International Journal of Academic and Applied Research (IJAAR)
ISSN: 2643-9603
Vol. 5 Issue 11, November - 2021, Pages: 139-145

Wavelet Coherence as a Tool for Assessing the Functioning of the Banking System (on the Example of Data From Ukraine)

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Abstract: *An efficient banking system is one of the factors for stable economic development. The ability to accumulate and redistribute financial resources contributes to the development of the economy and the financial sector. The stability of the functioning of the banking system contributes to the attraction of resources from such a source as the population. At the same time, it is important to analyze the functioning of the banking system in difficult conditions of its development: during the period of economic transformation, the influence of a set of various negative factors. Various methods and approaches are used for this analysis. The functioning of the banking system is described by various indicators and data sets. This reveals and shows the effectiveness of such a system from different points of view. Therefore, it is important to analyze the mutual dynamics of various characteristics that describe the functioning of the banking system. It is noted in the work that for such an analysis it is advisable to use the ideology of wavelet analysis. Wavelet coherence was chosen among the methods of such analysis. The use of wavelet coherence made it possible to construct an assessment of the functioning of the banking system on the example of data from Ukraine. For this, various data sets are considered, which reflect the functioning of the banking system from different points of view. On the basis of such assessments, the effectiveness of the functioning of the banking system of Ukraine has been analyzed. Results are presented based on real data analysis. This allows us to speak about the practical significance of such results, the possibility of their application for solving practical problems. Data and analysis results are presented in the form of informative graphs and diagrams. This allows us to understand the logic of the results obtained, to repeat this study and make similar assessments.*

Keywords—assessment; banking system; income; loans; deposits; financial market; wavelet analysis; wavelet coherence.

1. INTRODUCTION

The banking system is one of the key elements of a market economy. The banking system is able to accumulate and redistribute free financial resources between different business entities [1]-[3]. At the same time, the banking system is capable of generating new instruments and services, which is important for the development of the financial market. Thus, the banking system is also an important element of the financial market [4], [5]. At the same time, the banking system can be considered as one of the models of financial markets - bank based financial system [6], [7]. This arouses natural interest in the functioning and development of the banking system, its individual elements – banks.

Interest in the functioning and development of the banking system is important from different points of view. From the point of view of financial stability, it is important to overcome the negative phenomena that may arise in the financial sector. From the point of view of stability of functioning, this is important for the implementation of continuous financial and economic relations between various business entities, the possibility of implementing the accumulation function for the population, and the development of the economy as a whole. Therefore, a comprehensive analysis of data is important, which describe various processes, the dynamics of economic relations between the bank and its customers [8], [9]. It is important to take into account the fact that various indicators and data sets are used to assess the functioning of the banking system. This allows us to characterize the operation of such a system, taking into account the influence of various factors, different directions of its functioning and possible development. However, in this case, it is necessary to comprehensively take into account various indicators and data sets describing the banking system.

One of the approaches that allow you to analyze the functioning of the banking system is the approach based on the concept of financial flow [4], [10]. Then a set of different parameters for describing the activities of the banking system can be represented as a set of time series. This allows you to apply different methods to analyze the data and get the corresponding results that you can compare and make the most correct decision.

It is especially important to analyze the activities of the banking system for transitional, unstable economies that experience various difficulties and the influence of a combination of negative factors. Based on this, the main purpose of this article is to assess the functioning of the banking system using data from Ukraine as an example.

2. Materials and Methods

2.1 Related Work

Due to the important role of the banking system, which it plays in the system of financial and economic relations, the development of the economy and the country, many works have been devoted to its study.

In their study, S. Blank and J. Dovern give an answer to the question: what macroeconomic factors affect the banking system [11]. For this, the authors consider various micro- and macro- models. These models consider various factors that affect the resilience of the German banking system. At the same time, consideration of the influence of such factors is carried out in the pre-crisis and crisis periods of the functioning of the banking system. The authors investigate various sets of macroeconomic variables, indicators of stress. For this, the [11] sign restriction approach is applied. The article also analyzes the relationship between the financial situation and the macroeconomic environment. The authors note the importance of such a relationship for analyzing the efficiency of the banking system.

