

Stochastic Frontier Analysis as a Tool for Evaluating the Effectiveness of Banks Lending To the Real Economic Sectors in Ukraine

Valeria Baranova¹, Hryhorii Kots², Rami Matarneh³, Vyacheslav Lyashenko⁴

¹Department of Economy and Finances, Kharkiv National University of Internal Affairs, Kharkiv, Ukraine

²Department of Information Systems, Kharkiv National University of Economics, Kharkiv, Ukraine

³Department of Computer Science, Prince Sattam Bin Abdulaziz University, Al-Kharj, Saudi Arabia

⁴Department of Informatics, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine

ARTICLE INFO

ABSTRACT

corresponding Author:

Rami Matarneh³

³Department of Computer Science, Prince Sattam Bin Abdulaziz University, Al-Kharj, Saudi Arabia

This work focuses on the fluctuations of rating values of the bank lending efficiency in the real sector of the economy. The analysis is carried out on a sample of banks in Ukraine within the period from 2015 to 2016 years. To examining the values of bank lending efficiency in the real sector of Ukraine's economy, the article considers the efficiency stochastic boundary model, which is use the intermediary function for bank functioning description based on the asset approach. The forms of distribution by particular efficiency value levels of bank lending in the real sector of Ukraine's economy had been analyzed in detail. Results have revealed the tendency to increase in average values of bank lending efficiency in the real sector of Ukraine's economy. This is observed against the background of a reduction the number of banks and an actual lending to the real sector of the economy. At the same time it is shown that of bank lending efficiency the real sector of Ukraine's economy is determined in many respects a balanced deposits-loans system.

KEYWORDS: *Technical efficiency, bank lending, real sector of economy, stochastic efficiency boundary, loans, deposits, efficiency levels.*

INTRODUCTION

The banks play a relevant role in frame of economics, as by means of their activity the motion and reallocating of money and capital resources is organized. At the same time, special attention in processes of functioning of banking sector occupies lending of real sector of economy. It is connected by that in system of modern economic relationships principal sources of loan

are resources of banking sector of economy and equity market.

Many studies such as: (R. A. De Santis and P. Surico, 2013), (N. E. Magud, C. M. Reinhart and E. R. Vesperoni, 2014), (B. Égert and D. Sutherland, 2014), (K. Menyah, S. Nazlioglu and Y. Wolde-Rufael, 2014), (M. Quagliariello, 2009), discussed the observation of priority directions of lending of the real sector of the economy, in

addition they also examined the questions of interrelations between lending terms.

At the same time, based on the overall control of both the bank and any other economic frame there is an analysis of financial flows - motion (or change) financial resources of the definite subject of managing. It is accounted for by the fact that for the analysis of important is the dynamics of the incoming and outgoing cash flows of banks. The outgoing cash flow of banks is associated with bringing into effect active banking operations, where a significant role is allocated to banking transactions dealing with crediting, while the incoming cash flow embraces passive bank transactions, namely, bringing in resources, where a crucial importance is attributed to operations focusing on attracting the population funds to banks (Lyashenko, V., 2014) (Vasyurenko, O., Lyashenko, V., & Podchesova, V., 2014). It is therefore important to know the effectiveness of the bank's activities, the effectiveness of bank lending. Especially relevant the given analysis for the countries executing the economical transformation. It is conditioned by that, as demonstrates experience of the previous years, such transformations are accompanied by change and violation of adding up process of reproduction of financial resources.

At the same time it is necessary to notice, that research of efficiency of lending of real sector of economy as it is one of priority that proved by presence of big enough quantity of various works in the given direction (Assaf, A. G., Matousek, R., & Tsionas, E. G., 2013) (Asongu, S. A., 2012) (Garza-García, J. G., 2012) (Molyneux, P., & Williams, J., 2013).

Also is necessary to underline, that the analysis of efficiency of bank crediting affects various problem aspects in development of banking sector of economy, a banking system and bank efficiency which are the essential constituent of the general concept in research of economic processes and

economic dynamics of concerned issues (Kuzemin, A., & Lyashenko, V., 2008).

