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***Research paper***

# Use of Wavelet Analysis for Determining the Stability of the Banking System

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**Abstract**

The possibility and feasibility of using wavelet analysis to disclose the stability of the banking system operation were justified in the article. The main stages of wavelet analysis for disclosing the stability of the banking system operation were defined.

***Keywords***: *deposits, loans, banking operations, time series, wavelet analysis*

## 1. Introduction

The banking system as an open, multifaceted and multivalued set of diverse institutional units of a single monetary market takes a leading place both in shaping the financial system of the country and in its economic development. This is defined not only by the ability of the banking system to accumulate free financial resources and redistribute them among the participants in economic relations, but also by the ability to generate new financial resources, primarily due to creating conditions for rapid and continuous circulation of the raised funds and their multiplication, which is acceptable by all market participants. In other words, the banking system has significant impact on all sectors of the economy and all participants in economic interaction, is an integral part of the operation and development of all economic entities and an influential factor in the balanced development of the economic life of society.

At the same time, the stability of operation and the sustainability of development stand out from the key conditions for achieving the most acceptable influence of the banking system on all participants in economic interaction [1; 2]. This determines the urgency of the chosen area of research and its practical significance for the further development of the domestic banking system.

A number of methods and approaches are used to analyze and disclose the conditions for the banking system operation, and examine the factors influencing the achievement of its stability.

Traditionally, various statistical methods are used to analyze the banking system and its individual constituent elements [3; 4].

The use of such methods allows to review both mutual dynamics of movement of various indicators of financial flows in the banking system and possible areas of its further development, according to the available dynamics of individual indicators that determine the efficiency and current state of operation of the system under study.

At the same time, the feature of such an analysis is the disclosure of conditions for the banking system operation in accordance with the specifics of the applied analysis of time series.

More sophisticated methods and analysis approaches to studying the stability of the banking system operation can be used, based on a comparative generalization [5], fuzzy sets theory [6], definition of the space of phase portraits according to the theory of nonlinear systems [7], etc. At the same time, the use of more complicated methods and approaches also involves the use of various time series as the input information to analyze the banking system operation, which reflect the dynamics of individual indicators of banking activity.

Each of the methods and approaches that are used in such analysis emphasizes certain features of the functional activity of the banking system and discloses the conditions for achieving and securing its stability. However, time series are the input information for most of the used methods and approaches. This is related to the characteristic feature of time series: the object under study or the process is observed consistently in time, which allows to account for the reciprocity of individual data.

However, when applying classical methods and approaches, both simple and complex, to the analysis of the banking system, it must be understood that such an analysis, first of all, allows to determine the current trends of the object of research. Possible implicit trends and hidden interaction between the individual features of the time series remain beyond the analysis, which may affect the final establishment of reciprocity between the dynamics of time series.

As such, one of the tasks of analyzing the banking system operation, in accordance with the significance of its influence on various components of the objects and processes of economic interaction, should be to conduct an in-depth analysis that will secure a broader and more detailed disclosure of the stability of the banking system. [8; 9]

The goal of the study is to select a method for the in-depth study of the existing state of the banking system operation and to define the nature of such a method.

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## 2. Method of Wavelet Analysis as a Method of Extended Analysis of the State of the Banking System Operation

On the side of the feasibility of choosing a certain method for an extended analysis of the state of the banking system operation for the purpose of disclosing its stability, the method of wavelet analysis should be considered, which provides for the use of wavelet transform of the time series under study [10]. This choice is determined by the following:

First of all, the method of wavelet analysis allows to disclose the local features of the time series under review by splitting the input data into two data series, one of which is defined by a set of approximating coefficients and the other is defined by a set of detailing coefficients [11].

The approximating coefficients generalize the trend characteristics of the time series under study, and the detailed ones disclose the available features of the time series under review.

The wavelet transform allows for the definition of the hierarchical structure of the input time series under review, which expands the possibilities for the analysis. This statement is based on the fact that information flows that are generated by time series have fractal properties, which the wavelet transform recognizes and allows to get more information [12].

Consequently, the wavelet transform complements the characteristics of the input time series under review;

Secondly, wavelet analysis has found wide application in the disclosure of the dynamics of time series, which define various economic data.