B. Aver and P. D. Chatzoglou, A. D. Diamantidis, E. Vraimaki, E. Polychrou, K. Chatzitheodorou consider, respectively, the conditions for the functioning of the Slovenian banking system and the Greek banking system [12], [13]. This analysis is carried out on the basis of a large amount of empirical material and data. In their analysis, the authors of these articles consider various risks that arise in the process of carrying out banking activities. It also examines the factors that lead to certain risks, the stability of the banking system to such risks. For such a study, the methodology of comparative analysis, various statistical methods are used.

E. Martín, A. Bachiller and P. Bachiller investigate changes in the Spanish banking system [14]. These changes take place in the period 2009-2013, when the banking reform was carried out. To analyze the data, the authors applied the Data Coverage Methodology (DEA) and also calculated the Malmquist Index [14]. This analysis model was applied to data before and after changes in the Spanish banking system. This allowed for a comparative analysis and assessment of the effectiveness of the reforms.

H. Cong and Y. Chen analyze the possibilities of developing an economy with a shadow banking system [15]. For this analysis, the authors use a dynamic stochastic general equilibrium system. This makes it possible to assess the degree of influence of the shadow banking system and the traditional banking system on the formation and development of the economic structure.

O. V. Kuzmenko and V. V. Koibichuk analyze the effectiveness of the banking system in the context of gender policy [16]. The authors examine the impact of relevant indicators of gender policy on the functioning of the banking system. This influence is determined using econometric modeling based on correlation, regression and factor analysis tools [16].

D. Haralayya and P. S. Aithal use technical analysis methodology to study the efficiency of the Indian banking sector [17]. For data analysis, the authors also use log linear regression to determine the stochastic frontier production function. Among the indicators of the banking system, the authors consider: fixed assets, total assets, total number of employees, total deposits, and return on equity and capital adequacy ratio. These data allow you to cover all areas of the banking system.

J. Li and P. Li consider the emergence and development of global banking systemic risk [18]. At the same time, the authors conduct such an analysis in the context of the development of the COVID-19 pandemic. The authors consider the development of banking systems in four regions: North America, Europe, China and Japan. This allows one to give objective assessments of the impact of the pandemic on the level of development of global banking systemic risk.

Z. Korzeb and R. Samaniego-Medina consider the issue of sustainable development of the banking system and economies in general [19]. To this end, the authors conduct a comparative analysis of the functioning and development of banks in the Polish banking sector. The authors analyze the participation of the Polish banking sector in the sustainable development of the Polish economy. For this, multivariate estimates are used using the method of order preference by the method of ideal solution (TOPSIS) with different weight vectors [19].

E. Burlea and A. Spînu analyze the efficiency of the banking system of the Republic of Moldova [20]. The authors carry out this analysis on the basis of general indicators that reflect various areas of the banking system. At the same time, the authors divided all indicators on the effectiveness of the development of the banking system into negative and positive. This makes it possible to fine-tune individual indicators and their impact on the banking system.

N. Tkachuk uses the entropy-informational approach to analyze the self-organization of the banking system [21]. Taking into account the changes in the data that reflect different aspects of the functioning of the banking system, the author draws conclusions about the corresponding changes in the self-organization of such a system. For this, the concept of entropy is used. The expediency of this approach is based on the fact that entropy is a measure of the disorder of the system, and its growth increases chaos and can lead to destructive consequences in the functioning of the system [21].

Thus, the analysis of the functioning and development of the banking system is of great interest among researchers and scientists. Such studies are carried out in different areas of the functioning of the banking system, individual areas of banking services. For this, various methods and approaches are used. At the same time, to assess the effectiveness of the banking system, it is necessary to use methods, approaches, ideology

that allow for comparative analysis. It is in this context that we consider the feasibility of applying the ideology of wavelets.