Thus, definition, disclosure and generalization any of possible estimations of bank crediting is the important practical problem not only from a field of bank efficiency, but also economic development as a whole. It allows using such estimations for reviewing of efficiency of crediting of real sector of economy

METHODOLOGY

One of the most recently considered directions, allowing to disclose and investigate efficiency of economic processes, occurrences, aspects of activity of various subjects of managing is the analysis with use of methods of econometric analysis among them it is necessary to select stochastic frontier analysis (SFA). According to research M. J. Farrell this efficiency allows to define an ability estimation to receive a maximum outcome (certain outcome), using a lot of inputs that uncover an aggregate of various factors of possibility of reaching of certain outcome (a maximum input) (Farrell, M. J., 1957).

The essence of the method SFA is the construction of the efficiency frontier by statistical analysis methods, the positioning of researched economic process or object relatively resulting the efficiency frontier, the efficiency determining of researched economic process or object as a function characterizing the reachability of constructed efficiency frontier (Vasyurenko, O., Lyashenko, V., & Podchesova, V., 2014) (Aigner, D., Lovell, C. K., & Schmidt, P., 1977) (Battese, G. E., & Coelli, T. J., 1992).

Function characterising an accessibility of constructed boundary of efficiency can be written as (Jondrow, J., Lovell, C. K., Materov, I. S., & Schmidt, P., 1982):

$$TE = e^{-M(u|\hat{\varepsilon})}, \quad (1)$$

where TE – effectiveness of the researched process or effect, that can be expressed either as a fraction of the whole or as a percentage;

$M(u|\hat{\varepsilon})$ – the conditional expectation u by estimated values $\hat{\varepsilon}$, which are complicated composite casual members of model for the obtained boundary of efficiency of investigated process, occurrence or object by means of statistical analysis methods (Aigner, D., Lovell, C. K., & Schmidt, P., 1977) (Jondrow, J., Lovell, C. K., Materov, I. S., & Schmidt, P., 1982):

$$y = f(x, \beta) + \varepsilon, \quad (2)$$

$$\varepsilon = v - u, \quad (3)$$

where y – vector of the results of researched object or process (in this case - is bank lending to the real economy);

x – vector of used resources for receiving the certain results of researched object or process;

f – function of the efficiency frontier of researched object or process;

β – vector of parameters of the function f ;

ε – composite random member of the model;

v – vector of random vibration of the model;

u – vector describing the technical inefficiency of researched object or process.

Then an evaluation measure of the researched effectiveness can be represented as the ratio of corresponding model of efficiency frontier with the actual parameters to the efficiency frontier model for which is assumed the absence of parameters reflecting the model inefficiency (Aigner, D., Lovell, C. K., & Schmidt, P., 1977) (Jondrow, J., Lovell, C. K., Materov, I. S., & Schmidt, P., 1982):

$$TE = \frac{P}{P^{opt}}, \quad (4)$$

Where P – model of the researched process or effect which is characterized by its actual parameters;

P^{opt} – stochastic model of the researched process or effect which is characterized by its optimal parameters (by exception of inefficiencies factors).

Based on a necessary condition of positive values of all component vectors v and u it is conjectured that these casual components of formalization of model of boundary of efficiency can have the form of semi-normal distribution $v \approx N(0, \sigma_v^2)$ and $u \approx N_+(0, \sigma_u^2)$ but by their values σ_v^2 and σ_u^2 . Thus, considering unusual structure of errors of model of boundary of efficiency which has dissymmetric distribution and consists of two components, regression residuals are estimated by a method of a maximum probability. Also it is necessary to notice that as a whole the model of function of boundary of efficiency of investigated processes, occurrences or objects for derivation of estimations of efficiency, can be defined in functional form of a transyllable or its simplified representation in Kobb-Duglasi functional form. It is important to note that such model should include the multiplicative connections of the independent variables (Gluschenko, V., Lyashenko, V., & Somova, V., 2013) (Ahmad, M. A., Kots, G. P., & Lyashenko, V. V., 2015).

