study showed that the financial crises considerably deteriorated bank efficiency in the case of both crises 1994 and 2000–2001. However, the authors showed that bank efficiency levels were improved and in last two years of their analysis were rather constant and without differences between domestic and foreign banks. Kraft and Tirtiroglu [20] used stochastic cost frontier methodology and data for 1994 and 1995 in order to estimate X-efficiency and scale economies of banking industry in Croatia. Data were obtained from the audited final accounts of commercial banks in 1994 and 1995 provided to the supervision department of the NBC. 43 banks out of possible 53 were included into the sample. The results indicated that the degree of X-efficiency in the basic estimate ranged from 54.7% to 87.9% with average value of 80%. Out of the 43 banks, 27 had efficiency levels above 80%. Similarly to Kraft and Tirtiroglu, Jemric and Vujcic [21] also measured efficiency of banks in Croatia, but used different approach — Data Envelope Analysis. Their research indicated similar to previously described study results — average efficiency of sample was found to be approximately 83%. Hasan and Marton [22] estimated cost and profit inefficiency of Hungarian banks using stochastic frontier approach. The data comprised financial statements of all commercial banks that published in the Hungarian Financial and Stock Exchange Almanac during the 1993–1998 period and contained 193 bank observations. According to results of this study, average inefficiency for the whole sample was found to be 29.37 %. Weill [23] used the stochastic frontier approach to compute cost efficiency scores for a sample of Czech Republic and Polish banks. The author used unconsolidated accounting data from the 'Bankscope' database. The sample of banks included 31 Polish banks and 16 Czech banks. The results indicated an overall mean cost efficiency of 66.2 %.

Not only country-specific studies were done on banking efficiency in transition economies, but also cross-country ones. Bonin, Hasan & Wachtel measured cost and profit efficiencies by applying stochastic frontier estimation procedure to the sample of banks from eleven countries [24]. Their data set consisted of 225 banks from eleven transition economies (total of 856 bank-year observations) for a five-year period 1996–2000. The overall mean efficiency for the whole sample resulted into 0.777. Fries and Taci [1] examined cost efficiencies of banks in 15 East European post-communist countries. In their sample the authors included all banks from the BankScope database for which at least five years of data were available between 1994 and 2001. The final dataset included 289 banks for the period of 1994–2001. The sample included 14 Ukrainian banks. Their study revealed the simple average of bank inefficiency across all countries when country-level factors were not allowed to influence the position of the cost efficiency frontier to be 0.63. When country-level factors were allowed to influence the position of the cost efficiency frontier, the simple average of bank efficiencies across all countries was 0.71. Regarding cost efficiency of Ukrainian banks in the sample, the average cost efficiency was found to be 0.59 without country-level factors allowance and 0.73 when country-level factors were allowed. Grigorian and Manole studied efficiency of commercial banks of 17 transition countries for a period of 1995–1998 using Data Envelope Analysis [4]. The data used for analysis was compiled from BankScope database and resulted in total of 1074 observations for four-year period of 1995–1998. The sample included 54 observations on banks in Ukraine, which was approximately 20 per cent of Ukrainian banking industry. According to the results of the study, and overall average efficiency was 0.53 for the whole sample (maximum of 0.80 for Czech Republic in 1998 and minimum of 0.26 for Luthuania in 1995). Regarding Ukrainian banks in the sample, their mean efficiency was found to be 0.39 for observed time period.