2.2 Wavelet coherence as a tool for assessing the functioning of the banking system

The ideology of wavelets makes it possible to assess the change in a certain series of data ($z(t)$) over a certain time interval (t). For this, the concept of the mother wavelet ($\phi(t)$) and the scaling function $\varphi(t)$ are used [22]-[25]. Further, the concept of convolution between the input time series and the mother wavelet is used. This allows you to get the continuous wavelet transform (CWT) using the following expression [22]-[24]:

$$W(z(t)) = \frac{1}{\sqrt{a}} \int_{-\infty}^{+\infty} z(t)\phi(\frac{t-b}{a})dt, \quad (1)$$

where

$\phi(\frac{t-b}{a})$ – is a mother wavelet satisfying condition: $\int_{-\infty}^{+\infty} \phi(t)dt = 0$;

a, b – scale and center of time localization, that determine the scale and $\varphi(t)$ function offset in accordance with the scaling conditions: $\int_{-\infty}^{+\infty} \varphi(t)dt = 0$.

Then, if we have two time series ($z_1(t)$ and $z_2(t)$), we can describe the mutual relationship between these series in the form of the following expression:

$$K^2(a,b) = \frac{\left|\Delta(a^{-1}W_{z1z2}(a,b))\right|^2}{\Delta(a^{-1}\left|W_{z1}(a,b)\right|^2)\Delta(a^{-1}\left|W_{z2}(a,b)\right|^2)}, \quad (2)$$

where:

$K^2(a,b)$ – is the wavelet coherence;

$W(a,b)$ – is a values of cross wavelet spectra;

Δ – is a smoothing operator;

$0 \le K^2(a,b) \le 1$. If these values tend to zero, then we have a weak correlation. Otherwise, we have a strong correlation [25]-[27].

Wavelet coherence allows you to evaluate the mutual dynamics of data. This can be done based on the analysis of mutual cross-references, which are analogous to multiple correlations.

2.3 Data for Analysis

For the analysis, we will use the data on the banking system of Ukraine, which are presented on the website https://bank.gov.ua/. We consider the data for the period from 2019-2021 in their monthly presentation. Among such data:

– loans provided by the banking system of Ukraine and customer deposits that were attracted to the banking system of Ukraine. These data show us the general ability to carry out banking activities;

– interest income and interest expense, which characterize one of the areas of banking in Ukraine;

– non-interest income and non-interest expenses, which characterize one of the areas of banking in Ukraine;

– net income, which is a generalized indicator of the efficiency of the banking system.

In fig. 1 shows the dynamics of loans issued and attracted deposits in the banking system in Ukraine.

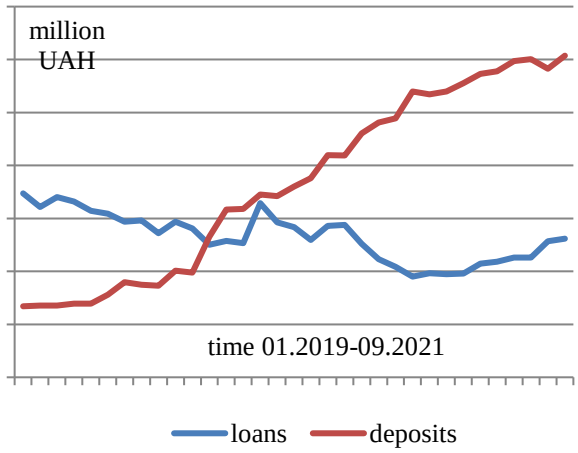

Figure 1: Dynamics of loans issued and attracted deposits in the banking system in Ukraine during 2019-2021

We see that the dynamics of loans issued and deposits attracted has a different direction. At the same time, there has been a slight increase in loans issued recently. These data indicate the insufficiently efficient operation of the banking system of Ukraine against the background of its interaction with the real sector of the economy.