Assessment of bank lending efficiency can be made by studying a set of banking activity indicators using different approaches for obtaining such valuables. In particular among the indicators, used for study of bank lending efficiency valuables, one can pick out:

- Volumes of loans granted to natural persons bank customers;
- Other banks' funds volumes on the accounts of each of the banks under study;
- The volume of the funds attracted in the form of deposits of natural legal persons;
- The volume of administrative and other operational costs.

On the whole the chosen variables corresponds totally the variables of the model of the banking activity description in accordance with the intermediary approach, based on the asset approach (Ahmad, M. A., Kots, G. P., & Lyashenko, V. V., 2015) (Mohammad, A., Kots, G., & Lyashenko, V., 2016).

Then the model of efficiency frontier for assessment of lending efficiency in the real sector of economy can be represented by the following multiplicative model:

$$KRF = \exp(\beta_0) \cdot MBP^{\beta_1} \cdot DP^{\beta_2} \cdot AV^{\beta_3} \cdot \exp(\varepsilon),$$

-----5

Where KRF – lending capacity of business entities in the real sector of economy in the context of each i -th from the group of banks under study on the certain date of time (loans to the business entities), mn. hrn.;

MBP – funds of other banks, that are attracted by means of interbank lending market in the context of each i -th from the group of banks under study on the certain date of time (money of the banks), mn. hrn.;

DP – a volume of the funds attracted in the form of deposits from natural and legal persons – bank customers in the context of each i -th from the group of banks under study on the certain date of time (deposits), mn. hrn.;

AV – a volume of administrative and other costs in the context of each i -th from the group of Ukraine's banks under study on the certain date of time (administrative and other operational costs), mn. hrn.

ε – Composite random member of the model, where $\varepsilon = v - u$;

$\beta_0, \beta_1, \beta_2, \beta_3$ – Model coefficients.

Taking into account the linearization function (5), the formalization of the additive frontier model take the following form:

$$\ln(KRF_i) = \beta_0 + \beta_1 \cdot \ln(MBP_i) + \beta_2 \cdot \ln(DP_i) + \beta_3 \cdot \ln(AV_i) + v - u$$

(6)

All the variables models of the efficiency frontier for the formula (6) are represented by vectors of corresponding data for various banks. Then we can write:

$$\ln(KRF_i) = \beta_0 + \beta_1 \ln(MBP_i) + \beta_2 \ln(DP_i) + \beta_3 \ln(AV_i) + v_i - u_i$$

(7)

$$TE_i = e^{-M(u_i|\hat{\varepsilon}_i)},$$

(8)

Where i – the number of researched banks.

DATA FOR THE ANALYSIS

In [18, 19] was investigated of lending efficiency in the real sector of economy in the period of years 2009 to 2014. For further realization of the model of the efficiency stochastic boundary for the purpose of obtaining the corresponding ratings of efficiency were studied the indicators the Ukraine's banks activity that were taken from the official site of the National Bank of Ukraine – bank.gov.ua. We are considering 60-70 banks and their activities in 2015-2016 years. Its different banks: big banks, small banks, middle banks, public banks, commercial banks, foreign banks.

Table 1 shows the particular stochastic characteristics of the investigated data series for the parameters of the model of efficiency stochastic boundary (the calculations were made at a significance level of 0.05).

Table 1: A descriptive statistics of the variables under study in the model (7-8)

A descriptive statistics	Variables			
	loans to the business entities (mn. hrn.)	money of the banks (mn. hrn.)	deposits (mn. hrn.)	administrative and other operational costs (mn. hrn.)
01.01.2016				
Average	8410.308	1950.063	10422.241	630.922
Min	9.786	0.002	7.416	10.268
Max	151705.002	31369.700	178121.357	8181.155
standard deviation	21399.250	5302.954	26146.669	1221.831
01.04.2016				
Average	10447.610	1824.588	11495.663	168.901
Min	3.334	0.006	50.817	3.096
Max	186334.917	33747.654	188144.911	2006.704
standard deviation	25868.691	4817.445	28586.526	328.328
01.07.2016				
Average	10710.365	1687.995	12910.235	374.485
Min	3.329	0.008	18.571	6.030
Max	166499.509	25787.371	189209.764	4358.846
standard deviation	24599.915	3956.396	30858.779	715.738

The general dynamics of the variables (the sum of the values for all banks) under study in the model (7-8) presented in the Figure 1.