Some studies which concentrated particularly on efficiency of Ukrainian banks. Mertens and Urga evaluated cost and profit efficiency and scale and scope economies for 79 out of 170 Ukrainian commercial banks in 1998 [25]. The data set used included aggregated balance sheets and income statements calculated at Ukrainian Interbank Currency Exchange (UICE) from the original detailed balance sheets of commercial banks using UICE's own methodology of aggregation. The results of the research indicated an overall cost efficiency of 0.672 for all sample. In addition, the authors found that large and medium banks' (those with more than 100m UAH of assets; 22 banks in sample) cost efficiency was 0.631, while small (less than 100m UAH of assets; 57 banks in sample) and very small banks (less than 49m UAH of assets; 31 banks in sample) had cost efficiency measures of 0.688 and 0.732 respectively. Therefore, authors concluded that small banks operate more efficiency in cost terms that large ones. Kyj and Isik [2] investigated managerial and scale x-efficiencies of commercial banks in Ukraine in a five-year period 1998–2003. Balance sheet data used in this study were obtained either directly from the National Bank of Ukraine (NBU), or from Visnyk, a financial publication of the NBU. The final dataset included 883 observations i.e. about 150 banks per year of research. Unlike previous authors, these used a non-stochastic frontier approach — Data Envelope Analysis. The results of this study were following: total technical efficiency of 0.41 and pure technical (managerial) efficiency of 0.29 and scale efficiency of 0.21.

Methodology

In order to measure cost efficiency I employ one of three main parametric approaches — stochastic frontier approach, introduced independently and almost simultaneously by Aigner et al. [26] and Meeusen and van der Broeck [27]. According to this approach, bank is inefficient if its costs are higher than those of an efficient bank which produces the same input/output quantities. This method allows for uncontrollable shocks as oppose to non-parametric approaches, which state that "distance between an inefficient observed bank and the efficient frontier is attributed entirely to inefficiency" [28]. According to Bauer et al. [29] and Eisenbeis et al. [30], such allowance for uncontrollable shocks can be shown to be more robust than the alternative method of data envelope analysis. The cost frontier is obtained by estimating a cost function with a composite error term, the sum of a two-sided error representing random fluctuations in cost and a one-sided positive error term representing inefficiency [15]. A bank's total cost is modeled to deviate from the cost efficient frontier because of random noise and inefficiency. Therefore, the stochastic cost frontier here has the following general (log) form:

$$lnTC_n = f(lnq_{i,n}, lnp_{j,n}) + \xi_n, \quad (1)$$

where $lnTC_n$ is the natural logarithm of total cost of nth bank, $lnq_{i,n}$ is the natural logarithm of ith output of nth bank, $lnp_{j,n}$ is the natural logarithm of the jth input price of the nth bank, and ξ_n is the error term which, as was mentioned earlier, has two components in it:

$$\xi n = u_n + v_n \quad (2)$$

where u_n captures the effects of uncontrollable (random) factors while v_n represents controllable factors [26]. u and v are independently distributed. u_n is assumed to have symmetric normal distribution with zero mean and variance σ_u^2, capturing the effects of random noise, $N(0, \sigma_u^2)$; v_n is assumed to be half-normally distributed, $|N(0, \sigma_u^2)|$, capturing the effects of inefficiency. Following Jondrow et al. [31], firm-specific estimates of technical efficiency, v_n, can be derived by using the conditional mean of the inefficiency term, given the estimate of the composed error term, ξ_n.

$$XE_n = E[v_n \mid \varepsilon_n] = \frac{\sigma\lambda}{(1+\lambda^2)} \left[\frac{\varphi(\varepsilon_n\lambda/\sigma)}{1-\Phi(\varepsilon_n\lambda/\sigma)} + \frac{\varepsilon_n\lambda}{\sigma} \right] \quad (3)$$

where XE_n is the X-efficiency of nth bank, $E[v_n \mid \varepsilon_n]$ is an unbiased but inconsistent estimator of v_n, since regardless of N, the variance of the estimator remains non-zero [32], λ is the ratio of the standard deviation of v to the standard deviation of u (i.e., σ_v/σ_u), φ and Φ are the standard normal distribution and the standard normal density functions respectively. According to Jondrow et al. [31], the ratio of the variability for v and u can be used to measure a banks' relative inefficiency, where $\lambda = \sigma_v/\sigma_u$, is a measure of the amount of variation stemming from inefficiency relative to noise for the sample. The X-inefficiency term, v, is assumed to remain constant over time for each bank. According to Olson et al. [33], estimates of this model can be computed by maximizing the likelihood function directly. Altunbas et al. [15] pointed out that previous studies modeling international bank inefficiencies, such as Allen and Rai [6] and those which examine US banks, such as Kaparakis et al. [34] and Mester [8], all use the half-normal specification to test for inefficiency differences between banking institutions.