In fig. 2 shows the data of interest income and interest expenses for the banking system in Ukraine. These data reflect the corresponding indicators in the context of accumulation for each month in the context of each year.

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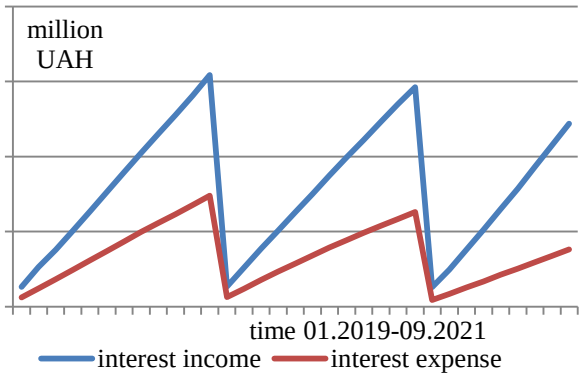


Figure 2: Data on interest income and interest expense by the banking system in Ukraine

In fig. 3 shows data on non-interest income and non-interest expenses in the banking system in Ukraine. These data reflect the corresponding indicators in the context of accumulation for each month in the context of each year.

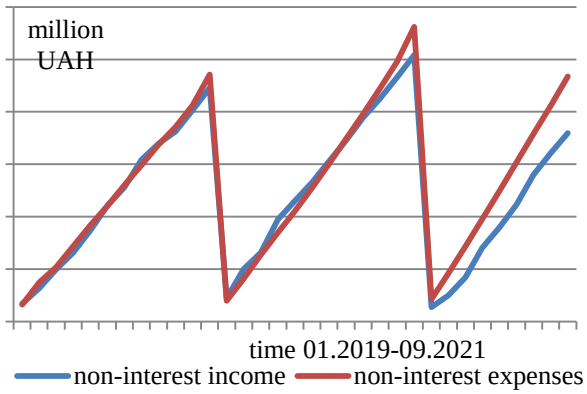


Figure 3: Data on non-interest income and non-interest expense by the banking system in Ukraine

We see that the dynamics of non-interest income and non-interest expense is almost identical in terms of the value of the respective indicators. At the same time, the dynamics of interest income and interest expense in terms of the value of the respective indicators is different. Thus, it can be stated that it is the dynamics of interest income and interest expense that determines the overall value of gross income in the banking system in Ukraine. Nevertheless, this dynamics is strongly influenced by the dynamics of loans issued and attracted deposits.

In fig. 4 shows the dynamics of net income for the banking system in Ukraine.

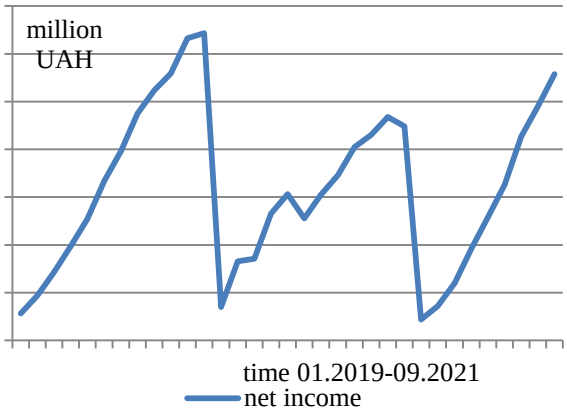


Figure 4: Dynamics of net income by the banking system in Ukraine

We see that the dynamics of net income inherits the dynamics of interest and non-interest income. Therefore, it is advisable to consider and evaluate the mutual dynamics of such data series.