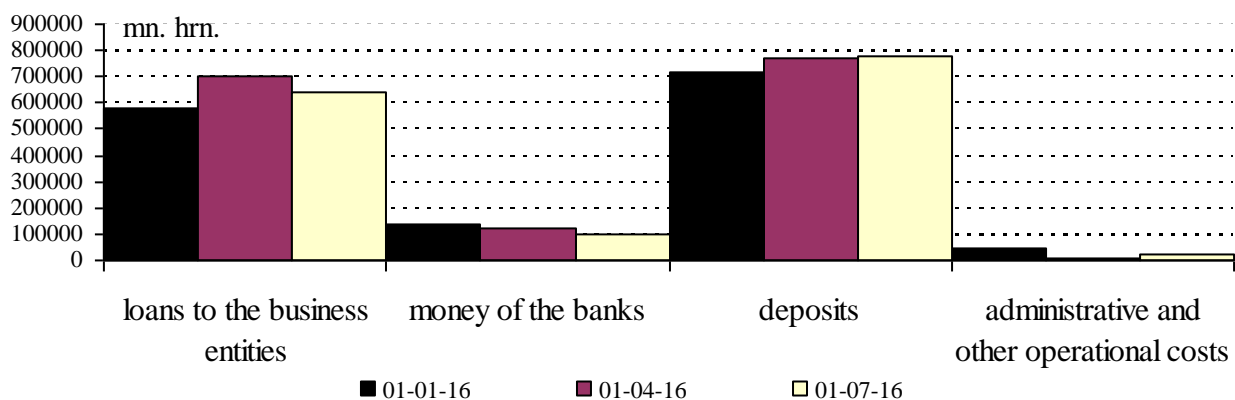


Fig. 1. Dynamics of the variables under study in the model (7-8).

As it can be seen from Figure 1:

- The general dynamics of bank lending in the real sector of Ukraine's economy it is variable;
- The general dynamics funds of other banks, that are attracted by means of interbank lending market it is negative;
- The general dynamics of bank deposit can be considered positive;
- The general dynamics a volume of administrative and other costs can be considered positive (these costs are reduced).

RESULTS AND DISCUSSION

To analyze the quantitative evaluation of the efficiency measure of bank lending in the real sector of economy the program FRONTIER4.1 was used which is in the free access (Ahmad, M. A., Kots, G. P., & Lyashenko, V. V., 2015).

In the Table 2 (the calculations were made at a significance level of 0,05) there are represented the parameters and statistical values for the efficiency frontier model of researched quantitative evaluations of the efficiency measure of bank lending in the real sector of economy for various time periods.

- Particularly, in the Table 1 are represented:
- Values of model coefficients – $\beta_0, \beta_1, \beta_2, \beta_3$;
- Value of total error variance – $\sigma^2 = \sigma_v^2 + \sigma_u^2$, which defines the key parameters of the distribution of random model values v and u ;
- Value share of inefficient component in the total error variance – $\gamma = \frac{\sigma_u^2}{\sigma^2}$;
- T-ratio of researched parameters.

First of all, we should note a significant part of ineffective component that, in particular, is a

confirmation of the reasonability of methodology use of analysis of stochastic frontiers for determining the efficiency of financial maintenance the bank employees (see Table 2, parameter γ).

The presented data in Table 2 also indicate the reliability and statistical significance of the researched efficiency frontier model for quantitative evaluations of the efficiency measure of bank lending in the real sector of economy (see Table 2, parameter – t-ratio).

Considering the influence of independent variables on dependent variable of the researched efficiency frontier model it should be noted:

- A significant effect on the loans to the business entities a volume of the funds attracted in the form of deposits from natural and legal persons – bank customers (see Table 2, parameter – β_2 , and coefficient). This effect is decrease over time. But the volume of deposits generates the necessary volume of loans. Therefore, it is important to have a balanced deposits-loans system;
- A slight effect on the loans to the business entities a volume of administrative and other costs. This effect is increases over time (see Table 2, parameter – β_3 , coefficient);
- A slight effect on the loans to the business entities funds of other banks, that are attracted by means of interbank lending market (see Table 2, parameter – β_1 , and coefficient). This effect is varies over time.