Next, functional form of the cost function needs to be specified. In this study I adopt transcendental logarithmic (or translog) functional form for cos. According to Kraft and Tirtiroglu [20], the translog form is common in the literature, since it does not require too many restrictive assumptions about the nature of the technology. Additionally, Berger and Mester [9] found that the translog and more preferable by many researchers Fourier flexible form [35, 36], Berger et al. [37] and Mitchell and Onvural [38] have stated that Fourier flexible form is the global approximation which can be shown to dominate the conventional translog form) yield a small difference in average efficiencies, and vary little difference in efficiency dispersion or rank of the individual banks. The stochastic cost function is defined as:

$$\begin{aligned} lnTC = {} & \alpha_0 + \sum_{i=1}^{m} \alpha_i \ln Q_i + \sum_{i=1}^{n} \beta_j \ln P_j \\ & + \frac{1}{2}\left[\sum_{i=1}^{m}\sum_{j=1}^{m} \delta_{ij} \ln Q_i \ln Q_j + \sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \ln P_i \ln P_j + \tau \ln E \ln E \right] \\ & + \sum_{i=1}^{n}\sum_{j=1}^{m} \rho_{ij} \ln P_i \ln Q_j + \sum_{i=1}^{m} \alpha_{ik} \ln Q_i \ln E \\ & + \sum_{j=1}^{m} \beta_{ik} \ln P_j \ln E + \varepsilon_n \end{aligned} \quad (4)$$

where TC is the total operating cost, P_j (j = 1, 2, 3) are input prices and Q_i are output quantities, E *is equity, ε is the error term. α, β, δ, γ, ρ are the coefficients to be estimated.*

Data and variables definition

This study uses data from banks' annual reports to National Bank of Ukraine (central bank of Ukraine) for a sample of Ukrainian banks between 2014 and 2019. Data was obtained from the National Bank of Ukraine (NBU) website and from financial publication of NBU — *Visnyk*. After reviewing data for errors, inconsistencies and inappropriate information, I resulted in an unbalanced panel of 1022 observations, which included 233 different banks. Data on three banks were removed from the dataset; those three banks had one observation each throughout entire sample and none of the observations provided any outputs (i.e. these banks did not originate any loans or invest any money). The sample is quite extensive and covers all the banks operating in Ukraine for observed period (excluding the three banks that were dropped from the sample). Table 1 presents number of banks included in the dataset by year and Table 2 presents data summary by years and overall descriptive statistics.

Table 1. *Number of banks included in the dataset, 2014–2019*

Year	Number of observations
2014	159
2015	163
2016	169
2017	173
2018	182
2019	176
Total	1022

Source: *NBU annual reports*

A variety of approaches have been proposed in the literature for the definition of banks' inputs and outputs. Regarding outputs, banks can be viewed as a producer, or an intermediary. According to producer view, banks provide services to consumers, such as account holders. On the other hand, the intermediary approach, originally proposed by Sealey and Lindley [39], treats banks as agents that provide intermediation between bor-