3. Some Data from Wavelet Analysis

Let us first consider the mutual dynamics of the data, which are presented in fig. 1 - fig. 3. We will evaluate such dynamics using wavelet coherence. The corresponding figures, which are presented below, reflect [25], [27]:

the abscissa is the time period that we are analyzing. These data are presented in the form of ordinal numbers of values of each month from the interval 01.2019-09.2021;

ordinate – depth of cross-references between time series;

the white dashed line that limits the values of the wavelet coherence with the most reliable level of significance;

the column on the right, which allows you to visualize the values of the wavelet coherence from 0 to 1 and have the corresponding color characteristic.

We also note that we are considering, first of all, the degree of interconnection and mutual influence between the data on the investigated time interval.

In fig. 5 shows an assessment of the wavelet coherence between the dynamics of loans provided by the banking system of Ukraine and the dynamics of deposits attracted by the banking system of Ukraine.

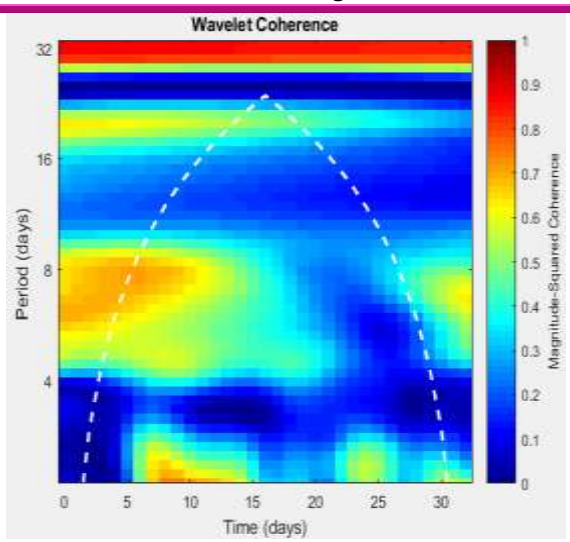


Figure 5: Wavelet coherence between the dynamics of loans provided by the banking system of Ukraine and the dynamics of deposits attracted by the banking system of Ukraine

We see that the corresponding data series have practically no consistency over the studied time interval. This corresponds to the data in fig. 1.

In fig. 6 shows an assessment of the wavelet coherence between interest income and interest expense in the banking system in Ukraine over the studied time interval.

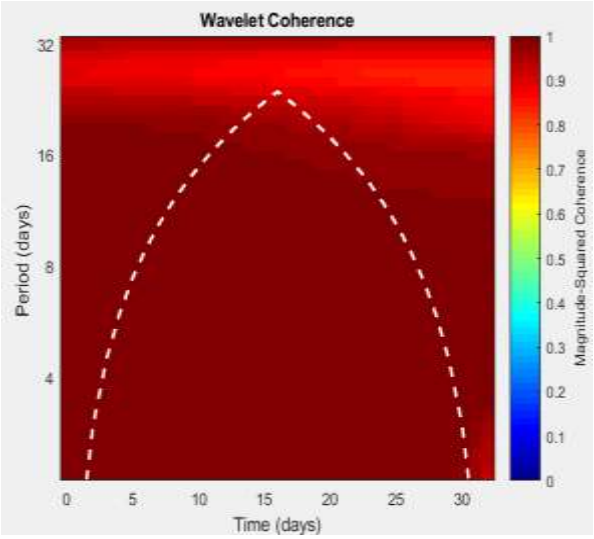
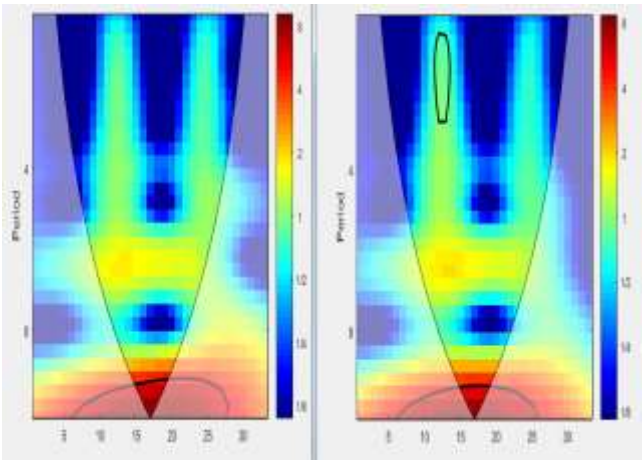


Figure 6: Wavelet coherence between interest income and interest expense across the banking system in Ukraine

We see that the corresponding data series are completely consistent over the studied time interval.