Table 2. Parameters and statistical values for the efficiency frontier model of the researched quantitative evaluations of lending efficiency in the real sector of economy

Parameter		01.01.2016	01.04.2016	01.07.2016
β_0	Coefficient	3.51E+00	2.18E+00	2.31E+00
	standard-error	2.56E-01	6.69E-01	6.85E-01
	t-ratio	1.37E+01	3.26E+00	3.37E+00
β_1	Coefficient	8.83E-02	6.76E-02	9.51E-02
	standard-error	2.06E-02	2.24E-02	2.18E-02
	t-ratio	4.28E+00	3.02E+00	4.37E+00
β_2	Coefficient	6.61E-01	7.12E-01	6.80E-01
	standard-error	6.23E-01	1.07E-01	8.05E-02
	t-ratio	1.06E+01	6.67E+00	8.45E+00
β_3	Coefficient	1.17E-01	1.81E-01	1.64E-01
	standard-error	1.08E-01	1.39E-01	1.11E-01
	t-ratio	1.08E+00	1.30E+00	1.48E+00
σ^2	Coefficient	2.31E+00	1.06E+00	8.43E-01
	standard-error	2.85E-01	2.54E-01	2.37E-01
	t-ratio	8.09E+00	4.19E+00	3.56E+00
γ	Coefficient	1.00E+00	8.83E-01	8.77E-01
	standard-error	2.79E-06	7.11E-02	9.90E-02
	t-ratio	3.58E+05	1.24E+01	8.85E+00
a number of banks		69	67	60

The figure 2 shows the value of quantitative evaluation of the efficiency measure of bank lending in the real sector of economy on 01.01.2016. The average value of quantitative

evaluation of the efficiency measure of bank lending in the real sector of economy on 01.01.2016 is at the level 0.39.

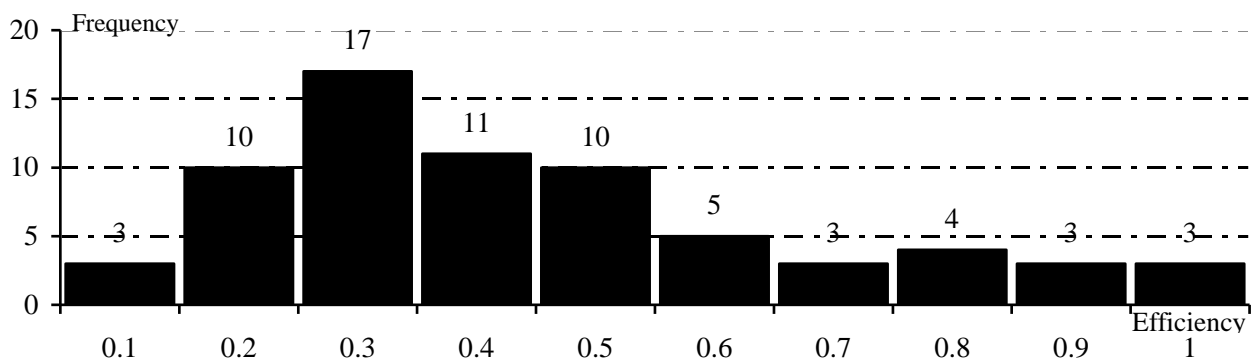


Fig. 2. A battery of bar graphs of bank lending efficiency in the real sector of Ukraine's economy on 01.01.2016

As it can be seen from Figure 2, most banks on 01.01.2016 had a rating of bank lending efficiency

in the real sector of the economy at the level 0.2–0.5.

The figure 3 shows the value of quantitative evaluation of the efficiency measure of bank lending in the real sector of economy on 01.04.2016. The average value of quantitative

evaluation of the efficiency measure of bank lending in the real sector of economy on 01.04.2016 is at the level 0.55.