Table 2. *Data summary and descriptive statistics, 2014–2019, 000s UAH*

	2014	2015	2016	2017	2018	2019	Mean	Median	Stdev	Min	Max
Total costs	10,459,732	13,535,499	19,498,995	30,887,872	61,161,786	105,922,767	236,964.33	38,026.00	768,809.14	1,032	9,767,301
Loans	87,453,515	142,276,760	245,522,526	430,052,035	741,815,979	726,295,788	87,711.07	17,501.00	276,979.21	105	4,900,837
Other assets	2,434,683	2,246,260	2,636,400	7,246,769	8,095,401	8,522,154	30,491.59	2,998.50	169,752.37	2.00	4,253,211
Capital expenses	4,784,103	6,005,248	7,807,701	11,957,774	19,188,261	39,634,493	138,468.44	30,651.00	354,507.64	27	3,107,590
Fixed assets	8,751,599	11,408,469	18,273,210	27,645,850	37,578,126	37,442,082	176,668.62	32,178.00	507,705.20	2	6,954,305
Annual interest expenses	7,755,828	10,907,350	16,578,668	28,609,811	50,816,146	65,357,516	2,641,620	445,450.00	7,222,638.15	20	75,795,412
Total deposits and other liabilities	115,926,440	188,427,131	297,613,176	529,797,811	806,807,959	753,238,308	61,627.92	11,667.00	171,555.58	69	2,129,251
Personnel expenses	3,369,411	4,690,776	6,994,096	11,595,701	17,836,774	18,312,089	3,029,109	534,632.00	8,224,996.07	27,636	86,066,131
Total assets	134,316,429	213,815,859	340,179,283	599,325,477	925,996,918	873,028,912	2,331,450	350,343.50	6,895,114.68	3,289	74,991,912
Equity	11,449,399	16,144,439	25,926,178	42,803,627	82,374,239	117,111,193	291,008.11	69,000.00	933,331.82	936	13,892,000

rowers and lenders. The difference between these two approaches is determined by the way the inputs are defined. Producer approach treats only physical capital and labor as inputs and suggests that only these two inputs are necessary to perform banking transactions. In contrast, the intermediary approach in addition to labor and physical capital treats deposits and borrowed funds as inputs used to provide earning assets. According to Elysiani and Mehdian [40], the intermediary approach is more inclusive of total banking cost because the interest expenses associated with deposits are not excluded and because it appropriately categorizes deposits as inputs. Taking this advantage into account, I will follow intermediary approach in my project.

The inputs are used to estimate the cost frontier and include physical capital, labor and borrowed funds (including deposits and all other interest-bearing liabilities). These inputs are assumed to fund the outputs. Regarding outputs, due to the lack of data I could not include aggregate securities or off-balance sheet items into the model as outputs, which is why I had to use other assets as second output, because it best suited the available data. The value of total aggregate loans was used as second output. The price of physical capital is proxied by proportion of total depreciation to other capital expenses and total fixed assets. The price of borrowed funds was constructed as a proportion of total interest expenses to total liabilities. The price of labor would be ideally reflected by proportion of personnel expenses to number of full-time employees. Unfortunately, the data on number of employees was unavailable, so I could not use the ratio of personnel expenses to number of full-time employees as a unit price of labor. Instead, the ratio of personnel expenses to total assets was used to proxy labor cost. Such approach is common in researches when data on number of employees is unavailable (e.g. [41–43]). Table 3 presents descriptive statistics of input and output variables used in the model.

In addition to estimating cost efficiency using full sample of banks, the cost frontier is also estimated separately for subsamples of large banks and small banks. Following Kwan [16], at each sampling period, banks whose total assets were above the median were classified as large and those that were below the median were classified as small. Banks that received dual classifications over the entire sampling period were included in the size group in which they were classified the majority of time. Bank classification according to its size is presented by year in Table 4.

Empirical results

Table 5 presents cost efficiency estimates for the whole sample and for groups according to banks size, as discussed in previous section. According to the results, an overall mean cost efficiency of Ukrainian banks in the sample is 0.593. This means that the same level of output could be produced with 59.3% of inputs if the