At the same time, it should be noted that the corresponding data have approximately the same power spectra (continuous wavelet transform spectrum - CWT, see fig. 7). These power spectra are strong enough for the entire time interval. This leads to the corresponding consistency between the data series.



a) b)

Figure 7: Spectrum of CWT for Interest Income (a) and Interest Expense (b)

In fig. 8 shows an assessment of the wavelet coherence between non-interest income and non-interest expenses in the banking system in Ukraine over the studied time interval.

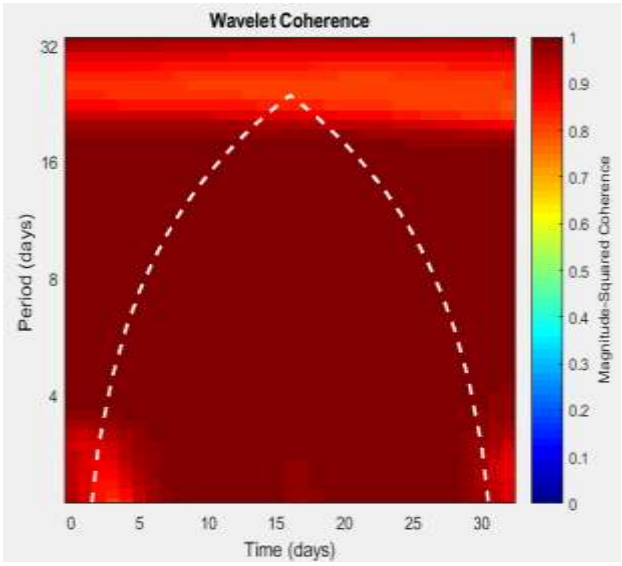


Figure 8: Wavelet coherence between non-interest income and non-interest expense in the banking system in Ukraine

We see that the corresponding data series are also completely consistent over the studied time interval. However, the consistency between interest income and interest expense is more significant (see fig. 6) than the consistency between non-interest income and non-interest expense (see fig. 8).

In fig. 9 shows an assessment of the wavelet consistency between net income and interest income in the banking system in Ukraine.

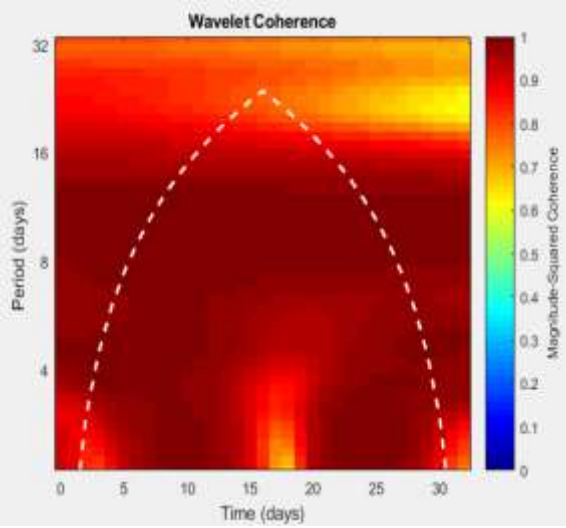


Figure 9: Wavelet Consistency between Net Income and Interest Income by the Banking System in Ukraine

In fig. 10 presents an assessment of the wavelet consistency between net income and non-interest income in the banking system in Ukraine.