First of all, the so-called method of multiple-scale analysis is used for wavelet analysis, which ensures the transformation of the input series under review in the form of approximating and detailing coefficients, followed by the possibility of decomposition of such coefficients.

If the input time series are small, their decomposition into approximating and detailing coefficients is normally limited to one level of the input data partition.

Economic data, including those relating to the disclosure of the existing state of the banking system, are usually discrete. Therefore, a discrete wavelet transform should be applied in order to summarize a multiple-scale research from the standpoint of the problem. [13; 14]

According to the discrete wavelet transform, the input time series $X(t)$, ($t = t_1, t_2, ...$) are a set of approximating and detailing coefficients:

$$X(t) = \sum_{k=1}^{N_a} apr(N,k)\varphi_{N,k}(t) + \sum_{j=1}^{N}\sum_{k=1}^{N_j} \det(j,k)\psi_{j,k}(t) \quad (1)$$

where $apr(N,k)$ is the approximating coefficients of level N;
$det(j,k)$ is the detailing coefficients of level $j$;
$N$ is the selected level of the maximum expansion of the input time series;
$N_j$ is the number of detailing coefficients at the $j$-th level of expansion;
$N_a$ is the number of approximating coefficients at the $N$-th level of expansion;
$\psi(t)$ is the parent wavelet function;
$\varphi(t)$ is the corresponding scaling function.

The approximating coefficients $a_X(j,k)$ and the detailed coefficients $d_X(j,k)$ of discrete transformation for the time series $X(t)$ for the particular parent wavelet $\psi(t)$ and the corresponding scaling function $\varphi(t)$ can be defined as follows:

$$a_x(j,k) = \sum_t X(t)\varphi_{j,k}(t) \quad (2)$$

$$d_x(j,k) = \sum_t X(t)\psi_{j,k}(t) \quad (3)$$

The found coefficients allow for the broader analysis of the input time series.

It must be noted that the approximating coefficients are a low-frequency component of the input time series, and the detailing coefficients are a high-frequency component. This allows to consider the input series as a time-frequency data set where the indicated coefficients localize possible places of inhomogeneity and differences in the input time series, while special methods determine the content under study.

It must be clarified that wavelet analysis of the definition of stability of the banking system is based on the available statistical data, which reflect the mobility of the main financial flows of the banking system.

The basic stages of wavelet analysis for disclosing the stability of the banking system operation can be presented as follows:

Firstly, a variety of time series is chosen that define the individual components of the banking activity, according to which the stability of the banking system operation is further determined (for example, the most characteristic financial flows of the banking system are defined by the time series of data on aggregate deposits of residents by sectors of economy and loan volumes provided by sectors of economy);

Secondly, the wavelet transform of time series of data is carried out based on the application of the multiple-scale analysis;

Thirdly, the change in approximating and detailing coefficients of wavelet transform of input time series is considered (in accordance with the formalization according to formulas (1)–(3) in the MATLAB environment based on the application of the classical DeBoshi-1 wavelet and the corresponding scaling function);

Fourthly, the time-frequency pattern of the series is defined (calculated using the method of determining cross-estimates of the wavelet transform of data and their coherence);

Fifthly, the wavelet coherence of the data series under analysis is found (calculated using the method of determining cross- estimates of the wavelet transform of data);

Sixthly, the comparative analysis of the results of various wavelet transforms is carried out, on the basis of which conclusions are drawn regarding the stability of the functioning of the banking system under review.

The manifestations of insufficient efficiency of the stable banking system operation include:

- not too significant greatest overall strength of possible intersections between the series of data under analysis, which is a manifestation of the mutual relationship of the dynamics of the analyzed data of the input time intervals under review;
- inhomogeneous coherence of the time series under study, which is a reflection of the imbalance of the cause-effect relationship of the leading lag in the series under review.

## 3. Conclusion

The study discloses the possibility of introducing a general method of wavelet analysis for the study of time series of indicators of banking activity and determining the conditions for the stability of the banking system. The idea to apply such method involves the introduction of a multiple-scale analysis of input data based on the wavelet transform in order to further define cross-estimates and coherence between the series of data under analysis.

Compliance with the general method of carrying out wavelet analysis allows to determine basic stages of the study on disclosing the stability of the banking system operation.

A more detailed analysis of individual structural elements of the main financial flows of the banking system should be chosen as an area for further research, according to the approach proposed above.

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