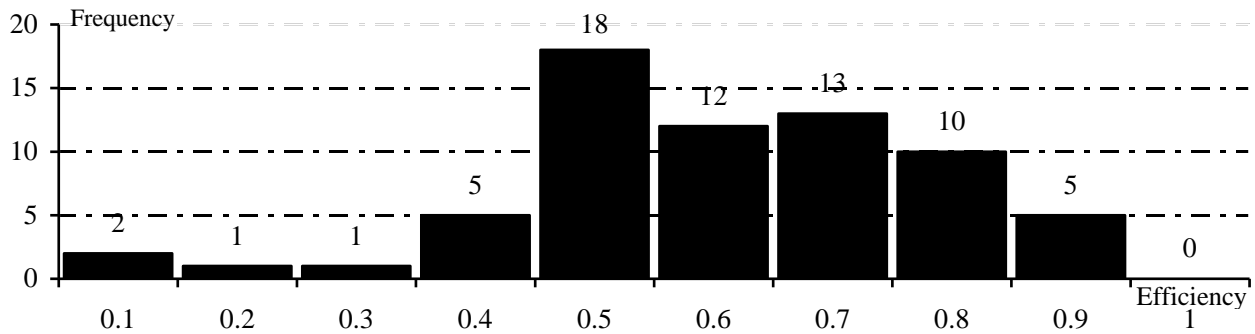


Fig. 3. A battery of bar graphs of bank lending efficiency in the real sector of Ukraine's economy on 01.04.2016.

As it can be seen from Figure 3, most banks on 01.01.2016 had a rating of bank lending efficiency in the real sector of the economy at the level 0.5–0.8. A number of banks with high the rating of bank lending efficiency in the real sector of economy increases.

The figure 4 shows the value of quantitative evaluation of the efficiency measure of bank lending in the real sector of economy on 01.07.2016. The average value of quantitative evaluation of the efficiency measure of bank

lending in the real sector of economy on 01.07.2016 is at the level 0.57. Thus, the average rating of the bank lending efficiency of the real sector of Ukraine’s economy increases gradually.

As it can be seen from Figure 4, most banks on 01.01.2016 had a rating of bank lending efficiency in the real sector of the economy at the level 0.5–0.9

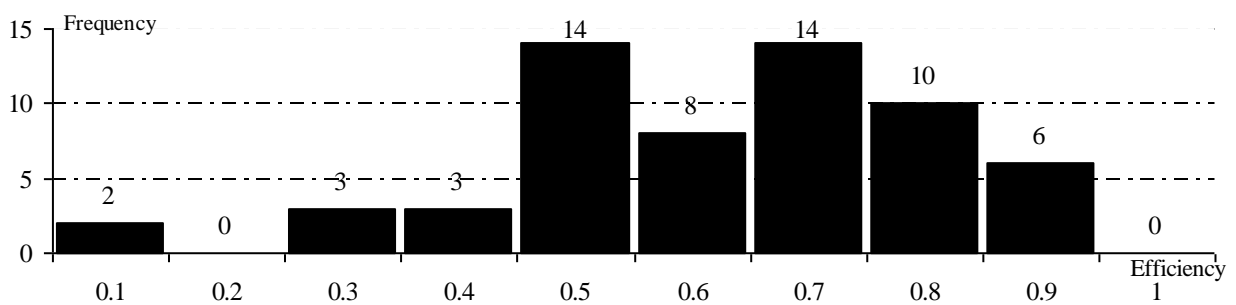


Fig. 4. A battery of bar graphs of bank lending efficiency in the real sector of Ukraine's economy on 01.07.2016.

The explanation of this fact is the current dynamic of economic processes occurring in banking services area in Ukraine, which is characterized by a reduction the number of banks and an actual lending to the real sector of the economy.

CONCLUSION

According to our research we can indicate the reasonability of using the methodology of the stochastic frontier analysis for the disclosure of quantitative evaluations of the measure of the bank lending efficiency in the real sector of the

economy. The use of method of stochastic frontier analysis has allowed to analyze the relationship between the parameters which allow to calculate the corresponding efficiency evaluations.

We have shown that it is the significant influence on the of the bank lending efficiency in the real sector of the economy a volume of the funds attracted in the form of deposits from natural and legal persons.