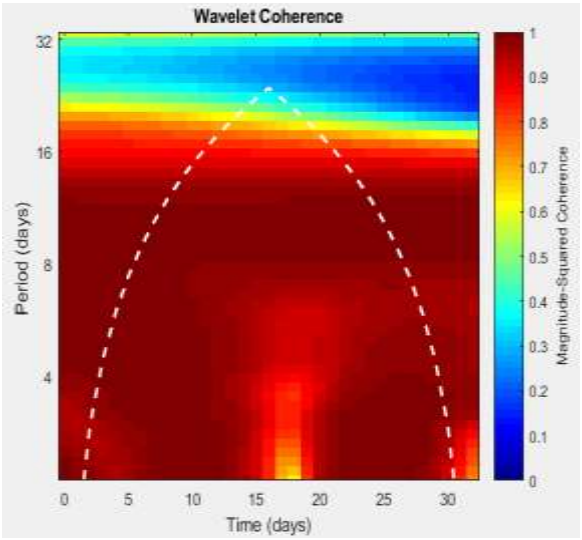


Figure 10: Wavelet Consistency between Net Income and Non-Interest Income by the Banking System in Ukraine

We see that the consistency between net income and interest income in the banking system in Ukraine is higher than between net income and non-interest income in the banking system in Ukraine. This is fully consistent with the data in Fig. 2 and fig. 3. The data obtained are also consistent with the results of studies by other authors [28], [29].

4. Conclusion

The paper deals with the analysis of the functioning and development of the banking system. Such an analysis is proposed to be done using the wavelet ideology. For this, we use estimates of the wavelet coherence. This approach makes it possible to assess the mutual dynamics of different indicators of banking activity.

The work considers real data about the banking system of Ukraine. The estimates of wavelet coherence were obtained for such data as loans issued and attracted deposits, interest income and interest expenses, non-interest income and non-interest expenses, net income and interest income, net income and non-interest income. It is shown that the estimates obtained are consistent with the dynamics of data that characterize the functioning and development of the banking system of Ukraine.

5. References

[1] 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, 5-11.

[2] Brei, M., Gadanecz, B., & Mehrotra, A. (2020). SME lending and banking system stability: Some mechanisms at work. Emerging Markets Review, 43, 100676.

[3] Bukhtiarova, A., & et al.. (2020). Assessment of financial monitoring efficiency in the banking system of Ukraine. Banks and Bank Systems, 15(1), 98.

[4] Vasiurenko, O., & Lyashenko, V. (2020). Wavelet coherence as a tool for retrospective analysis of bank activities. Economy and Forecasting, (2), 43-60.

[5] Baranova, V., & et al.. (2019). Stochastic Frontier Analysis and Wavelet Ideology in the Study of Emergence of Threats in the Financial Markets. In 2019 IEEE International Scientific-Practical Conference Problems of Infocommunications, Science and Technology (PIC S&T) (pp. 341-344). IEEE.

[6] Moradi, Z. S., Mirzaeenejad, M., & Geraeenejad, G. (2016). Effect of bank-based or market-based financial systems on income distribution in selected countries. Procedia Economics and Finance, 36, 510-521.

[7] Benito, A. (2005). Financial pressure, monetary policy effects and inventories: firm-level evidence from a market-based and a bank-based financial system. Economica, 72(286), 201-224.

[8] Kots, G. P., & Lyashenko, V. (2012). Banking sectors of the economies of European countries in the representation of statistical interrelation between indices that characterize their development. European Applied Sciences, 1, 461-465.

[9] Kuzemin, A., & Lyashenko, V. (2009). Methods of comparative analysis of banks functioning: classic and

new approaches. Information Theories & Applications, 16(4), 384-396.

[10] Kuzemin, A., & et al.. (2005). Analysis of movement of financial flows of economical agents as the basis for designing the system of economical security (general conception). In Third international conference «Information research, applications, and education (pp. 27-30).