Table 3. *Descriptive statistics of the variables in the model, 2014–2019*

Variables	Description	Mean	Median	StDev	Min	Max
TC	Total cost (operating and financial cost) (UAH 000s)	236.964	38.026	768.809	1.032	9.767.301
Q1	The value of total aggregate loans (all types of loans) (UAH 000s)	2.331.450	350.344	6.895.114.68	3.289	74.991.912
Q2	Other assets (UAH 000s)	30.491.59	2.998.5	169.752.37	2.000	4.253.211
P1	Price of physical capital (%) (total depreciation and other capital expenses / total fixed assets)	1.7690	0.6394	5.4813	0.0476	125.4444
P2	Price of borrowed funds (%) (annual interest expenses / total liabilities)	0.0726	0.0710	0.0330	0.0003	0.2263
P3	Price of labor (annual personnel expenses / total assets)	0.0247	0.0210	0.0188	0.0005	0.2281
E	The value of total aggregate equities (UAH 000s)	291.008	69.000	933.331.82	936	13.892.000

Source: *NBU annual reports.*

Table 4. *Bank classification by size*

Year	Small banks	Large banks
2014	99	60
2015	83	79
2016	72	97
2017	48	124
2018	41	140
2019	46	130

Source: *NBU annual reports.*

Table 5. *Cost efficiency estimates*

Group of banks	Efficiency estimates
All sample (233 banks)	0.593
Large banks (more than 350 UAH mil of assets, 119 banks)	0.567
Small banks (less than 350 UAH mil of assets, 114 banks)	0.605

Table 6. *Cost efficiency studies comparison*

Study	Functonal Form	Results
This study sample of 233 Ukrainian banks for 2044–2019	translog	0.593
Mertens&Urga sample of 79 Ukrainian banks for 1998 [25]	translog	0.672
Fries&Taci sample included 14 Ukrainian banks for 1994–2001 [1]	translog	0.59*

** The result of 0.59 was found when model was tested without country-level factors. When country-level factors were present, the results indicated 0.73 mean efficiency level for Ukrainian banks in the sample.*

banks were operating on the efficient frontier. Table 6 presents comparison of findings of this study and those done previously using sample of Ukrainian banks and using the Stochastic Frontier methodology. All three studies used the translog functional form in order to specify the cost function. The results reveal almost 8% difference in cost efficiency measures between this study and the one done by Mertens & Urga [25]. This could be the case because the data used by Mertens & Urga includes only one-year period of time (1998) and only 46% of the commercial banks in the industry. Results of another study done by Fries & Taci [1] reported in Table 6 are similar to the ones received in this study.

Regarding the size of the banks and its correlation with cost efficiency, results given in Table 5 suggest that small banks operate more efficiently in cost terms than large banks, which is consistent with findings of Mertens & Urga on Ukrainian banks [25].

Conclusions

This study applied the Stochastic Frontier methodology and translog functional form to the sample of 233 Ukrainian banks for a six-year period of 2014–2019 in order to measure cost efficiency. The mean cost efficiency of this sample was found to be 0.593. Another finding of this study is that small banks operate more efficiently in cost term than large ones, which is consistent with studies previously done on cost efficiency of Ukrainian banking [25]. According to studies by Grigorian and Manole [4] and Fries and Taci [1], Ukrainian banking sector is referred to as inefficient and high cost. Results of this study confirm these claims since roughly 40% of inputs are wasted during the production of financial services process.

Given that the data on some necessary information like number of employees, total value of securities or off-balance sheet items was not available to me, future research that will be able to find these data might provide more robust results.

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Ефективність банківського сектору України

Метою статті є дослідження ефективності витрат банківського сектору України на основі даних річних звітів банків до Національного банку України. У дослідженні застосовано методологію аналізу стохастичних границь до вибірки з 233 українських банків за шестирічний період з 2014 по 2019 рік. Аналіз демонструє, що загальна середня ефективність витрат українських банків у вибірці становить 0,593, що свідчить про те, що такий самий рівень можна було б отримати, використовуючи 59,3 % ресурсів, якби банки працювали на межі ефективної діяльності. Результати дослідження підтверджують неефективність та високозатратність українського банківського сектору, оскільки близько 40 % ресурсів втрачається в процесі виробництва фінансових послуг.

Ключові слова: *метод стохастичної границі, модель стохастичної границі ефективності, транслог, банківський сектор, оцінка економічної ефективності, змінні*