Presented in the study retrospective of bank lending efficiency of Ukraine's economy shows the tendency to efficiency increase of the corresponding segment of bank lending. This is observed against the background of a reduction the number of banks and an actual lending to the real sector of the economy. So, the key issue of increase of efficiency of processes of bank lending efficiency in the real sector of Ukraine's economy is a matter of adequate usage of real resources of banks.

REFERENCES

1. De Santis, R. A., & Surico, P. (2013). Bank lending and monetary transmission in the euro area. *Economic Policy*, 28(75), pp. 423-457.
2. Magud, N. E., Reinhart, C. M., & Vesperoni, E. R. (2014). Capital inflows, exchange rate flexibility and credit booms. *Review of Development Economics*, 18(3), pp. 415-430.
3. Égert, B., & Sutherland, D. (2014). The Nature of Financial and Real Business Cycles: The Great Moderation and Banking Sector Pro - Cyclical. *Scottish Journal of Political Economy*, 61(1), pp. 98-117.
4. Menyah, K., Nazlioglu, S., & Wolde-Rufael, Y. (2014). Financial development, trade openness and economic growth in African countries: New insights from a panel causality approach. *Economic Modelling*, 37, pp. 386-394.
5. Quagliariello, M. (2009). Macroeconomic uncertainty and banks' lending decisions: the case of Italy. *Applied Economics*, 41(3), pp. 323-336.
6. Lyashenko, V. (2014). Efficiency of bank crediting of real sector of economy in the context of separate banking groups: an empirical example from Ukraine. *International Journal of Accounting and Economics Studies*, 2(2), pp. 74-79.
7. Vasyurenko, O., Lyashenko, V., & Podchesova, V. (2014). Efficiency of lending to natural persons and legal entities by banks of Ukraine: methodology of stochastic frontier analysis. *Herald of the National Bank of Ukraine*, 1, pp. 5-11.
8. Assaf, A. G., Matousek, R., & Tsionas, E. G. (2013). Turkish bank efficiency: Bayesian estimation with undesirable outputs. *Journal of Banking & Finance*, 37(2), pp. 506-517.
9. Asongu, S. A. (2012). Bank efficiency and openness in Africa: do income levels matter?. *Published in: Review of Finance and Banking*, 4(2), pp. 115-122.
10. Garza-García, J. G. (2012). Determinants of bank efficiency in Mexico: a two-stage analysis. *Applied Economics Letters*, 19(17), pp. 1679-1682.
11. Molyneux, P., & Williams, J. (2013). Bank efficiency in Latin America. *Efficiency and Productivity Growth: Modelling in the Financial Services Industry*, pp. 1-18.
12. Kuzemin, A., & Lyashenko, V. (2008). Analysis of Spatial-Temporal Dynamics in the System of Economic Security of Different Subjects of Economic Management. *International Journal Information Technologies and Knowledge*, 2, pp. 234-238.
13. Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal*

- Statistical Society. Series A (General)*, 120(3), pp. 253-290.
14. Aigner, D., Lovell, C. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6(1), pp. 21-37.
15. Battese, G. E., & Coelli, T. J. (1992). Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. In *International Applications of Productivity and Efficiency Analysis* (pp.149-165). Springer Netherlands.
16. Jondrow, J., Lovell, C. K., Materov, I. S., & Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of econometrics*, 19(2-3), pp. 233-238.
17. Gluschenko, V., Lyashenko, V., & Somova, V. (2013). Components of a comparative analysis of the efficiency of the tax burden on income: application of stochastic frontier analysis. *International Journals of Marketing and Technology*, 3(10), pp. 136-145.
18. Ahmad, M. A., Kots, G. P., & Lyashenko, V. V. (2015). Bank Lending Efficiency in the Real Sector of the Economy of Ukraine within the Period of 2011 to 2014 Years. *Modern Economy*, 6(12), pp. 1209-1218.
19. Mohammad, A., Kots, G., & Lyashenko, V. (2016). Statistical Study of Bank Lending Efficiency in the Real Sector of the Economy of Ukraine within the Period of Years 2009 to 2012. *Asian Academic Research Journal of Multidisciplinary*, 3(2), pp.104-120.