[11] Blank, S., & Dovern, J. (2010). What macroeconomic shocks affect the German banking system?: Analysis in an integrated micro-macro model. Journal of Financial Economic Policy, 2(2), 126-148.

[12] Aver, B. (2008). An empirical analysis of credit risk factors of the Slovenian banking system. Managing Global Transitions, 6(3), 317-334.

[13] Chatzoglou, P. D., & et al.. (2010). Banking productivity: an overview of the Greek banking system. Managerial Finance, 36(12), 1007-1027.

[14] Martín, E., Bachiller, A., & Bachiller, P. (2018). The Restructuring of the Spanish banking system: analysis of the efficiency of financial entities. Management Decision, No. ART-2018-104419.

[15] Cong, H., & Chen, Y. (2018). Effect of Confidence Shock on an Economy with a Shadow Banking System: Analysis Based on Dynamic Stochastic General Equilibrium Model. Theoretical Economics Letters, 8(15), 3285-3300.

[16] Kuzmenko, O. V., & Koibichuk, V. V. (2018). Econometric modeling of the influence of relevant indicators of gender policy on the efficiency of a banking system. Cybernetics and Systems Analysis, 54(5), 687-695.

[17] Haralayya, D., & Aithal, P. S. (2021). Technical Efficiency Affecting Factors in Indian Banking Sector: An Empirical Analysis. Turkish Online Journal of Qualitative Inquiry (TOJQI), 12(3), 603-620.

[18] Li, J., & Li, P. (2020, October). Dynamic Copula Analysis of the Effect of COVID-19 Pandemic on Global Banking Systemic Risk. In BenchCouncil International Federated Intelligent Computing and Block Chain Conferences (pp. 449-460). Springer, Singapore.

[19] Korzeb, Z., & Samaniego-Medina, R. (2019). Sustainability Performance. A Comparative Analysis in the Polish Banking Sector. Sustainability, 11(3), 1-1.

[20] Burlea, E., & Spînu, A. (2018). Efficiency analysis of banking system of the Republic of Moldova based on general indicators. EcoSoEn, (1-2), 93-103.

[21] Tkachuk, N. (2019). Entropy-informational approach to analysis of self-ogranization of banking system. EUREKA: Social and Humanities, (3), 44-50.

[22] Torrence, C., & Webster, P. J. (1999). Interdecadal changes in the ENSO–monsoon system. Journal of climate, 12(8), 2679-2690.

[23] Heil, C.E., & Walnut, D.F. (1989). Continuous and discrete wavelet transforms. SIAM review, 31(4), 628-666.

[24] Kingsbury, N. (1999). Image processing with complex wavelets. Philosophical Transactions of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences, 357(1760), 2543-2560.

[25] Lyashenko, V., & et al.. (2021). Wavelet ideology as a universal tool for data processing and analysis: some application examples. International Journal of Academic Information Systems Research (IJAISR), 5(9), 25-30.

[26] Vasiurenko, O., & et al.. (2020). Spatial-Temporal Analysis the Dynamics of Changes on the Foreign Exchange Market: an Empirical Estimates from Ukraine. Journal of Asian Multicultural Research for Economy and Management Study, 1(2), 1-6.

[27] Baranova, V., & et al.. (2019). Wavelet Coherence as a Tool for Studying of Economic Dynamics in Infocommunication Systems. In 2019 IEEE International Scientific-Practical Conference Problems of Infocommunications, Science and Technology (PIC S&T) (pp. 336-340). IEEE.

[28] Babenko, V. , & et al.. (2021). Classical Machine Learning Methods in Economics Research: Macro and Micro Level Example. WSEAS Transactions on Business and Economics, 18, 209-217.

[29] Matar, A. (2020). Does electricity consumption impacting financial development? Wavelet analysis. Future Business Journal, 6(1), 1-9.